113th Congress, 2d Session – – – – – – – – – – – – – House Document 113–131

NEUSE RIVER BASIN INTEGRATED FEASIBILITY REPORT AND ENVIRONMENT ASSESSMENT FINAL REPORT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, THE DEPARTMENT OF DEFENSE

TRANSMITTING

A FINAL REPORT ON THE NEUSE RIVER BASIN ECOSYSTEM RESTORATION PROJECT, NORTH CAROLINA

JULY 10, 2014.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAY -2 2014

Honorable John Boehner
Speaker of the House
of Representatives
U.S. Capitol Building, Room H-232
Washington, D.C. 20515-0001

Dear Mr. Speaker:

In response to a July 23, 1997 resolution of the Committee on Transportation and Infrastructure of the House of Representatives, the Secretary of the Army recommends authorization of the Neuse River Basin Ecosystem Restoration Project, North Carolina. The proposed project is described in the report of the Chief of Engineers, dated April 23, 2013, which includes other pertinent documents. The views of the state of North Carolina and the U.S. Coast Guard are set forth in the enclosed reports. The report includes an Environmental Assessment and a Finding of No Significant Impact.

The Neuse River is one of the major sources of freshwater for the Albemarle-Pamlico estuary. The recommended plan would have a substantial beneficial impact on biological integrity, freshwater mussel populations, anadromous fish populations, emergent freshwater and estuarine wetlands, and the quantity and quality of oyster reef habitat in the Neuse River watershed. The Albemarle-Pamlico estuary, which is part of the National Estuary Program, is a nursery for 90 percent of the commercial seafood species caught in North Carolina. It is one of the nation's largest and most productive coastal estuaries. The recommended plan is the national ecosystem restoration plan.

Based on October 2013 price levels, the estimated project first cost is $37,216,000. In accordance with the cost sharing provisions of Section 103(c) of the WRDA 1986, as amended, ecosystem restoration features are cost shared at a rate of 65 percent federal and 35 percent non-federal. The federal share of the project first cost is estimated to be $24,190,000 and the non-federal share is estimated at $13,026,000. The costs of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal (LERRD) areas are estimated at $256,000, all of which is eligible for LERRD credit. The state of North Carolina, acting through the Department of Environment and Natural Resources would be the non-federal sponsor responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, at an average annual cost estimated to be $24,000.

Based on a 3.50 percent discount rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $1,667,000, including monitoring and OMRR&R. The recommended project would contribute to the restoration of the Neuse River Basin ecosystem through construction of bottomland hardwood wetlands, estuarine emergent wetlands and oyster habitat. Additionally, modifications to a small dam on a Neuse River tributary would re-connect the system with historical spawning habitat for anadromous fishes. The plan would restore about 686 acres of aquatic habitat and provide a total of 241 average annual functional units of restoration benefits in the basin.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress. However, OMB also noted that should the Congress authorize this project for construction, it would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter, dated January 15, 2014, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also sending an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

7 Enclosures

1. Report of the Chief of Engineers, Apr 23, 2013
2. U.S. Coast Guard, Jan 30, 2013
3. HQUSACE Response to Coast Guard, Feb 26, 2013
4. State of North Carolina – Letter of Intent, Feb 27, 2013
5. OMB Letter, Jan 15, 2014
6. Final Report – Neuse River Basin Integrated Feasibility Report and Environmental Assessment, Nov 2012 (DVD)
7. Summary for the Office of the Parliamentarian

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, D.C. 20310-2600

DAEN

APR 2 3 2013

SUBJECT: Neuse River Basin, Ecosystem Restoration Project, North Carolina

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on ecosystem restoration in the Neuse River Basin, North Carolina. It is accompanied by the report of the district and division engineers. These reports are in final response to two resolutions by the Committee of Public Works of the United States House of Representatives, adopted April 15, 1966, and the Committee on Transportation and Infrastructure, adopted July 23, 1997. The 1966 resolution requested a review of the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document Numbered 175, Eighty-ninth Congress, and other pertinent reports to determine whether any modifications to the recommendations contained in the report are advisable. The 1997 resolution further requested a review of House Document 175 to determine where modifications of the recommendations are advisable in the interest of flood control (flood risk management), environmental protection and restoration, and related purposes. Preconstruction engineering and design activities for the Neuse River Basin ecosystem restoration project will continue under the authority adopted in July 1997.

2. The Neuse River Basin, the third-largest river basin in North Carolina contains a total area of 6,234 square miles, is one of only four watersheds entirely within the state. It originates at the confluence of the Eno and Flat Rivers in north central North Carolina near the city of Durham and flows southeasterly until reaching tidal waters upstream of the city of New Bern, North Carolina where the river broadens dramatically and changes from a unidirectional freshwater regime to a mixed tidal regime of the Neuse River Estuary before flowing out into Pamlico Sound and the Atlantic Ocean. The Neuse River Basin has experienced severe flooding in the past; consequently elements of the Basin ecosystem have shown signs of significant stress and degradation.

The ecosystem significance of the area is demonstrated on the national, regional, and local level. The Neuse River Basin includes 7 essential fish habitats and 12 significant natural heritage areas. The Neuse River Basin feeds one of the nation's largest and most productive coastal estuaries (Albemarle-Pamlico Sounds). The Albemarle-Pamlico estuary system, which is in the National Estuary Program, is a nursery for 90 percent of the commercial seafood species caught in North Carolina. In 2011 the value of seafood landed in North Carolina had an estimated dockside value of $72.8 million.

The federally listed shortnosed sturgeon will directly benefit from the opening of the dam which will improve passage for migration. The Neuse River Basin is also home to 17 species of rare freshwater mussels, two of which are federally listed as endangered, and a rare snail species. The federally listed dwarf wedgemussel and Tar River spinymussel will benefit from the restoration by increasing fish host for transportation. The Neuse River basin also provides habitat for 7 other federally listed

Encl 1

endangered species which include, the West Indian manatee, Red-cockaded woodpecker, Leatherback sea turtle and the Kemp's Ridley sea turtle.

3. The reporting officers recommend authorization of a plan to restore four components of the Neuse River Basin ecosystem. The plan includes construction of rock sills approximately 3,500 feet long at Gum Thicket Creek and 5,200 feet long at Cedar Creek, built at distances of about 60 feet offshore; regrading a previously filled area within the Kinston East wetland complex to the approximate elevation of the adjacent bottomland hardwood forest and allowing natural revegetation of the site by bottomland hardwood species and limited planting; modifying the Low-head Dam on the Little River to allow migration of anadromous fish; and the creation of 10 acres of 4 foot-high oyster reef within an 80 acre service area. The recommended plan is the National Ecosystem Restoration Plan. Implementation of the recommended plan will have a substantial beneficial impact on biological integrity, freshwater mussel populations, anadromous fish populations, emergent wetlands, and the quantity and quality of oyster reef habitat.

4. Based on an October 2012 (FY13) price level the estimated project first cost is $35,774,000. In accordance with the cost sharing provisions contained in Section 103(c) of the Water Resources Development Act of 1986 (WRDA 1986), as amended (33 U.S.C. 2213(c)), ecosystem restoration features are cost-shared at a rate of 65 percent Federal and 35 percent non-Federal. Thus the Federal share of the project first cost is estimated to be $23,253,100 and the non-Federal share is estimated at $12,520,900, which includes the costs of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD) estimated at $254,000. The non-Federal will receive credit for the costs of LERRD towards the non-Federal share. The North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) is the non-Federal cost-sharing sponsor for the recommended plan. The State of North Carolina would be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, an average annual cost currently estimated at $24,000.

5. Based on a 3.75 percent discount rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $1,671,000, including monitoring estimated at $312,000 and OMRR&R. All project costs are allocated to the authorized purpose of ecosystem restoration and are justified by the restoration of 241 average annual functional units in the Basin. The plan would restore the habitats in the most cost-effective manner. The restoration would include 1) creating 80 acres of oyster reef sanctuary with approximately 10 acres of reef top resulting in improved water quality and habitat for commercial and recreational seafood, 2) increasing wetland habitat by 14.5 acres of bottomland hardwoods, creating 15 acres of estuarine marsh, preventing degradation of another 60 acres of estuarine march and protecting a 240 acre wetland conservation easement area for wetland species and improved water resource function, and 3) restoring hydrologic connectivity for 46 miles of important spawning habitat for anadromous fish species.

6. The recommended plan was developed in coordination and consultation with various Federal, State, and local agencies using cost effectiveness and incremental cost analysis techniques to formulate ecosystem restoration solutions and evaluate the impacts and benefits of those solutions. Plan formulation evaluated a wide range of non-structural and structural alternatives under Corps policy and guidelines as well as consideration of a variety of economic, social and environmental

goals. The recommended plan delivers a holistic, comprehensive approach to solve water resources challenges in a sustainable manner.

7. In accordance with the Corps Engineering Circular on sea level change, the study performed an analysis of three Sea Level Rise rates, a baseline estimate representing the minimum expected sea level change, an intermediate estimate, and a high estimate representing the maximum expected sea level change. Projecting the three rates of change over a 50 year period provides a predicted low level rise of 0.42 feet (ft), an intermediate level rise of 0.85 ft and a high level rise of 2.2 ft. Accelerated sea level rise is expected to impact only one part of the recommended plan, which is the Gum Thicket/Cedar Creek site. Accelerated rates of future sea level rise may lead to drowning scenarios of North Carolinas tidal coastal wetlands. It is estimated in the without project condition, at the Gum Thicket reach up to 450 ft of erosion could occur under the historical rate of sea level rise, 671 ft of erosion could occur under the baseline estimate and up to 1,381 ft of erosion could occur under the high estimate over the 50 year period of analysis. At the Cedar Creek reach, 100 ft, 149 ft and 306 ft of erosion could occur under historical sea level rise and for baseline, intermediate and high scenarios, respectively, over the 50 year period of analysis. The environmental benefits of the recommended were based on erosion occurring at the historical rate of sea level rise, this means that the environmental benefits from the plan would actually increase with the accelerated sea level rise scenarios. Average annual habitat benefits for the recommended plan at Gum Thicket/Cedar Creek under the baseline scenario are estimated at 52.7 habitat units (a 10.0 habitat unit increase as compared to the historical sea level rate). Both the shoreline stabilization and marsh creation at Gum Thicket and Cedar Creeks would be affected by sea level rise. The project is designed based upon a historical rate of sea level rise. To reduce risks from potential accelerated sea level rise on the plantings, marsh restoration would include both low and high marshes allowing upslope mitigation of low-lying marshes. The sill design accounts for the historical rate of sea level rise applied over 50 years.

8. In accordance with Corps Engineering Circular on review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and vigorous review process to ensure technical quality. This included District Quality Control, Agency Technical Review (ECO-PCX), Policy and Legal Compliance Review, Cost Engineering Directory of Expertise Review and Certification, and Model Review and Approval. Given the nature of the project, an exclusion from the requirement to conduct a Type I Independent External Peer Review was granted on 18 May 2012. Concerns expressed by the ECO-PCX team have been addressed and incorporated in the final report.

9. Washington level review indicates the plan recommended by the reporting officers is technically sound, environmentally and socially acceptable, and on the basis of Congressional directives, economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principal and Guidelines for Water and Land Related Resources Implementation Studies. The recommended plan complies with other administration and legislative policies and guidelines. The views of interested parties including Federal, State and local agencies have been considered. State and Agency comments received during review of the final report and environmental assessment included concerns raised by the North Carolina Clearinghouse, the Environmental Protection Agency and the United States Coast Guard with design refinements for compliance with regulations and benefit improvements, as well as a request for continued coordination during the Preconstruction, Engineering and Design phase. The concerns were addressed through USACE response letters dated 7 March 2013, 12 February 2013,

and 26 February 2013, respectively.

10. I concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the plan for ecosystem restoration in the Neuse River Basin, North Carolina be authorized in accordance with the reporting officers' recommended plan at an October 2012 (FY13) estimated cost of $35,774,000 with such modifications as in the discretion of the Chief of Engineers may be advisable. My recommendation is subject to cost sharing, financing, and other applicable requirements of Federal and State laws and policies, including Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended (33 U.S.C. 2213). Accordingly, the non-Federal sponsor must agree with the following requirements prior to project implementation.

a. Provide 35 percent of total ecosystem restoration costs as further specified below:

(1) Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

(2) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

(3) Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal obligations for the project unless the Federal agency providing the Federal portion of such funds verifies in writing that expenditure of such funds for such purpose is authorized by Federal law;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

d. Shall not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

e. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 Code of Federal Regulations (CFR) Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

f. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

g. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

h. Hold and save the United States free from all damages arising from the design, construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

i. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of three years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;

j. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*));

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under the lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigation unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

l. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction or operation and maintenance of the project;

DAEN
SUBJECT: Neuse River Basin, Ecosystem Restoration Project, North Carolina

m. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

11. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

U.S. Department of Homeland Security

United States Coast Guard

Commander
Fifth Coast Guard District

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16518
January 30, 2013

Headquarters
U. S. Army Corps of Engineers - CEC-W-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

Dear Mr. Theodore Brown:

I recently received your request to review and provide comments regarding my jurisdiction for the USACE's Neuse River Basin ecosystem restoration efforts. The Coast Guard's interest in this project falls within the realm of impacts to navigation safety. Due to the complexity and the dynamics of the Neuse River, and the fact that we need more detailed information to accurately process your request, I was not able to respond by January 26, 2013. I hereby respectfully request additional time and information to provide feedback to you. Information in the next paragraph outlines a proposed pathway forward for your consideration.

The U.S. Coast Guard Fifth District recently provided comments regarding navigational safety for a similar restoration project on Harris Creek, Maryland to the USACE Baltimore District. This letter is enclosed and provided for your convenience to garner the key concerns addressed in that project as it continues to progress. In addressing restoration in Maryland, my office worked closely with the Maryland Department of Natural Resources and USACE. I look forward to working together to identify areas for restoration that will not impede navigational safety, as we have in the Baltimore District

In order for us to comment on this project, I need additional information regarding the exact locations, including the type of restoration to take place at the various proposed ecosystem restoration sites. If you are interested in taking a similar approach for this project with a small working group, please provide me your POC and I will be glad to coordinate a meeting of the key stakeholders to discuss navigation issues.

The Coast Guard sincerely appreciates the multi-agency approach USACE has taken to minimize or eliminate any navigational concerns and or constraints restoration projects may pose. This project remains a priority for the Waterways Management Staff. Please contact Mr. John Walters at (757) 398-6230 for updates concerning this matter.

Sincerely,

L. P. HARRISON, JR.
Commander, U. S. Coast Guard
Chief, Waterways Management
Fifth Coast Guard District

Encl: CG ltr fm D5 to Baltimore Corps District dtd 09 November 2012
Copy: CG Sector North Carolina
Commandant (CG-WWM)
Commandant (CG-47)

ENCL 2

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, N.W.
WASHINGTON, D.C. 20314-1000

FEB 2 5 2013

Planning and Policy Division

Commander L. P. Harrison, Jr.
United States Coast Guard
Fifth Coast Guard District
431 Crawford Street
Portsmouth, VA 23704-5004

Dear Commander Harrison:

This letter is in response to your January 30, 2013, comments regarding the U.S. Army Corps of Engineers Final Integrated Feasibility Report and Environmental Assessment for the Neuse River Basin Project. The Neuse Feasibility Report was circulated for State and Agency Review as required by the Flood Control Act of 1944, as amended. The Corps partnered with the North Carolina Department of Environment and Natural Resources Division of Water Resources to conduct the study.

The U. S. Coast Guard Fifth District (USCG) requested additional information regarding the exact locations, including the type of restoration to take place at the various proposed ecosystem restoration sites. The following information is provided to address this request. The lower Neuse Estuary is wide and fairly deep, with mid-river depths ranging from about 20 to 26 feet (ft). The location of the Federal Navigation Channel is shown on Figure 6-1 enclosed. Existing conditions in the mid-river are characterized by many unmarked natural reef tops at elevations ranging from about 18 to 21 ft. The existing depths in the proposed shoreline reef areas are approximately 12 ft deep.

The Neuse River Basin Feasibility study identified general areas with the conditions for successful oyster reef creation. Specific sites will be identified in Plans and Specifications. However, in an attempt to ensure there is no conflict with navigational use of the general area, the conceptual reef designs will provide at least 14 ft of navigational clearance in the mid-river sanctuaries and near shore reefs will have at least 7 ft of navigational clearance. Mid-river reef structures would be designed to not exceed the controlling elevations of the natural reefs that currently exist in those locations. Sanctuary foot print areas will avoid navigation channels as identified by navigation channel markers. All restored reef sites will be clearly marked with navigational buoys and no significant navigational hazard is expected. Other than this general information on conceptual reef design contained within the Feasibility Report, no additional design information has been developed at this time. Supplemental field data collection efforts scheduled for the upcoming project design will provide the detail required to aid in specific site selection for oyster reef construction.

As requested, the Corps Wilmington District is willing to engage in a small working group. When the field data collection efforts are completed, coordination with the USCG and others will occur to establish the small working group. The small working group will review the gathered data and the Corps proposed site recommendation for each restored reef to assure that final site selection will not constitute increased navigational hazards to marine traffic.

Thank you for your comments and I look forward to future coordination with your agency.

Sincerely,

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Enclosure

NCDENR

North Carolina Department of Environment and Natural Resources

Division of Water Resources

Beverly Eaves Perdue
Governor

Thomas A. Reeder
Director

Dee Freeman
Secretary

February 27, 2012

Colonel Steven A. Baker
District Commander, Wilmington District
U.S. Army Corps of Engineers
69 Darlington Avenue
Wilmington, NC 28403

Dear Colonel Baker:

It is the intent of the State of North Carolina to be the non-Federal sponsor for the Neuse River Basin ecosystem restoration project. We have reviewed the draft Integrated Feasibility Report and Environmental Assessment dated October 2011 and the State expresses its support for the Tentatively Selected Plan as described in the draft report.

As the non-Federal project sponsor we anticipate that implementation costs of the project, currently estimated at $35,318,000, would be shared 35% non-Federal and 65% Federal. The State's share is currently estimated at $12,361,000 including cash, in-kind services, and lands, easements, relocations, rights-of-way, and borrow or disposal areas. The State's ability to provide these funds is dependent upon the approval of appropriations for the project in future State budgets.

We would also assume all responsibility for operation, maintenance, repair, rehabilitation and replacement for the life of the project, at an estimated $390,000 average annual cost. Prior to construction, we anticipate signing a Design Agreement and a Project Partnership Agreement (PPA) that will explicitly state Federal and non-Federal costs and responsibilities.

We appreciate the efforts of the Corps of Engineers on this project.

Sincerely,

Tom Reeder

1611 Mail Service Center, Raleigh, North Carolina 27699-1611
Phone: 919-733-4064 \ FAX: 919-733-3558 \ Internet: www.ncwater.org

Encl 4

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

January 15, 2014

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget (OMB) has completed its review of your recommendation for the Neuse River Basin project, North Carolina.

We appreciate this effort by the Corps, which identified aquatic ecosystem restoration opportunities in the Neuse River Basin. Each of the four features proposed in this study would likely have a positive environmental effect; some of them could also benefit Federally-listed species, including the Dwarf wedge mussel, Tar River spinymussel, and Atlantic sturgeon. The Corps identified these features through the type of collaborative, systems-based planning that the Administration supports. The relevant Federal, state, and local agencies and other stakeholders were actively involved in the planning process, helping the Corps identify restoration opportunities that would build upon ongoing efforts in the Basin.

While the proposed plan would likely benefit this ecosystem, the study does not provide a robust basis for the Corps' involvement in the construction of this project. The project is not designed to repair ecosystem degradation caused by past Corps activities. Instead, the need for restoration stems from actions undertaken by local communities, private landowners, and others. Nor does their construction seem to require special expertise that only the Corps can provide or involve work to restore one of the nationally significant ecosystems identified by the Administration. With the tight competition for Federal funds, ecosystem significance, connectivity, species diversity and a determination on which entities are best equipped to do the work will continue to be a paramount issue. However, we are encouraged that the Corps is working to better define its role in aquatic ecosystem restoration and are interested in continuing discussions with you on this issue as it relates to both authorization and budgeting of projects.

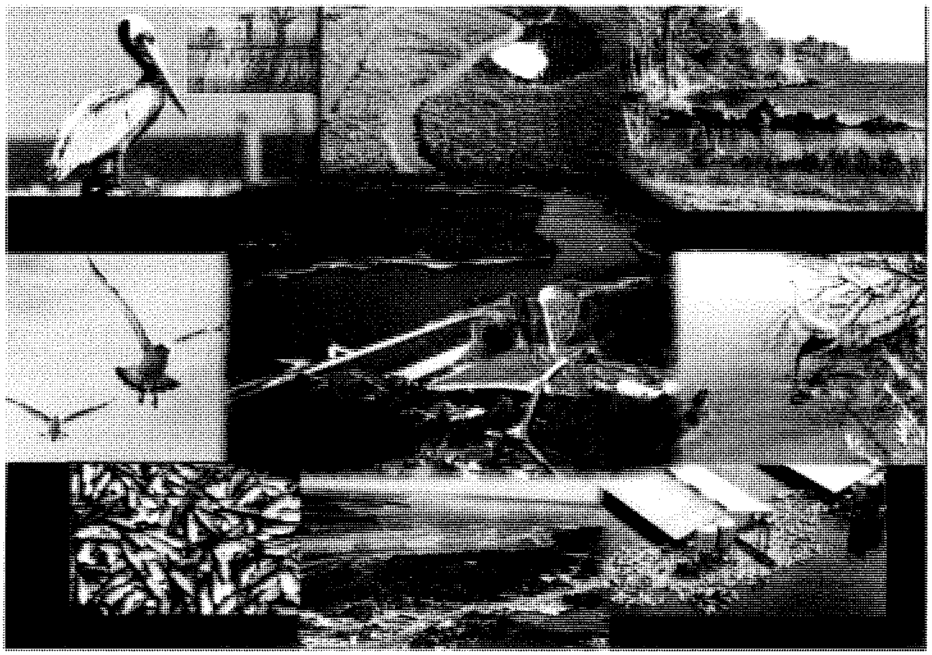
Encl. 5

The Office of Management and Budget does not object to you submitting this report to Congress. However, when you do so, please advise the Congress that should Congress authorize this project for construction, the project would need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science, and Water

Neuse River Basin Integrated Feasibility Report and Environmental Assessment



IN COOPERATION WITH

NCDENR

PREPARED BY:

US Army Corps of Engineers®
Wilmington District

November 2012

EXECUTIVE SUMMARY

Background

This *Integrated Feasibility Report and Environmental Assessment* (EA) was prepared in response to the Congressional Resolution adopted July 23, 1997, which requested review of the report of the Chief of Engineers on the Neuse River Basin, (published as House Document 175, 89th Congress), and reads as follows:

> July 23, 1997: *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control (flood risk management), environmental protection and restoration, and related purposes.*

This document meets the technical requirements for USACE feasibility reports and also for full NEPA compliance. The study investigates the quality of the overall Neuse River Basin ecosystem and the level of flood risk in the watershed. The USACE is partnering with the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) to conduct the study. This study encompasses the Neuse River Basin, a total area of 6,234 square miles and the third-largest river basin in North Carolina (Figure ES-1).

The study team focused its resources on identifying the most critical areas of need within the river basin, performing full functional assessment only on those sites, developing solutions to area-specific problems, and identification of the most cost-effective means for their restoration. The Environmental Assessment (EA) found within this integrated feasibility report was written pursuant to and complies with ER 200-2-2 (33 CFR Part 230): Environmental Quality Procedures for Implementing the National Environmental Policy Act (NEPA) and 40 CFR Parts 1500 to 1508 the Council on Environmental Quality (CEQ) Regulations for Implementing the National Environmental Policy Act (NEPA).

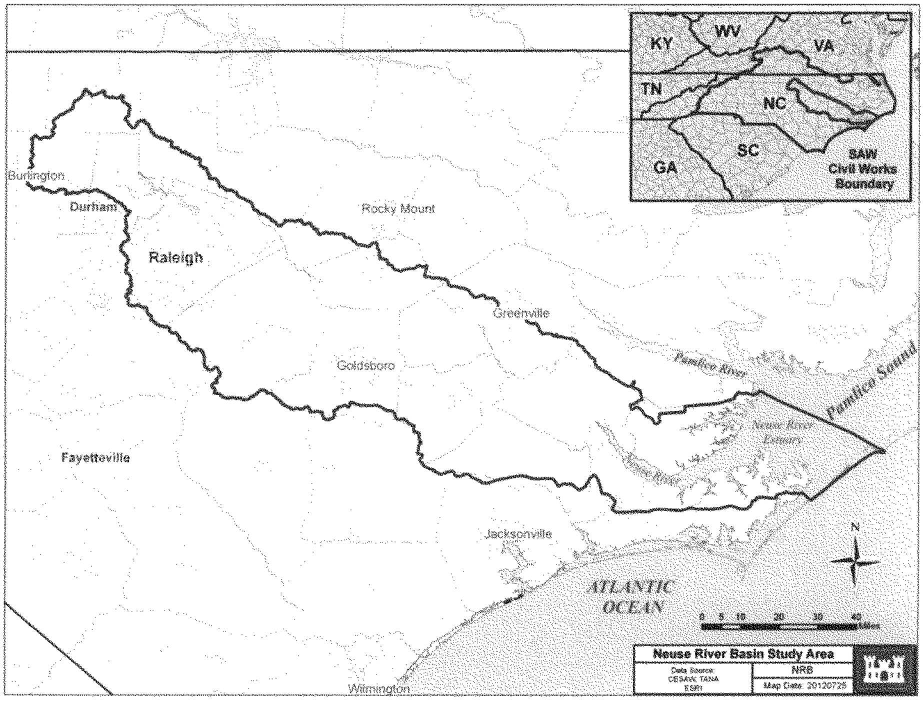


Figure ES-1. Neuse River Basin

The feasibility study effort has evaluated numerous problem areas throughout the river basin. Many identified problems are currently being addressed through the efforts of the State of North Carolina, and other Federal and non-Federal partner agencies, such as Federal, State and local efforts to address water quality issues through the National Pollutant Discharge Elimination System (NPDES) program. Because of these on-going efforts, and the narrower mission area provided by the study language, the feasibility study focused on the identification of problem areas within the arena of flood risk management and ecosystem restoration, with other areas within the water resources arena being addressed by other partner agencies. A summary of findings from the initial study of these two focus areas follows.

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The study also identified, but did not conduct detailed functional assessment or CE/ICA, on the second tier of sites. These second tier sites do not have as serious a degree of degradation and could not necessarily be conclusively determined for Federal interest at this time. Nonetheless, the team determined the sites should be examined periodically for ecosystem quality, with regards to on-going or future impacts as the watershed continues to change. These sites would then be identified for pursuit in follow-on study efforts.

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Specific problems identified for evaluation in this study included:

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- Declines in eastern oyster populations.

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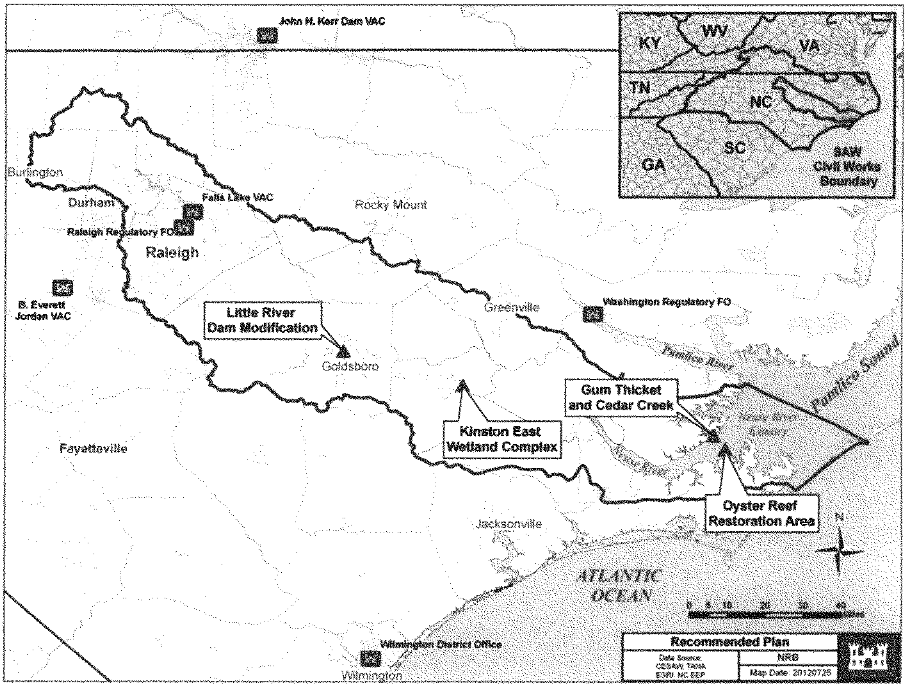

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The estimated total first cost for the Recommended Plan is $35,774,000, based on 2013 (Oct 2012) price levels. Cost-sharing for the Recommended Plan would be 65 percent Federal and 35 percent non-Federal, based on current policy for ecosystem restoration projects.

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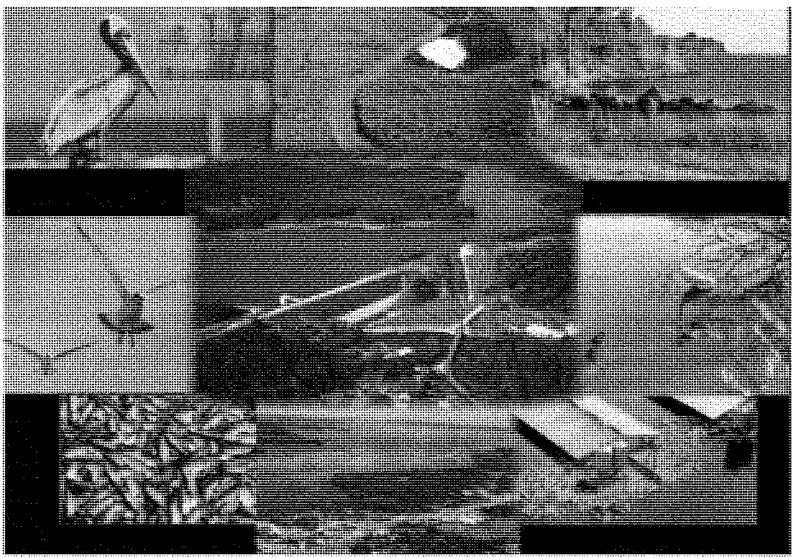
Neuse River Basin Integrated Feasibility Report and Environmental Assessment



IN COOPERATION WITH

NCDENR

PREPARED BY:

US Army Corps of Engineers®
Wilmington District

November 2012

EXECUTIVE SUMMARY

Background

This *Integrated Feasibility Report and Environmental Assessment* (EA) was prepared in response to the Congressional Resolution adopted July 23, 1997, which requested review of the report of the Chief of Engineers on the Neuse River Basin, (published as House Document 175, 89th Congress), and reads as follows:

> July 23, 1997: *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control (flood risk management), environmental protection and restoration, and related purposes.*

This document meets the technical requirements for USACE feasibility reports and also for full NEPA compliance. The study investigates the quality of the overall Neuse River Basin ecosystem and the level of flood risk in the watershed. The USACE is partnering with the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) to conduct the study. This study encompasses the Neuse River Basin, a total area of 6,234 square miles and the third-largest river basin in North Carolina (Figure ES-1).

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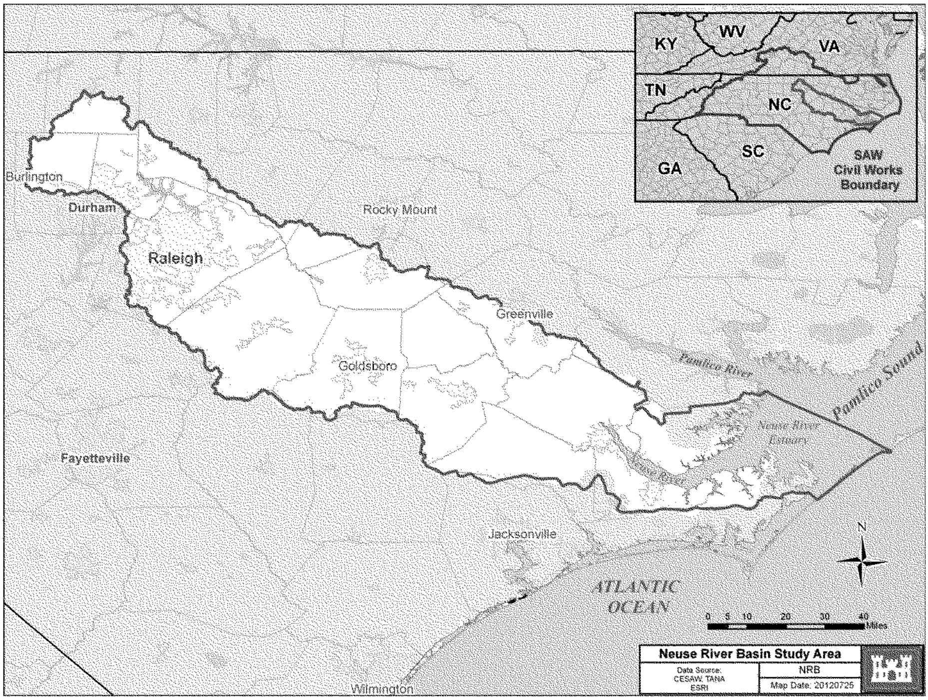

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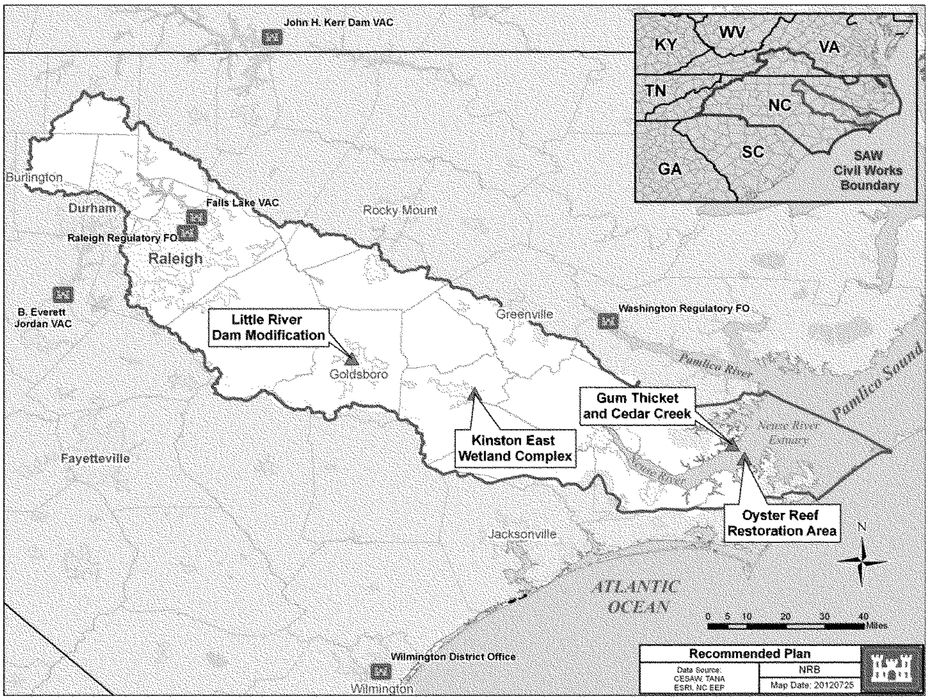

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FINDING OF NO SIGNIFICANT IMPACT
NEUSE RIVER BASIN INTEGRATED FEASIBILITY REPORT and ENVIRONMENTAL ASSESSMENT

The EA documents the environmental considerations, alternatives considered, and the FONSI documents the decision that no significant impacts to the human environment would occur if the proposal is implemented. The EA and FONSI have been prepared pursuant to NEPA in accordance with the Council on Environmental Quality (CEQ) regulations as contained in 40 CFR Parts 1500 to 1508, which directs federal agencies on how to implement the provisions of NEPA and the US Army Corps of Engineers Department of the Army procedures for implementing NEPA (33 CFR Parts 230).

Description of the Proposed Action and No Action Alternative:

The IFR/EA, dated November 2012 describes the proposed action as a Recommended Plan, the National Ecosystem Restoration (NER) Plan that reasonably maximizes ecosystem restoration benefits and is acceptable to the USACE and local sponsor. The recommended plan would improve biological integrity, improve freshwater mussel populations, improve anadromous fish populations, restore emergent wetlands, and increase the quantity and quality of oyster reef habitat. The recommended plan includes construction of rock sills approximately 3,500 feet long at Gum Thicket Creek and 5,200 feet long at Cedar Creek, built at distances of about 60 feet offshore; regrading a previously filled area within the Kinston East wetland complex to the approximate elevation of the adjacent bottomland hardwood forest and both allowing natural revegetation of the site by bottomland hardwood species and limited planting; modifiying the Low-head Dam on the Little River to allow migration of anadromous fish; and the creation of 10 acres of 4 foot-high oyster reef within an 80 acre service area. The alternative action would be the No Action Alternative: wherein no Neuse River Basin restoration measures would be implemented under this authority.

Public and Agency Coordination:

On November 30, 2011, the IFR/EA, dated October 2011 was mailed to federal and state agencies, local communities, and the interested public for a 30-day review and comment period. As a result of this review period, comments from state and agencies yielded refinements to all components of the proposed action with the exception of the Neuse River Estuary Oyster Reef Restoration component. The IFR/EA, dated November 2012,was also circulated in December 2012 for State and Agency Review as required by the Flood Control Act of 1944, as amended (33 U.S.C. 701-1). As a result of this review period, additional coordination will occur with state and agencies during the preconstruction, engineering and design phase to consider beneficial design refinements and other construction requirements. Comments received during both review periods were reviewed and considered in making the decision to sign the FONSI.

a. Summary of Environmental Resources and Impacts:

Section 4.0 of the IFR/EA provides information on the affected environment present in the Neuse River Basin. The probable consequences (impacts and effects) of the No

Action Alternative and the four components of the Recommended Plan on the environmental resources in the Neuse River Basin were evaluated. In the long-term, implementation of the Proposed Action will result in positive effects for the Neuse River Basin natural resources. No adverse long-term effects would be expected. For the No Action Alternative no project impacts would occur; however, the overall long-term restoration benefits of the Recommended Plan would be forgone.

b. Facts and Conclusions Leading to the Finding of No Significant Impact (FONSI):

Based on the results of the impact analyses, it has been determined that no significant impacts would occur as a result of implementing the Proposed Action. The Proposed Action would not have any unavoidable adverse effects, nor would it result in the irreversible or irretrievable commitment of resources. Proceeding with the Proposed Action would not significantly or adversely impact the affected environment. Additionally, no significant cumulative effects would be expected.

c. Finding of No Significant Impact:

I have reviewed the Neuse River Basin Integrated Feasibility Report and Environmental Assessment (EA), the information provided by interested parties, and the information contained in this Finding of No Significant Impact, and I find that the Recommended Plan will not significantly affect the quality of the human environment. Therefore, preparation of an Environmental Impact Statement pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969, as amended, is not required.

Date:____________________

____

Steven A. Baker
Colonel, U.S. Army
District Commander

ACRONYMS AND ABBREVIATIONS

AAFU	Average Annual Functional Unit
ac	acre(s)
APNE	Albemarle-Pamlico National Estuary
BMP	best management practice
CAP	Conservation Action Plan
CE/ICA	Cost-Effectiveness and Incremental Cost Analysis
cfs	cubic feet per second
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CoP	community of practice
CEQ	Council on Environmental Quality
CRSP	Cultural Resources Study Plan
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DNL	Day-night average sound level
EA	environmental assessment
EBA	environmental benefits analysis
EC	Engineering Circular
EFH	Essential Fish Habitat
EMC	Environmental Management Commission
EOP	environmental operating principles
ER	Engineering Regulation
FC	Full Compliance
FCSA	Federal Cost Sharing Agreement
FEMA	Federal Emergency Management Agency
FI	functional index
FSC	Federal species of concern
FSCA	feasibility cost-sharing agreement
ft	foot, feet
FU	functional unit
GI	General Investigation

HAPC	Habitat Area of Particular Concern
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
HQ	Headquarters
HU	Habitat Unit
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IWR	Institute of Water Resources
km	kilometer(s)
LPP	Locally Preferred Plan
m	meter(s)
mi	mile(s)
mg/L	milligram(s) per liter
mgd	million gallon(s) per day
mm	millimeter(s)
NCAC	*North Carolina Administrative Code*
NCCF	North Carolina Coastal Federation
NCCRC	North Carolina Coastal Resources Commission
NCDAQ	North Carolina Division of Air Quality
NCDEM	North Carolina Division of Emergency Management
NCDENR	North Carolina Department of Environment and Natural Resources
NCDMF	North Carolina Division of Marine Fisheries
NCDOT	North Carolina Department of Transportation
NCDWQ	North Carolina Division of Water Quality
NCDWR	North Carolina Division of Water Resources
NCEEP	North Carolina Ecosystem Enhancement Program
NCSU	North Carolina State University
NCWRC	North Carolina Wildlife Resources Commission
NED	National Economic Development
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NRCS	National Resources Conservation Service
NSW	Nutrient Sensitive Waters
NTU's	nephelometric turbidity units
NWP	National Wetland Permit
OGA	oyster growing area
OMRR&R	operation and maintenance, repair, replacement, and rehabilitation
ORSC	Oyster Restoration Steering Committee
OSE	other social effects
PC	Partial Compliance
PDT	project delivery team
PED	preconstruction engineering and design
PM	particulate matter
PMP	Project Management Plan
PNA	Primary Nursery Area
PPA	Project Partnership Agreement
ppt	part(s) per thousand
PSP	Project Study Plan
RED	Regional Economic Development
SAD	South Atlantic Division
SAV	submerged aquatic vegetation
SHEM	Stream Habitat Evaluation Method
SHPO	State Historic Preservation Office
sq mi	square mile(s)
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TSP	Tentatively Selected Plan
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service

USGS	U.S. Geological Survey
WAM	Water Management and Assessment Support [model]
WASP	Water Quality Assessment Program
WRDA	Water Resources Development Act

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1.0 INTRODUCTION

1.1 Study Authority

The Neuse River Basin (Basin) Feasibility Study is being pursued under the U.S. Army Corps of Engineers (USACE) General Investigation (GI) Program. The North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) is the cost-sharing sponsor for this study. This *Integrated Feasibility Report and Environmental Assessment* (EA) is being prepared in response to the following resolution adopted July 23, 1997:

> July 23, 1997: *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control (flood risk management), environmental protection and restoration, and related purposes.*

At the request of several members of the North Carolina Congressional Delegation in response to growing water resource development needs, Congress in 1956 directed the USACE to undertake a study of the Neuse River Basin to determine whether improvements for flood control, conservation of water resources, water supply, and other purposes were warranted. The Chief of Engineers' report, completed in 1965, addresses the need for flood protection, municipal and industrial water supply, water quality controls, power, irrigation, and recreation. That study found an immediate and urgent need to provide flood protection, water supply, water quality controls, and recreation. Ultimately, the report resulted in the construction of Falls Lake Dam. In May 1984 another reconnaissance report was completed under the previous authority to look at various possibilities to reduce flooding throughout the Basin. Although variations of a few of the recommended plan components were implemented locally, no Federal action was taken. The *Neuse River Basin, North Carolina, Reconnaissance Report* (May 26, 2000) was undertaken as an initial step in response to the House Committee Resolution and performed in accordance with Section 905(b) of the Water Resources Development Act of 1986 (WRDA).

1.2 Study Purpose and Need

As stated above, this *Integrated Feasibility Report and EA* has been prepared in response to the 1966 and 1997 study resolutions referenced in Section 1.1. The study investigated the quality of the overall Basin ecosystem and the level of flood risk in the watershed. Past flooding in the Basin has been severe, and elements of the Basin ecosystem have shown signs of significant stress and degradation. While deferred from evaluation in this study at the request of the sponsor, the State of North Carolina, water management and evaluation of existing water projects for potential modification or de-authorization may be further assessed in future studies. . The *Integrated Feasibility Report and EA* purpose is to:

- Identify the level of flood risk and potential measures to reduce potential damages;
- Identify and inventory changes to the Neuse River Basin ecosystem over time;
- Identify the key components of the Basin ecosystem that have degraded and lost value in terms of diversity or environmental production or both;
- Develop and evaluate measures to restore lost environmental values throughout the Basin;
- Recommend collaborative and sustainable watershed-based solutions;
- Incorporate Basin stakeholders into an active watershed planning process.

This study seeks to identify areas of significant benefit where there might be a Federal interest in cost-shared implementation of actions resulting in ecosystem restoration or flood risk management.

Due to the significance of the environmental resources in the Neuse River Basin, stakeholders are actively involved in regional planning and restoration efforts throughout the watershed. The NCDENR is a leader in such efforts. The NCDENR implements numerous environmental initiatives through various internal divisions to improve water quality, remove human-made obstructions to fish and wildlife movement, implement actions to restore the quality of the environment, and protect coastal habitat throughout the state. The Neuse River Basin study authority provides an opportunity for the USACE to work collaboratively with the NCDENR and other stakeholders in the region for the protection and restoration of important environmental resources within the Basin.

NCDENR is the non-Federal sponsor for this feasibility study. The USACE, Wilmington District, and the NCDENR (through NCDWR), executed a Feasibility Cost-Sharing Agreement (FCSA) in May 2002. The FCSA formalized initiation of the feasibility study upon approval of the Project Study Plan (PSP), now referred to as the Project Management Plan (PMP). The *Neuse River Basin Integrated Feasibility Report* and EA PMP (2005 update) is attached to this report as Appendix A.

Comments and concerns identified by the study scoping process (see Section 11) were grouped into four broad subject areas. Study workgroups were formed to collaborate and build upon the active efforts of other agencies and organizations working within these subject areas to identify ecosystem and flooding issues and restoration opportunities throughout the Basin. The four workgroups include:

- Wetlands, Streams, and Riparian Buffer Restoration Workgroup
- Anadromous Fish Habitat Restoration Workgroup
- Estuarine Resources Workgroup
- Flood Risk Management Workgroup

Various stakeholders in the region, including members of other Federal agencies, state agencies, local governments, and nongovernment environmental organizations were contacted during the scoping process (see Section 1.8). Coordination with interested parties throughout the planning process allowed the USACE to develop measures. This coordination assisted the USACE with developing measures throughout the Basin that would contribute to flood risk management and ecosystem restoration. Efforts were made to identify measures that were consistent with the ongoing activities of other agencies and organizations.

For a complete list of study participants, see Section 1.8. The USACE coordinated with these workgroups throughout the planning process. This coordination assisted the USACE with developing measures throughout the Basin that would contribute to flood risk management and ecosystem restoration, consistent with the ongoing activities of other agencies and organizations.

1.2.1 Flood Risk Management

Preliminary planning efforts to identify problems and opportunities for flood risk management measures in the Basin under this study were undertaken consistent with the study authority. Falls Dam and Lake, located in the upper Neuse Basin (constructed and operated by USACE) already provide significant flood risk management benefits to the lower Neuse Basin. In response to flooding in the lower Neuse Basin associated with Hurricanes Fran (1996) and Floyd (1999), the North Carolina Department of Crime Control and Public Safety, Division of Emergency Management (NCDEM) and the Federal Emergency Management Agency (FEMA) have worked collaboratively to acquire more than 1,000 residential structures in the Basin (as of May 2006) through a voluntary buyout program (Section 2.2.1.1 and Appendix B provide more information on the buyout program). That program has eliminated a significant portion of the potential damages that might otherwise have justified additional flood risk management measures as a result of this study. In addition, the NCDEM has aggressive programs in floodplain mapping, emergency preparedness and response, and risk communication for low-lying coastal areas and inland flood prone areas, largely enhanced by lessons learned from numerous encounters with hurricanes and tropical storms over the past two decades. As a result, the USACE and NCDENR determined that no large-scale flood risk reduction opportunities within the Neuse River watershed can be identified at this time. However, land-uses within the watershed will continue to evolve, and that development may alter flood peaks, durations, and even flood risk over time, that follow-on studies be performed at the Sponsor's discretion.

1.2.2 Problems and Opportunities

Due to the lack of flood risk management opportunities in the study area (Section 1.2.1) and the deferment of water management, water supply, and evaluation of existing water projects for modification or de-authorization, the focus of this study is ecosystem restoration. The scoping process, summarized previously, was initiated to assist in identifying problems and opportunities. Existing conditions within the Basin we inventoried and assessed, as well as prior and ongoing actions and permitting activities that other Federal agencies, state agencies, local governments, nongovernment environmental organizations, and others are undertaking. The inventory identified the following ecosystem restoration problems/issues within the study area, and as a result the study focuses on wetlands and stream riparian buffers, anadromous fish habitat, and estuarine resources:

- Impaired biological integrity in the Basin as a result of altered hydrology from urban development and unprotected stream banks,
- Decrease in historical mussel populations attributed to declining water quality in the Neuse River Basin,
- Declines in anadromous fish populations due to the construction of man-made structures that obstruct connection to historic upstream spawning habitat,
- Damaged or eliminated natural riparian buffer resulting from adjacent land use,
- Loss of estuarine emergent wetlands over time in the Neuse River Estuary associated with subsidence and shoreline erosion, and exacerbated by anthropogenic activities
- Declines in eastern oyster (*Crassostrea virginica)* populations as a result of oyster reef habitat depletion in the Neuse River Estuary associated with historic over harvesting and a reduction in water quality, and
- Impacts of sea level rise on coastal resources.

The following opportunities were then developed as means to address those problems in the study area:

- Manage the risk of sea level rise through project design and adaptive management,
- Improve biological integrity,
- Improve habitat for fish and freshwater mussels,
- Improve anadromous fish populations,
- Restore damaged or eliminated natural riparian buffers,
- Restore estuarine emergent wetlands, and
- Increase the quantity and quality of oyster reef habitat.

These problems and opportunities are discussed in more detail in Section 3 of this report.

1.3 Report Organization

This *Integrated Feasibility Report and EA* has been organized to be consistent with the planning process. The USACE's six-step planning process, specified in Engineering Regulation (ER) 1105-2-100 (*Planning Guidance Notebook*), was used to develop, evaluate, and compare the array of candidate alternatives, and consists of the following enumerated steps: Plan formulation covers the first five steps of the planning process, up to the identification of the TSP. The plan formulation of this study is contained in Sections 3 through 5 of this report.

1. Identify (or specify) problems and opportunities. Section 2 of the report discusses the Basin location and environmental setting, and presents the existing conditions of the resources throughout the study area as an established baseline against

which the opportunities to restore environmental outputs can be assessed. Problems and opportunities are more clearly defined in Section 3. These problems and opportunities were first understood through scoping efforts coordinated with the public, and the stakeholders and agencies listed in Section 1.7. The significance of problems in the Basin is presented in Section 1.5. Site-specific objectives were established for each of the locations selected for further evaluation during screening.

2. Inventory and forecast conditions. The problems expected to persist into a future without-project condition are described in Section 4. The future without-project condition is one in which no additional USACE ecosystem restoration projects have been implemented in the Basin. An inventory of opportunities throughout the Basin was conducted as presented in Section 3. The opportunities were evaluated further, and future conditions were forecast using an environmental benefits analysis detailed in Section 4.

3. Formulate alternative plans. During the formulation process, management measures were initially selected to address problems as presented in Table 3-3. At each of the locations where opportunities exist to address problems, site-specific management measures were identified. Management measures can be structural or nonstructural, but equal consideration was given to each during the planning process. Appropriate combinations of management measures were used to develop various alternatives to meet the site-specific objectives.

4. Evaluating alternative plans. As the planning process is iterative, initially each of the alternative plans was evaluated to determine environmental benefits compared to a future without-project condition. The alternatives were also evaluated to establish the alternatives' contribution to meeting the site-specific objective and overall Basin opportunities. After Step 5 was conducted on site-specific alternatives, Step 4 was revisited with a more detailed evaluation of combinations of alternatives presented in Section 6.1

5. Comparing alternative plans. A cost-effectiveness/incremental cost analysis using IWR Plan was conducted to prioritize and rank alternatives (Section 6.1). The beneficial and adverse effects of each alternative were also compared.

6. Selecting a plan. Tentative selection was based upon the identification of the plan that reasonably maximized ecosystem benefits compared to costs, consistent with the basin-basin-wide opportunities. Justification for the TSP is described in Section 6.3. Plan selection was based upon a comparison of the alternative plans' effects across the four accounts defined by the Principles and Guidelines (para. 1.6.2(c)). The four accounts are: national economic development (NED), national ecosystem restoration (NER), regional economic development (RED), and other social effects (OSE). Comparison of alternatives utilizing these accounts is presented in Table 6-4.

Plan formulation meets Federal planning requirements and congressional authority for identifying restoration needs in the Basin. The feasibility study is being carried out in a manner consistent with the USACE Environmental Operating Principles (EOPs). The principles are consistent with NEPA; the Army's Environmental Strategy with its four pillars (prevention, compliance, restoration, and conservation); and other environmental statutes that govern USACE activities. Finally, the implementation framework proposed as part of the study, seeks to work collaboratively, fully engaging individuals, agencies, and local groups in identifying, planning, and implementing restoration efforts.

1.4 National Environmental Policy Act (NEPA)

As an integrated report, this document meets the technical requirements for USACE feasibility reports and NEPA compliance. This EA is written pursuant to and complies with ER 200-2-2 (33 CFR Part 230): Environmental Quality - Procedures for Implementing the National Environmental Policy Act (NEPA) and 40 CFR Parts 1500 to 1508 the Council on Environmental Quality (CEQ) Regulations for Implementing the National Environmental Policy Act (NEPA).

NEPA and the CEQ regulations require that Federal agencies consider the environmental consequences of major Federal actions and perform an EA to ensure that the environmental consequences of the proposed project are fully considered. The public must also be informed of those consequences and allowed the opportunity to provide comment. Should the results of the EA indicate the proposed project effects cannot be mitigated to a less-than-significant level; an environmental impact statement would be prepared documenting the actions to be taken to achieve full environmental compliance. Per paragraph 10(c) of ER 200-2-2 [33 CFR 230.10 (c)], the project EA is incorporated (integrated) into this feasibility report. NEPA requires an assessment and consideration of the environmental impacts from a range of reasonable project alternatives and the consideration of those impacts in the process of formulating the Recommended Plan. This document presents the formulation and evaluation of the alternatives in addition to the Recommended Plan.

Iterative participation of watershed stakeholders has resulted in the establishment of strong working relationships among key Federal and state agencies in the region. The iterative participation has provided a strong source of collaborative input throughout the study planning process; accordingly, initiation of a formal cooperating agency agreement pursuant to 40 CFR 1501.6 and 1508.5 would not have provided significant enhanced benefit.

1.5 Study Area and Location

The study area encompasses the Neuse River Basin, the third-largest river basin in North Carolina. The Basin contains a total area of 6,234 square miles (sq mi) (Figure 1-1), and it is one of only four watersheds entirely within the state. The Neuse River originates at the confluence of the Eno and Flat Rivers in north-central North Carolina near the city of Durham (in Person and Orange counties) and flows southeasterly until reaching tidal waters near State Highway 43, upstream of the city of New Bern, North Carolina. At New Bern the river broadens dramatically and changes from a unidirectional freshwater regime to a mixed tidal regime of the Neuse River Estuary. The Neuse River then flows through the estuary and out into Pamlico Sound before reaching the Atlantic Ocean. The upper one-third of the Basin is in the Piedmont physiographic province, while the lower two-thirds lie in the Mid-Atlantic Coastal Plain physiographic province. Elevations in the Basin range from 905 feet (ft) in the western part of the Basin to sea level where the Neuse River Estuary joins Pamlico Sound.

The uppermost 22 miles (mi) of the river immediately downstream of the confluence of the Eno and Flat Rivers are impounded by Falls Lake, a multipurpose reservoir completed in 1983 and managed by the USACE. Falls Lake provides storage capacity for flood risk management, water quality releases, water supply storage, and recreation purposes. It is the primary drinking water source for the city of Raleigh. Below Falls Lake, the river flows southeast for about 180 mi, past the Cities of Smithfield, Goldsboro, Kinston, and New Bern.

There are 19 reservoirs throughout the Basin, most in the upper portion of the Basin. Eighteen of these reservoirs are owned and operated by non-Federal entities (Falls Lake is the largest and only Federal reservoir). Those reservoirs consist of a wide variety of structures including millponds, beaver impoundments, water supply reservoirs and flood storage structures, all of which are typical of the Piedmont region of the upper Basin. Fewer reservoirs are in the lower Basin because the Coastal Plain physiographic province generally consists of relatively flat topography underlain by highly pervious sands.

The Neuse River Basin study area is in the 1st, 2nd, 3rd, 4th, 7th, and 13th congressional districts (Figure 1-2).

The Neuse River Basin can be divided into three sub-regions (upper, middle, and lower) in the two physiographic provinces of the Piedmont and the Coastal Plain.

Upper Neuse River—Piedmont Region. The upper portion of the Basin is in the Piedmont region, beginning in the headwaters of the Neuse River and extending as far east as Goldsboro. The upper Basin includes most of Wake and Johnston counties; parts of Durham, Granville, Orange, Person, and Wayne counties; and minor portions of Duplin, Franklin, Harnett, Sampson, and Wilson counties (Figure 1-1). This portion of the Basin consists of 17 percent developed land; 0.2 percent bare earth; rock, sand, or clay; 39.4 percent forested land; 8.9 percent shrub or grassland; 26.8 percent agricultural land; and 7.5 percent wetlands, as illustrated in Figure 1-3 Neuse River Basin land use. The upper Basin, encompassing much of the Raleigh-Durham area, is the most heavily populated and industrialized part of the Basin. Despite the increasingly urban nature of the region, agricultural activity and forest cover remain widespread. In fact, the upper Basin contains more forested land cover than all other sub-basins of the Neuse River Basin (NCDENR 2009a).

Middle Neuse River—Inner Coastal Plain. The middle portion of the Basin is primarily in the inner Coastal Plain. The middle Basin includes most of Lenoir County; parts of Craven, Wayne, and Pitt counties; and minor areas of Beaufort, Greene, and Jones counties (Figure 1-1). This portion of the Basin consists of 8.2 percent developed land; 0.1 percent bare earth, rock, sand, or clay; 26.2 percent forested land; 11.8 percent shrub or grassland; 34.4 percent agricultural land; and 19.4 percent wetlands, as illustrated in Figure 1-3 Neuse River Basin land use. The middle Basin contains the highest concentration of agricultural lands in the Neuse River Basin. In general, forestry and agriculture are the primary land use activities in the Coastal Plain (Figure 1-3). Agriculture tends to be more concentrated upstream of New Bern. The urban areas are relatively small in area around the cities of Smithfield, Wilson, Goldsboro, Kinston, and New Bern.

Lower Neuse River - Outer Coastal Plain. The lower Basin, which is in the outer Coastal Plain region, includes most of Jones County, part of Craven, Lenoir, and Pamlico counties, and minor parts of Carteret, Duplin, and Onslow counties (Figure 1-1). This portion of the Basin consists of 6.2 percent developed land; 0.1 percent bare earth; rock, sand, or clay, 28.8 percent forested land; 11.3 percent shrub or grassland; 18.5 percent agricultural land; and 35.1 percent wetlands, as illustrated in Figure 1-3 Neuse River Basin land use. The lower Basin contains more wetlands (both freshwater and saline) than all other sub-regions of the Neuse River Basin (NCDENR 2009a). The open waters of the Neuse River Estuary are used intensively for recreational boating and fishing and for commercial fishing and shellfish harvesting (NCDENR 2009a).

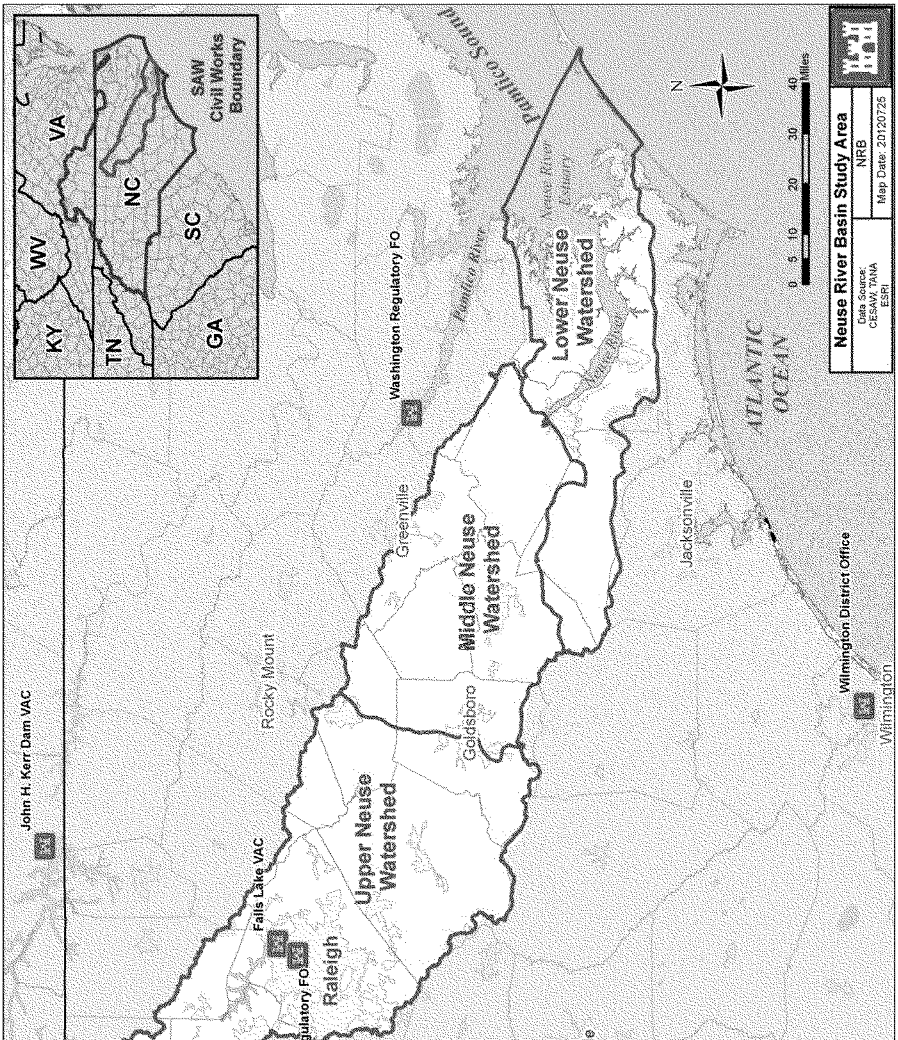


Figure 1-1. Neuse River Basin study area.

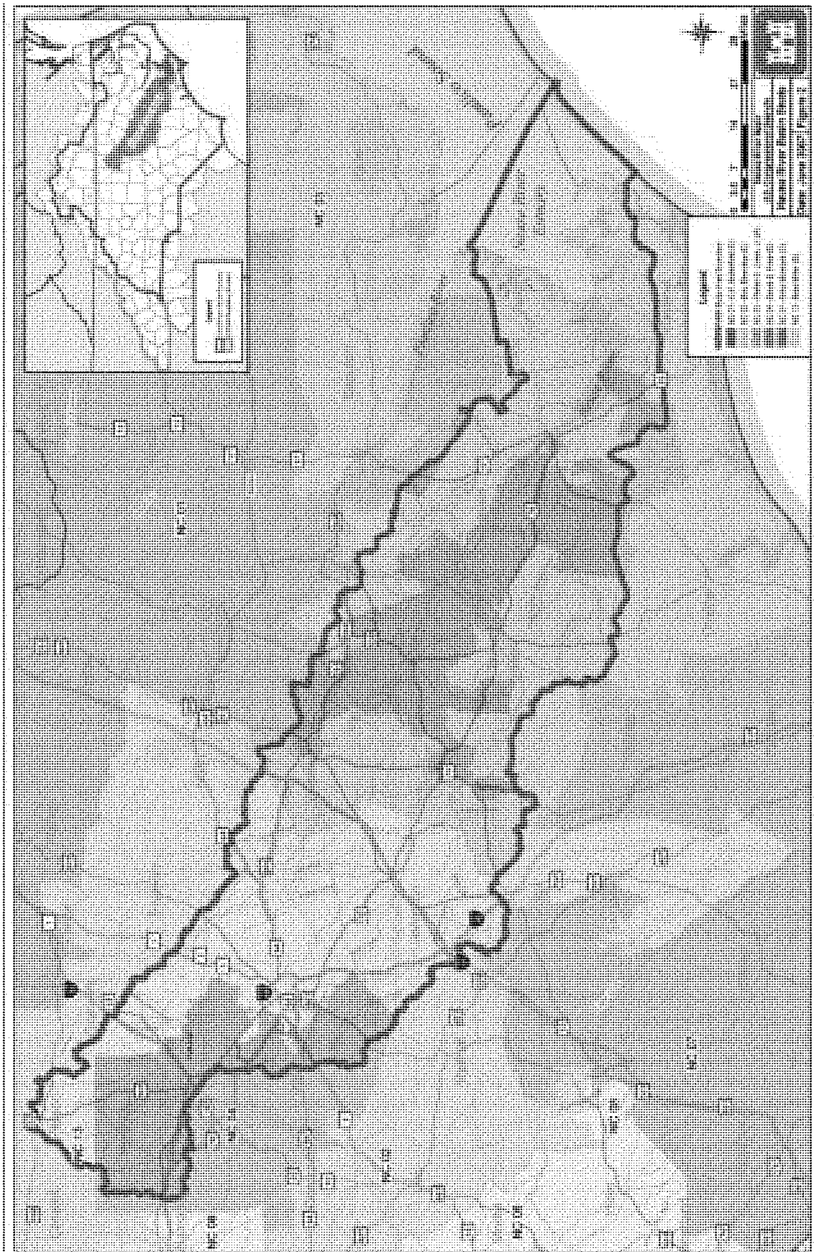


Figure 1-2. U.S. Congressional Districts.

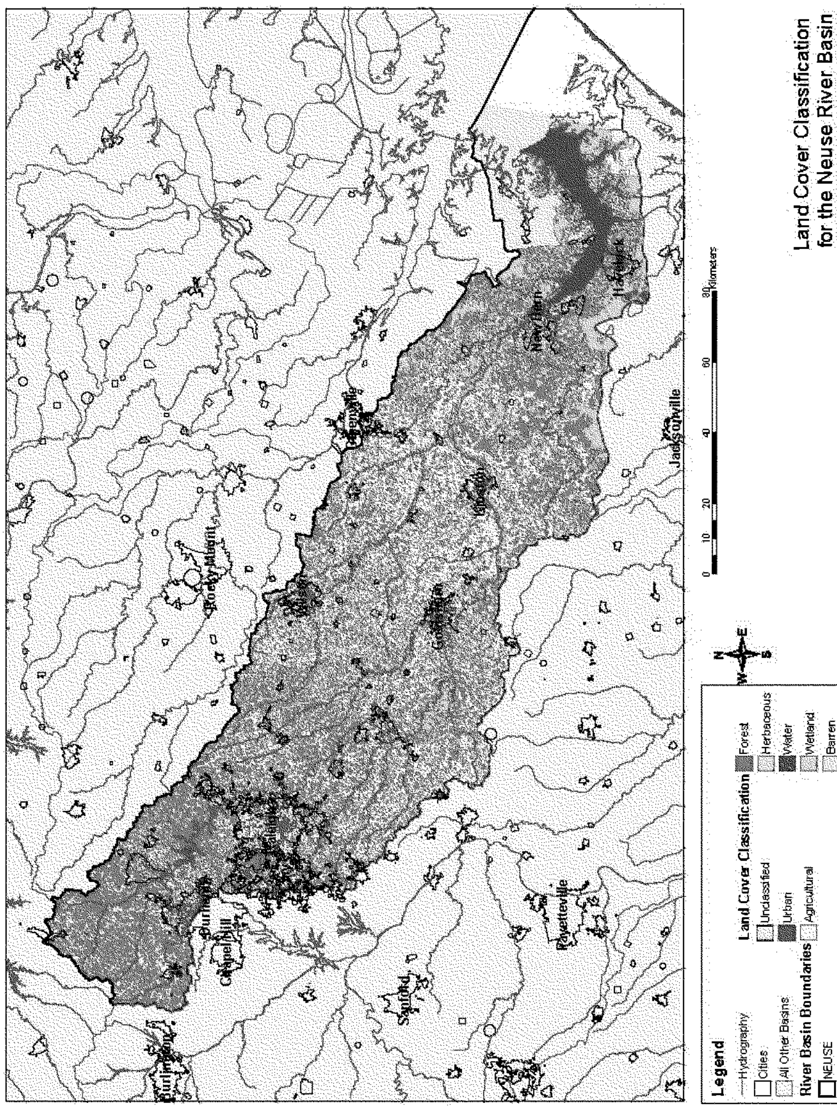


Figure 1-3. Neuse River Basin land use.

1.6 Significance of the Neuse River Basin

The USACE defines *significance* in terms of three factors: (1) institutional recognition, (2) technical recognition, and (3) public recognition (ER 1105-2-100). The aquatic ecosystem resources in the Basin and estuary have been deemed significant for all three factors.

Institutional Recognition. The state and several Federal agencies have prioritized efforts to improve aquatic quality in the Basin and estuary by funding programs that support these activities to ensure the future of scarce aquatic resources. After designating the Basin as "Nutrient Sensitive Waters", the state funded several programs to improve water quality through education outreach and Basin planning (NCDENR 2002 and 2009a).

State and Federal agencies recognize the significance of potential anadromous fish spring migrations on the Neuse River. The Neuse River produced more catches of shad than any other river in North Carolina at the beginning of the 20^{th} century. Since 1997, four dams have been removed from the Neuse (Quaker Neck Dam) and Little Rivers (Cherry Hospital, Rains Mill, and Lowell Mill dams) allowing migrating species to access 90 percent of their original spawning grounds (NCOEE 2010).

The U.S. Environmental Protection Agency (USEPA) has also recognized the significance of the Neuse River through its designation of the Upper Neuse River (HUC0320201) as a priority watershed. Priority watersheds are those where USEPA Region 4 and states agree to focus resources to protect and restore waters. In addition to investing in priority watersheds, the USEPA provides a major investment into the National Estuary Program.

In 1987 the Albemarle-Pamlico Sound was federally recognized through its designation in the National Estuary Program. The Neuse River Estuary is part of the Albemarle-Pamlico Sound Estuarine System, the second-largest estuarine system in the country and the largest within one state. The Albemarle-Pamlico Sound National Estuary Program receives funding from USEPA to achieve a variety of goals, including conserving and protecting vital fish habitats (APNEP 2008).

The USACE has also prioritized estuarine habitat restoration through the Estuary Habitat Restoration Strategy (*Code of Federal Regulations* Vol. 67, No. 232, December 3, 2002), which ensures a comprehensive approach to restoration activities and fosters coordination of Federal and non-Federal efforts with a goal to restore one million acres of estuary habitat by the year 2010.

The Neuse has received national recognition from the American Rivers, a Non–Governmental Organization (NGO) focused on conservation. In addition, a call for protection of the Basin is supported by a number of local NGOs including Riverkeepers. In 1995, 1996, 1997, and 2007, American Rivers designated the Neuse River and Estuary as one of the most threatened rivers in North America. The Neuse River Foundation was created in 1980, one of the first water quality groups to be created in eastern North Carolina. Their mission has been "to protect, restore and preserve the Basin through education, advocacy and enforcement, to provide clean water for drinking, recreation and enjoyment to the communities that it serves." The Neuse River Foundation supports two Riverkeepers: the Lower Neuse Riverkeeper based in New Bern and the Upper Neuse Riverkeeper based in Raleigh.

Resources being considered for restoration include important coastal resources including oyster reefs, estuarine emergent wetlands, and spawning river connections for anadromous fish. These resources are generally scarce on a national scale since they only occur in, or are connected to, coastal watersheds. The narrow United States coastal fringe covers only 17 percent of the nation's contiguous land area (NOAA 2011).

During 1998 to 2004, a period when general wetland gains were reported for the United States by Stedman and Dahl (2008), coastal Atlantic watersheds of the United States were experiencing losses with estuarine emergent wetlands showing the greatest decline. In addition to the considerable loss of wetlands, the NCDMF has identified a significant decrease in anadromous fish populations in the Neuse River Basin. As well, a recent study by Beck et al. (2011), suggests that oysters are scarce at the global scale estimating an 85 percent loss of historic oyster reefs.

Technical Recognition. Stretching about 248 mi from the Falls Lake Reservoir Dam in the Piedmont to its mouth at Pamlico Sound, the Neuse River is the longest river in North Carolina. At its mouth, it is one of the widest rivers in America—6 mi across. The Neuse River Basin is North Carolina's third largest Basin and contains roughly one-sixth of the state's population. There are 18 counties in the Basin which include 74 municipalities.

The Neuse River feeds one of the nation's largest and most productive coastal estuaries (Albemarle-Pamlico). The Albemarle-Pamlico estuary system is a nursery for 90 percent of the commercial seafood species caught in North Carolina. The rivers and streams of the Neuse River Basin are spawning areas for shad, herring, striped bass, and other anadromous fish—species that live as adults in the ocean but migrate upriver to spawn. Other important recreational and commercial species include catfish, bass, flounder, blue crabs, shrimp, and oysters.

The Neuse River Basin is home to 17 species of rare freshwater mussels and a rare snail species. Two of these mussels, the dwarf wedge mussel and Tar River spinymussel, are federally listed as endangered. The largest known population of the dwarf wedge mussel is found in the Connecticut River, but North Carolina has the greatest distribution of this mollusk, with tiny populations in small streams throughout 12 counties.

Essential Fish Habitat (EFH) identified by the National Marine Fisheries that exist in the Neuse River Estuary include emergent wetlands, submerged aquatic vegetation (SAV), oyster reefs and shell banks, intertidal flats, palustrine emergent and forested wetlands, aquatic beds, estuarine water column, creeks, and areas with mud bottom creeks. State-designated areas of importance for managed species are in primary nursery areas. Those areas provide habitat for bluefish, summer flounder, gray snapper, cobia, king mackerel, Spanish mackerel, black sea bass, spiny dogfish, brown shrimp, pink shrimp, white shrimp, important food for fish species, striped mullet, sheepshead minnow, and munnichog.

Public Recognition. In the Neuse River Basin the public widely acknowledges the importance of the river, its associated activities, uses, resources and ecosystem services as something that provides benefits to people and their well-being. The Neuse River Basin has recently had a strong and vocal support of its uses and activities including water supply for municipal and industrial use, public use, water quality, fish and wildlife, recreation, and commercial fishing, among others. The public has had increased awareness of their ecological address (the river basin in which a person lives).

The Neuse River Foundation's Neuse River Spring Clean-up, which spans nearly 80 river miles from Falls Dam to below Smithfield (including sections of Crabtree Creek), has to date encouraged over 1,200 citizens to take a more active role in cleaning up the Neuse River. More than 85,000 pounds of trash has been removed from the Neuse River in the last six years alone. It has become the largest single-river clean-up event in the state. (NRK 2010).

1.7 Related Studies, Reports, Water Resource Projects, and Initiatives

This section describes two of the studies completed by the state in their efforts to characterize the Neuse River Basin. Appendix C summarizes the many additional planning studies, reports, projects, and initiatives in the Basin produced through the collaborative efforts of the Basin's stakeholders. The North Carolina Division of Water Quality (NCDWQ) produces the *Neuse River Basin-wide Water Quality Plan* every five years that addresses pollutants and upland stressors impacting water quality (NCDENR 2009a). This plan represents the most comprehensive management plan for the Basin, and is the product of collaborative Basin planning efforts. The Neuse River Basin is also included within a number of other regional management plans, such as the *Coastal Habitat Protection Plan* (CHPP) produced by the NCDMF (NCDENR 2010).

The *Neuse River Basin-wide Water Quality Plan* summarizes water quality conditions in the Basin and land management activities that are being conducted to improve water quality and habitat conditions throughout the watershed. The most recent plan, finalized in 2009, describes water quality in the Basin between 2002 and 2006. In the entire Neuse River Basin, 459 freshwater stream miles (14 percent of the total miles), 13,538 ac freshwater (76 percent), 35 mi saltwater stream (25 percent), and 57,648 ac saltwater (16 percent) were impaired for one or more surface water quality standards. The majority of the freshwater stream miles in the Neuse River Basin are impaired due to impaired biological integrity (BI), low dissolved oxygen levels and elevated turbidity (Section 2.2.1.4). The majority of the fresh and saltwater area are impaired as a result of elevated chlorophyll *a* and high pH (from elevated nutrients), turbidity, and bacteria (fecal coliform and enterococci) levels (NCDENR 2009a).

The goals of *Neuse River Basin-wide Water Quality Plan* are to:

- Identify water quality problems and restore full use to impaired waters
- Identify and protect high-value resource waters

- Protect unimpaired waters yet allow for reasonable economic growth (NCDENR 2009a)

These goals are accomplished through the following objectives:

- Collaborating with other agencies to develop appropriate management strategies which include providing agencies information related to financial and funding opportunities
- Assuring equitable distribution of waste assimilative capacity for discharges
- Evaluating cumulative effects of pollution.
- Improving public awareness and involvement (NCDENR 2009a)

This plan is intended to benefit water quality in the Basin by:

- Focusing resources on one river Basin at a time.
- Using sound ecological planning and fostering comprehensive National Pollutant Discharge Elimination System (NPDES) permitting by working on a watershed scale
- Ensuring better consistency and equitability by clearly defining the program's long-term goals and approaches regarding permits and water quality improvement strategies
- Fostering public participation to increase involvement and awareness about water quality
- Integrating and coordinating programs and agencies to improve implementation of point and nonpoint source pollution reduction strategies (NCDENR 2009a)

In addition to the recommendations of the *Neuse River Basin-wide Water Quality Plan* to address water quality issues in the Basin, the CHPP (Street et al. 2005) identified gaps in the protection provided for important fish habitats under other programs. The plan identified ways to benefit habitats through enforcement of existing rules and better coordination among agencies. The State Fisheries Reform Act of 1997 called for a plan to focus on activities regulated by the Marine Fisheries, Coastal Resources and Environmental Management Commissions. In 2005 the NCDENR adopted plans to implement the recommendations in the CHPP.

As part of the CHPP, each year the NCDMF prepares an annual report for the Joint Legislative Commission on Seafood and Aquaculture and the Environmental Review Commission of the North Carolina General Assembly highlighting accomplishments from the last year and identifying needs for the upcoming year. Initial implementation plans, developed in 2005, detailed more than 100 specific steps to implementing recommendations from the CHPP. In 2007 a second implementation plan was developed, which, again, detailed more than 100 specific plans to meet the goals of the plan. More specific actions from the 2009 Annual Report include education and outreach efforts, designing monitoring and inspection programs, developing shared data systems to coordinate interagency efforts, and developing fish-based habitat indicators and indicators of estuarine and near shore coastal health for the state (NCDMF 2010).

The CHPP's goals follow:

1. Improve Effectiveness of Existing Rules and Programs Protecting Coastal Fish Habitats
2. Identify, Designate, and Protect Strategic Habitat Areas
3. Enhance Habitat and Protect it from Physical Impacts
4. Enhance and Protect Water Quality

The USACE looked to the goals in the activities and management plans of these reports, as well as others (listed in Appendix C), to establish where the authority for this study could add value to the extensive work already being conducted by others in the Basin. It is important to note, therefore, that the TSP proposed in this feasibility report is not meant as a comprehensive stand alone solution, but instead complements the watershed restoration already being accomplished by other agencies. The process of identifying potential projects and alternatives is described later in Sections 3, 4, and 5.

1.8 Study Process and Participants

The *Neuse River Basin Integrated Feasibility Report and EA* was a collaborative effort accomplished through participation from interested state, Federal and local agencies, local governments, and stakeholders in the region (Appendix D). Preparation of the report was coordinated during the scoping process with the following agencies:

- U.S. Army Corps of Engineers (USACE)
- U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS)
- U.S. Environmental Protection Agency (USEPA)
- U.S. Fish and Wildlife Service (USFWS)
- National Marine Fisheries Service (NMFS)
- Conservation Trust for North Carolina
- North Carolina Coastal Federation (NCCF)
- North Carolina Department of Transportation (NCDOT), Highway Division 4
- North Carolina Department of Coastal Management (NCDCM)
- North Carolina Division of Marine Fisheries (NCDMF)
- North Carolina Division of Soil and Water Conservation (NCDSWC)
- North Carolina Division of Water Quality (NCDWQ)
- North Carolina Division of Water Resources (NCDWR)
- North Carolina Ecosystem Enhancement Program (NCEEP)
- North Carolina Oyster Restoration Steering Committee
- North Carolina State Historic Preservation Officer
- North Carolina State University (NCSU)
- North Carolina State University Cooperative Extension Service

- North Carolina Wildlife Resources Commission (NCWRC)
- City of Durham Stormwater Services
- City of Goldsboro
- City of Kinston
- City of Raleigh Utilities
- Craven County Soil and Water Conservation District (SWCD)
- Greene County SWCD
- Pitt County Planning
- Pitt County SWCD
- Pride of Kinston
- Town of Farmville, North Carolina
- Triangle J Council of Governments
- Wake County Environmental Services
- Wake County Facilities Design and Construction
- Wake County Parks and Recreation
- Wake County SWCD
- Wilson County Government
- Wilson County SWCD
- Neuse Riverkeepers
- The Nature Conservancy
- Upper Neuse River Basin Association
- Representatives from the local community

The USACE established a Project Delivery Team (PDT) to develop the products necessary to implement this feasibility study. The PDT included interdisciplinary team members from both the Wilmington and Savannah Districts of the USACE and from NCDENR as the non-Federal sponsor. Frequent communication among the members of the PDT was strongly encouraged to ensure that complete and consistent execution of technical analyses and recommendations was accomplished in a timely manner.

Workgroups contained a mix of USACE PDT members as well as other Federal, state, and local government and agency representatives. Subject matter experts were consulted for information and advice as needed. The workgroup structure allowed the PDT to work collaboratively toward identifying, planning, and potentially implementing restoration efforts.

Public involvement was essential to obtaining relevant and available study information and citizen concerns. Section 11.0 *Public Involvement, Review, and Coordination* summarizes the public involvement to date for this study.

On May 15, 2006, a Notice of Intent (NOI) to prepare an EIS was published as part of the public scoping process. A scoping letter was also distributed by USACE in April 2006. Responses to the NOI and the scoping letter are presented in Appendix D. However, this study indicates that impacts associated with the TSP are less than significant and therefore, do not warrant an EIS. An EA is integrated into this report to address the effects of the TSP. The PDT ensured that the comments and concerns of the public received full consideration in the planning process. Table 1-1 presents a timeline of future milestones for this project.

Table 1-1. Neuse River Basin project milestones

Milestone	Date
Alternative Formulation Briefing	March 2011
Distribute Integrated Feasibility Report and EA for Public/NEPA Review	November 2011
Completion of Final Integrated Feasibility Report—Division Commander's transmittal letter	June 2012
Initiate Preconstruction Engineering and Design	June 2012
Civil Works Review Board for Approval	Oct 2012
Execute Design Agreement	August 2013
Complete PED	September 2015
Sign PPA*	October 201
Initiate Real Estate Acquisition	November 2015
Complete Real Estate Acquisition	May 2017
Award Construction Contract	August 2017

*Assumes project is authorized by 2014

1.9 Campaign Plan

Goals and Objectives of the USACE's Campaign Plan (September 2008) are derived, in part, from the Commander's Intent, the Army Campaign Plan, and the Office of Management and Budget. The four goals and their associated objectives also build on prior strategic planning efforts. Each goal and objective is led by a USACE senior leader who manages and oversees actions to reach the goal and objectives.

The successful achievement of the goals and objectives contained in this Campaign Plan are dependent on actions implemented by the entire USACE team. The implementing actions supporting each goal and objective are contained in the headquarters staff and MSC implementation plans to this Campaign Plan.

The four goals, associated objectives and senior leader champions are listed below.

Goal 1: Deliver USACE support to combat, stability, and disaster operations through deployed and reach back capabilities.

Goal 2: Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.

Goal 3: Deliver innovative, resilient, sustainable solutions to the Armed Forces and the Nation.

Goal 4: Build and cultivate a competent, disciplined, and resilient team equipped to deliver high quality solutions.

The Neuse River Basin Ecosystem Restoration Feasibility Study supports two objectives of Goal 2:

> **Objective 2a:** Deliver integrated, sustainable, water resources solutions.
>
> **Objective 2b:** Implement collaborative approaches to effectively solve water resource problems.

This study recognizes Neuse River Basin as an interdependent system consisting of several past, present, and future man and nature induced perturbations throughout the watershed and bounding water bodies. The study utilizes a combination of existing information, modeling tools, and in-situ data collection efforts to consider a systems-based approach in the identification of the problems and opportunities. Professional and technical expertise was attained for this study by encouraging interagency collaboration through the creation of technical workgroups and consistent project coordination team meetings. This process fostered trusting relationships with project partners and stakeholders. Through multi-agency collaboration, a diversity of technical input was received from multiple disciplines.

1.10 Compliance with Environmental Operating Principles

The Neuse River Basin Feasibility Study and EA were conducted in a manner consistent with the intent of the USACE's Environmental Operating Principles, that is, to ensure its commitment to the environmental quality of the Neuse River Basin in balance with the economy of the region. This integrated feasibility study complies with the Environmental Operating Principles as follows:

A. Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse, and sustainable condition is necessary to support life. Through the careful application of state of the art, appropriate scientific tools and analytical models in combination with site-specific data collection and analysis of significant habitat parameters, sustainable restoration measures and sites have been identified to support targeted restoration outputs over the period of analysis.

B. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of USACE programs and act accordingly in all appropriate circumstances. This integrated feasibility report/EA uses an approach that considers interrelated environmental impacts on all resources, including socioeconomic resources, interdependently with ecosystem restoration plan formulation and project recommendations.

C. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another. The *Neuse River Basin Integrated Feasibility Report and EA* has been conducted in a multiagency, regional planning context to ensure that land use, residential, and commercial development patterns and economic considerations are incorporated into the development of sustainable and synergistic ecosystem restoration solutions. BMPs or restoration initiatives have been identified in a manner that achieves a balance between human development activities and the natural environment.

D. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems. Analyses conducted in support of this study did not identify previous USACE projects in the watershed that directly contributed to degradation of ecosystem quality. Existing problems at Federal projects, like nutrient loading into Falls Lake, are being addressed through programs by other agencies. The components of the recommended plan have been formulated to ensure that no significant adverse impacts to human health and welfare will result from project implementation.

E. Seek ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work. A cumulative impact analysis has been incorporated into this study to ensure full impact disclosure and adherence to the concept of full integration of plan formulation and environmental compliance. A systems-based approach that considers all elements of the Basin environment was applied to confirm that cumulative effects from project implementation on the environment are beneficial (as the project purpose is ecosystem enhancement and restoration). No cumulative impacts have been identified to non-biological resources in the Basin.

F. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work. Through effective coordination between the project delivery team and technical workgroups comprised of a variety of Basin stakeholders, a multidisciplinary team has been established to ensure the project recommendations benefit from a range of diverse perspectives and ideas. This integrated knowledge base enhances the performance and sustainability of project features, through incorporation of a greater understanding of the Neuse River Basin and Estuary.

G. Respect the views of individuals and groups interested in USACE activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment. As indicated above, the *Neuse River Basin Integrated Feasibility Report and EA* has benefitted from incorporating a range of diverse perspectives and regional technical expertise. Interagency collaboration has been fostered through the efforts of technical workgroups and project delivery team meetings held regularly. By implementing a multiagency collaboration and public involvement strategy, a range of technical input was incorporated into the study analyses from multiple disciplines. This approach built trust and positive relationships, supporting innovative win-win solutions to identified ecosystem restoration issues.

2.0 AFFECTED ENVIRONMENT/EXISTING CONDITIONS

This section describes existing conditions in the Neuse River Basin, focusing on aquatic ecosystem resources as restoration of these resources is a high-priority mission of the USACE. The study area is confined to the Basin, but it does extend outside the watershed boundaries for those resources requiring a larger analytical context from which to assess potential project effects. A comprehensive understanding of the existing condition of the resources within the watershed and ongoing regional planning and restoration efforts is essential when developing succinct and focused problem statements. The problem statements that are derived from the existing conditions are summarized in Section 3.0. Later sections go on to define specific management measures to address Basin problems and the opportunities that exist for the future. Following a discussion of the opportunities in the Basin, future conditions without restoration are defined in Section 4.0. Understanding the future without-project condition, management measures were proposed to maximize environmental benefits and resolve problems in the Basin. Environmental effects of the No Action Alternative and TSP are discussed in Section 8.0.

2.1 Physical Resources

Physical resources are defined as those resources that comprise the components of a study environment (including geology and topography, soils and prime farmland) and the climatic features of a region that influence, change, or provide support to study area resources (including precipitation, wind, temperature and tides). A thorough characterization and understanding of how these physical resources support and influence the living resources within an ecosystem is critical to defining system quality and restorative measures that will enhance system outputs over time.

2.1.1 Climate

The following information regarding climate and growing season information for the Neuse River Basin was predominantly taken from the National Climatic Data Center, NOAA, U.S. Department of Commerce in Asheville, North Carolina.

The Basin has a temperate climate with moderate winters and warm, humid summers. Extreme hot and cold temperatures rarely occur. During the summer the average high temperature is in the high to low 90s, and the winter minimums are in the mid to low 30s. The average annual precipitation over the Basin is about 48 inches (in), but there is considerable variation in the mean annual precipitation in different areas of the Basin. Rainfall is well distributed throughout the year, but it is greatest near the coast and decreases moving toward the northwest direction. The upper northwestern end of the Basin at Durham, North Carolina, receives about 46 in per year as compared to about 53 in per year at New Bern, North Carolina, near the coast. Snow constitutes only a small portion of the precipitation and does not affect runoff or water supply appreciably.

Storm occurrences in the Basin are usually of three general types—thundershowers, northeasters, and hurricanes. The most severe floods of record across the Basin have been associated with hurricanes. Hurricanes are storms of tropical origin and are most severe near the Atlantic Ocean coastline of the Neuse River Basin. Hurricane season begins in June 1 through November 30, potentially generating high winds, and heavy and prolonged precipitation. The maximum monthly rainfall averages 6.0 inches and occurs during July; the driest month is November, with an average rainfall of 2.9 inches. Most of the stream gauges throughout the Basin were installed between 1927 and 1930 by the U.S. Geological Survey (USGS). Before then, flooding characteristics throughout the Basin were primarily anecdotal. From anecdotal indications, severe flooding might have occurred in the Basin during 1865, 1877, and 1901. A study of the rainfall records from the National Climate Center, Asheville, North Carolina, indicates the wettest year of record to be 1975. Droughts occasionally damage crops throughout the Basin and cause water shortages. The most recent drought was from 2006 to 2008.

In the Piedmont, the average growing season (from last frost to first frost) is approximately 202 days (generally from April 6 to October 26 of any year). On average, the growing season within the entire Coastal Plain along the Pamlico Sound is about 225 days (from March 30 to November 11).

2.1.1.1 Global Climate Change and Sea Level Rise

The earth's average surface temperature has risen approximately 0.6 degree Celsius (1 Fahrenheit) over the past century, and the nine warmest years have all occurred since 1980 (Titus and Narayanan 1995). Vermeer and Rahmstorf (2009) reported a simple relationship linking global sea-level variations on time scales of decades to centuries to global mean temperature. When applied to observed data of sea level and temperature for 1880–2000, and taking into account known anthropogenic hydrologic contributions to sea level, the correlation is >0.99, explaining 98 percent of the variance. The earth's history has been characterized by periods of marked sea level fluctuations associated with various natural phenomena. As an example, the rate of global sea-level rise decelerated significantly from a rate much faster than seen today about 5,000 years ago (Vermeer and Rahmstorf 2009).

USACE guidance, Engineering Circular (EC) 1165-2-212, titled *Sea-Level Change Considerations in Civil Works Programs*; (USACE 2011) outlines a process for estimating local sea level rise variations into the future for analysis and incorporation into the planning and design of Civil Works Projects. This guidance supersedes the sea level change analysis outlined in the *Planning Guidance Notebook*, ER 1105-2-100 (2002).

Using the methods published in EC 1165-2-212, the relative sea level rise curves were developed for *low*, *intermediate*, and *high* rates of future sea level change. The low sea level change curve is simply an extrapolation of the observed sea level trend obtained by averaging the sea level rise rates from three local gauges. The intermediate curve represents sea level rise using the National Research Council (NRC) Curve I and the high curve represents NRC Curve III. In addition to these required curves, an additional intermediate curve was developed between NRC Curves I and III which represented NRC Curve II.

While a long-term gauge measuring sea level trends was not available at the project location, a long-term gauge was available relatively close to the project area at Beaufort Inlet. The Beaufort tide gauge used in this analysis is a long-term data gauge with a 53-year record used to develop the mean sea level trend seen in Figure 2-1. As shown in Figure 2-2, the gauge is within approximately 22 mi of the project location and should provide an adequate representation of historic sea level rise affecting the project area.

Figures 2-3 and 2-4 are the sea level rise curves developed in response to EC 1165-2-212. The curves cover the 50-year duration of the project, which is scheduled to begin in fiscal year 2015. Figure 2-3 contains the sea level rise curves based exclusively on the estimated value for global sea level rise, which is 1.7 mm/year. Presenting those curves on the same graph shows the extreme variation between the historic rates extrapolated over 50 years to the most aggressive sea level rise prediction seen in NRC curve III. The historic rate extrapolation produced a sea level rise increase of 0.085 m (3.3 in) by the year 2065 while using NRC curve III predicts a sea level rise over the 50-year project of approximately 0.63 m (2.1 ft), or a 0.55 m (1.79 ft) difference.

The relative sea level rise curves shown in Figure 2-4 include the eustatic (global) sea level rise plus increases due to local land subsidence, and as such are a more appropriate measure of the impacts of sea level increases on the project area. The trend established at the project site as discussed earlier is +2.57 mm/year, which is approximately 0.87 mm/year larger than the 1.7 mm/year value used to estimate global sea level rise. Projecting the observed sea level rise rate over the 50-year project life of the study shows an increase of 0.13 m (5.1 in) when looking at the historic curve extrapolation. The increase found using the NRC curve III projection is approximately 0.67 m (2.2 ft). The variation of sea level change values between the historic projection and the use of NRC curve III remains approximately 0.55 m (1.79 ft), the same variation predicted when using the eustatic values only.

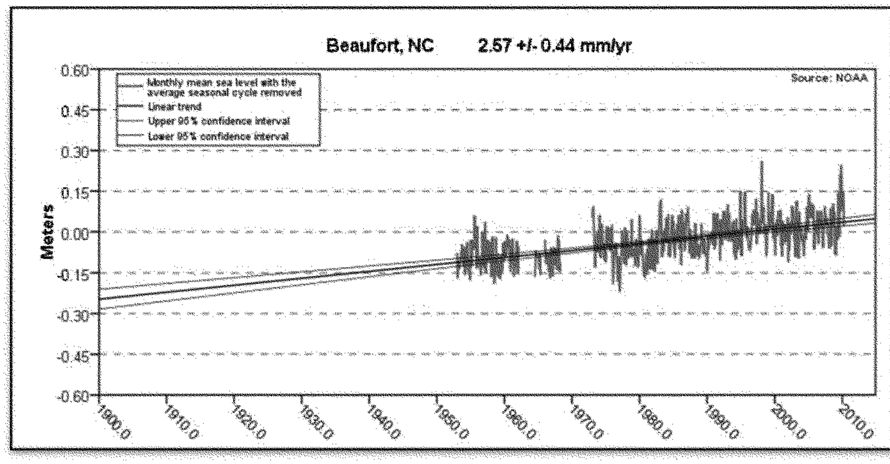


Figure 2-1. Beaufort Inlet, NC. tidal gauge historic sea level trend.

Figure 2-2. Tide gauge and project location.

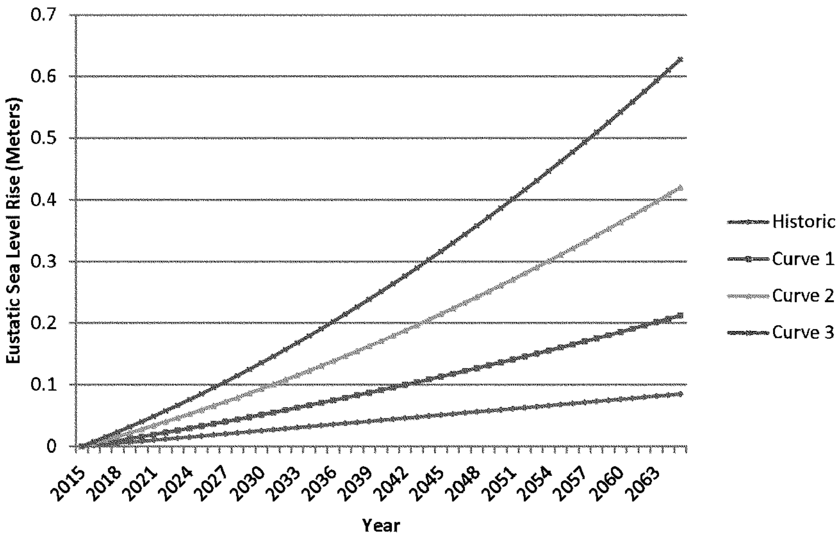


Figure 2-3. Eustatic sea level rise curves.

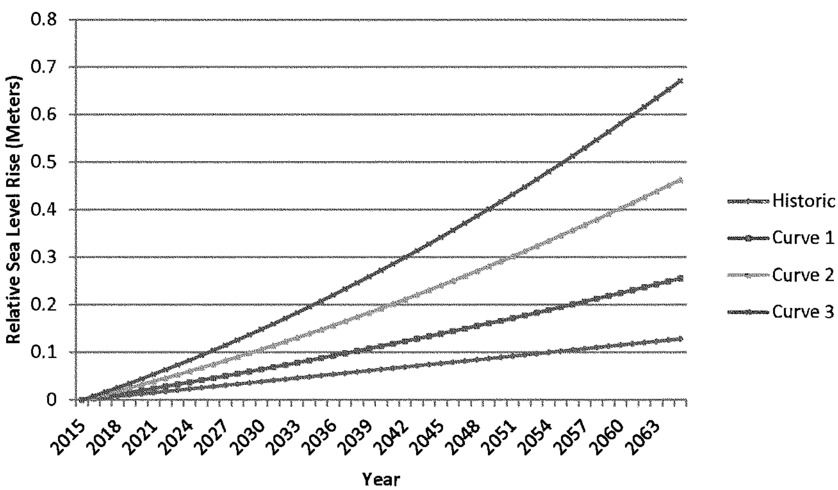


Figure 2-4. Relative sea level rise curves.

2.1.2 Geology and Topography

The Neuse River Basin is in the Piedmont and Coastal Plain physiographic provinces (Figure 2-5). Those provinces are characterized by belts of sediment and rock with various ages and lithologies. The westernmost physiographic province is the Piedmont, where Proterozoic and Paleozoic metamorphic and intrusive igneous rocks are present and sediments fill Mesozoic rift Basins. To the east of the Piedmont are the Cretaceous and Tertiary deposits of the Coastal Plain Physiographic Province (Soller and Mills 1991).

The significant change in lithology and elevation between the Piedmont and Coastal Plain is marked by an abrupt change in stream gradients that causes numerous rapids in associated watercourses. This fairly linear zone or boundary is commonly known as the fall zone or fall line (Soller and Mills 1991).

The Coastal Plain can generally be divided into two parts, the Outer Coastal Plain and the Inner Coastal Plain. The Outer Coastal Plain consists of the Outer Banks, a string of barrier islands separated from the mainland by sounds or inlets, and the Tidewater region (NCDENR 2010).

The Tidewater region is the area along North Carolina's coast affected by tides. The mouths of many major streams and rivers empty into sounds or the ocean. Seven sounds are in the Tidewater region—the Pamlico, Albemarle, Currituck, Croatan, Roanoke, Core, and Bogue. The Inner Coastal Plain, a higher, drier area, begins west of the Tidewater. Its rich, sandy soil is some of the state's best farmland. In the southwestern corner of the Inner Coastal Plain are the Sandhills, a sub-region of rolling, sandy hills. That area has the highest elevation on the Coastal Plain, ranging from about 900 to 1,000 ft above sea level (NCDENR 2010).

The western third of the Basin is in the Piedmont Physiographic province, a rolling plateau of red clay soil roughly 150 mi (240 kilometers [km]) wide, rising from an elevation of 30 ft to 600 ft (90 to 180 m) in the east to 1,500 ft (460 m) in the west (NCDENR 2010).

2.1.3 Soil

The Piedmont province is characterized by clay soils, rolling topography with broad ridges and sharply indented stream valleys, and streams composed of a series of sluggish pools separated by riffles and occasional small rapids. The Coastal Plain soils are predominately sandy material with little clay and a shallow water table (NCDENR 1993). Figure 2-6 shows the typical soils in the Neuse River Basin.

Coastal Plain soils in the back swamp portion of the floodplains and coastal wetlands are typically hydric. Hydric soils are commonly associated with wetland areas and are strongly influenced by the presence of water. A soil is considered hydric if it has been flooded or saturated with water long enough during the growing season to become anaerobic (that is, without the presence of oxygen). Organic matter (usually in the form of decomposing plant material) often accumulates in these soils, and chemical processes

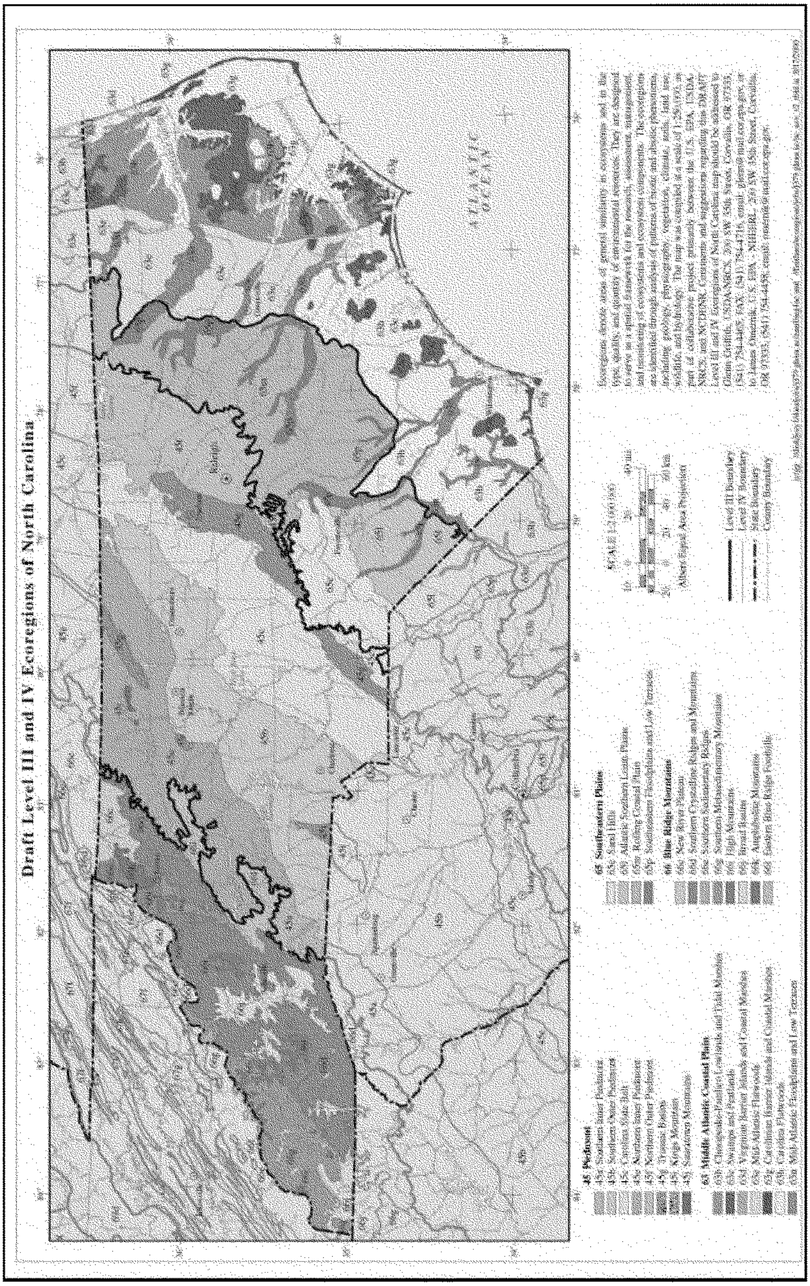


Figure 2-5. North Carolina ecoregions.

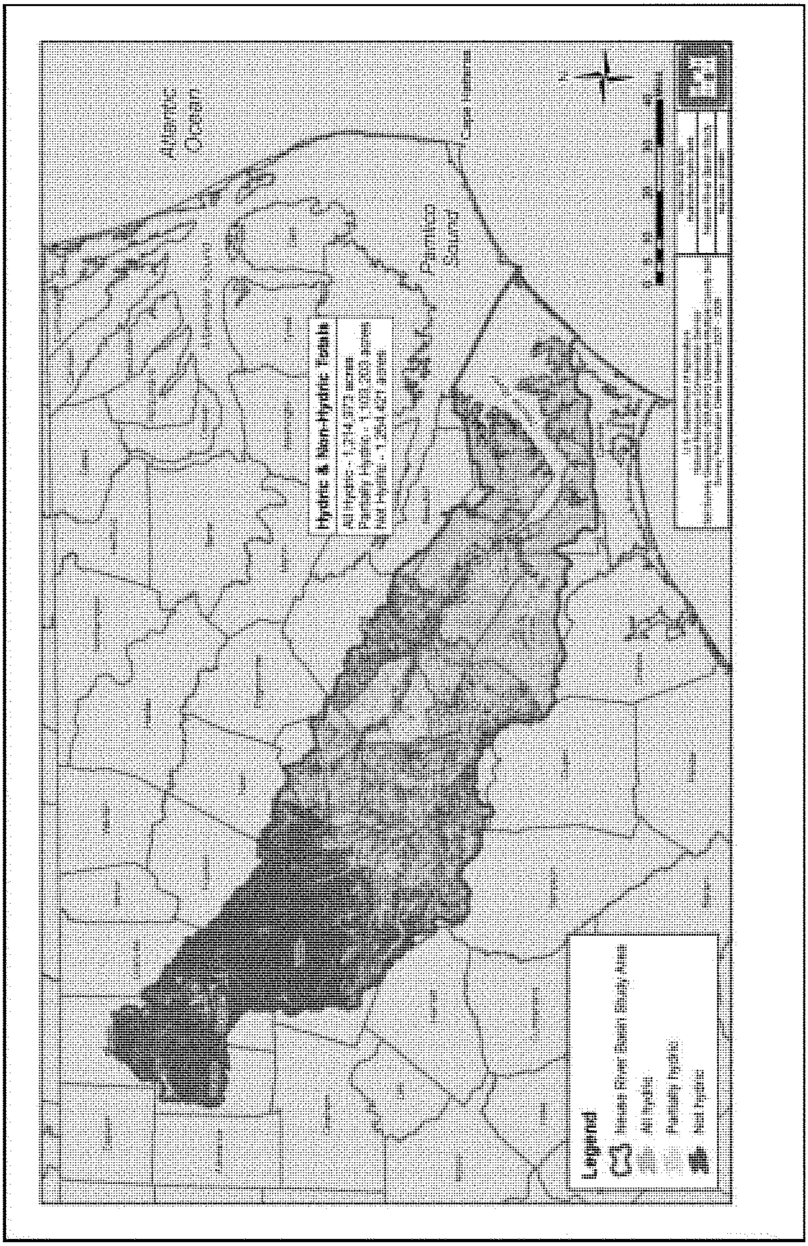


Figure 2-6. Neuse River Basin soils.

often result in grey or black soil colors, quite different from the usual reddish or yellowish soils typical of aerobic (i.e. oxygen-rich) environments. Sometimes mottles, or spots of different color, appear in the soil profile. Hydric soils are also capable of supporting plants adapted to oxygen-free conditions. In the Piedmont floodplain portions of the Upper Neuse River Basin, the typical hydric soils include the Chewacla, Wehadkee-Chastain association, and Bibb. Typical Coastal Plain hydric soils in the floodplains and coastal marshes of the middle and lower Neuse River Basins are the Muckalee, Dorovan, and Currituck (NCDENR 2010).

Non-hydric soils are usually found in the elevated levees (along the stream channel) and upland portion of the floodplain. Those soils are typically aerobic, their color is yellowish-brown, and they are mainly loamy sand with little or no organic material. The water table is usually greater than 12 in below the ground surface, and flooding is infrequent. The Basin Piedmont non-hydric soils are Goldsboro, Wagram, and Altavista. The Coastal Plain non-hydric soils are Craven, Augusta, and Tarboro in the Basin (NCDENR 2010).

2.1.4 Stream Geomorphology and Dynamics

Stream morphology is influenced by Basin geology, topography, soils, and stream flows. In the Piedmont physiographic region, at the headwaters of the Basin streams are characterized by a series of pools and riffles. Streams, including the mainstem of the Neuse River, are much more meandering and slow moving (primarily because of lower elevation, which produces lower stream velocities) in the Coastal Plain than those of the upper Basin. Floodplain features within the Piedmont portion of the Basin are forested and narrow, compared with the flatter, low-lying and swamp/estuary features of the Coastal Plain. Coastal Plain stream morphology is characterized by lower banks and is often bordered by extensive swamps, bottomland hardwood forests, or marshes, particularly in the lower half of the region (NCDENR 1993). Freshwater streams flowing through low-lying swamplands are naturally discolored by tannic acid from decomposing plant material, and are known as *black water streams* from their tea-colored appearance. Streams originating in the Coastal Plain are black water; however, streams originating in the Piedmont flowing into the Coastal Plain are referred to as brown water (relatively high in turbidity caused by sediment), perhaps becoming black water as relative influence of the Coastal Plain increases (Simmons 1988).

2.1.5 Agriculture

Within the Neuse River Basin, agriculture provides important revenues and commodities for the state's economy. Primary crops are cotton, soybeans, corn, wheat, sweet potatoes, peanuts, and tobacco. In 2008 agriculture provided North Carolina with about $9.7 billion in revenues and within the Neuse Basin, more than $500 million in agricultural commodities was sold (USDA 2009). In the entire Basin, agriculture (cultivated crops and pasture/hay) accounts for approximately 29.5 percent of the land use (NCDENR 2009a). According to the *Neuse River Basin-wide Water Quality Plan* dated 2009 (NCDENR 2009a), about 17 percent of agriculture cultivated crop lands have been reduced since 1997. It appears that those lands have been removed largely because of urban sprawl (NCDENR 2009a).

2.1.6 Prime and Unique Farmlands

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. It is also available for those uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods (USDA 1987). Prime farmland soils are typically found in upland areas and outside the riparian and estuarine areas that are the principal focus of this study. They have the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management. In general, prime farmland has an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. The soils are permeable to water and air. Prime farmland soils are not excessively erodible or saturated with water for a long period, and they either do not flood frequently or are protected from flooding (USDA 1993). About seven prime farmland soil types are in the Basin, which account for about 1.3 percent (53,496 ac/3,989,760 ac) of all the soils in the project area (Figure 2-7).

Unique farmland is land other than prime farmland that is used for producing specific, high-value food and fiber crops. It has the special combination of soil quality, location, growing season, and moisture supply needed to economically produce sustained high-quality or high yields of a specific crop when treated and managed according to acceptable farming methods, Examples of such crops are citrus, tree nuts, olives, cranberries, fruit, and vegetables. In the Neuse River Basin, unique farmlands exist and are depicted in Figure 2-7(USDA 1993).

2.2 Water Resources

2.2.1 Surface Water

The Basin has a drainage area of 6,234 sq mi, which includes 3,497 mi of freshwater streams and 21 mi of Atlantic Ocean coastline (see Figure 1-1). Freshwater reservoirs and lakes cover 25.6 sq mi (16,414 ac or < 1 percent of the Basin), and the Neuse River Estuary covers 578 sq mi (369,977 ac or 9 percent of the Basin). The NCDWR has divided the Basin into 14 hydrologic sub-basins (Figure 2-8), which are described by a six-digit code (03-04-01 to 03-04-14). The last two digits refer to the sub-basin, e.g., Sub-basin 01, Figure 2-8 (NCDENR 2002).

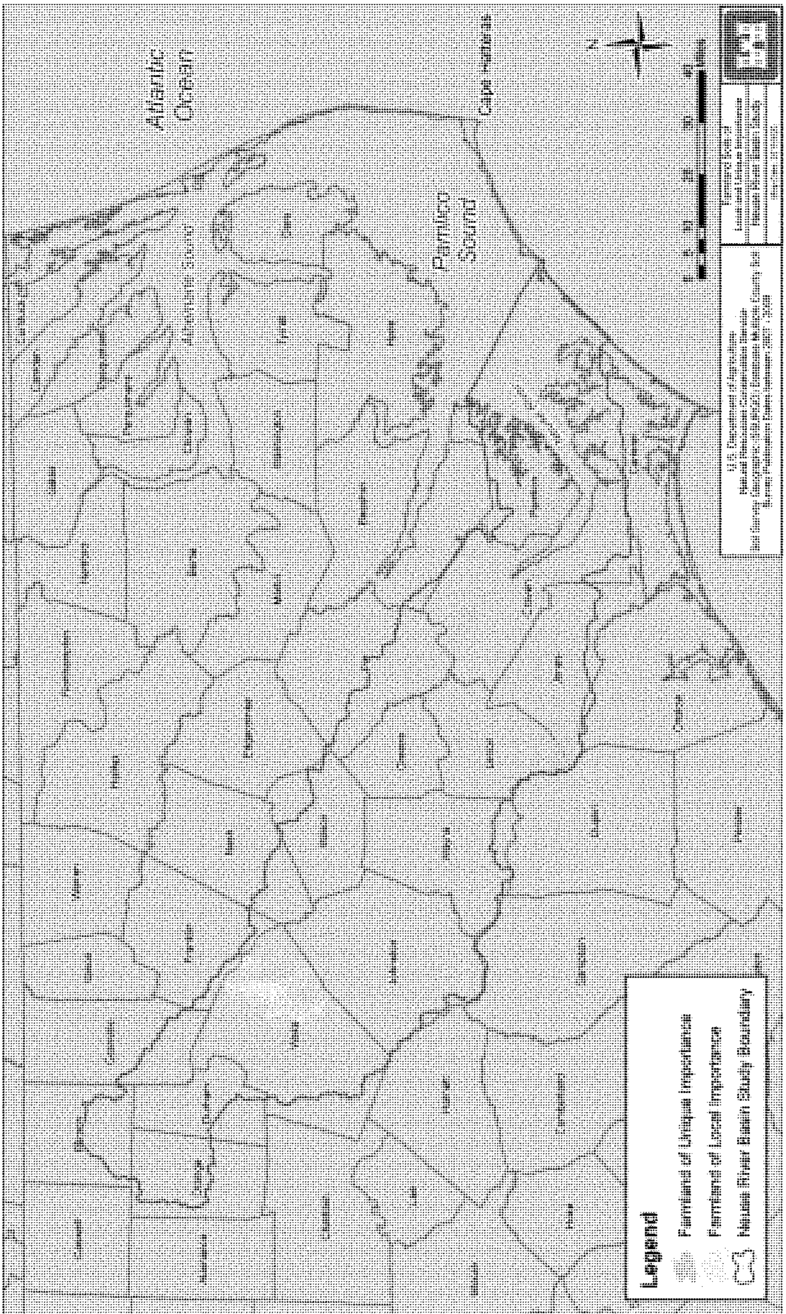


Figure 2-7. Prime farmland.

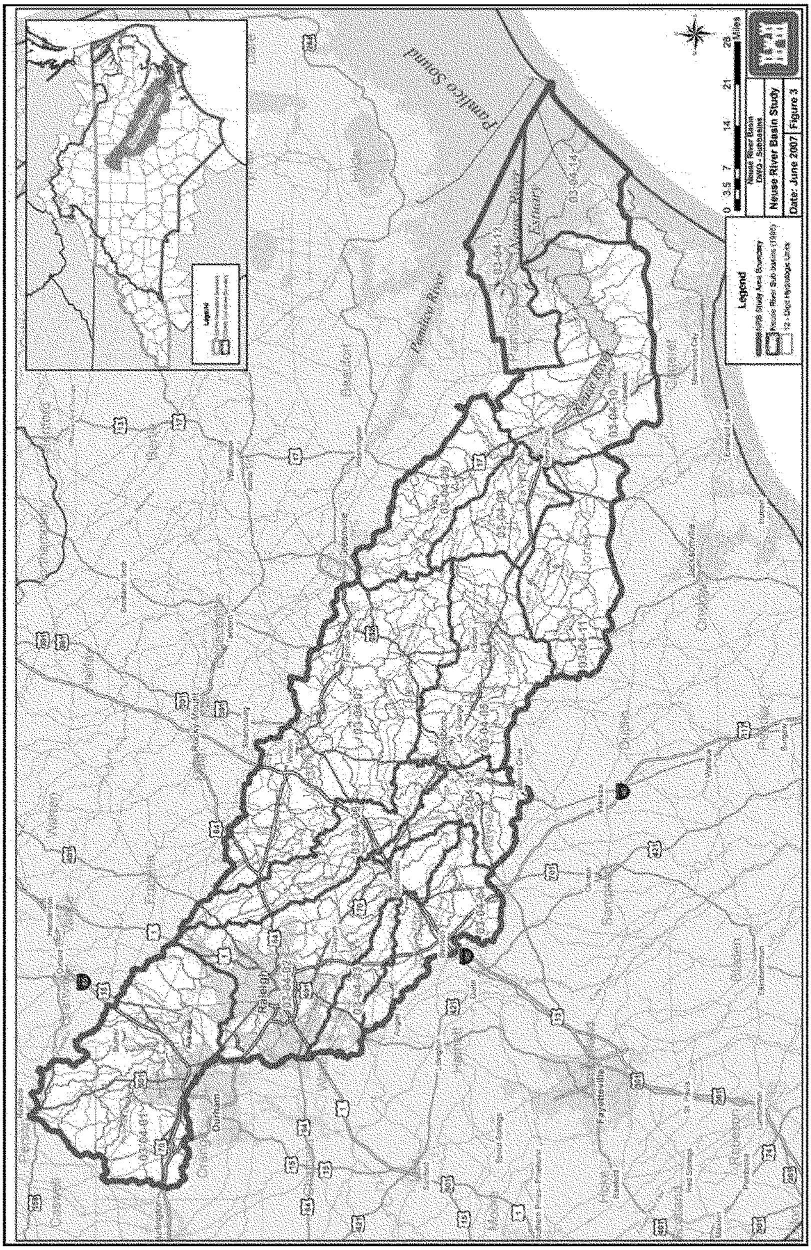


Figure 2-8. Neuse River sub-basins.

The largest tributaries to the Neuse River are Contentnea Creek and Trent River. The Contentnea Creek sub-basin drains 1,024 sq mi. The headwaters of Contentnea Creek are in the Piedmont physiographic region and flow downstream into the Coastal Plain below Wilson. Contentnea Creek joins the Neuse River east of Grifton at the junction of Pitt, Lenoir, and Craven counties. The Trent River sub-basin drains 434 sq mi, mostly in Jones and Lenoir counties. The Trent River joins the Neuse River near New Bern, where the Neuse River becomes a wide, tidally influenced estuary on its way to Pamlico Sound (Figure 2-8).

As described in Section 1.4, Falls Lake is a USACE multipurpose, flood risk management project in the upper portion of the Neuse River Basin. The facility is the primary drinking water source for Raleigh. According to the *USACE Water Control Manual*, dated September 1990, Falls Lake Reservoir is required to discharge a minimum flow of 60 cubic feet per second (cfs) from November to March and 100 cfs from April to October of any year. Several recent drought events (during 1998, 2001, 2002, 2005, 2007, and 2008) have necessitated deviations from the approved Drought Contingency Plan. In 2008 the Wilmington District, in coordination with Neuse River stakeholders, proposed a revised drought contingency plan to update the *1990 Falls Lake Water Control Manual*. That revised plan was approved in March 2008 and is now in effect. Plan revisions did not include operational changes.

2.2.1.1 Flooding and Drought

The Basin has experienced numerous significant flood events over the past 100 years and flooding is expected to continue to be an issue in the future. Most commonly, overbank flooding along the Neuse River is related to the occurrence of strong hurricanes and extreme episodic regional weather conditions such as the El Niño – Southern Oscillation (ENSO). Notable major hurricanes (category 3 or greater) that have affected portions of the Basin since 1950 include Hazel (1954), Connie (1955), Ione (1955), Helene (1958), Donna (1960), Diana (1984), Gloria (1985), Emily (1993), Fran (1996), Floyd (1999), and Isabelle (2003) (NCDENR 2009a).

In coastal areas of the Neuse River Basin, low-lying areas and areas near the shoreline are at high risk of flooding from high river flows and storm surges during major hurricane events regardless of flow regulations from Falls Dam. Falls Lake and Dam, in the upper Neuse River Basin in portions of Durham, Wake, and Granville counties, is used for flood risk management and flood peak attenuation. Flood flows are stored behind the dam and are gradually released after peak flows have passed to minimize flood damages to downstream facilities and properties to the greatest extent possible. Falls Lake and Dam provides controlled flood storage up to elevation 264.8 ft mean sea level (the elevation of the emergency spillway). Maximum design releases from Falls Dam reach 10,000 cfs. Approximately 6,500 cfs was released in 1996 as a result of flood flows directly related to Hurricane Fran, which was a category 3 storm and in which between 2 to 10 in of rain fell across the Neuse River Basin (NOAA 2010).

In May of 2006, the NCDEM and FEMA implemented a voluntary buyout program in which a licensed real estate appraiser determined the pre-flooding fair market value of properties in these flood-prone areas. These agencies subsequently acquired more than 1,000 residential structures throughout the Basin following hurricanes Fran, Bonnie, and Floyd (Appendix B). The FEMA buyout areas around Kinston are shown in Figure 2-9. Similar buyouts in other parts of the Basin have also occurred; those areas are illustrated in Appendix B.

Increased runoff volumes and elevated peak flows associated with less severe storm events can result in localized nuisance flooding of roads. Nuisance flooding, often caused by debris dams, blocked storm drains, or inadequate infrastructure capacity, is not likely to cause standing water in residential homes or structures. Issues with nuisance flooding are being managed through stormwater programs developed by municipalities across the Basin (NCDENR 2009a).

Periods of drought have also occurred in the Basin in past years and will continue to do so in the future. In 2001 and 2002, much of North Carolina experienced the worst drought on record (NCDENR 2009a). In 2006 to 2008 an additional severe drought occurred (NCDENR 2009a). These events were periods of extremely low rainfall for extended periods. Periods of low rainfall decrease baseflow in-stream and do not provide rainfall to refill dwindling storage reservoirs. Falls Lake and Dam is managed for multiple purposes. Water is released from the dam to provide minimum flows downstream to meet water quality standards for aquatic species, while water is conserved in the lake to meet water supply needs. Municipalities such as Raleigh imposed water usage restrictions in 2001 and 2002 and again in 2006 through 2008 to retain water.

2.2.1.2 Water Use

The NCDWR summary of water use in counties in the Neuse River Basin estimated total water use in the Basin at 197.2 million gallons per day (mgd), with approximately 73 percent coming from surface water sources and 26 percent from groundwater (NCDENR 2010). In 2008 domestic water withdrawals were estimated at 146 mgd, 111.7 mgd from surface water, and 34.3 mgd from groundwater. The state has taken proactive steps in its *2010 Neuse River Basin Water Resources Plan* (NCDENR 2010) by projecting future use in the Basin to allow time to plan sustainable solutions. As part of this planning study, recognition was given to water use by aquatic species. NCDWR recognized the need to maintain ecological integrity in the Neuse River Basin through ecological flows. The plan and associated study predicts deficits in available water to meet the projected 2050 demands illustrated in Figure 2-10.

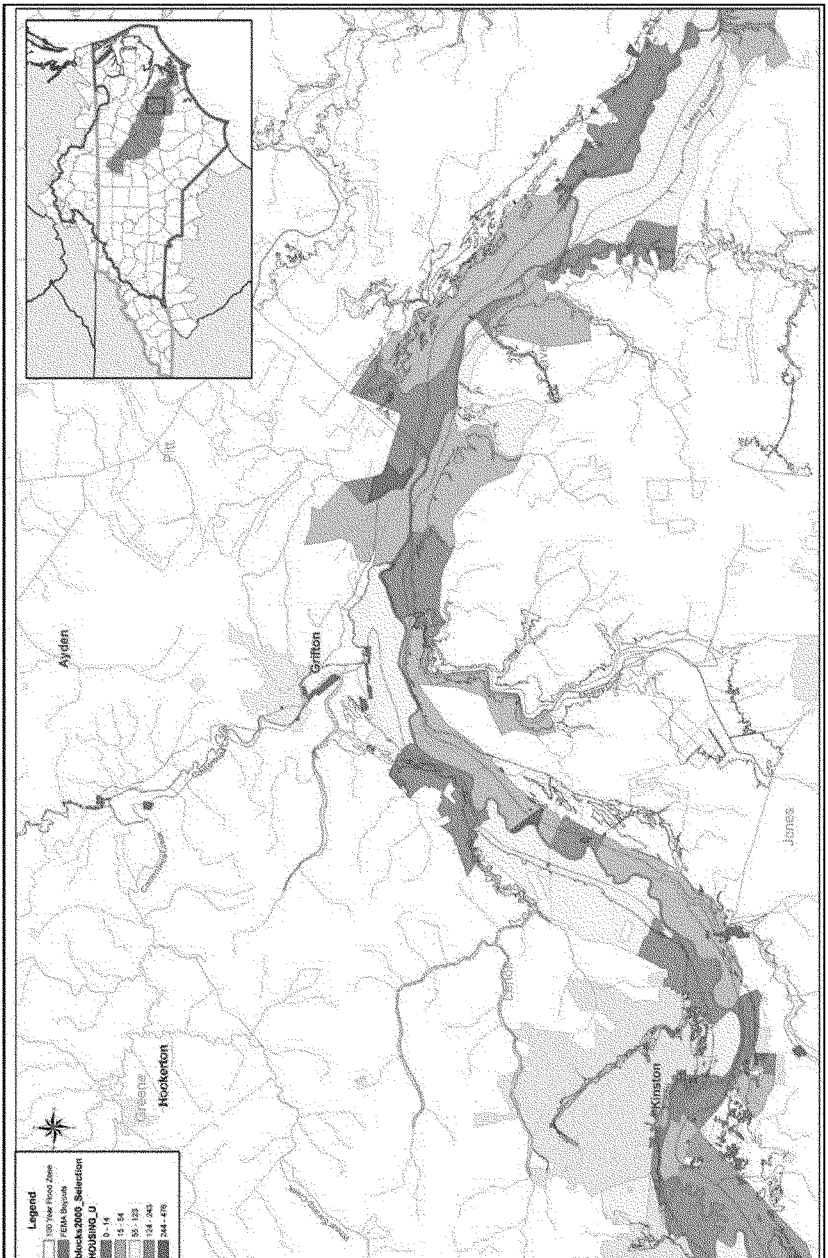
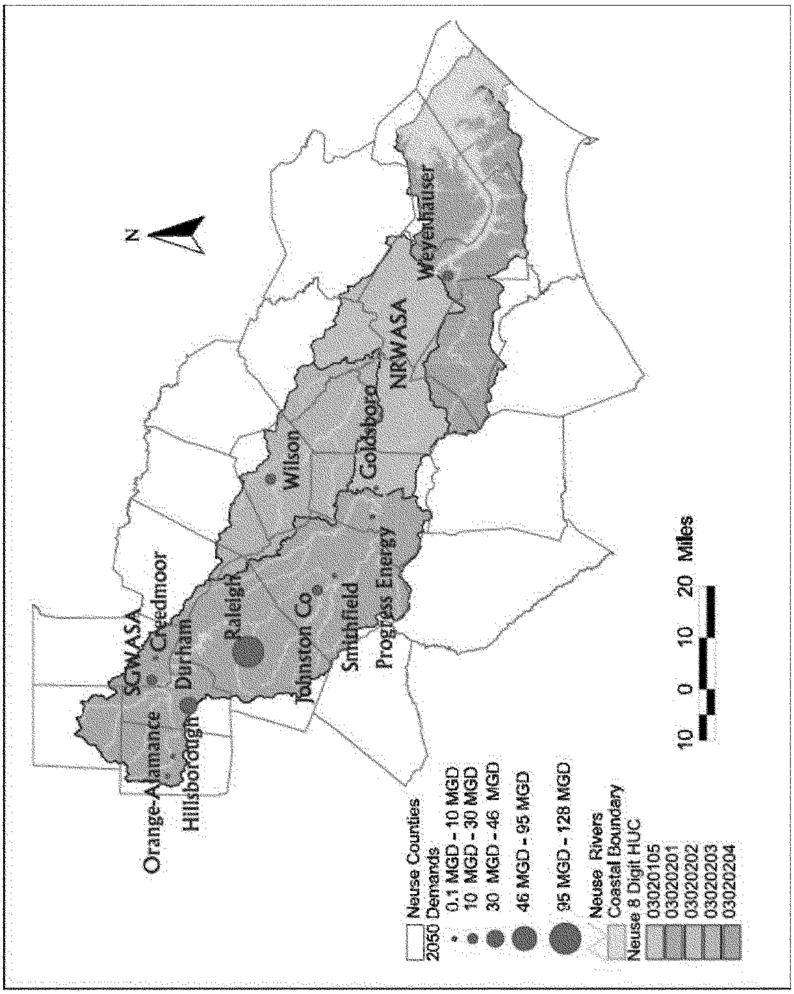


Figure 2-9. Neuse River flood buyouts near Kinston, NC.



Source: NCDENR 2010

Figure 2-10. 2050 Major demand locations.

2.2.1.3 Designated Use Classification

The NCDWQ classifies surface waters according to their best intended uses. Classifications found in the Neuse River Basin are presented in Table 2-1 (NCDENR 2009a). Determining how well a water body supports its uses (its *use support status*) is an important method for interpreting water quality data and assessing water quality. Surface waters are generally rated as *supporting* or *impaired*, depending on whether the water quality of a specific water body is adequate to support its state-designated uses (e.g., water supply, aquatic life protection, recreation). For example, waters classified with designated beneficial uses of fish consumption, aquatic life protection, and secondary recreation (Class C for freshwater or SC for saltwater) are rated *supporting* if the data indicate water quality is sufficient to support these uses. If the criteria required to support those uses are not adequate to allow for the beneficial uses, the waters are rated *impaired*. Waters with inconclusive data are listed as *not rated*, and waters lacking data are listed as *no data*.

Table 2-1. Primary and supplemental surface water classifications.

Class	Best use
C and SC	Aquatic life propagation/protection and secondary recreation.
B and SB	Primary recreation and Class C uses.
SA	Waters classified for commercial shellfish harvesting.
WS	*Water Supply watershed*. There are five WS classes ranging from WS-I through WS-V. WS classifications are assigned to watersheds on the basis of land use characteristics of the area. Each water supply classification has a set of management strategies to protect the surface water supply. WS-I provides the highest level of protection, and WS-IV provides the least protection. A Critical Area (CA) designation is also listed for watershed areas within one-half mile and draining to the water supply intake or reservoir where an intake is.
Sw	*Swamp Waters*: Recognizes waters that will naturally be more acidic (have lower pH values) and have lower levels of dissolved oxygen.
HQW	*High-Quality Waters*: Waters possessing special qualities including excellent water quality, Native or Special Native Trout Waters, Critical Habitat areas, or WS-I and WS-II water supplies.
ORW	*Outstanding Resource Waters*: Unique and special surface waters which are unaffected by pollution and have some outstanding resource values.
NSW	*Nutrient Sensitive Waters*: Areas with water quality problems associated with excessive plant growth resulting from nutrient enrichment.

Primary classifications beginning with S are assigned to saltwaters.

2.2.1.4 Water Quality

Section 303(d) of the Clean Water Act (CWA), originally enacted in 1972, requires states, territories, and authorized tribes to (1) identify and establish a priority ranking for waters for which technology-based effluent limitations are not stringent enough to attain and maintain water quality standards, (2) establish total maximum daily loads (TMDLs) for the pollutants causing impairment in those waters, and (3) develop and submit the list of impaired waters and TMDLs to USEPA. USEPA is required to approve or disapprove the state-developed 303(d) list within 30 days. For each segment impaired by a pollutant and identified on the 303(d) list, a TMDL must be developed. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet applicable water quality standards, along with an allocation of that load among the various sources of the pollutant. The 2008 303(d) list and finalized TMDLs are provided in Appendix E (NCDENR 2009a). The updated draft 303(d) list was submitted to USEPA on March 29, 2010 (NCDNR 2010). The most recent available electronic data are available for 2008 and illustrated in Figure 2-11.

In 2008, within the Neuse Basin, the portion of freshwater miles designated as impaired are 459 mi plus there are 13,538 ac of impaired freshwater impoundments. In addition to the impaired inland waters, 303(d) listed portions of the tidally influenced aquatic environment also designated as impaired include portions of the tidal estuarine and saltwater bays, inlets, and tidal areas, 57,648 ac, and 35 mi of shoreline. Those impairments affect shellfish health and associated harvesting. There are an estimated 1,696 mi impacted by nonpoint sources of runoff from urban, agriculture, and silviculture land management activities (NCDENR 2009a).

Point and Nonpoint Nutrient and Sediment Loads. Pollutants entering waters are from two general source categories, *point sources* and *nonpoint sources*. Point sources are typically piped discharges, and they are controlled through regulatory programs administered by the state. All regulated point source dischargers in North Carolina must apply for and obtain an NPDES permit from the state. NPDES permits are also given to activities that discharge to storm drains and to municipalities that manage storm drains through a NPDES stormwater permit (NCDENR 2009a). Additional information on NPDES permits are found in Appendix E.

Discharges from urban areas in the Basin are regulated through the NPDES stormwater program. Urban development in the Basin is altering the watershed hydrology, resulting in nuisance flooding, streambank erosion, channel incision, and also contributes to increased nutrient loading and turbidity that degrade aquatic habitat and biological health (NCDENR 2009a). Excessive nutrient loading is the primary stressor in the Basin, resulting in the impairment by chlorophyll *a* of Falls Lake and the Neuse River Estuary (NCDENR 2002). That impairment contributes to persistent estuarine bottom hypoxia during the summer. Hypoxia is the condition when oxygen concentrations fall below the level necessary to sustain most animal life—generally defined by dissolved oxygen less than 2 milligrams per liter (mg/L) (Committee on Environment and Natural Resources 2000). Hypoxia in the Neuse River Estuary primarily affects mid and deep waters where circulation is limited during periods of low wind mixing. Studies of hypoxia in the Neuse River Estuary document hypoxia to be of a lesser concern in shallower areas (Lenihan and Peterson 1998). In shallower areas (less than 3 m), less water stratification occurs, and the water column is thoroughly mixed (NCDENR 2009a).

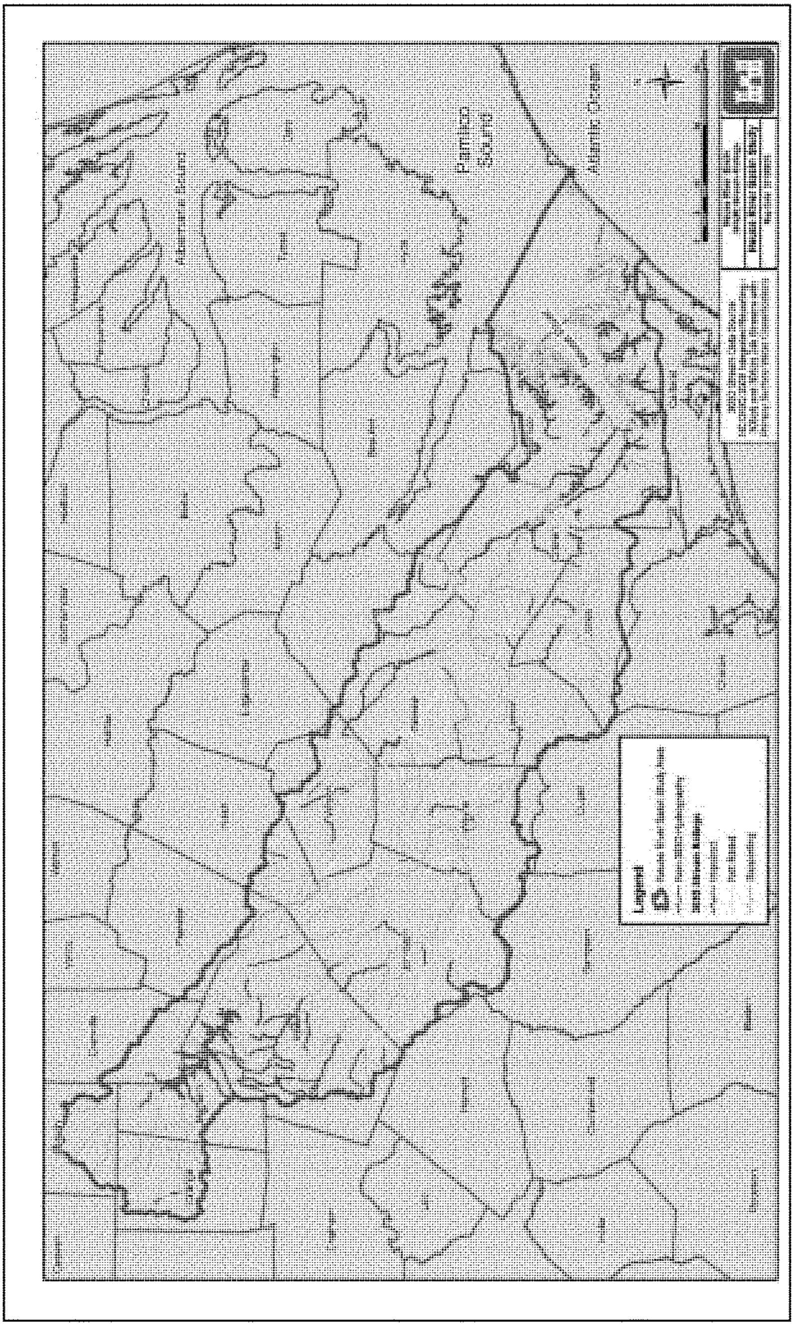


Figure 2-11. 2008 303(d) listed waters.

The North Carolina dissolved oxygen (DO) standards for Falls Lake and the Neuse River are 5 mg/l, with a minimum value of 2.8 mg/l. (NCDENR 2009a). Falls of the Neuse Reservoir was monitored by NC DWQ a total of 42 times between March 2005 and December 2006. Percent dissolved oxygen saturation values were elevated (>120 percent). These high values indicate biological productivity due to algal photosynthesis; as evidenced by the high phytoplankton populations found in the most upstream section of the reservoir, near Interstate 85. The results of this study, as reported above, found Falls Lake to be suffering from nutrient over enrichment and elevated sedimentation. Upper Neuse River Basin Association Initiative has developed a watershed management plan that would help protect all waters in Falls Lake from the increasing potential for sediment and nutrient impacts. The watershed management plan recommends a comprehensive suite of management strategies covering new development, monitoring and enforcement, watershed stewardship and agricultural measures, watershed restoration and point sources (NCDENR 2009a).

Downstream of Falls Lake dam, in the Neuse River low dissolved oxygen levels were seen at both of the ambient monitoring stations; however they did not exceed the state standard by greater than 10 percent (NCDENR 2009a).

Chlorophyll *a* concentrations are an indicator of phytoplankton abundance and biomass in coastal and estuarine waters. They can be an effective measure of trophic status, are potential indicators of maximum photosynthetic rate, and are a commonly used measure of water quality. High levels often indicate poor water quality and low levels often suggest good conditions. Although great strides have been made in reducing the nitrogen contribution from point and nonpoint sources to the Basin, many challenges remain in developing a thorough understanding of the complex nutrient delivery system and the management strategies that would be most effective in achieving timely water quality improvements. The state is working to address nutrient issues in the Basin through its basin-wide planning program (NCDENR 2009a).

Since full implementation of the Nutrient Sensitive Waters Management Strategy by the North Carolina Environmental Management Commission (EMC) in 1988, nitrogen loads from point sources throughout the watershed have decreased by 65 percent and nitrogen levels in runoff from agricultural areas have decreased by 45 percent (NCDENR 2009a). The Nutrient Sensitive Waters Management Strategy gave point source dischargers with flows greater than 0.5 mgd and all new facilities a total phosphorus limit of 2.0 mg/L in an effort to improve water quality in the Basin.

In December 1997, the EMC approved the Neuse NSW rules. Those rules are a comprehensive management strategy that includes mandatory measures for both point and nonpoint sources of nutrients (NCDENR 2009a). USEPA's *Nutrient Sensitive Waters Management Strategy* and NPDES stormwater regulations have caused actions to be taken to control sediment discharge from inland sources into rivers and streams and decrease the volumes of stormwater runoff that might result in adverse in-channel sediment movement.

The Natural Resources Conservation Service (NRCS) also has two programs that are working to improve water quality throughout the Neuse River Basin by offering funding to farmers and ranchers to address soil, water, and natural resources issues. The NRCS Environmental Quality Improvement Program provides technical, educational, and financial assistance to eligible farmers to improve management practices on local farms. Conservation Partnership Initiative Awards are given to agricultural partnerships to support environmentally beneficial activities in watersheds and airsheds of special significance (NRCS 2010). In 2005 the Center for Agricultural Partnerships received $66,000 to reduce nutrient and pesticide loadings in the Neuse River Basin. As described in Section 1.6, the result of concerted efforts to improve water quality through the *Neuse River Basin-wide Water Quality Plan* and state regulations are beneficial. Improved biological integrity and removal from the 303(d) list in Nahunta Swamp and Core Creek are the result of implementing agricultural BMPs. Funding by the Clean Water Management Trust Fund and the Agriculture Cost Share Program was successful in reducing the water quality effects on the biological community from the agricultural practices within these watersheds. The macroinvertebrate community ratings went from fair to good-fair in 2005.

Data from USGS sites on the Contentnea Creek Basin and the Neuse River at Kinston were reviewed for trends in major ions, sediment, nutrients, and pesticides during the period 1974-2003 (NCDENR 2009a). Decreasing trends in the Neuse River at Kinston were identified for water quality parameters such as dissolved oxygen, sediment concentrations, ammonia, and nitrogen; with increasing trends detected for parameters such as potassium, alkalinity, and chloride. Decreasing trends in Contentnea Creek were detected for silica, sulfate, and sediment concentrations during 1979–2003; with increasing trends detected for pH, hardness, and alkalinity. Total nitrogen concentrations increased in the Neuse River until about 1990 and then declined in both locations, primarily because of declines in nitrate. Those observations, along with a reduction in extremes, suggest that the 1997 Neuse River management rules have had a detectable effect on nitrogen concentrations. Concentrations of dissolved and total phosphorus and orthophosphate reduced in a step trend in 1988 at both locations. This reflects the 1988 phosphate detergent ban in North Carolina. Orthophosphate concentrations have continued a recent decline in Contentnea Creek (Harned 2003).

The largest nonpoint source of pollution in the Basin is agriculture (NCDENR 2009a). Nonpoint source pollutants come from a broad range of land use activities and are typically carried directly to waters by rainfall, runoff, and snowmelt. Sediment and nutrients are most often associated with nonpoint source pollution; other pollutants include fecal coliform bacteria, heavy metals, oil and grease, and any other substance that might be washed off the ground or deposited from the atmosphere into surface waters. The pollutants can result in impairment of the recreation and shellfish harvesting use support categories. Unlike point sources, nonpoint sources are diffuse in nature and occur intermittently, depending on rainfall events and land disturbance. Given those characteristics, it is often difficult and resource-intensive to quantify nonpoint contributions to water quality degradation in a given watershed.

According to the NCDENR (2009), "While great strides have been made in the reduction of nitrogen contribution from both point and nonpoint sources to the Neuse River Basin, many challenges remain in developing a thorough understanding of the complex nutrient delivery system and the management strategies that will be most effective to achieve timely water quality improvements."

Sediment transported into the streams by runoff also causes impairment. Many stream miles have elevated turbidity levels (greater than 7 percent exceedance of the state standard). Excess sediment causes these water bodies to be classified as impaired on the 303(d) list.

Sediment transport and deposition are dependent on changes in land use and human-related activity. As development consumes forests and fields within the Basin, the impacts on rivers, lakes, and streams can be significant and will become permanent if stormwater runoff is not controlled (Orr and Stuart 2000). As watershed vegetation is replaced by impervious surfaces in the form of paved roads, buildings, parking lots, and residential homes and driveways, the ability of the environment to absorb and diffuse the effects of natural rainfall is diminished. Urbanization results in increased surface runoff and correspondingly earlier and higher peak stream flows after rainfall. Flooding frequency increases as well. The effects are compounded when small streams are channelized (straightened) or piped and when storm sewer systems are installed to increase the transport of stormwater downstream. More frequent high-flow events can increase flow velocities and cause down cutting or lateral movement of stream channels, resulting in deposition of excess sediment in pool/riffle habitat. Excess sediment deposition causes embeddedness where gravel substrate or other coarse sediments become embedded by finer sediment like silt and clay. Finer sediments cover macroinvertebrate habitat filling in substrate they would have attached to and negatively altering in-stream conditions for biota. Such water bodies are identified on the North Carolina 303(d) list as having *impaired biological integrity*. The 2008 303(d) list of the Basin is provided in Appendix E.

Effective August 1, 2000, North Carolina adopted the Neuse River Riparian Buffer Protection Rule for maintaining and protecting existing riparian buffers in the Basin (15A NCAC 2B .0233). That strategy consists of a series of rules to protect and preserve existing riparian buffers to maintain their nutrient-removal functions in the Basin. The main rule, called the Neuse River Riparian Buffer Protection Rule, requires that existing vegetated riparian buffers in the Basin be protected and maintained on both sides of intermittent and perennial streams, lakes, ponds, and estuarine waters (Figure 2-12).

Specific activities are identified in the rule as *exempt*, *allowable*, *allowable with mitigation*, or *prohibited*. Examples of exempt activities are driveway and utility crossings of certain sizes through zone 1, and grading and revegetation in zone 2. Allowable activities and activities that are allowable with the incorporation of mitigation require review by NCDWQ staff, and they include activities such as creating new ponds in drainage-ways and water crossings.

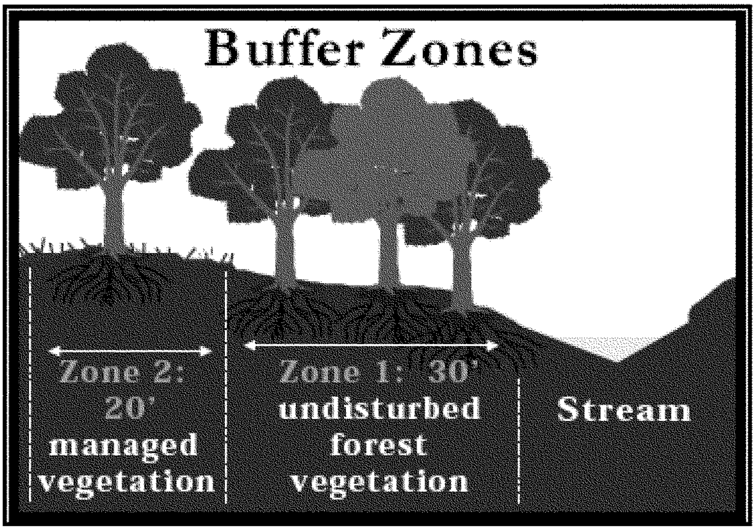


Figure 2-12. Buffer zones established by the Neuse River Riparian Buffer Protection Rule.

Wide, contiguous riparian buffers (including adjacent wetlands and floodplains) have greater and more flexible potential than other options to maintain biological integrity (Horner et al. 1999) and can ameliorate many ecological issues related to land use and environmental quality (Naiman et al. 1993). Important functions of an interconnected river-floodplain ecosystem include water control and purification, groundwater recharge, soil enrichment, erosion control, and support for downstream fisheries (Harris et al. 1984).

2.2.1.5 Estuarine Hydrology and Hydrodynamics

Pamlico Sound is a shallow (average depth of 6 m or 20 ft), long, broad inlet of the ocean connecting four river estuaries (Roanoke, Alligator, Pamlico, and Neuse).

The total area of Pamlico Sound is approximately 1,318,400 ac of water (Giese et al. 1979). There are about 369,977 ac of estuarine surface area and 21 mi of Atlantic Ocean coastline (Giese et al. 1979). The Neuse River Estuary itself covers approximately 369,977 ac and varies from about 6.3 mi wide and an average depth of 17 ft at its mouth near Maw Point to a width of about 0.9 mi and an average depth of about 8 ft at New Bern. From New Bern to the head of tide near Fort Barnwell, the estuary narrows considerably and maximum depths are 3 ft in any cross section.

Salinity stratification often occurs near the mouth of the Neuse River Estuary at Oriental resulting in higher salinities at depth. That condition, typical of estuarine systems, is caused by the density differential between freshwater riverine flows and saline seawater. Conditions of minimum saltwater encroachment in the Neuse River Estuary occur during April, and conditions of maximum saltwater encroachment occur in December from about New Bern to Oriental (Figure 1-1).

Wind Conditions within the Neuse River Estuary. Winds in the Basin are primarily from the southwest during spring and summer and from the north-northeast during fall and winter (Giese et al. 1979).

Wave Conditions within the Neuse River Estuary. Wave energy and duration are dependent on the fetch of water that generates the waves. Wave conditions are usually driven by prevailing winds in the Neuse River Estuary because the Outer Banks barrier islands (Bodie Island, Hatteras Island, Ocracoke Island, and Portsmouth Island) block, to a large extent, any waves generated in the Atlantic Ocean.

Tide Levels and Tidal Currents within the Neuse River Estuary. The Neuse River Estuary is a shallow system with a poor connection to the open ocean. Bodie Island, Hatteras Island, Ocracoke Island, and Portsmouth Island are barrier islands that, to a large extent, block lunar tides from the estuarine portion of the Basin. As previously stated, the lunar tidal range in Pamlico Sound near the barrier island inlets is about a meter. Because of the distance from the inlet of the sound relative to the size of the sound tide levels near the mouth of the Neuse River Estuary at the town of Oriental, (about 40 mi west of the inlets) average about 10 cm (0.3 ft). Within the estuarine portion of the Basin, northerly winds can cause a high tide and southerly winds can cause a low tide (Giese et al. 1979).

2.2.2 Groundwater

2.2.2.1 Groundwater Flow and Recharge

Soils in the Piedmont are underlain by a fractured rock formation with limited water storage capacity. The supply of groundwater in the Piedmont is limited to areas where small pockets can occur in fractures. In contrast, the Coastal Plain is underlain by deep sands, and shallow groundwater is more abundant. As a result of abundant groundwater, permeable soils, and flat terrain, there are few large surface impoundments used for water supply storage in the Coastal Plain region (NCDENR 2009a). Naturally impounded water in the Coastal Plain is often standing water or swamps.

Monitoring by NCDWR in the central Coastal Plain portion of the Basin has shown a decline of groundwater supplies that is expected to continue as populations increase. Dewatering of the groundwater table below the top of the aquifer has been observed as much as 150 ft below the top of aquifers of the Basin and in surrounding areas (NCDENR 2009a). Kinston, North Carolina, provides an example of groundwater supply conditions in the Basin. In 1998 yields from wells that were a few years old had declined 50 percent from their original yield. NCDWR also found in 1998 that dewatering was occurring in Greene, Pitt, and Lenoir counties, all of which intersect with the Basin. NCDWR has also noted declines in groundwater in Craven and Pamlico counties (NCDWR 1998). More recent NCDWR monitoring indicates that the groundwater supply in the central Coastal Plain continues to decline with increases in population and demand (NCDWR 2010).

Withdrawing water from the ground can cause permanent damage to aquifers, including saltwater intrusion and compaction of aquifer pore spaces. In some coastal areas, as freshwater is withdrawn it is replaced by saltwater; saltwater intrudes into an aquifer that was once freshwater. Saltwater intrusion is discussed in more detail in Section 2.2.2.3. In other areas, pore space in the ground that was filled with fresh water can become compacted as the water in the aquifer is withdrawn. The rate of water recharging the aquifer can also decrease because air fills the empty pore spaces.

To address the decline in aquifer recharge rates and the threat of permanent aquifer damage, NCDWR is working with local governments to assess future water supplies and develop alternative strategies. As part of the effort, NCDWR is conducting studies of groundwater withdrawals in the Neuse River Basin and other coastal river Basins (NCDWR 2010).

2.2.2.2 Groundwater Use

Approximately 26 percent of the domestic water requirements for residential consumers within the Neuse River Basin are obtained from groundwater resources (NCDENR 2010). In coastal counties within the Neuse River Basin, groundwater provides a much higher percentage of domestic water requirements than elsewhere in the state. For example, Craven County uses twice as many millions of gallons daily of groundwater (34.62) than it does surface water (17.72) for domestic use. The state began a groundwater classification system in 1983 and maintains three classifications for groundwater—GA, GSA, and GC; see Table 2-2, below. GA waters are a suitable source of potable drinking water. GSA waters are suitable for use as potable water after treatment to reduce concentrations of naturally occurring substances. They are mostly limited to the sections of aquifers that abut the Atlantic Ocean and to the deeper, heavily mineralized Coastal Plain aquifers. GC waters do not meet the quality criteria for GA or GSA and use would not be technologically feasible or not in the best interest of the public. Continued consumption of waters of that class by humans could result in adverse health effects.

Table 2-2. Groundwater classifications in the Neuse River Basin

Class	Use
GA	All groundwater that have chloride concentrations less than 250 mg/L and are a suitable source of potable drinking water
GSA	All groundwater that have chloride concentrations greater than 250 mg/L, but may be considered suitable for use as potable water after treatment to reduce concentrations of naturally occurring substances.
GC	All groundwater that do not meet the quality criteria for either GA or GSA. Continued consumption of these waters by humans could result in adverse health effects.

2.2.2.3 Groundwater Quality

Saltwater intrusion is defined as the movement of saline water into freshwater aquifers, and it is most often caused by groundwater pumping from coastal wells. Saltwater intrusion reduces fresh groundwater storage and, in extreme cases, leads to the abandonment of supply wells when concentrations of dissolved ions exceed drinking-water standards (Barlow 2003).

Currently saltwater intrusion has not been identified as a problem in the Neuse River Estuary (Thorndyke 2010). However, increasing drawdown of groundwater resources throughout the basin may result in future saltwater intrusion into the coastal portions of the basin. Future sea level rise could also increase the potential or possibility of saltwater intrusion into the aquifers. Saltwater intrusion already has been identified as an issue in portions of Pitt and Beaufort counties, which are located north of the Neuse River Basin in coastal North Carolina. Both Pitt and Beaufort Counties are not located within the Neuse River Basin watershed boundary.

Saltwater intrusion could result in issues associated with future potable groundwater supplies and a decrease in the amount and quality of fresh groundwater discharge to coastal saltwater ecosystems. As saltwater contains high concentrations of total dissolved solids and certain inorganic constituents, it is unfit for human consumption and many other anthropogenic uses. The proximity of coastal groundwater aquifers to saltwater has the potential to create problems with respect to long-term groundwater sustainability in coastal regions. The state is considering these problems and potential solutions in the *Neuse River Basin Water Resources Plan* (NCDENR 2010).

2.2.3 Navigation

The 228 mi of the Neuse River upstream of Pamlico Sound are considered Navigable Waters under Section 10 of the Rivers and Harbor Act. Additional areas of the Basin are navigable by small, flat-bottom boats or canoes during periods of high water. The lower Neuse Estuary is wide and deep, being 20- to 26-ft deep with unmarked, natural reef tops at about 18–21 ft. Water depths along the shoreline are shallower with depths 150 ft offshore about half the depth in the mid-river. The lower Neuse River Estuary is a popular, predominately recreational, sailing and boating area containing the Neuse River Navigation Channel and the Atlantic Intracoastal Waterway maintained by the USACE.

2.3 Biological Resources

2.3.1 Vegetation

2.3.1.1 Terrestrial Vegetation

The Basin has a number of upland terrestrial zones in the Piedmont and Coastal Plain. The North Carolina Natural Heritage Program (2010) has identified several natural community types within the Neuse River Basin. These include Dry Oak – Hickory, Mesic mixed hardwood (coastal and piedmont), Mesic pine flatwoods, Coastal plain heath bluff, Pine/scrub oak sandhill, and Xeric sandhill scrub (Natural Heritage Program 1990). Forests in the upland portion of the Piedmont are typically vegetated with an overstory of loblolly pine (*Pinus taeda*) and long-leaf pine (*Pinus palustris*), southern red oak (*Quercus falcate*) and white oak (*Quercus alba*), yellow poplar (*Liriodendron tulipifera*), and hickory (*Carya* spp.) and an understory of dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), American holly (*Ilex opaca*), and red cedar (*Juniperus virginiana*). Longleaf pines are native to the area. Coastal Plain forests are vegetated with an overstory of sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*). The understory consists of dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and greenbrier (*Smilax* spp.) (NCDENR 2009a). Figure 1-3 illustrates vegetative land cover in the Basin.

Herb layers in these terrestrial zones range from moderately dense and diverse to sparse in heavily shaded areas. Herbs may include species such as pineland threeawn (*Aristida stricta*), western brackenfern (*Pteridium aquilinum*), pineland threeawn (*Aristida stricta*), pineland scalypink (*Stipulicida setacea*), Spotted Wintergreen (*Chimaphila maculate*), Littlebrownjug (*Hexastylis arifolia*), and Christmas fern (*Polystichum acrostichoides*) (NCDENR 2009a). Table 2-3 defines the land cover in the Basin.

Table 2-3. Land cover in the Neuse River Basin

Land cover	Square miles	Percent of Basin
Urban land cover	2,225	35
Deciduous forest	720	12
Evergreen forest	850	14
Mixed forest	230	4
Shrub/scrub	110	2
Grassland/herbaceous	460	7
Pasture/hay	400	6
Cultivated crops	1,240	20

Source: NCDENR 2009a

Within the urban and agricultural portions of the Basin, the natural forests have largely been removed. Urban areas contain substantial impervious surfaces where the soil is covered with man-made structures such as shopping centers, roads, and homes. Urban area density is highest in Durham and Raleigh with other smaller urban areas spread throughout the river Basin. Agricultural areas are also dispersed throughout the Neuse River Basin and support the growth of row crops, such as corn, soybeans, and cotton. According to the *Neuse River Basin-wide Water Quality Plan* (NCDENR 2009a) about 17 percent of agriculture cultivated crop lands have been reduced since 1997. It appears that those lands have been removed largely because of urban sprawl (NCDENR 2009a).

Riparian forests, such as those found along the Neuse River, have long been recognized as having outstanding value to fish and wildlife resources because of their high productivity and their ability to provide food, cover, and water. As expansion of developed areas continues into the watershed, wildlife habitats can change, become fragmented, and even disappear. Riparian buffers provide travel corridors and habitat areas for wildlife displaced by development. Kellison et al. (1998) give a broad overview of the wildlife associated with major alluvial floodplains in the South. They note that the forested riparian areas provide some of the most important fish and wildlife habitats in the region. The high soil fertility of riparian areas supports high forest productivity, which, in turn, produces more high-quality food than is found on poorer sites.

Large portions of the riparian forests in the Basin have been cleared as a result of road construction, agriculture, and urban development. Because of the removal of riparian vegetation in the Basin and the fragmented nature of the remaining wooded habitat, wildlife value has been diminished in some portions of the Basin. High-quality natural areas remain, including extensive bottomland hardwood forests and swamps, and wildlife value has the potential to improve through restoration and natural regeneration. Collaborative efforts in the Basin have begun to restore some of the lost vegetation. The driver of these efforts was the Neuse River Riparian Buffer Protection Rule put in place by the state to maintain and protect existing riparian buffers in the Basin (15A NCAC 2B .0233) as described in Section 2.2.1.4.

2.3.1.2 Wetlands

Wetlands are areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, as defined by the *Code of Federal Regulations* (33 CFR 328.3). Wetlands have three essential characteristics: hydrophytic vegetation, hydric soils, and wetland hydrology.

Wetland habitats throughout the Basin provide nutrient cycling, wildlife habitat, and hydrologic storage, amongst other important functions. The rivers and streams of the Basin provide spawning areas for anadromous fish, such as shad and herring, which are saltwater species that migrate up rivers to spawn in freshwater. Wetlands and open water areas (including the Neuse River Estuary and large impoundments) compose more than 7 percent of the surface area of the Basin (Figure 2-13). Table 2-4 presents the approximate area of wetlands in the Neuse River Basin. In addition to those listed in Table 2-4 the Neuse River Basin also supports isolated wetlands including pocosin and submerged aquatic vegetation (SAV). There are 115,618 acres of pocosin wetlands and 91 ac of SAV in the Neuse Basin.

Table 2-4. Neuse River Basin wetland inventory

Wetlands (Total Acreage)							
Estuarine			Riverine				
Salt/brackish marsh	Estuarine forest	Estuarine shrub/scrub	Freshwater marsh	Bottomland hardwood	Riverine swamp forest	Headwater swamps	percent of total land area*
14,386	26	1,367	3,878	68,175	146,400	9,283	7

Source: Street et al. 2005 from North Carolina's Division of Coastal Management wetland mapping.
*Land area based on Neuse River CHPP management unit.

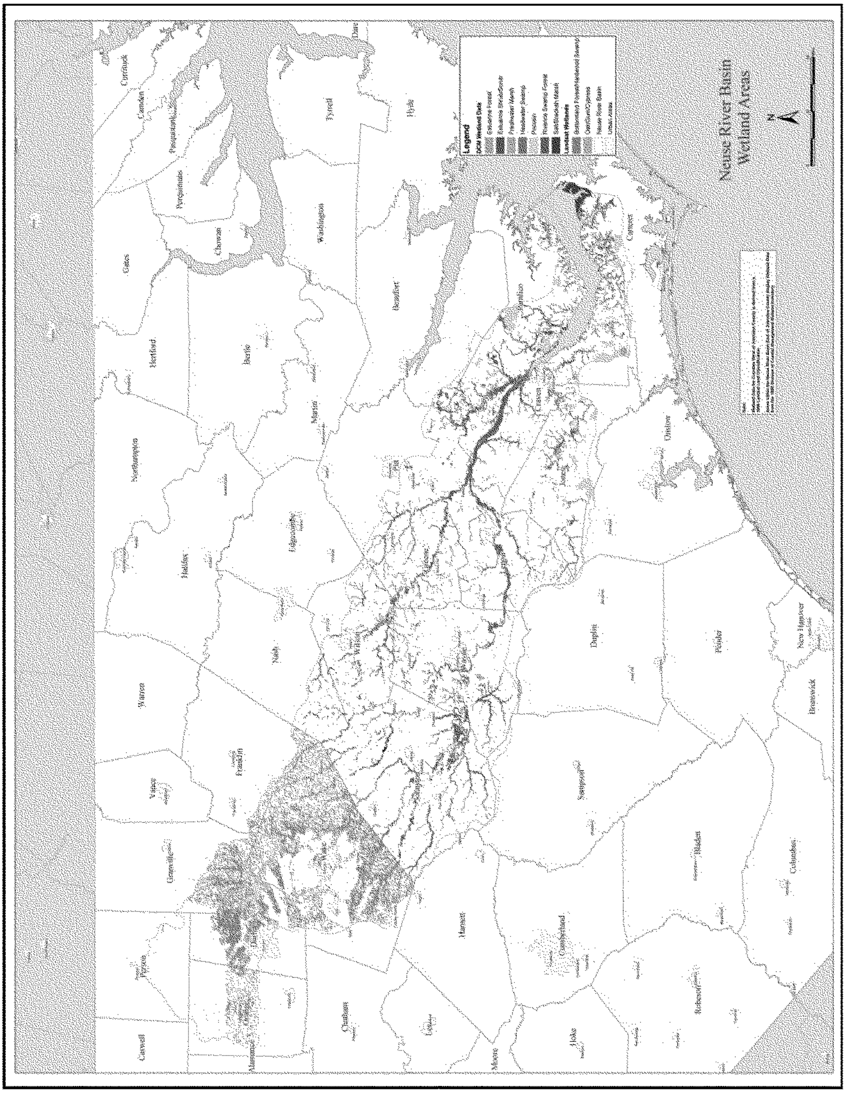


Figure 2-13. Wetlands in the Neuse River Basin.

According to Dahl (1990), by the mid-1980s, North Carolina had lost up to 50 percent of its estimated original wetlands acreage. From 1998 to 2004, in the United States, wetland gains are estimated at 32,000 acres annually (Stedman and Dahl 2008). However, during that same period, coastal watersheds of the United States adjacent to the Atlantic Ocean experienced a net loss of 15,000 acres of estuarine intertidal and freshwater wetlands (Stedman and Dahl 2008). Estuarine emergent wetlands showed the greatest loss declining by about 1 percent on the Atlantic Ocean coast during the 6-year period of analysis. According to Stedman and Dahl (2008), more than half of the U.S. population lives in coastal areas, and development was a major factor in the loss of coastal wetlands along the Atlantic and Gulf of Mexico. Rising sea level, subsidence, and erosion processes also contribute to coastal wetland loss (Stedman and Dahl 2008).

In the Neuse River estuary, wind and wave erosion is causing extensive wetland and high ground losses along the northern shoreline of the Neuse River in Pamlico County (Corbett et al. 2008). The North Carolina CHPP (Street et. al 2005) reports, "The trend in wetland loss for North Carolina mirrors national trends." Assuming a similar 1 percent loss rate and conservative base line of 14,000 brackish marsh acres, about 140 acres of estuarine marsh could have been lost in the Neuse River Estuary during 1998 to 2004.

The following is a brief description of the different wetland categories found in the Neuse River Basin as summarized from the CHPP (Street et al. 2005).

Pocosin Wetlands. One unique type of wetland found in North Carolina and in the Neuse River Basin are *pocosins*. The term pocosin is an Algonquian Indian word meaning *swamp on a hill*. Although the land is relatively flat, pocosins are generally slightly higher in elevation. Organic soils in pocosins hold water like a sponge, releasing it very slowly to surrounding areas. Historically, pocosins remained wet for long periods because of the poor drainage and slow water movement. Precipitation is normally the exclusive water input and evapotranspiration is the primary output of water. Predominant vegetation in pocosins is characterized by a very dense growth of mostly broadleaf evergreen shrubs with scattered pond pine. Pocosin wetlands are extremely flat, and their natural drainage is poor. The top layer of soil is composed of mostly organic material or peat. That organic matter consists of leaves, sticks, and other organic debris that were once submerged in water and decomposed slowly. Schafale and Weakly (1990) state that pocosins are "part of domed peatlands on poorly drained interstream flats and peat filled Carolina bays and swales." They have a dense shrub layer, and the communities are extremely nutrient poor (Schafale and Weakley 1990). According to Richardson (2003), in North Carolina about 33 percent of pocosins have been destroyed.

Freshwater Marsh. Freshwater marshes occur in the innermost riverine and estuarine regions and are dominated by various rushes, sedges, panic grasses, cattails, and arrowheads. These marshes produce readily digested plant material (detritus) an important food for worms, insect larvae, snails, and amphipods that support small fish, grass shrimp, crayfish, and crabs at the base of the food web. Detritus export is relatively low, and much of the production remains on-site. However, as water exchange increases, detritus export increases from freshwater marsh into tidal brackish areas. The freshwater marshes grade seaward into tidal brackish and salt marshes as described above.

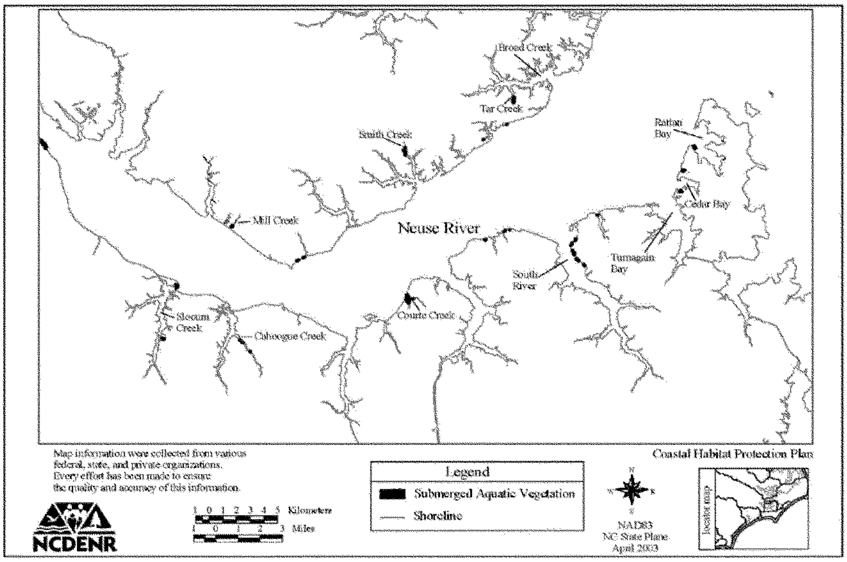
Forested Wetlands. The swamp-forest shorelines along the Neuse River are dominated by wetland trees and shrubs such as cypress, bald cypress, water tupelo, black gum, willow, red maple, and wax myrtle. They occur within the freshwater, riverine floodplains of the uppermost portions of trunk and tributary estuaries. Cypress-gum swamp and bottomland hardwood communities are present on the Neuse River floodplain upstream of New Bern in northwestern Craven County and below Smithfield in Johnston County. Forested wetlands are also highly productive; however, leaves and woody plant materials break down more slowly than succulent marsh vegetation. Forested wetlands support abundant invertebrate food for swamp resident chain pickerel, bowfin and gar, and opportunistic river such as largemouth bass and catfish.

Tidal Salt Marsh. Tidal salt marshes are intertidal wetlands that occur along much of the shoreline of the lower Neuse River Estuary. Typical plant species in tidal salt marsh includes smooth cordgrass, black needlerush, glasswort, saltgrass, sea lavender, bulrush, saw grass, cattail, salt-meadow grass, and salt reed-grass. Nearly all estuarine shorelines in North Carolina are experiencing some level of shoreline recession as sea-level slowly rises (Riggs and Ames 2003).

These intertidal wetlands are very important ecologically for a variety of reasons. They have high primary productivity and high detritus export rates. Their role as nursery areas for larvae and juveniles of many important marine species make them very important habitat. Intertidal wetlands also provide refuge and forage to a wide variety of locally and regionally significant birds, such as herons, ibis, rails, and egrets.

Tidal salt marshes also provide aesthetically valuable natural and open space areas. The wetland communities in and adjacent to the tidal marsh in the lower Neuse River Basin as described above are important primary producers of organic matter. They serve as part of the base of the aquatic food web, supporting various fish, shrimp, and crabs in the Basin ecosystem. Tidal marshes in the Neuse River Estuary provide nursery habitat for many commercially valuable species of marine and estuarine organisms. These include ocean spawning estuarine dependent spot, Atlantic croaker, brown shrimp, and southern flounder and estuarine spawning, red drum, spotted sea trout, and blue crab.

Submerged Aquatic Vegetation. According to the North Carolina CHPP (Street et al. 2005), SAV provides fish habitat and is dominated by one or more species of underwater vascular plants, such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrighitii*), widgeon grass (*Ruppia maritima*) in higher salinity estuarine waters and native wild celery (*Vallisneria americana*) and sago pondweed (*Potamogeton pectinatus*) in low salinity freshwater. Occurrences of SAV beds are limited by water clarity and water depth (Street et al. 2005). According to the CHPP (Figure 2-14), an estimated 91 ac (36.82 hectares (ha)) of SAV are in the Neuse River Estuary.



Source: Street et al. 2005

Figure 2-14. Submerged aquatic vegetation in the Neuse River Basin.

2.3.1.3 Exotic and Invasive Vegetation

The following state listed aquatic exotic and invasive vegetation occur in North Carolina and presently or potentially occur in the Neuse River Basin, however they are not considered to cause significant problems within the study area..

- Alligatorweed *(Alternanthera philoxeroides)*
- Creeping Water Primrose *(Ludwigia grandiflora)*
- Egeria (*Egeria densa*)
- Eurasian watermilfoil (*Myriophyllum spicatum*)
- Giant Salvinia (*Salvinia molesta*)
- Hydrilla (*Hydrilla verticillata*)
- Parrotfeather *(Myriophyllum aquaticum)*

In addition *Phragmites australis*, or common reed, is a wetland plant species found in Neuse River coastal marshes. This species is not state listed as a noxious weed. It is however considered an invasive species. Phragmities is not currently a concern in the study area but could be problematic in the future if present in marsh restoration sites.

The *Aquatic Weed Control Act of 1991* directs and regulates the North Carolina Division of Water Resources Aquatic Weed Control Program. The purpose of the program is to assist North Carolina citizens and local governments burdened with aquatic weed infestations.

2.3.2 Fish and Wildlife Resources

North Carolina's wide variety of ecosystems supports an abundance of fish and wildlife populations for the residents of the state to enjoy. North Carolina waters and lands are home to oysters, shad, ducks, white-tailed deer, black bear, eastern wild turkey, geese, doves, quail and other game and nongame wildlife species.

2.3.2.1 Aquatic Resources

The following subsections describe aquatic resources, including macroinvertebrates and fisheries, in the Neuse River Basin.

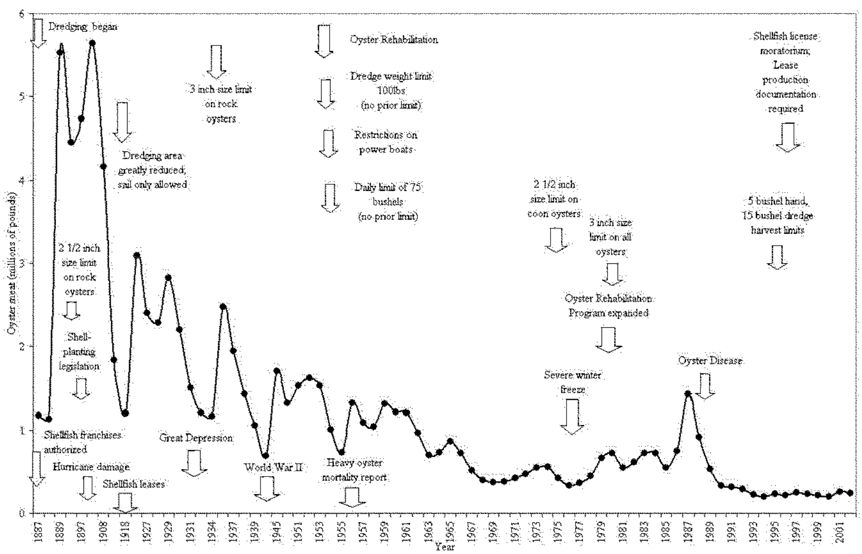
Freshwater Benthic Macroinvertebrates. The NCDWQ reports that several rare or unusual invertebrate species were collected during recent surveys (NCDENR 2009a) from several genera, including the Panhandle pebblesnail (*Somatogyrus virginicus*), which is a Federal species of concern (FSC). Pebblesnails were relatively widespread within the portion of the Eno River protected by the state park. Two species of rare crayfish (*Cambaridae*) were also found in the Basin (NCDENR 2002). More common macroinvertebrates found in the Neuse River Basin are mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), caddisflies (*Trichoptera*), beetles (*Coleoptera*), dragonflies/damselflies (*Odonata*), midges (*Chironomidae*), and snails (*Gastropods*).

North Carolina is home to more than 60 species of freshwater mussels; 24 of these occur in the Basin, most of which are in the genus *Eliptio* (Bogan 2002). The last healthy populations of these freshwater mussels in North Carolina and the Basin were found in 1958 (Walter 1958). Recent field surveys in the Basin have found a significant decrease in the historical mussel populations (Bill Adams, Biologist, USACE (retired), Wilmington District, personal communication, August 30, 2007). The decline in freshwater mussels has been attributed to poor water quality and habitat conditions.

Estuarine Soft Bottom and Shell Bottom Benthic Resources. This section summarizes these resources according to the CHPP (Street et al. 2005). Benthic microalgae are a key part of the food chain in estuarine soft-bottom and shell-bottom habitats. These habitats support a high diversity of benthic invertebrates. Soft bottoms support clams and polychaete worms. Larger, mobile invertebrates live on the surface of soft bottoms. Fiddler crabs use intertidal flats and submerged flats, and shallow bottoms support blue crab. Other mobile invertebrates inhabiting soft bottoms include horseshoe crab, whelks, tulip snails, moon snails, shrimp, and hermit crabs. Most of these species also inhabit shell bottoms. However, shell bottoms also support the more diverse oyster reef community, which includes species such as the mud crab and pea crab, barnacles, soft-shelled clams, mussels, anemones, hydroids, bryozoans, flatworms, and sponges. In the Neuse River Estuary, deepwater hypoxia events frequently affect benthic resources.

Hypoxia or anoxic conditions are defined as low oxygen conditions in the Neuse River Estuary. Those conditions are the combined effect of stratification from a lack of wind mixing and excess nutrients. Hypoxia can occur under natural conditions but is thought to occur more often in the Neuse River Basin because of increased nutrient loading to the estuary from the larger watershed. High-relief, shell bottom habitat provides an elevated refuge from hypoxia events for estuarine species.

The eastern oyster is a keystone estuarine species because other species rely on it for food and its habitat. Healthy oyster reefs are vital to the estuarine ecosystem (NCDMF 2001). Oysters provide important ecological services, including water filtration and habitat for benthos, fish, and shrimp (Mann 2001, Peterson et al. 2003, Posey et al. 1999, Soniat et al. 2004). Eastern oyster populations are declining, especially on sub-tidal reefs in the middle Atlantic Ocean coast (Ault et al. 1994, Hargis and Haven 1988, NCDMF 2001, Rothschild et al. 1994). In 2007 the National Oceanic and Atmospheric Administration's (NOAA's) Eastern Oyster Biological Review Team conducted a status review of the eastern oyster (EOBRT 2007). The review determined that the oyster harvest along the East Coast of the United States is only 2 percent of the peak historical harvest and that oyster restoration and enhancement efforts are "necessary to sustain populations" in about half of the estuaries in the middle and south Atlantic Ocean coast. The historical oyster harvest in North Carolina is showing significant decline, Figure 2-15 (Street et al. 2005). Oyster degradation in the Neuse River Estuary is particularly apparent where viable oyster beds have been "displaced downstream roughly 10-15 miles" since the late 1940s (Jones and Sholar 1981, Steel 1991).



Source: Street et al. 2005

Figure 2-15. Historical oyster harvest (as pounds of oyster meat) in North Carolina.

The primary causes of the historical oyster decline in the Neuse Estuary are the cumulative effects of pollution (Cooper et al. 2004, Pinckney et al. 1998), disease, and depletion of habitat from historical harvesting using destructive oyster dredges (Lenihan and Peterson 1998). To combat the decline, North Carolina implemented *the Neuse River Rules* to control pollution from upstream waters, and current harvest limits imposed by NCDMF manage harvest to acceptable levels. In fact, overharvesting is now only a minor threat to current oyster populations nationwide (EOBRT 2007).

Some stressors on oysters continue in the Neuse River Estuary. Harvest by oyster dredge is allowed and reefs continue to be stressed by the ubiquitous presence of oyster disease pathogens. The protozoan *Perkinsus marinus* causes Dermo disease in infected oysters. It lives in the oyster's immune cells and is thought to suppress their function. Natural expansion of healthy oyster reefs is not expected because adjacent areas lack attachment substrate, and any shell that was sloughed from a reef would be subject to deep water hypoxia where reef establishment is unlikely.

High-profile oyster reefs are a persistent feature in the Neuse River Estuary, having been recorded on bathymetric charts by the U.S. Coast Guard and Geodetic Survey as far back as 1868 (Lenihan and Peterson 1998). Lenihan et al. (1999) report more than "50 large natural oyster reefs (each 0.20–2 ha in surface area) occurring in water depths from 3 to 6.5 m." In addition, a study was funded by North Carolina Sea Grant to rectify the location and determine the presence or absence of live oysters at several historical Neuse River Estuary reefs. These reefs were sampled in December 2006. No live oysters were found upstream of the state's existing Neuse River Oyster Sanctuary.

To establish existing conditions for the *Neuse River Basin Integrated Feasibility Report and EA*, the USACE first identified potential reef locations using side-scan survey and limited multi-beam data from concurrent tows (USACE 2008a). All the surveys were conducted in waters greater than 4 m deep because those waters had not been subjected to previous oyster surveys by the NCDMF. A full-coverage multi-beam survey was conducted on all identified areas to confirm the presence of reefs. The USACE identified 131 reefs ranging in size from less than 0.25 ha (0.6 ac) to about 6.5 ha (16 ac), and totaling about 99 ha (244 ac). Known reefs are found in both high and low oyster habitat suitability. Suitability is lower in upstream reaches of the Neuse River Estuary Oyster Growing Area (OGA) and higher in downstream reaches with the highest suitability found near the mouth of the estuary (USACE 2008a).

From the 131 reefs, USACE sampled 39 representative reef tops (Figure 2-16) to determine existing oyster populations and conditions using a scientific oyster dredge as described in Appendix F. Findings from this effort are summarized in Tables 2-5, 2-6, 2-7 and discussed below comparing low suitability reaches (upstream) to high suitability reaches (downstream).

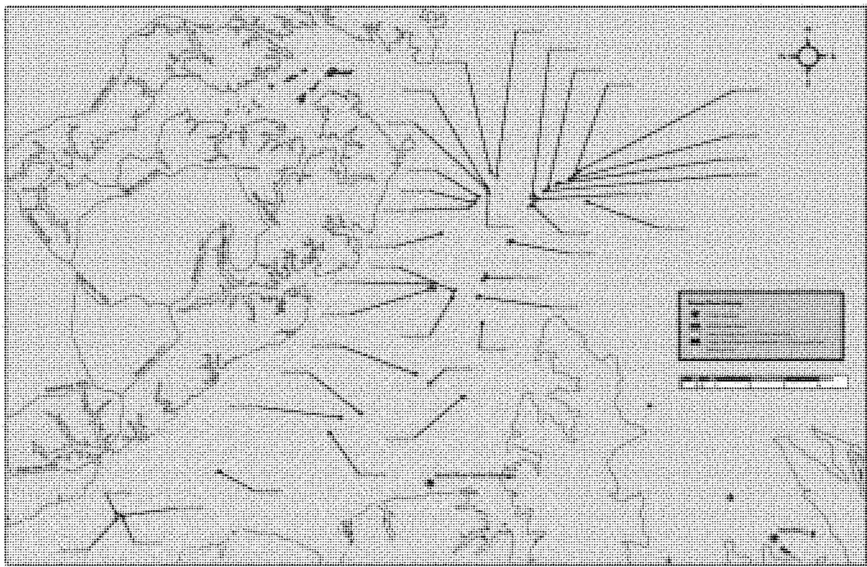


Figure 2-16. Reef tops sampled by USACE.

Table 2-5. Amount of sampling effort conducted in high and low suitability reaches

	Number of reefs sampled		Number of tows		Tow length (meters)	
Oyster Suitability	High	Low	High	Low	High	Low
Total	15	7	45	21	n/a	n/a
Mean	n/a	n/a	n/a	n/a	11	41
Max	n/a	n/a	n/a	n/a	28	136
Min	n/a	n/a	n/a	n/a	4	99

Source: USACE 2008a

Table 2-6. Percentage live oysters to shell in high and low suitability reaches

	Individual sample volume (l)		% of Sample live oysters		% of Sample oyster box		% of Sample brown shell		% of Sample of black shell	
Oyster Suitability	High	Low	High	low	High	Low	High	Low	High	Low
Mean	19	20	70%	19%	3%	1%	33%	75%	0%	4%
Max	26	40	88%	94%	11%	6%	73%	99%	8%	18%
Min	14	13	47%	1%	0%	0%	8%	11%	0%	0%

Source: USACE 2008a

Table 2-7. Oyster conditions in high and low suitability reaches

	Total oysters		Oyster length (mm)		Number of recent box		Number of old box		Number of spat 13-24 mm		Number of oysters >75mm	
Oyster Suitability	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Mean	362	68	52	45	8	3	2	1	19	6	9	<1
Max	817	202	124	94	19	10	5	5	104	25	18	2
Min	127	16	24	25	0	0	0	0	0	0	4	0

Source: USACE 2008a

The sections to follow describe the results of this monitoring contrasting results from high and low suitability oyster reefs. The sampled reefs in high suitability are natural reefs open to seasonal harvest. If these reefs were sanctuaries they would be expected to support higher populations of oysters because harvest would not be allowed.

Monitoring Results for High Suitability Sites. Forty-five tows with an average length of 11 m were made in highly suitable areas in the Neuse River Estuary. Each sample had an average volume of about 9 liters of reef material, which was primarily live oysters and brown shell with black anoxic shell generally absent (Table 2-6). Ample brown shell cultch with box oyster (recent dead) present indicates high potential for these reefs to provide good spat settlement sites. The lack of black shells is an indication that the reef matrix has not been severely damaged by harvest.

As shown in Table 2-7 high suitability reefs had oysters larger than 75 mm (3 in) with specimens over 100 mm (4 in) present on most reefs and up to 120 mm at several sites. The maximum length collected was 124 mm (5 in). The presence of large oysters is an indicator of potential natural disease resistance. Dermo disease was present on all reference standard reefs (USACE 2008a). Dermo disease causes delayed mortality generally by two growing seasons or when oysters are about 75 mm in height. Therefore, oysters that survive beyond those limits are potentially resistant to Dermo (Encomio et al. 2005). While the NCDMF continues to consider the status of the Oyster Stock as *Concern* because of historic reductions in oyster harvest, state sampling data show, "Dermo has declined in recent years, and commercial landings have shown improvement" (NCDMF 2010). USACE (2008a) sampling showed the reefs to support 16–17 size classes (4 mm) indicating high recruitment over several years.

Monitoring Results for Low Suitability or Degraded Sites. Twenty-one tows with an average length of 41 m were made on degraded reefs. Longer tows were required to collect adequate numbers of live oysters for analysis because of low oyster populations on these reefs. Each sample had an average volume of about 20 liters of reef material, which was primarily brown shell with less than 20 percent live oysters. Black anoxic shell was present—an indicator of reef damage (see Table 2-6). Brown shell with high quantities of old shell fragments (shell hash) and few box oyster (recently dead), indicate poor cultch conditions with low potential for the reefs to provide good spat settlement sites. Fewer oyster size classes (8–11) were present on degraded reefs, and large oysters were absent, suggesting that present populations were associated with recent short-term conditions.

USACE sampling identified spat as present in both sampling areas. Spat was more abundant in the reference standard sites (USACE 2008a). However, detailed quantification of spat numbers were not made because the system is not considered spat-limited according to previous studies. Lenihan and Peterson (1998) sampled spat set on newly constructed reefs in the lower Neuse River estuary. They found heavy larval settlement in August through early September of 1993. By May 1994 spat grew to an average length of 39 mm and a density per 0.16 square meter that varied with depth from 106 spat at 3 m, to 58 spat at 4 m, and 146 at 6 m.

Historic maps, drawn by Francis Winslow from the 1880s, indicate that Pamlico Sound was filled with oyster reefs. By some accounts, more than 20,000 ac of oysters covered the bottom of the sound (NC Sea Grant 2009). The state is working to quantify existing acreage, but the data are not available. Of the reef footprint area sampled by the USACE in 2008, 17 percent was found to have significantly lower oyster density than the high output reference standard reefs. However, remnant high relief (3- to 4-ft tall) oyster shell structures in both areas indicate that oyster reefs in degraded areas once were thriving. Assuming a similar 17 percent reduction occurred throughout Pamlico Sound, a conservative estimate could be that more than 3,000 footprint ac of oyster reef have been degraded or lost.

NC Oyster Restoration Goals. To offset the historic catastrophic loss of oysters and oyster habitat, the North Carolina ORSC Northern work group developed a Conservation Action Plan (CAP) identifying how much in-the-water restoration is needed to promote the recovery of native oysters in the Albemarle-Pamlico National Estuary (APNE). The CAP concluded that the efforts to restore oysters must be ambitious and aggressive, in the water and on land, with at least 500 ac of new rock reef constructed and designated as oyster reef sanctuary, protected from fishing and harvesting, by 2018 (NCCF 2008). At a February 10, 2010, Northern work group meeting of the ORSC, a 100-ac sanctuary goal was set for the Neuse River. Current or proposed sanctuary area in the Neuse River Estuary includes approximately 6 ac at the state's Neuse River Sanctuary site and 7 ac in West Bay, for a total of approximately 13 ac. To meet the ORSC's 100-ac goal, 87 ac of new sanctuary in the Neuse River Estuary would be required. Since 2008 only one new 30-ac sanctuary site, Gibbs Shoal, has been designated in the APNE. In addition, about 45,000 tons of limestone rocks, providing about 45 sanctuary acres, have been distributed over several sanctuaries for reef construction.

Anadromous Fish. Anadromous fish species such as striped bass (*Morone saxatilis*), hickory shad (*Alosa mediocris*), American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), shortnose sturgeon (*Acipenser brevirostrum*), and Atlantic sturgeon (*Acipenser oxyrhynchus*) have historically formed a significant component of the fishery resource of the Neuse River estuarine system. At one time, more American shad and striped bass were caught in North Carolina than in any other state (Smith 1907). Water quality degradation, alteration and destruction of the estuary's habitats, alteration of river flow, and commercial and recreational overfishing are factors thought to have contributed to the declines in population. Commercial fish-landing records from NCDMF indicate a significant decrease in anadromous fish in the Neuse River in the past 20 years. Water quality issues peaked in the 1990s, when significant fish kills occurred in the Neuse River. Such severe water quality issues caused North Carolina to implement the Neuse River Buffer Rules (Section 2.2.1.4).

Construction of dams on some river systems like the Neuse River led to a reduction in spawning area for these fish. The USACE worked with USFWS to establish the existing condition of obstructions in the Neuse River and its tributaries. An inventory of 27 obstructions in the Basin was developed through review of Basin studies and a paddling guide. The two major dams on the mainstem of the Neuse River, Milburnie and Quaker Neck dams were constructed in 1907 and 1952, respectively. A reduction in spawning area meant fewer eggs produced and, therefore, fewer fish. Recognition of the problem led to the removal of Quaker Neck Dam on the Neuse River and Cherry Hospital Dam on the Little River (tributary of the Neuse River).

In the case of the Quaker Neck Dam, the owner, Progress Energy (formerly Carolina Power and Light), voluntarily cooperated in the investigation of the benefits of the removal of the dam, and worked with several state and Federal agencies, and private conservation organizations to remove of the dam. The Quaker Neck Dam removal project restored anadromous fish access from Goldsboro to Raleigh, restoring approximately 78 mi of the mainstem of the Neuse River and 925 mi of tributary streams as spawning habitat for the native anadromous fish. The Cherry Hospital Dam removal project restored 76 mi of additional tributary streams for anadromous fish habitat in the Little River tributary of the Neuse River Basin (Personal communication, Mr. Mike Wicker, Biologist, U.S. Fish and Wildlife Service, April 2, 2005).

Two additional dams (Rains Mill Dam and Lowell Dam) on the Little River, a tributary of the Neuse River have also been removed. One low-head dam near Goldsboro is the last major obstruction to fish passage on the mainstem of Little River. Data collected by North Carolina State University has confirmed this obstruction has adverse effects on fish migration by affecting the timing of migration and possibly spawning (Raabe and Hightower 2010).

Fisheries. Recreational fishing and commercial fishing are important economic activities in the estuarine and freshwater portions of the Basin. Important fisheries include flounder, catfish, bass, blue crabs, and oysters (Street et al. 2005). Commercial fishing in the Basin is conducted with long-haul seines, shrimp trawls, crab trawls, crab pots, oyster dredges, drift gill nets, bait fish pound nets, and eel pots. According to the NCDMF's 2010 Stock Status report (NCDMF 2010) "saltwater fish populations in North Carolina are stable and, in many cases, improving but with some species showing declines." Summer flounder remains listed as *recovering*. Oysters, while remaining listed as *concern*, have shown signs of improvement with increased landings and increased spat fall in both wild harvest areas and in sanctuaries. Spotted seatrout, however, moved from concern to depleted on the basis of a 2009 stock assessment. The assessment indicated the stock is overfished according to data from 1991 to 2008. Blue crabs continue to support North Carolina's most valuable commercial fishery, topping the list for overall pounds harvested. Harvests from the Pamlico/Core sounds and tributaries continue to remain significantly below historical contributions. Shrimp are the second most valuable commercial fishery in North Carolina and stocks are considered *viable*.

Freshwater Fish. In 1962 Bayless and Smith prepared a comprehensive report on the fishes of the Basin. Table 2-8 lists the most abundant fishes found in the study area at the time of the survey. Of those, the catadromous American eel (*Anguilla rostrata*), resides in the upper river but passes through the Neuse River Estuary as it travels to and from its offshore spawning grounds.

A total of about 95 species, representing 27 families, were collected during the fishery survey of the Neuse River and its tributaries (Bayless and Smith 1962). The USFWS (USFWS DCAR 2008) says, "This report is still considered to be a good characterization of the fish in the Neuse River Basin."

In 2000 North Carolina Wildlife Resources Commission (NCWRC) designated the Neuse River from Pitchkettle Creek (near Grifton, North Carolina) upstream to Milburnie Dam, including Craven, Pitt, Lenoir, Wayne, Johnston, and Wake counties, as *Inland Primary Nursery Areas* (15A NCAC 10C .0503). NCDMF defines a Primary Nursery Area (PNA) as that portion of the estuarine system where initial post-larval development takes place. PNAs include both water and marsh areas.

Table 2-8. Common fishes in the Neuse River Basin

Common name	Scientific name
Bowfin	*Amia calva*
Redfin pickerel	*Esox americanus*
Chain pickerel	*Esox niger*
Bluehead chub	*Hybopsis leptocephala*
Swallowtail shiner	*Notropis procne*
Channel catfish	*Ictalurus punctatus*
American eel	*Anguilla rostrata*
Mosquitofish	*Gambusia affinis*
Redbreast sunfish	*Lepomis auritus*
Bluegill	*Lepomis macrochirus*
Johnny darter	*Etheostoma flabellare*

Source: Bayless and Smith 1962

Falls Lake, a 20,000-ac impoundment of the Neuse River just north of Raleigh, supports a highly valued largemouth bass (*Micropterus salmoides)* fishery. During 2001 more than 250 tournaments were held for largemouth bass on the reservoir. Crappies (*Promoxis* spp.) are also a highly prized species for anglers on Falls Lake, along with channel catfish (*Ictalurus punctatus*). Other species of interest include white bass (*Morone chrysops*), white perch (*Morone americana*), and a variety of sunfish (*Lepomis* spp.) species (Street et al. 2005).

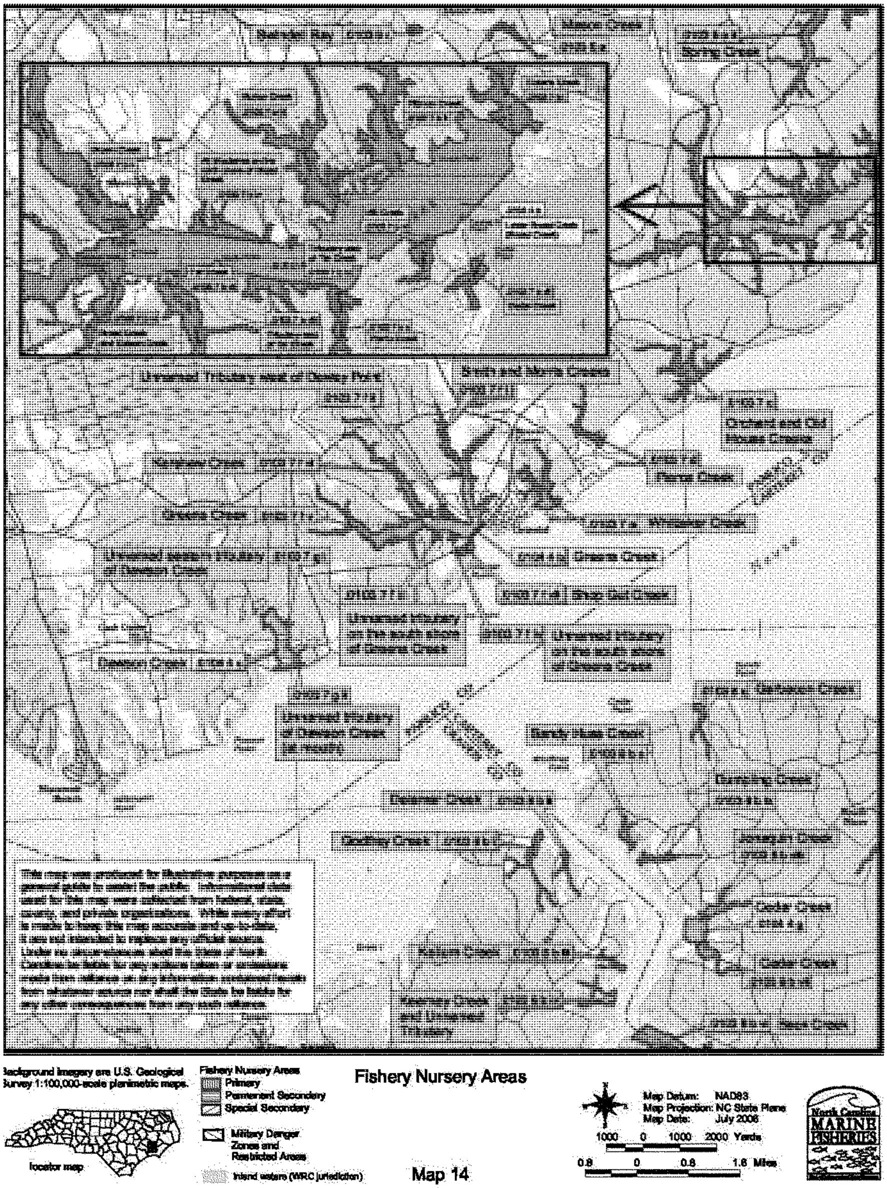
Estuarine Fish. Neuse River estuarine fish can be grouped into three categories—estuary-dependent species, permanent resident species, and seasonal migrant species, as summarized from the CHPP in this section (Street et al. 2005). The most abundant are the estuary-dependent species, which inhabit the estuary as larvae and the ocean as juveniles or adults. This group includes species that spawn offshore, such as the Atlantic croaker (*Micropogon undulatus*), spot (*Leiostomus xanthurus*), Atlantic menhaden (*Brevoortia tyrannus*), star drum (*Stellifer lanceolatus*), southern kingfish (*Menticirrhus americanus*), flounders (*Paralichthys* spp.), mullets (*Mugil* spp.), anchovies (*Anchoa* spp.), blue crab (*Callinectes sapidus*), and penaeid shrimp (*Farfantepenaeus* spp., *Litpenaeus setiferus*), as well as species that spawn in the estuary, such as red drum (*Sciaenops ocellatus*) and weakfish (*Cynoscion regalis*). Resident species of soft bottoms include flounders (*Paralichthys* spp.), sting ray, (*Dasyatis americana*), clear nosed skate (*Raja eglantaria*), naked goby (*Gobisoma bosc*), striped blenny (*Chasmodes bosquianus*), feather blenny (*Hypsoblennius hentzi*), freckled blenny (*Hypsoblennius ionthas*), skilletfish (*Gobiesox strumosus*), and oyster toadfish (*Opsanus tau*) (Coen et al. 1999, Lowery and Paynter 2002). Common migrant species include the bluefish (*Pomatomus saltatrix*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*Scomberomorus cavalla*), cobia (*Rachycentron canadum*), Florida pompano (*Trachinotus carolinus*), and spiny dogfish (*Squalus acanthias*).

Plankton. Plankton includes drifting organisms (animals, plants, archaea, or bacteria) that inhabit the pelagic zone of oceans, seas, or bodies of freshwater. They are defined by their ecological niche rather than by their genetic classification. Plankton provides a crucial food source for aquatic life (Street et al. 2005).

Phytoplankton is concentrated in the greatest abundance near the surface because they are free-floating photosynthetic organisms in aquatic systems. They include diatoms, desmids, and dinoflagellates. Zooplankton (depending on species) are scattered throughout the water column. Unlike phytoplankton, zooplankton cannot produce their own food, and therefore are consumers. Zooplankton consists mainly of small crustaceans, eggs, and larvae of larger animals, such as fish, crustaceans, and annelids. At depths where no primary production occurs, zooplankton and bacterioplankton instead make use of organic material that sinks from the more productive surface waters above (Street et al. 2005).

Within the Neuse River Basin, a dinoflagellate species, *Pfiesteria piscicida*, has been blamed for killing fish and possibly causing health problems in humans (NCDNR 2010). Only recently identified in estuaries in North Carolina, Delaware, and in the Chesapeake Bay and its tributaries by North Carolina State University Researcher Dr. JoAnn Burkholder, *Pfiesteria* is potentially a problem at only certain times of the year (usually April to October) and in only some locations (usually found in parts of the Neuse, Pamlico, and New River estuaries). It is not a problem in lakes, inland waters, or ocean waters in North Carolina. *Pfiesteria* persists in the environment in a dormant state and can come alive again at any time, though it rarely does. *Pfiesteria* has been associated with excessive nitrogen and phosphorus, but current scientific evidence is inconclusive. Studies are ongoing (Environmental Defense Fund 2010).

Primary Nursery. NCDMF defines Primary Nursery Areas (PNAs) as those areas of the estuarine system where initial post larval development takes place. Such areas are within the uppermost sections of the estuarine system where populations are uniformly very early juveniles (Street et al 2005). The estuarine system includes tidal saltwater marsh (including adjacent, shallow, open water areas) that provide essential habitat for the early development of commercially important fish and shellfish such as ocean spawning estuarine dependent spot, Atlantic croaker, brown shrimp, and southern flounder and estuarine spawning, red drum, spotted seatrout and blue crab. NCDMF has identified a total of 80,144 ac of PNAs statewide. According to the NCDMF, approximately 2,835 ac of primary nursery are in the Neuse River Estuary (Trish Murphey, NCDMF, personal communication, May 16, 2007). The Basin PNAs are illustrated in Figure 2-17. Protection of juvenile fish is provided in the areas by prohibiting many commercial fishing activities, including the use of trawls, seines, dredges, or any mechanical methods of harvesting clams or oysters (NCDMF 2008).



Source: http://www.ncfisheries.net/maps/FNA_maps/index.html

Figure 2-17. Neuse River estuary primary nursery areas.

Essential Fish Habitat. Table 2-9 shows the categories of Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) for managed species that were identified in the Fishery Management Plan Amendments of the South Atlantic Fishery Management Council. Table 2-10 identifies the species of the Basin and Pamlico Sound. These fish species and habitats require special consideration to promote their viability and sustainability. In an e-mail dated December 15, 2008, the National Marine Fisheries Service (NMFS) provided lists of EFH species to the PDT.

Table 2-9. Categories of EFH and HAPC

	Potential presence Neuse River Estuary
Estuarine areas	
Estuarine emergent wetlands	Yes
Submerged aquatic vegetation (SAV)	Yes
Oyster reefs and shell banks	Yes
Intertidal flats	Yes
Palustrine emergent and forested wetlands	Yes
Aquatic beds	Yes
Estuarine water column	Yes
Sea grass	Yes
Creeks	Yes
Mud bottom	Yes
Geographically defined HAPC	
Area-wide	
State-designated areas of importance for managed species (PNAs)	Yes
Submerged aquatic vegetation (SAV)	Yes
North Carolina	
Pamlico Sound at Hatteras and Ocracoke Islands	No

Source: NCDMF 2008

Table 2-10. EFH species of the Neuse River Basin and Pamlico Sound, North Carolina

Fish Species	Eggs	Larval	Juvenile	Adult
Bluefish	X	X	X	X
Summer flounder		X	X	X
Gag grouper			X	
Gray snapper			X	
Cobia	X	X	X	X
King mackerel			X	X
Spanish mackerel			X	X
Black sea bass		X	X	X
Spiny dogfish	X	X	X	X
Brown shrimp	X	X	X	X
Pink shrimp	X	X	X	X
White shrimp	X	X	X	X
Important food for fish species				
Striped mullet		X	X	X
Sheepshead minnow	X	X	X	X
Munnichog	X	X	X	X

Source: NCDMF 2008

2.3.2.2 Fauna

The overall fauna present in the Basin can be characterized by the wildlife found on the cliffs of the Neuse State Park and in the Eno River State Park. Those state parks have published fauna studies. The cliffs are near Goldsboro, within the Coastal Plain; the Eno River State Park is in Durham, which is in the upper Basin.

The North Carolina Division of Parks and Recreation notes that the Cliffs of the Neuse State Park in Wayne County) have abundant and diverse wildlife. Opossums, raccoons, and foxes can be found in the campground and along hiking trails (http://ils.unc.edu/parkproject/visit/clne). River otter and muskrat can be observed swimming along the river. Reptiles, amphibians, small nocturnal rodents, and white-tailed deer are also present in the park. The northern parula (*Parula americana*) nests in clumps of Spanish moss, while the prothonotary warbler (*Protonotaria citrea*) lives along the river. Migratory waterfowl can be found in the fall and winter joining the native wood duck.

The Eno River begins in northwest Orange County and flows eastward for approximately 33 mi. At that point, it converges with the Little and Flat Rivers to become the Neuse River, which flows into Falls Lake. According to *Wildlife of the Eno River State Park and Occoneechee Mountain State Natural Area* (NCDENR 2000), about 30 species of mammals, 154 species of birds (of which 62 species are known to nest in the park; the remainder migrate through the area), and 28 species of reptiles are found in the Eno River State Park. Mammals ranging from southern short-tailed shrew (*Blarina carolinensis*) to white-tailed deer (*Odocoileus virginianus*), birds from the Carolina chickadee (*Poecile carolinensis*) to wild turkey (*Meleagris gallopavo silvestris*), and reptiles from the snapping turtle (*Chelydra serpentina*) to the copperhead (*Agkistrodon contortrix*) are found in the park. The state park provides the wildlife species with habitat within an increasingly urban landscape.

2.3.2.3 Federal Threatened and Endangered Species and State-Protected Species

Coordination with the USFWS and the NMFS has been conducted to identify endangered and threatened species (as well as Federal Species of Concern [FSC]) that might be present in the vicinity of the study area. Table 2-11 is based on a list of Federally listed threatened and endangered species taken from the USFWS Draft Coordination Act Report dated August 11, 2008, and from an email transmission from NMFS dated December 15, 2008. Table 2-12 is a list of state-protected species that can be found in the Basin, provided by the North Carolina Wildlife Resources Commission (NCWRC) (NCDENR 2009a). The list of Federally Threatened and Endangered Species found in Table 2-11 are also mentioned in Table 2-12 the list of State Protected Species. Additionally, the State Protected Species found in Table 2-12 includes additional species not found in Table 2-11.

Table 2-11. Federally threatened and endangered species potentially present in the study area

Species common names	Scientific names	Federal status
Vertebrates		
American alligator	*Alligator mississippiensis*	T(S/A)
Eastern cougar	*Felis concolor couguar*	Endangered
Green sea turtle[a]	*Chelonia mydas*	Threatened
Hawksbill turtle	*Eretmochelys imbricata*	Endangered
Kemp's Ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Piping plover	*Charadrius melodus*	Threatened
Red-cockaded woodpecker	*Picoides borealis*	Endangered
Roseate tern	*Sterna dougallii*	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
West Indian manatee	*Trichechus manatus*	Endangered
Bridle shiner	*Notropis bifrenatus*	FSC
Carolina darter	*Etheostoma collis collis*	FSC
Carolina redhorse	*Moxostoma sp.*	FSC
Neuse madtom	*Noturus furiosus*	FSC
Pinewoods shiner	*Lythrurus matutinus*	FSC
Invertebrates		
Dwarf wedge mussel	*Alasmidonta heterodon*	Endangered
Tar spinymussel	*Elliptio steinstansana*	Endangered
Atlantic pigtoe	*Fusconaia masoni*	FSC
Brook floater	*Alasmidonta heterodon*	FSC
Green floater	*Lasmigona subviridus*	FSC
Savanna lilliput	*Toxolasma pullus*	FSC
Yellow lampmussel	*Lampsilis cariosa*	FSC
Yellow lance	*Elliptio lanceolata*	FSC
Panhandle pebblesnail	*Somatogyrus virginicus*	FSC
Vascular plants		
American chaffseed	*Schwalbea americana*	Endangered
Michaux's sumac	*Rhus michauxii*	Endangered
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened
Sensitive jointvetch	*Aeschynomene virginica*	Threatened

Notes: Status and definition by USFWS 2008 and NMFS 2008:

Endangered: A taxon in danger of extinction throughout all or a significant portion of its range.

Threatened: A taxon likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

T(S/A): Threatened because of similarity of appearance (e.g., American alligator)—a species that is threatened because of its similarity in appearance to other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to consultation under Section 7 of the Endangered Species Act.

FSC: Federal species of concern. A species under consideration for listing, for which there is insufficient information to support listing at this time. These species might or might not be listed in the future, and many of these species were formerly recognized as *C2* candidate species.

a. Green turtles are listed as threatened, except for breeding populations in Florida and on the Pacific Coast of Mexico, which are listed as endangered.

Table 2-12 List of State Protected Species in the Neuse River Basin (NC Natural Heritage Program 2010)

Group	Scientific Name	Common Name	State Status
Invertebrate Animal			
	Alasmidonta heterodon	Dwarf Wedgemussel	E
	Alasmidonta undulata	Triangle Floater	T
	Elliptio lanceolata	Yellow Lance	E
	Elliptio marsupiobesa	Cape Fear Spike	SC
	Elliptio roanokensis	Roanoke Slabshell	T
	Elliptio steinstansana	Tar River Spinymussel	E
	Fusconaia masoni	Atlantic Pigtoe	E
	Lampsilis cariosa	Yellow Lampmussel	E
	Lampsilis radiata	Eastern Lampmussel	T
	Lasmigona subviridis	Green Floater	E
	Ligumia nasuta	Eastern Pondmussel	T
	Lynceus gracilicornis	Graceful Clam Shrimp	SC
	Orconectes carolinensis	North Carolina Spiny Crayfish	SC
	Strophitus undulatus	Creeper	T
	Villosa constricta	Notched Rainbow	SC
Vascular Plant			
	Aeschynomene virginica	Sensitive Jointvetch	E
	Asplenium heteroresiliens	Carolina Spleenwort	E
	Baptisia australis var. aberrans	Prairie Blue Wild Indigo	T
	Cystopteris tennesseensis	Tennessee Bladder-fern	E-SC
	Delphinium exaltatum	Tall Larkspur	E-SC
	Echinacea laevigata	Smooth Coneflower	E-SC
	Isoetes piedmontana	Piedmont Quillwort	T
	Lindera subcoriacea	Bog Spicebush	T
	Lysimachia asperulifolia	Rough-leaf Loosestrife	E
	Macbridea caroliniana	Carolina Bogmint	T
	Minuartia godfreyi	Godfrey's Sandwort	E
	Myriophyllum laxum	Loose Water-milfoil	T
	Phemeranthus sp. 1	Piedmont Fameflower	E
	Platanthera integra	Yellow Fringeless Orchid	T
	Platanthera nivea	Snowy Orchid	T
	Portulaca smallii	Small's Portulaca	T
	Pyxidanthera brevifolia	Sandhills Pyxie-moss	E
	Rhus michauxii	Michaux's Sumac	E-SC

Group	Scientific Name	Common Name	State Status
	Ruellia humilis	Low Wild-petunia	T
Vascular Plant			
	Solidago ptarmicoides	Prairie Goldenrod	E
	Solidago verna	Spring-flowering Goldenrod	T
	Solidago villosicarpa	Coastal Goldenrod	E
	Trillium pusillum var. virginianum	Virginia Least Trillium	E
	Utricularia olivacea	Dwarf Bladderwort	T
Vertebrate Animal			
	Acipenser brevirostrum	Shortnose Sturgeon	E
	Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	E
	Alligator mississippiensis	American Alligator	T
	Ambystoma talpoideum	Mole Salamander	SC
	Ambystoma tigrinum	Eastern Tiger Salamander	T
	Ammodramus henslowii susurrans	Eastern Henslow's Sparrow	SC
	Condylura cristata pop. 1	Star-nosed Mole - Coastal Plain population	SC
	Corynorhinus rafinesquii macrotis	Rafinesque's Big-eared Bat - Coastal Plain subspecies	SC
	Crotalus adamanteus	Eastern Diamondback Rattlesnake	E
	Crotalus horridus	Timber Rattlesnake	SC
	Dendroica cerulea	Cerulean Warbler	SC
	Dermochelys coriacea	Leatherback Seaturtle	E
	Egretta caerulea	Little Blue Heron	SC
	Egretta thula	Snowy Egret	SC
	Etheostoma collis pop. 2	Carolina Darter - Eastern Piedmont population	SC
	Gelochelidon nilotica	Gull-billed Tern	T
	Haliaeetus leucocephalus	Bald Eagle	T
	Hemidactylium scutatum	Four-toed Salamander	SC
	Heterodon simus	Southern Hognose Snake	SC
	Ixobrychus exilis	Least Bittern	SC
	Lampetra aepyptera	Least Brook Lamprey	T
	Lanius ludovicianus	Loggerhead Shrike	SC
	Laterallus jamaicensis	Black Rail	SC
	Malaclemys terrapin centrata	Carolina Diamondback Terrapin	SC
	Myotis austroriparius	Southeastern Myotis	SC
	Necturus lewisi	Neuse River Waterdog	SC
	Nerodia sipedon williamengelsi	Carolina Watersnake	SC

Group	Scientific Name	Common Name	State Status
Vertebrate Animal			
	Notropis bifrenatus	Bridle Shiner	E
	Noturus furiosus	Carolina Madtom	T
	Peucaea aestivalis	Bachman's Sparrow	SC
	Picoides borealis	Red-cockaded Woodpecker	E
	Rynchops niger	Black Skimmer	SC
	Sistrurus miliarius	Pigmy Rattlesnake	SC
	Sternula antillarum	Least Tern	SC
	Trichechus manatus	West Indian Manatee	E

NC Status – Endangered (E); Threatened (T); Special Concern (SC); Extirpated (EX). E, T, and SC status species are given legal protection status by the NC Wildlife Resources Commission. Extirpated species are no longer believed to occur in the state.

State Protected Species - Amphibians. The Neuse River waterdog or Carolina waterdog (*Necturus lewisi*), an amphibian with a state status of special concern, occurs in the Basin. The state has identified it as a species of special concern because it is believed to be affected by poor water quality conditions. The species inhabits rivers and large streams in the Neuse and Tar River drainages. On a global scale, the species is considered very rare throughout its range. A 2001 survey (Lambiase 2001) found that Neuse River waterdog populations in the Eno River seemed healthy and yielded the highest number of captures compared to sampling stations at Crabtree Creek (Wake County), Flat River (Durham County), Little Creek (Johnston County), Little River (Durham County), Middle Creek (Johnston and Wake counties), and Swift Creek (Johnston County). Populations of the Neuse River waterdog are also found in Mill Creek (Johnston County).

State Protected Species - Fish. North Carolina is home to nearly 200 native species of freshwater fishes. On the basis of data from the NCDENR (2002), Bayless and Smith (1962), and Menhinick (1991), 95 species of fish are known from the Basin. Five species of fish are listed as FSC in the 18 counties that compose most of the Basin.

The five state fish species of special concern in the Basin are the least brook lamprey (*Lampetra aepyptera*), Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*), bridle shiner (*Notropis bifrenatus*), the Neuse River population of the Carolina madtom (*Notropis furiosus*), and the eastern Piedmont population of the Carolina darter (*Etheostoma collis lepidinion*) (NCDENR 2002). The least brook lamprey, a nonparasitic fish, occurs in warm, mostly slow, sandy, slightly acidic, and small creeks. The species is listed as state threatened and has a state rank of S2, indicating that it is imperiled in North Carolina because of rarity or because of some factor(s) that make it vulnerable to extirpation. In the Basin, it is found in Wake and Franklin counties. NCDENR conducted fish community assessments in several watersheds of the Basin in 2000 (NCDENR 2002). One Carolina darter was collected in Smith Creek (Granville County), and three bridle shiners (also an FSC) were collected from Batchelor Creek (Craven County).

The following detailed information on Federally listed species is provided since these species may be found in the project area. Species not found in the project area were not mentioned in this section.

Federally Listed Shortnose sturgeon. This species ranges along the Atlantic seaboard from southern Canada to northeastern Florida (USFWS 1999b). The shortnose sturgeon feeds on invertebrates and stems and leaves of macrophytes. From historical accounts, it appears that this species was once fairly abundant throughout North Carolina waters; however, many of these early records are unreliable because of confusion between this species and the Atlantic sturgeon (*Acipenser oxyrhynchus*). Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults. This species ranges along the Atlantic seaboard from the Saint Johns River in New Brunswick, Canada, to the Saint Johns River, Florida. No known current records of the shortnose sturgeon have been documented in the Neuse River Basin project area (Oakley 2003).

From June 2001 to September 2002, the Neuse River was sampled for both shortnose and Atlantic sturgeon (Oakley 2003). More than 200 hours of gill net surveys from the upstream obstruction of Millburnie Dam to Northwest Creek (south of New Bern) in the Neuse River were conducted in compliance with the NMFS shortnose sturgeon sampling protocol. No shortnose sturgeons were found in the Neuse River during the 2-year field survey (Oakley 2003). However four juvenile Atlantic sturgeons were encountered in the New Bern area (Oakley 2003).

Federally Listed Atlantic Sturgeon. Although specifics vary latitudinally, the general life history pattern of Atlantic sturgeon is that of a long lived, late maturing, estuarine dependent, anadromous species. The species' historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida (Murawski and Pacheco 1977, Smith and Clungston 1997). Atlantic sturgeons are found in the lower Neuse River Estuary (Oakley 2003).

Population stressors evaluated throughout existing literature indicate that by-catch mortality, water quality, lack of adequate state or Federal regulatory mechanisms, and dredging activities are the most significant threat to the viability of Atlantic sturgeon populations. Additionally, some populations were affected by unique stressors, such as habitat impediments (e.g., dams on the Cape Fear and Santee-Cooper rivers) and apparent ship strikes (e.g., Delaware and James rivers). Dams on the Neuse River and its tributaries and possible ship strikes might also have adversely affected Atlantic sturgeon populations in the Neuse River Basin.

Invertebrates (Mussels and Snails). Approximately 72 percent of North American freshwater mussel species qualify for classification as endangered, threatened, or of special concern at the Federal level (Williams et al. 1993), and habitat loss is the primary causal factor. North Carolina is home to more than 60 species of freshwater mussels. Twenty-four freshwater mussel species are or were historically found in the Neuse River Basin (Bogan 2002). That includes 17 species designated as endangered, threatened, or of special concern in the state. Eight mussel species (*Pelecypoda*), two listed as Federally endangered and six as FSC, and one snail species (*Gastropoda*) listed as FSC, as reported in Table 2-11, are found in the Basin. The greatest mussel diversity in the Basin occurs in the Flat River in the northern part of the Basin and in the Little River in Johnston County (NCDENR 2002). The dwarf wedge mussel occurs mainly near the fall line; the best populations occur in the Johnston County portion of the Little River. The Atlantic pigtoe (*Fusconaia masoni*), an FSC, occurs in the Little River of Johnston County and the Flat River in Person and Durham counties. The yellow lance (*Elliptio lanceolata*), an FSC, also occurs mainly near in the fall line in the watershed of Middle, Swift, and Mill Creeks. The yellow lampmussel (*Lampsilis cariosa*), an FSC, is found in the Flat, Little, Eno, and Little rivers (Figure 1-1).

Water quality in the Neuse River Basin has influenced the ability of freshwater mussels to thrive. Like other large rivers in North Carolina, excess sediment and nutrients in the mainstem of the Neuse River limit its ability to support populations of rare freshwater mussels. According to the *Neuse River Basin-wide Water Quality Plan*, the future of these populations is uncertain (NCDENR 2009a).

Federally Listed Threatened Dwarfwedge mussel and Tar spinymussel. Both of these invertebrates are found in the Little River, several miles upstream of the Rains Mill Dam that was demolished in 1999 (Personal Comunication, Dale Sutter, Biologist, USFWS, Raleigh Area Office, 24 March 2010). The Rains Mill Dam was on the Little River near Princeton, in Johnston County and was about 15 mi upstream of the existing Little River Dam at Goldsboro. These Federally listed Threatened mussels are not found in the estuary.

Federally Listed Sea Turtles. Federally listed threatened and endangered sea turtles are found within the waters of the Neuse River estuary (Personal Communication, Dr. Matthew Godfrey, North Carolina Sea Turtle Coordinator, North Carolina Wildlife Resources Commission, September 15, 2010). They are not known to nest in the area but are found feeding and resting in the adjacent waters of the Neuse River estuary and Pamlico Sound.

Federally Listed West Indian Manatee. The manatee is an occasional summer resident off the North Carolina coast and has been seen in the Neuse River Basin. Sightings of this animal have occurred in New Bern and Oriental (Personnel Communication, Howard Hall, Biologist, USFWS, 30 July 2010). The species can be found in shallow (5 ft to usually <20 ft), slow-moving rivers, estuaries, saltwater bays, canals, and coastal areas (USFWS 1991). The West Indian manatee is herbivorous and eats aquatic plants such as eelgrass (USFWS 1999a). During winter months, the U.S. manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. They are sighted infrequently in southeastern North Carolina, with most records occurring in July, August, and September as they migrate up and down the coast (Clark 1993). However, scattered records of this species being sighted in the region can span all seasons.

2.4 Cultural Resources

The Basin contains a wealth of prehistoric and historic period sites that reflect more than 12,000 years of human discovery and settlement. Prehistoric sites within the Basin range from the typically limited physical remains of Paleo-Indian hunter-gatherers (~12,000 B.C.) to the extensive collections recovered from large agricultural villages that came to dominate the floodplain and terraces by the 1400s. The larger villages represent the final stages of Native American dominance, circa 1700 A.D.

European explorers who arrived at the eastern sounds first encountered Algonquian tribes. These Native Americans were the southernmost of the eastern Algonquian language family, which extended northward to the maritime provinces of Canada. The Carolina branch of the Algonquian occupied the central Tidewater region of North Carolina from the Neuse River north to the Chesapeake Bay. To the west of the Carolinas lived the Iroquoian-speaking Tuscarora, Meherrin, and Nottaway. At the western extremity of the Basin, the influential Occoneechee controlled trade and served as intermediaries between early European explorers and other Native American tribes.

The Neuse River also reflects an area of distinction between earlier prehistoric groups of differing cultures. Archaeologists generally recognize stylistic differences in the early pottery styles of two sub-regions evident within the Basin, and those differences are attributed to culturally distinct influences emanating from South Carolina and Georgia on the west and the Mid-Atlantic on the east. The distinctions seem to date back to the Late Archaic Period, around 3,000 years ago, when the region saw the emergence of the earliest pottery styles, the rise of regional agriculture, and the establishment of more or less permanent, defended, ethnic territories.

Historically, the most populated sites on the Neuse River are New Bern, James City, and Kinston (Figure 1-1). New Bern is the second-oldest town in North Carolina, and it boasts the well-known Tryon Palace and New Bern Historic District. Less well known are the historic archaeological ruins that have been unearthed in various parts of the city. Across the Trent River from New Bern is James City, one of North Carolina's better-known Freedmen Towns. Freedmen Towns were established by freed African American slaves after the Civil War. Kinston is known for the *CSS Neuse* museum, with its famous full-scale reconstruction of this Confederate gunboat.

Less well known are the earlier explorations of an Englishman named John Lawson. John Lawson visited Indian villages in the winter of 1700 – 1701 and provided valuable insights to historians and archaeologists attempting to reconstruct Native American history and the era of European contact. Lawson and his party were captured when they stumbled upon the Tuscarora and other tribes preparing to wage war on English settlers in North Carolina. Lawson was well known by his captors but was inexplicably executed, though his associate was spared. That tumultuous time is recounted at several sites in the Basin and northward in neighboring Roanoke River Basin. Displaced tribes traveled great distances to escape European conflict and, in some cases, were not welcomed by those Indians already established in a local territory, who had to face their own struggles with Europeans.

2.5 Socioeconomic Resources

This section includes a description of the local economy and demographics of the study area, giving insight into the study area's socioeconomic characteristics and part of the basis for different facets of the economic impact evaluation in Section 8. The data obtained and analyzed is on a state, county, and Census tract basis and was collected through the 2008 partial Census (Bureau of Labor Statistics 2010).

The Neuse River Basin is approximately 9 percent of the state's total area with 23 counties. The 23 counties are Beaufort, Carteret, Craven, Duplin, Durham, Edgecombe, Franklin, Granville, Greene, Harnett, Johnston, Jones, Lenoir, Nash, Onslow, Orange, Pamlico, Person, Pitt, Sampson, Wake, Wayne and Wilson. The major municipalities and population centers within the Basin are Durham, Raleigh, Cary, Smithfield, Goldsboro, Kinston, and New Bern.

2.5.1 Total Population

The aggregated population of the Neuse Basin counties was 2,832,358, according to 2008 Census figures. Populations in the Neuse River Basin increased almost 50 percent during the 1990 to 2008 period. The population of North Carolina and the United States increased 16.6 percent and 13.1 percent, respectively, over the same period.

Population in the Basin is expected to increase to more than 3.2 million residents by 2019, and nearly 3.7 million by 2029, a 40 percent growth over the 2008 population estimates.

2.5.2 Minority Populations

The minority populations in the Neuse River Basin include African-Americans, Hispanic, and Native Americans. North Carolina's African-American population is 2,026,000, which is 21.6 percent of the state's total population. In the Neuse River Basin, the African-American population is more than 600,000, about 30 percent of the Basin's population. The Basin has a significant portion of the population that claims Hispanic origin. Of the 2.8 million residents, approximately 7 percent are Hispanic, according to 2008 population estimates. Native American populations in the Basin are less than that of the state, at 0.5 percent and 1.3 percent, respectively. Percentages of minority populations within counties in the Neuse River Basin are shown in Figure 2-18.

2.5.3 Economy

Generally, strong wholesale and retail trade, government, and service sectors characterize North Carolina's economy. North Carolina's temperate weather and extensive coastline and mountains attract vacationers and other visitors and help make the state a popular destination for people all over the country. Agricultural production is also an important sector of the state's economy and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in

North Carolina, but high-technology manufacturing has begun to emerge as a significant sector in the state over the past two decades.

The Neuse River Basin, like the rest of North Carolina, has seen a shift from an agricultural and manufacturing-based economy, to that of a service economy. Farm employment has decreased an average of 14 percent from 2000 to 2008 in the Basin, while nonfarm employment has increased an average of 10 percent during that same time. While declining, agriculture remains an important source of revenue for the Basin's and state's economy. In the entire Basin, agriculture (cultivated crops and pasture) accounts for approximately 29.5 percent of the land use (NCDENR 2009a), and in 2008, agriculture provided North Carolina with about 9.7 billion in revenues and in the Basin, more than $500 million in agricultural commodities was sold (USDA 2009).

The unemployment rate for North Carolina is 9.8 percent (Bureau of Labor Statistics 2010), while the unemployment rate for the Neuse Basin ranges from 7 to over 10 percent. Any individual with total income less than an amount deemed to be sufficient to purchase basic needs of food, shelter, clothing, and other essential goods and services is classified as poor. The amount of income necessary to purchase these basic needs is the poverty line or threshold and is set by the Office of Management and Budget (U.S. Census 2010). The 2010 poverty line for an individual under 65 years of age is $11,161. The poverty line for a three-person family with one child and two adults is $17,268. For a family with two adults and three children the poverty line is $25,603 (U.S. Census 2010).

Percentages of people below poverty level within counties in the Neuse River Basin are shown in Figure 2-19. The percentage estimates in this figure represent characteristics of population and housing as of 2008 according to the U.S. Census Bureau. Similar to trends in minority populations, in general people below poverty level are at their highest incidence in counties geographically centered between the Neuse River's headwaters and estuary; Greene, Jones, Lenoir, Wayne, and Wilson counties each have populations of people below poverty level of over 16.2 percent.

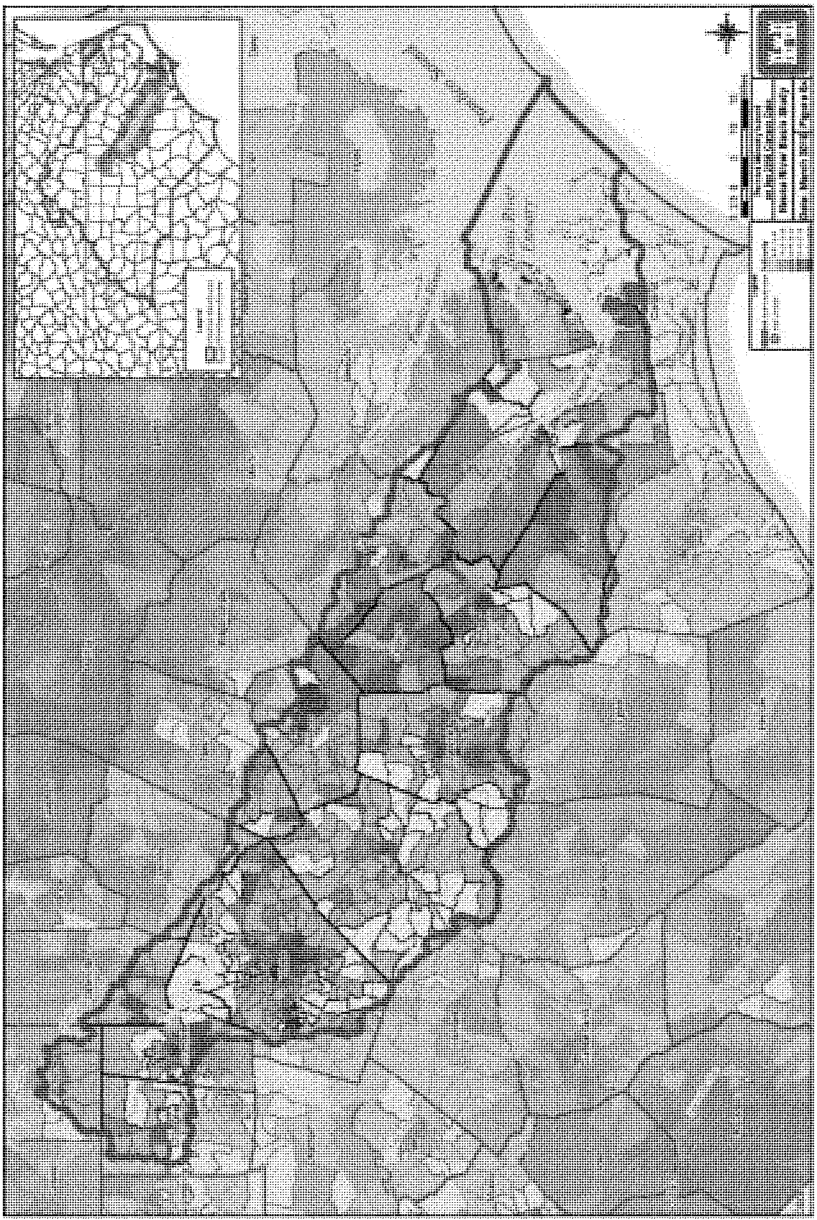


Figure 2-18. Percentages of minority populations in counties in the Neuse River Basin (2006–2008).

Figure 2-19. Percentages of people below poverty level in the past 12 months (for whom poverty status is determined) incounties in the Neuse River Basin (2006–2008).

2.5.4 Recreation

In the Basin, hunting, fishing, bird and wildlife watching, and trapping add millions of dollars to the economy through license fees and sales of equipment and supplies. These revenues are directly dependent on the ability to maintain and enhance the natural resources of North Carolina. According to the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation in North Carolina, 376,000 residents 16 years or older hunt in North Carolina (NCDENR 2002). North Carolina residents spent $271 million in the United States on hunting-related activities during 1991—$83 million in trip-related expenses, $134 million on equipment, and $54 million on items such as magazines, membership dues, and licenses. In-state, trip-related expenses amounted to $58 million during the 1991 season.

Many people also participate in non-consumptive wildlife activities such as watching birds and photographing wildlife. Two point two million North Carolinians 16 years or older took part in non-consumptive activities (NCDENR 2009a). Residents spent a total of $262 million on such activities for trip-related expenses, equipment, and other items such as magazines.

Increased numbers of hunters, hikers, anglers, and other outdoor enthusiasts place a greater demand on public land resources and create potential conflicts in land-use patterns. Conflicts can arise, for example, between preservation of deer and waterfowl habitat and expansion of agriculture or development activities.

The Neuse River has not been designated as a "Wild and Scenic" river or any other Federal or State unique category.

The NCWRC manages about 4,000 ac of game land in the Basin. This property is owned by the NCWRC or leased to it by government, corporate, or private entities for public use by hunters and anglers. The state also operates six fish hatcheries and stocks warm-water fishes to maintain recreational fish stocks in heavily fished lakes and streams. About 100,000 ac of additional game land is managed by other entities in the Basin, including the USDA Forest Service and the USACE. The open waters of the Neuse River Estuary are used intensively for recreational boating and fishing and for commercial fishing and shellfish harvesting (NCDENR 2009a). Additional State Comprehensive Outdoor Recreation Program data are in the socioeconomic Appendix G.

2.6 Air Quality

The Clean Air Act requires USEPA to set National Ambient Air Quality Standards for six common air pollutants. These common air pollutants (also known as *criteria pollutants*) are found all over the United States. They include particle pollution (often referred to as particulate matter or PM) including PM10 (10 micron-sized particles) and PM2.5 (2.5 micron-sized particles), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. These pollutants can harm human health and the environment in addition to causing property damage. Of the six criteria pollutants, particle pollution and ground-level ozone represent the most widespread health threats. USEPA calls these pollutants criteria pollutants because the agency regulates them through the establishment of standards for non-exceedance on the basis of human health risk or environmentally based risk criteria (science-based guidelines). The resulting set acceptable limits for these pollutants are called the *primary standards*. Another set of non-exceedance limits intended to prevent environmental and property damage is called the *secondary standards*.

The North Carolina Division of Air Quality (NCDAQ) works with the state's citizens to protect and improve outdoor (ambient) air quality in North Carolina for the health and benefit of all. To carry out that mission, the NCDAQ administers programs for monitoring air quality, permitting and inspecting air emission sources, developing plans for improving air quality, and educating and informing the public about air quality issues.

The NCDAQ, which is part of the NCDENR, also enforces state and Federal air pollution regulations. In North Carolina, the general assembly enacts state air pollution laws, and the EMC adopts most regulations dealing with air quality. In addition, USEPA has designated the NCDAQ as the lead agency for enforcing Federal laws and regulations, including the Clean Air Act, dealing with air pollution and potential project impacts to air quality in North Carolina. The NCDAQ does not handle indoor air pollution issues, workplace safety, secondhand smoke, asbestos, mold contamination, radon, and radiation protection. Those are regulated by the North Carolina Public Health, a division of the North Carolina Department of Health and Human Services.

In the Basin, USEPA has designated six counties (Orange, Durham, Person, Johnston, Franklin, and Wake) as not meeting the ozone standard and has recommended them for nonattainment designation (Figure 1-1). Ozone (or smog), develops across North Carolina on hot summer days as a result of emissions from cars, trucks, smokestacks and other sources (Environment North Carolina 2010). USEPA has not designated any of the counties in the Basin as not meeting the standards for fine particulate matter (PM2.5 standard). The NCDAQ is actively working with USEPA to update standards and state programs to meet standards (NCDAQ 2010).

2.7 Noise

North Carolina counties have the authority to regulate noise, pursuant to North Carolina General Statute 153A-121(a) (1991), which grants counties the general power to enact ordinances, stating that "[a] county may by ordinance define, regulate, prohibit, or abate acts, omissions, or conditions detrimental to the health, safety, or welfare of its citizens and the peace and dignity of the county; and may define and abate nuisances."

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) defines noise as unwanted sound. Potential adverse environmental impacts associated with noise may include diminished privacy and quiet at home; interrupted sleep; interrupted conversation and entertainment; interruptions at work and school; property damage such as broken windows; and injury to wildlife, livestock, or pets. The Federal Aviation Administration (FAA) and Department of Defense (DOD) utilize a DNL (day-night average sound level) threshold of 65 decibels (dBA) for identifying potentially significant noise impacts in residential areas.

Existing noise levels in the Neuse River Basin are expected to vary widely from urban areas to rural agricultural areas, to vast open water areas. Typical ambient noises in the Basin include construction, aircraft/airports, roadways, farming equipment, and factory/manufacturing. The frequency to express the perception of sound by humans is described in a-weighted decibels (dBA). Sounds encountered in daily life and their approximate levels in a-weighted decibels are provided in Table 2-13.

Table 2-13. Common sounds and levels

Outdoor	Sound Level (dBA)	Indoor
Snowmobile	100	Subway train
Farming Equipment (tractor)	90	Garbage disposal
Noisy restaurant	85	Blender
Downtown (large city)	80	Ringing telephone
Freeway traffic	70	TV audio
Normal conversation	60	Sewing machine
Rainfall	50	Refrigerator
Quiet residential area	40	Library

Source: Harris 1998.

3.0 PROBLEMS & OPPORTUNITIES, GOALS & OBJECTIVES, AND CONSTRAINTS

3.1 National Objective

Ecosystem restoration is one of the primary goals of the USACE Civil Works Program. The USACE objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). NER contributions include increases in the net quantity and/or quality of desired ecosystem resources. NER measurements are changes in ecological resource quality as a function of improvement in habitat quality and/or quantity. The units are expressed quantitatively in physical units or indexes that are not based on monetary units. Net changes are measured in the study area and in the rest of the Nation. Single-purpose ecosystem restoration plans are formulated and evaluated in terms of their net contributions to increases in NER output.

3.2 Problems and Opportunities

The existing basin-wide condition described in Section 2 is the basis for understanding problems, or undesirable conditions, in the Neuse River Basin. With every problem, there is an opportunity to improve.

This section begins the plan formulation process by clearly defining problems and opportunities for aquatic ecosystem restoration and flood risk management in the Neuse River Basin. First, through clearly understanding the problems presented in Section 2, opportunities are identified that address the problems. The opportunities were then used to identify management measures. Opportunities were identified, in part, by looking to other's work in the watershed. Using screening factors that considered partnership opportunities, technical feasibility, implementation by other stakeholders, and sustainability, the management measures have been screened down to actions and sites in the Basin at which restoration activities will provide an overall systemic benefit to the Neuse River ecosystem that will complement other watershed activities currently being undertaken and planned for the future by other organizations.

The sections to follow carry the planning process forward. Section 4 defines the future without-project condition. Understanding the future without-project condition, the management measures were refined to meet the opportunities of various sites, and the environmental benefits for future with-project conditions were quantified (Section 5). The environmental benefits and associated costs were the inputs for a cost effective/incremental cost analysis (Section 6.1). The purpose of the analysis was to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs. Ultimately, a final array of best buy, basin-wide alternatives was compared to display positive and negative effects. The comparison was used to select the TSP presented in Section 6.3.

3.2.1 Problems

Table 3-1 represents the problems identified through understanding existing conditions in the watershed.

Table 3-1. Neuse River Basin existing problems

Existing problem	Cause
Flooding	1) Hurricane storm surges combined with rainfall. 2) Debris dams block storm drains. 3) Inadequate infrastructure capacity.
Surface water supply for people and aquatic species	Increasing population and occurrences of drought. Competition for limited water resources.
Groundwater supply	Groundwater pumping, and compaction of aquifer pore space in Central Coastal Plain
Impaired biological integrity (embedded aquatic habitat/sediment impairment/turbidity/streambank erosion)	Altered hydrology from urban development and unprotected stream banks
Decrease in historical mussel populations	Declining water quality (NCDENR 2002) and habitat loss (Williams et al. 1993)
Declines in anadromous fish populations	Existing dams on some river systems like the Neuse led to a reduction in spawning area for these fish. A reduction in spawning area meant fewer eggs produced and, therefore, fewer fish.
Damaged or eliminated natural riparian buffer	Development of land adjacent to waterbodies; including road construction, agriculture activities, and urban development.
Loss of estuarine emergent wetlands	Wind and wave erosion is causing extensive wetland and high ground losses along the northern shoreline of the Neuse River in Pamlico County (Corbett et al. 2008). Boat traffic could also be a cause.
Chlorophyll *a* impairment of Falls Lake and the Neuse River Estuary	Excessive nutrient loading
Deepwater hypoxia (low or no oxygen levels)	Excessive nutrient loading
Dinoflagellate species (*Pfiesteria piscicida*) blamed for killing fish and possibly causing health problems in humans.	Unknown but thought to be caused by excessive nitrogen and phosphorus
Declines in Eastern oyster populations	Historic cumulative effects of pollution (Cooper et al. 2004, Pinckney et al. 1998), disease, and depletion of habitat from historical harvesting (Lenihan and Peterson 1998)
Water Supply	Growing populations within the Neuse River watershed are placing increasing strain on water supply, particularly in the Raleigh-Durham metropolis
Water Management and Existing Water Projects	Existing water management and water projects may require re-evaluation in the future, to determine if changes are needed.

3.2.1.1 Problems Addressed by Others

The problems being addressed by others can be generally categorized into flooding, water supply, and nutrient loading.

Flooding. As described in Section 2.2.1.1, the NCDEM and FEMA have worked collaboratively to acquire residential structures in the Basin. Appendix B illustrates the extent of buyouts in the Basin. In addition, the NCDEM has taken proactive steps to update flood plain maps and prepare for emergencies.

Efforts by NCDWQ to improve water quality also benefit nuisance stormwater flooding on roads. Techniques to minimize the negative impacts of new development on water quality require construction of stormwater detention ponds. Nuisance flooding caused by debris dams, blocked storm drains, or inadequate infrastructure capacity, is being managed through stormwater programs developed by municipalities across the Basin (NCDENR 2009a).

Water Supply. The state has taken proactive steps in its 2010 *Neuse River Basin Water Resources Plan* to project future water use in the Basin and plan sustainable solutions (NCDENR 2010). Those efforts are described in Section 2.2.1.2. Given sponsor interest and funding, it could be considered whether appropriate to do a reevaluation of existing water projects within the watershed, in the interests of modifications or adjustments to ensure the viability of long-term water supply, under the 1966 or 1997 resolutions.

Nutrient Loading. Nutrient loading from point and nonpoint sources of pollution has caused problems of increased chlorophyll *a* and hypoxia (low dissolved oxygen levels) in the Neuse River Basin and Estuary. Dinoflagellate species (*Pfiesteria piscicida*) is blamed for fish kills in the estuary. Although the cause is still unknown, it is thought to be caused by excessive nutrient loading. Water quality is monitored by the state and reevaluated every 5 years through the state's basin-wide planning program. Since initial implementation of the Nutrient Sensitive Waters Management Strategy as described in Section 2.2.1.4, nitrogen loads in stormwater runoff from point sources throughout the watershed have decreased by 65 percent, and nitrogen levels in stormwater runoff from agricultural areas have decreased by 45 percent. Given the aggressive continuing efforts by the state, USEPA, NRCS, and other Federal agencies to decrease nutrient loading and improve water quality throughout the Neuse River Basin, those problems will not be addressed in this study.

3.2.1.2 Problems Addressed in this Study

The problems that remain unaddressed in the Basin are those presented in Table 3-2. The problems that remain are those that are not being addressed *throughout* the Basin; however, there could be specific sites in the Basin where these problems are being addressed by local, state, or Federal agencies. Table 3-2 goes on to identify management measures that could be implemented to address these problems in the Neuse River Basin.

Table 3-2. Management measnres to address problems identified in this study of the Nense River Basin

Existing problem	Potential Management Measures
Impaired biological integrity (embedded aquatic habitat/sediment impairment/ turbidity/streambank erosion)	Stream restoration to stabilize channel grade Stream restoration to provide aquatic habitat in the channel Bank stabilization with hard material (riprap) Riparian planting of native vegetation Retrofit existing stormwater outfalls Upland stormwater detention Ordinances to limit impervious area
Decrease in historical mussel populations	Stream restoration to provide aquatic habitat in the channel and improve water quality Restore biological integrity through management measures identified above Remove obstructions to improve connectivity of habitat
Declines in anadromous fish populations	Full Rock Arch Weir with one foot or less vertical drop for every 20 ft of horizontal distance Fish bypass Roughened channel Removal/modification of structure Conventional fish ladder
Damaged or eliminated natural riparian buffer	Riparian planting of native vegetation
Loss of estuarine emergent wetlands	Stabilize eroding shoreline with riprap Stabilize eroding shoreline with vegetation Plant marsh vegetation along shoreline Plant native upland and wetland vegetation Construct low rock sills (Rogers and Skrabel 2001)
Declines in eastern oyster populations	Construct rock structures for oyster spat attachment Construct deep water reef in suitable habitat areas Create oyster reef sanctuary

The discussion below expands on the information presented in Table 3-2 through a discussion of why specific management measures were chosen and how those measures could be implemented to address these problems in the Neuse River Basin.

Impaired Biological Integrity. The biological integrity of nine percent of freshwater streams in the Neuse River Basin has been identified as impaired on the 2008 303(d) list of impaired waterbodies (NCDENR 2009a). The cause of the impairments has been identified as altered hydrology from urban development and unprotected streambanks. Frequent high-flow events increase velocities in stream channels, causing down cutting or lateral movement. The result of the changes in stream morphology can be deposition of excess sediment in pool/riffle habitat. Excess sediment deposition of fine silts and clays where gravel substrate or other coarse sediments once were is referred to as *embeddedness*. Embeddedness impairs habitat for aquatic species, like macro-invertebrates and freshwater mussels. Turbidity, (sediment suspended in the water column) has also caused impairment to waterbodies across the Basin.

The problem of embeddedness can be addressed by managing upland and in-stream stressors. Riparian vegetation and improved stream buffers help to stabilize streambanks and filter overland runoff. Ordinances to limit impervious area and manage upland stormwater would also be effective in addressing this problem. The EPA's NPDES stormwater program has established regulations to address stressors caused by increased impervious area. In-stream efforts to address impaired biological integrity are management measures that stabilize channels and streambanks. Bank and channel stabilization can be achieved by implementing stream restoration to stabilize channel grade or by providing aquatic habitat, bank stabilization using hard material like riprap and planting riparian vegetation.

Decrease in Historic Mussel Populations. Freshwater mussels depend on fish during their glochidia life stage until they develop into juvenile mussels. For periods of a few weeks to several months, they attach to fish gills or skin as temporary parasites. Once they achieve a juvenile stage, they detach from the host fish and begin their lives on stream and lake beds. Dams or other obstructions block the movement of host fish and therefore restrict movement of freshwater mussels like the federally listed Dwarf wedge and Tar River spinymussel. As previously described, water quality in the Neuse River Basin has influenced the ability of freshwater mussels to thrive. Like other large rivers in North Carolina, excess sediment and nutrients in the mainstem of the Neuse River limit its ability to support populations of rare freshwater mussels. According to the *Neuse River Basin-wide Water Quality Plan*, the future of freshwater mussel populations is uncertain (NCDENR 2009a). Improvements in channel habitat would be expected to decrease excess sediment for transport in waterways improving benthic conditions and conditions in the water column. Finally, removal of obstructions could also allow freshwater mussels access to unavailable habitat by providing host species with greater access.

Decreasing Anadromous Fish Populations. NCDMF has identified a significant decrease in anadromous fish populations in the Neuse River Basin over the past 20 years. Existing dams on some river systems like the Neuse River has led to a reduction in spawning area for these fish, with a corresponding drop in the number of eggs produced and, therefore, dwindling populations. Methods to address these problems were identified by the USFWS Draft Coordination Act Report, Appendix H (USFWS 2008). Those methods include those listed in Table 3-3: full rock arch weir with one foot or less vertical drop for every 20 ft of horizontal distance, fish bypass, roughened channel, removal/modification of the structure, and conventional fish ladder.

Damaged or Eliminated Natural Riparian Buffers. Agricultural practices and progressive urban and suburban development along the Neuse River have damaged or eliminated the natural riparian buffers that historically existed along the Neuse River and its tributaries. The District has used "reason to believe" and conducted tiered approachs for sediment evaluations at specific locations where sediment traps occur and sediment contaminates may be mobilized by potential projects. The District did not address contaminated sediments as a basin issue. As a transitional habitat between the aquatic riverine system and terrestrial upland habitats, these riparian buffers provide multifaceted beneficial functions critical to sustained quality of Basin resources. These linear strips of vegetation generally line channel banks, providing habitat for both flora and fauna, corridors for wildlife movement, and filtering of runoff from adjacent upland areas. Population growth is expected to continue throughout the watershed, with a consequential increase in impervious surface area associated with residential and commercial construction and infrastructure improvements.

This increase in population density and development is not expected to result in future degradation of existing riparian buffers, because of implementing the Neuse River Riparian Buffer Protection Rule. That rule is a component of North Carolina's Nutrient Sensitive Waters Management Strategy, formulated as a tool for maintaining and protecting existing riparian buffers in the Basin (15A NCAC 2B .0233). Through that regulation, the state has taken an active role in measurably improving stormwater management, particularly associated with forest harvesting and agricultural activities in and adjacent to riparian corridors.

The state's basin-wide plan for 2009 identifies habitat degradation as impaired on more than 50 percent of all the 303(d) listed impaired freshwater streams (NCDENR 2009a). The NCEEP's mitigation banking program, and other similar mitigation efforts, to offset degradation of aquatic habitat from current and future development, would continue to identify sites that meet the criteria for mitigation and improve damaged or eliminated natural riparian buffers. The mitigation efforts would not, however, account for riparian degradation caused by historic activities, and riparian degradation would maintain the existing status quo. Planting native vegetation in areas degraded by historic activities is the most effective way to address the problem of damaged or eliminated natural riparian buffers.

Loss of Estuarine Emergent Wetlands. From 1998 to 2004, in the United States, wetland gains are estimated at 32,000 ac annually (Stedman and Dahl 2008). However, during that same period, coastal watersheds of the United States adjacent to the Atlantic Ocean experienced a net loss of 15,000 ac of estuarine intertidal and freshwater wetlands (Stedman and Dahl 2008). Coastal development, rising sea level, subsidence, and erosion processes contribute to coastal wetland loss (Stedman and Dahl 2008). Estuarine emergent wetlands showed the greatest loss declining by about one percent on the Atlantic Ocean coast during the 6-year period of analysis.

In the Neuse River estuary, wind and wave erosion is causing extensive wetland and high ground losses along the northern shoreline of the Neuse River in Pamlico County (Corbett et al. 2008). This erosion is natural, but may be exacerbated by boat traffic and other factors. The North Carolina CHPP (Street et al. 2005) reports, "The trend in wetland loss for North Carolina mirrors national trends." Assuming a similar one percent loss rate and conservative base line of 14,000 brackish marsh ac, about 140 ac of estuarine marsh could have been lost in the Neuse River Estuary during 1998 to 2004.

Other than work being done by the state's NCEEP and mitigation banking efforts to offset permitted impacts, no other wetland restoration efforts are underway or expected in the Basin. Some protection is afforded to wetlands by Federal and/or state laws. Continued wetland degradation is also expected from systemic factors such as erosion, mentioned in the preceding paragraph. To address the problem, measures should be taken to stabilize eroding shoreline with riprap, stabilize eroding shoreline with vegetation, plant marsh vegetation along the shoreline, plant native upland wetland vegetation, and construct low rock sills as designed by Rogers and Skrabel (2001).

Declines in Eastern Oyster Populations. The cause of the historical oyster decline in the Neuse Estuary is the cumulative effect of pollution (Cooper et al. 2004, Pinckney et al. 1998), disease, and depletion of habitat from historical harvesting using destructive oyster dredges (Lenihan and Peterson 1998). Ongoing oyster restoration efforts in the Pamlico Sound provide restoration benefits but are not at a scale large enough to offset the historic catastrophic loss of oysters and oyster habitat in the Sound (Jeff Deblieu, The Nature Conservancy, personal communication, June 2004).

The NCDMF has an ongoing oyster reef sanctuary development program as described in Sections 1.5 and 2.3.2.1. However, funding and operational constraints limit the state's ability to construct reefs at a scale and production rate to achieve the sanctuary goals recommended by the Oyster Restoration Steering Committee (ORSC) (NCCF 2008). Since 2008 the only new 30 ac sanctuary site, Gibbs Shoal, north of the Neuse River Estuary, has been designated in the APNE. Assuming continuous fully funded state production, by 2018 about one-half of the ORSC plan's goal of 500 ac for the APNE will have been met.

Creating new rock structures where oyster spat can attach, including deep water reef in suitable habitat areas designated as oyster reef sanctuary, is the most effective management measures to address decreasing oyster populations. Consideration of placement can be given to areas where water quality is suitable for oyster growth, minimizing problems caused by pollution. Problems caused by over harvesting can be addressed by designating constructed reef as sanctuary where no harvesting would be allowed.

3.2.2 Opportunities

Restoration opportunities are means to address problems. Restoration opportunities were identified and analyzed within the context of numerous other restoration partnerships and initiatives by other Federal agencies, state agencies, local governments, nongovernment environmental organizations, and others. Study efforts were conducted such that the recommendations would complement the other activities, not conflict with or duplicate them. Opportunities were identified to address the problems associated with those presented in Table 3-2. The Wetlands, Streams, and Riparian Buffer Restoration; Anadromous Fish Habitat Restoration; and Estuarine Resources Workgroups each conducted an inventory of problem areas throughout the watershed. Workgroup inventories were conducted to add value to the restoration efforts of others in the Basin. The inventories took into account the framework and goals of other organizations, including those set by the NCDMF CHPP, as described in Section 1.7.

The workgroups sought opportunities with the understanding that implementing separable project elements throughout the watershed would likely be necessary to achieve the overall goal of increased basin-wide ecosystem outputs. To provide a defensible initial screening analysis of potential project locations, an analysis was conducted at the sub-watershed scale. Table 3-3 lists potential opportunities to address existing problems.

Table 3-3. Potential opportunities for aquatic ecosystem restoration

Existing problem	Potential opportunity
Impaired biological integrity (embedded aquatic habitat/ sediment impairment/ turbidity/streambank erosion)	Improve biological integrity
Decrease in historical mussel populations	Improve freshwater mussel populations
Declines in anadromous fish populations	Improve anadromous fish populations
Damaged or eliminated natural riparian buffer	Restore damaged or eliminated natural riparian buffers
Loss of estuarine emergent wetlands	Restore estuarine emergent wetlands
Declines in Eastern oyster populations	Increase the quantity and quality of oyster reef habitat

An inventory of potential ecosystem restoration project locations throughout the entire watershed was conducted to identify opportunities to address problems where degraded ecosystems would otherwise persist. These specific locations within the Neuse River Basin, if restored, when coupled with activities by other agencies and nongovernment interests, would cumulatively contribute to ecosystem restoration and long-term sustainability throughout the watershed.

The workgroups accomplished this task at the onset of this study by reviewing available data to assess overall watershed quality and opportunities to address problem areas. The Wetlands, Streams, and Riparian Buffer Restoration Workgroup did a desktop analysis of the entire watershed to inventory opportunities to improve biological integrity, restoring damaged or eliminated natural riparian buffers, and restore emergent wetlands. The Anadromous Fish Habitat Restoration Workgroup focused on opportunities to improve freshwater mussel and anadromous fish populations. The Estuarine Resources Workgroup focused on opportunities to increase the quantity and quality of oyster reef habitat.

The success of removing a problem, or restoring ecosystem components, is often more clearly defined at the location of the problem. To be consistent with this understanding and guidance in the *Planning Manual—Institute of Water Resources* (IWR) Report 96-R-1, pages 82-83, site-specific objectives were established. The subject and location, timing, duration, and measurement of each opportunity carried forward were defined in the site-specific objective. Site-specific objectives are defined in Section 5.0.

Under the USACE authority for this study, potential constraints include Federal regulations that protect wetlands, wildlife, and cultural resources and limited physical space for locating measures that will provide sufficient hydrologic improvements. These are things that limit the plan formulation process.

3.2.2.1 Opportunities to Improve Biological Integrity, Natural Riparian Buffers, and Emergent Wetlands

The Wetlands, Streams, and Riparian Buffer Restoration Workgroup used information collected to define the health of aquatic habitats within specific watershed subunits (defined by Hydrologic Unit Codes [HUCs]) to pinpoint potential project sites throughout the Basin. The health of a watershed is often measured by the diversity of aquatic species and the availability of specified habitats, including wetlands. The scoring system for inventorying existing conditions by sub-watershed was developed to identify areas where metrics of a healthy watershed were absent, representing poor ecological integrity, or in abundance, representing good ecological integrity. Geospatial data and monitoring data were gathered to conduct this inventory as a desktop analysis. The scoring system used to measure the health of each 14-digit HUC included:

- Average of fish Index of Biological Integrity (IBI) ratings. IBI ratings for fish community sites sampled by NCDWQ using state protocols.
- Average bioclass from benthic macroinvertebrate samples. Water quality classification was based on NCDWQ biological monitoring of benthic macroinvertebrates.
- Intersection with anadromous fish spawning area. NCDMF designated locations of sites where fish swim upstream to spawn.
- Natural heritage element occurrences of aquatic species. Locations of rare and endangered species, wildlife habitats, and ecosystems (Natural Heritage Element Occurrences) maintained by the North Carolina Natural Heritage Program.
- Proportion of wetland species alliance. Location and extent of wetland vegetation classified by the North Carolina Gap Analysis Program.
- Presence of significant natural heritage area. Areas where ecologically significant natural communities or rare species have been identified by the North Carolina Natural Heritage Program.

Each 14-digit HUC sub-watershed received a score from 1 to 5, with 1 representing poor ecological integrity and 5 representing excellent ecological integrity. Watersheds with scores of 4 or less were evaluated further. Scores above 4 were thought to indicate the highest-quality areas, more suitable for preservation than for restoration. Potential project sites throughout the Basin, illustrated in Figure 3-1, were identified from existing studies and communication with various participating agencies identified in Section 1.8. Those potential sites for further evaluated if they were within one of the 192 14-digit HUCs that received scores of 4 or less. This scoring system is detailed in Appendix I.

3.2.2.2 Opportunities to Improve Freshwater Mussel and Anadromous Fish Populations

The Anadromous Fish Habitat Restoration Workgroup's initial inventory included locating obstructions to habitat migration for both freshwater mussels and anadromous fish. That was done by locating known structures, reviewing state paddling guides (Ferguson 2007) for additional structures, and paddling undocumented tributaries of the Neuse River. Twenty-seven obstructions were found. Once the locations of obstructions were known, they were compared with state-designated areas for anadromous fish spawning habitat (Street et al. 2005). The presence of anadromous fish spawning habitat was used during the inventory as an indicator of connectivity between the aquatic estuary and the riverine habitats and an impetus for further consideration for restoration. From the 27 sites with obstructions, the workgroup identified six problem areas on the basis of (1) the availability of habitat for federally threatened and endangered freshwater mussels and fish and (2) historic anadromous fish spawning. A matrix of the obstructions in the watershed, showing whether they meet the two criteria, is presented in Appendix J.

3.2.2.3 Opportunities to Increase the Quantity and Quality of Oyster Reef Habitat

The PDT, based on input from the Estuarine Resources Workgroup, identified a need to (1) inventory existing oyster reefs; (2) define existing oyster populations, condition, and health (presence and degree of disease) at specific reefs; and (3) develop a system of tools to access water quality conditions and identify areas for suitable oyster habitat in the Neuse River Estuary on the basis of past and expected future water quality conditions.

The USACE conducted several studies between 2005 and 2008 to fill in the data gaps. The first two data needs were met through a study that mapped existing oyster reefs and sampled oysters to determine their population and condition under various conditions throughout the estuary (USACE 2008a). The third data gap was filled by updating three-dimensional hydrodynamic and water quality models, originally developed by USEPA and NCDWQ to establish a TMDL for nutrients in the estuary. That modeling effort was used to identify areas in the estuary with suitable habitat conditions for oyster reefs. The final reports of modeling and monitoring studies conducted to fill the data gaps are provided in Appendix F.

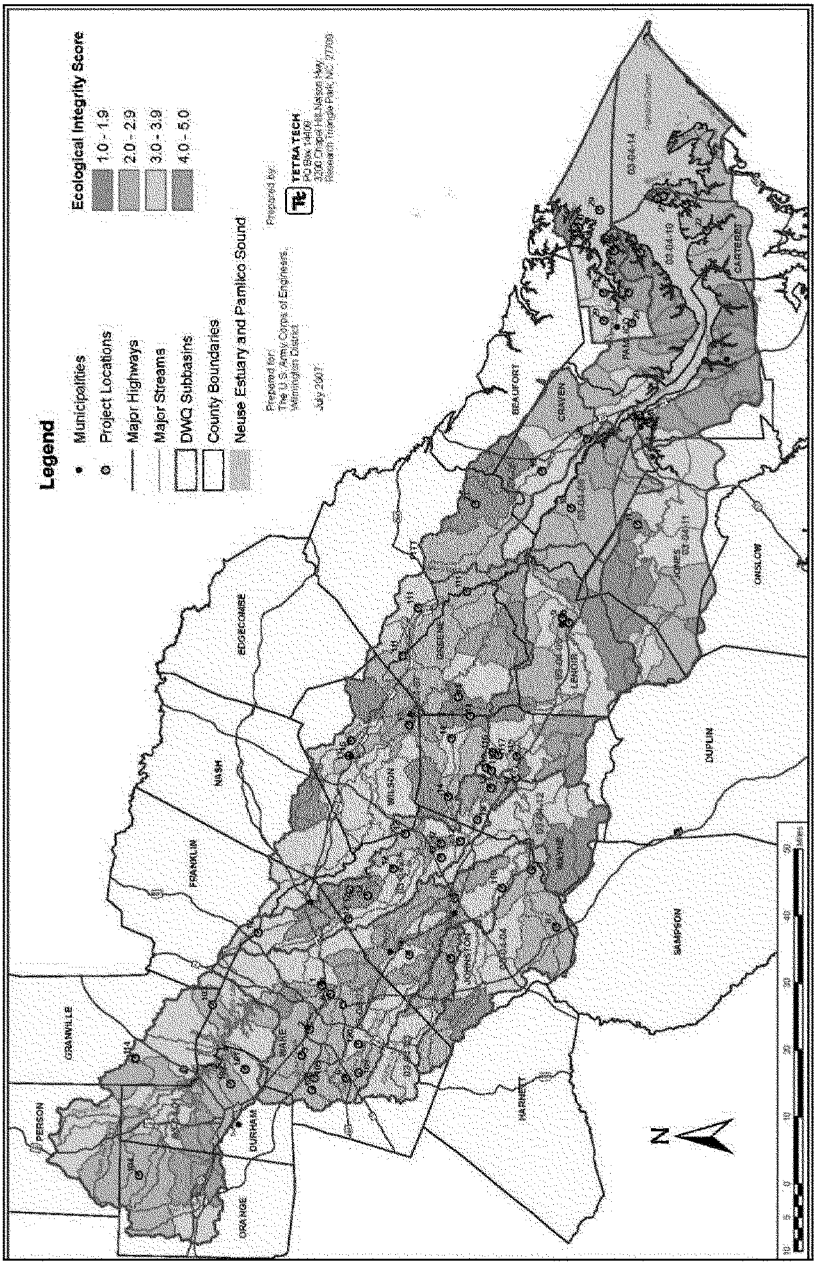


Figure 3-1. Neuse River Basin Ecological integrity scores and restoration opportunities

3.2.2.4 Summary of Opportunities to be Addressed in this Study

Based on the processes described in Sections 3.2.2.1 to 3.2.2.3, a refined list of problem sites were identified that warranted further consideration (Table 3-4). The sites were located anywhere from the headwaters of the Neuse to the estuary. Each of these sites can be considered as a potential opportunity to accomplish the overall goal of the study. These sites were qualitatively evaluated based on their potential contribution towards addressing the problems identified in Section 3.2.1, site constraints, and site status. The information contained in this table was the basis for screening down this list of sites to a smaller group which would potentially provide the greatest impact within the watershed, and which would then undergo more detailed analysis. Site constraints were things that could either affect the feasibility of implementing particular measures at the site, or implementing any restoration actions at all. Site status was used to identify if others are working at the site to address the identified problems and therefore do not require additional Federal actions (Figure 3-2). Sites that were being addressed by others were not carried forward. Additional considerations were other miscellaneous factors that were considered when deciding whether a site would be screened out or not. At this initial stage, detailed costs and economic feasibility were not a screening consideration. Detailed cost effectiveness/incremental cost analyses were reserved for subsequent iterations of plan formulation and selection (see Section 6.1). However, a more general consideration of costs was used to screen out some sites. For instance, several sites contained hazardous/toxic/radioactive waste (HTRW). For the Anadromous Fish Habitat Restoration Workgroup's identified stream obstructions USFWS completed a Tier 1 evaluation (copy found in Appendix H) of the sediments. The Wetlands, Streams, and Riparian Buffer Restoration Workgroup used HTRW as a inherent screening process. This screening system is detailed in Appendix I. The Estuarine Resources Workgroup did not use HTRW as a screening process because there are no HTRW sites located in the lower Neuse River estuary.

Although exact costs for HTRW mitigation were not determined, it is known that these costs would be high enough that any alternative involving HTRW mitigation would not be cost-effective; additionally for the most part other non-Federal entities have been identified as the responsible party for remediation and restoration at these sites. The last column in the table, Findings, indicates whether the site was carried forward or not for more detailed analysis, and the rationale for that decision.

Table 3-4. Summary of restoration opportunities

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Adkin Branch	Improve biological integrity and restore damaged or eliminated natural riparian buffers. This degraded first-order stream is in the Neuse River floodplain and discharges directly to the Neuse River. The structures in the floodplain have been bought out as part of the FEMA buyout program. The reach upstream of Lincoln Street is being restored through the NCEEP for mitigation credit.	Power lines and sewer lines are adjacent to the reach. This could constrain lateral movement of the channel.	Not being pursued by others	None	Carried Forward. The site is directly connected to the Neuse River and potentially provides one of the better opportunities to restore connectivity in a part of the watershed.
Gum Thicket/Cedar Creek	Improve biological integrity, restore estuarine emergent wetlands, and increase the quantity and quality of oyster reef habitat. The shoreline along Gum Thicket Creek and Cedar Creek are severely eroded. Submerged aquatic vegetation is present, and existing mussel beds have been eroding.	None	Not being pursued by others	None	Carried Forward. This site provides one of the best and easiest opportunities for restoring wetland habitat in the estuary.
Ellerbe Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers. This is a degraded stream reach just downstream of I-85 near Northgate Park in Durham. Durham is restoring a reach downstream.	Sewer easement and adjacent parking lots and structures create lateral constraints. USACE flood control project may be a constraint,	Not being pursued by others	None	Carried Forward. The site offers one of the better opportunities to restore connectivity in part of the watershed, as adjacent reaches are already being restored.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Kinston East Wetland Complex	Restore damaged or eliminated natural riparian buffers. Former bottomland hardwood forest adjacent to the Neuse River has been filled, which disconnected the floodplain.	None	Not being pursued by others	None	Carried Forward. The site offers one of the better opportunities in the watershed to restore a larger, contiguous area of forested wetland.
Low-head dam in Goldsboro	Improve anadromous fish populations and freshwater mussel populations. A portion of this structure has been removed or *notched*, and under high-flow conditions, some anadromous species are able to pass over the structure. However, under low-flow conditions, anadromous species have not been able to pass and access their spawning habitat.	A backup city water withdrawal is upstream, which requires a set water level for emergency needs.	American Rivers is also pursuing this alternative	None	Carried Forward. The site offers one of the better opportunities to restore anadromous fish passage in part of the watershed. American Rivers, with NOAA Fisheries, has completed a study of alternatives for the low-head dam on the Little River in Goldsboro, North Carolina and would consider potential funding of additional efforts should a Corps funded project not receive construction funding during a reasonable time frame. The NOAA Fisheries study recommended pursuit of a rock ramp structure, an alternative studied by the Corps but not recommended as a NER element due to cost. Funding of this alternative is not considered the "most likely future condition" due to high uncertainties associated with funding of the rock ramp alternative.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Little River and Buffalo Ck Watershed (eight sites were considered)	Improve biological integrity and restore damaged or eliminated natural riparian buffers. The eight sites considered were degraded stream reaches.	None	Raleigh is pursuing mitigation in this area.	None	Not Carried Forward. Opportunity is being pursued by others
Hominy Swamp	Improve biological integrity, and restore emergent wetlands. The stream reach and wetlands in this area are degraded.	None	NCEEP has targeted this watershed for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others
South River, Neuse Sub-estuary (two sites were considered)	Improve biological integrity, and restore estuarine emergent wetlands. A drainage ditch and associated stream reach are degraded.	None	Restoration is being pursued by others.	None	Not Carried Forward. Opportunity is being pursued by others
Rattan Bay, Neuse Sub-estuary	Improve biological integrity, and restore emergent wetlands. A drainage ditch and associated stream reach are degraded.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others
Turnagain Bay, Neuse Subestuary	Improve biological integrity, and restore estuarine emergent wetlands. A drainage ditch and associated stream reach are degraded.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others
Trent River near RR Bridge (two sites were considered)	Improve biological integrity and restore damaged or eliminated natural riparian buffers. A drainage ditch and associated stream reach are degraded.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others
Little Lick Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers. Riparian habitat is degraded.	None	NCEEP has a restoration project identified in the Little Lick Creek Watershed.	None	Not Carried Forward. Opportunity is being pursued by others.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
New Light Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None	NCEEP has implemented a restoration project on the upper portion of the stream. The reach downstream is planned for mitigation.	None	Not Carried Forward. Opportunity is being pursued by others
Swift Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers. The reach appears historically straightened and appears to have poor aquatic habitat.	Public roads and houses limit the lateral expansion of the riverine corridor in the upper portion of the reach.	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others
Little Contentnea Creek	Improve biological integrity. Beaver dams have caused extensive flooding along a sewer easement.	The town has looked into using beaver deceiver devices but have determined they would be difficult to maintain.	Not being pursued by others	There are limited opportunities for restoration, other than removal of beavers.	Not Carried Forward. Limited opportunity for restoration.
Ledge Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None.	The watershed plan has been identified for mitigation opportunities.	None	Not Carried Forward. Opportunity is being pursued by others.
Unnamed Tributary	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others.
Reedy Branch (two sites were considered)	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Upper Stoney Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None.	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others.
Howell Creek	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	None	NCEEP has identified this reach as a pursuit for future restoration.	None	Not Carried Forward. Opportunity is being pursued by others.
Yates Mill Run Borrow Pit	Restore damaged or eliminated natural riparian buffers. There are invasive vegetation issues that could be controlled.	A mining operation has cleared land upstream.	NCEEP has identified this site for wetland creation.	None	Not Carried Forward. Opportunity is being pursued by others.
Milburnie Dam	Improve biological integrity, improve freshwater mussel populations, and improve anadromous fish populations. Moving upstream from the estuary, Milburnie Dam is the last obstruction on the mainstem of the Neuse River before Falls Lake Dam. Allowing fish passage upstream of this point would allow anadromous fish and others access to the maximum historic limits. The landowner is moving forward with dam removal to establish a mitigation bank (19-20 July 2005)	No technical obstacles identified.	The existing owner is planning on removing the dam and developing a mitigation bank.	None	Not Carried Forward. Opportunity is being pursued by private landowner. Currently, the property owner has applied for a Section 404 permit from the Raleigh Regulatory Area Office to establish a Wetlands Mitigation Bank at the Milburnie Dam site. The permit application is still being processed and being reviewed by the public, State and Federal agencies. At this time, no Section 404 permit has been issued.
Bay River: Neuse Sub-estuary (seven sites were considered)	Restore estuarine emergent wetlands. The shoreline of the Intracoastal Waterway is eroding.	Waterfowl impoundment and aquaculture facilities upstream might require coordinated water quality efforts.	Not being pursued by others	There is a federal interest that might be more appropriately addressed through authorities allowing the beneficial use of dredged material for marsh restoration.	Not Carried Forward. Restoration of the site is better pursued through a different authority.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
State Rds 1664, 1649, 2000	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Crabtree Creek/New Hope Rd.	Improve biological integrity.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Sand Mine, Kinston	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	Further site visits indicated the site is not hydrologically connected to the Neuse River and any benefit would be isolated.	Not Carried Forward. Restoration would not address any of the identified problems.
Big Ditch, near Goldsboro	Restore damaged or eliminated natural riparian buffers.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Nahunta Swamp (four sites were considered)	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Contentnea/ Little Contentnea Ck Wtsd	Restore damaged or eliminated natural riparian buffers.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Toisnot Swamp	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Core Ck at NC 55/State Rd 1001	Restore damaged or eliminated natural riparian buffers.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Swift Ck nr Askin	Restore damaged or eliminated natural riparian buffers.	No technical obstacles identified.	Not being pursued by others	Subsequent site visits indicated limited opportunities for restoration.	Not Carried Forward. No need based on site visits.
Clayroot Swamp	Restore damaged or eliminated natural riparian buffers.	The drainage is being managed for farm drainage.	NA	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Brice River and Trent Estuary	Restore damaged or eliminated natural riparian buffers.	No technical obstacles identified.	NA	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Jones and Middle Bays: Neuse Sub-estuary, (two sites were considered)	Restore damaged or eliminated natural riparian buffers or restore estuarine emergent wetlands.	No technical obstacles identified.	NA	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. The restoration potential exists if canals are filled to restore salt marsh. As the area exists, functional marsh habitat is supported
Lick Creek	Improve biological integrity.	No technical obstacles identified.	NA	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
N. Fork Little River	Improve biological integrity and restore damaged or eliminated natural riparian buffers.	No technical obstacles identified.	NA	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Black Creek	Improve biological integrity.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Crabtree Creek	Improve biological integrity.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Little Creek	Improve biological integrity.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Neuse Bottomlands	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Little Contentnea Creek (two reaches were considered)	Improve biological integrity.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Musselshell Creek	Improve biological integrity.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended
Waste Lagoon near Kinston	Restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Slough and Pond Near Neuse River, Kinston	Restore damaged or eliminated natural riparian buffers.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Neuseway Park Storm Drainage	Restore damaged or eliminated natural riparian buffers.	HTRW issues at the site	Not being pursued by others	None	Not carried Forward. Pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Lassiter Dam on Crabtree Creek	Improve freshwater and anadromous fish populations. This obstruction limits fish passage upstream	HTRW issues upstream of the dam.	Not being pursued by others	The dam is designated as an important cultural resource by the NC Division of Cultural Resources.	Not Carried Forward. Dam has cultural significance and pursuant to paragraph 6(b) of ER 1165-2-132, the construction of Civil Works projects in HTRW areas should be avoided to the extent practicable.
Contentnea Creek in Wilson County	Improve freshwater mussel and anadromous fish populations.	None	Not being pursued by others	The dam is used for water supply purposes.	Not Carried Forward. Potential impacts to municipal water supplies.

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Kelly's Mill Pond Dam	Improve freshwater mussel and anadromous fish populations. The original mill pond has drained. Debris from the failed dam blocks upstream passage.	None	The landowner is planning to restore the dam.	None	Not Carried Forward. Opportunity is being pursued by others. Currently the property owner decided not to be included in the Corps funded project and is seeking other private funding sources to repair the existing breach in the Kelly's Mill Pond Dam. Once these funding sources have been established, the property owner will need to apply for the required Section 404 permit from the Wilmington Regulatory Division. Additionally, the land owner will need to obtain the necessary permits from the North Carolina Division of Water Quality for the Section 401 Water Quality Certificate and the NC Dam Safety Office. At this time, no permits have been issued for this activity.
Mill Creek (two sites were considered)	Improve biological integrity or restore damaged or eliminated natural riparian buffers.	None	Not being pursued by others.	There is an insufficient amount of data to confirm that this opportunity would adequately address the problems identified in the study.	Not Carried Forward. Damage does not appear to be extensive; however, long-term monitoring is recommended

Area	Opportunity	Potential Site Constraints	Site Status	Additional Considerations	Findings
Contentnea Ck near Stantonsburg	Restore damaged or eliminated natural riparian buffers.	A DOT easement is within the reach, but representatives stated that a permanent conservation could overlap the easement.	Not being pursued by others.	Subsequent site visits indicated that the site is recovering well on its own.	Not Carried Forward. The site is expected to recover on its own.
Swift Ck at NC 118	Restore damaged or eliminated natural riparian buffers.	No technical obstacles identified.	Not being pursued by others.	Subsequent site visits indicated that the site is recovering well on its own.	Not Carried Forward. The site is expected to recover on its own.
Neuse River Oyster Growing Area (OGA)	Restore deep water oyster reef habitat. Oyster growing areas in deep water are depleted as compared to historical conditions.	None	Some areas in the OGA are being pursued by others, but other opportunities still remain.	Impacts to existing fishing practices should be minimized.	Carried Forward. The OGA presents the best opportunity in the watershed to meet the goal of restoring deep water oyster reef habitat.

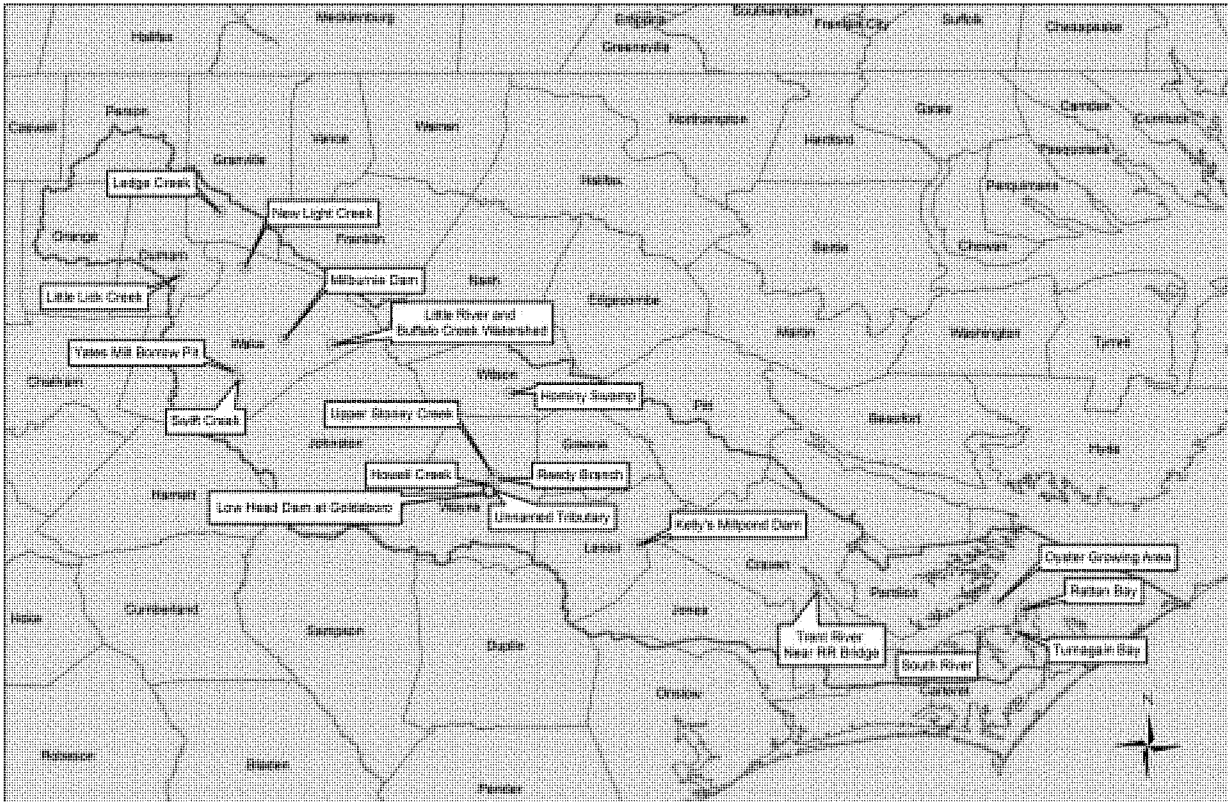


Figure 3-2. Restoration opportunities in the study area being pursued by others.

As presented in Table 3-4, six opportunities were identified to be carried forward in this study:

1. Adkin Branch, Kinston, North Carolina
2. Gum Thicket and Cedar Creeks, Neuse River Sub-estuary
3. East Wetland Complex, Kinston, North Carolina
4. Ellerbe Creek, Durham, North Carolina
5. Low-head dam near Goldsboro, North Carolina
6. Neuse Estuary Oyster Reefs Restoration Area

Those locations are illustrated in Figure 3-3. The six sites (1) are not being addressed by other agencies or nongovernment interests and (2) would not show significant improvement without intervention, or would further degrade in functional quality. Where proposed projects were identified as being restored by others, it is assumed that restoration would be implemented by landowners and various local, state, and Federal agencies. The rationale is discussed under the no action alternative sections in Chapter 4.

It is worth noting that the Milburnie Dam was considered in the initial stages of this study and thought to have substantial benefit to allow fish passage from dam removal. Later, it was learned that the private landowner was proceeding with removal and it was therefore no longer considered for evaluation in this study. The private landowner is planning on using the proposed removal of the Milburnie Dam as a private non-governmental Mitigation Bank and sell credits to individuals. The private landowner is presently obtaining the required State and Federal authorizations to complete this activity. This component is not included as part of the TSP because of its current status. However, if the landowner is not able to proceed with removal, the USACE could include it as a Federal project in a reevaluation report.

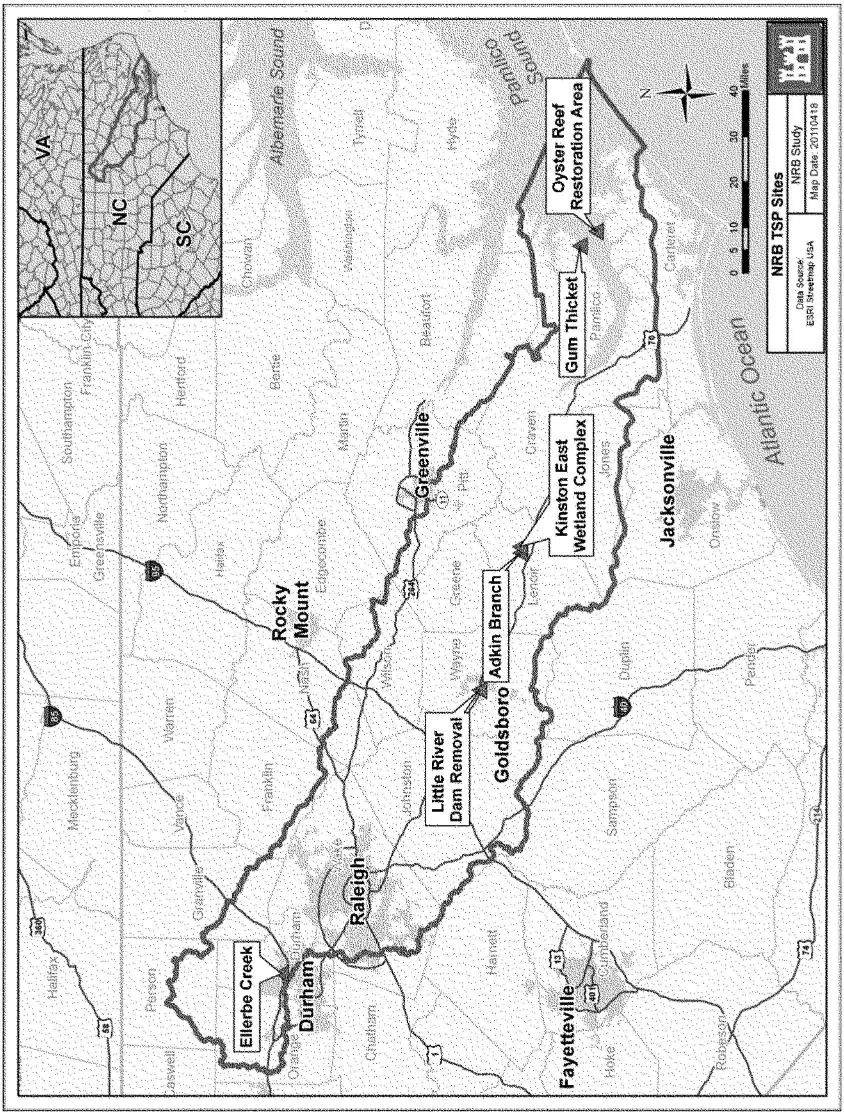


Figure 3-3. Location of potential six restoration areas.

3.3 Goals and Objectives

The overall goal for this study is restoration of degraded aquatic ecosystems within the Neuse River Basin in support of increased basin-wide environmental outputs.

Planning objectives are directly related to the problems and opportunities previously discussed and were used for the identification, formulation, and evaluation of measures and alternatives. The following watershed-level planning objective was identified for this study:

Over the 50-year period of analysis, throughout the Neuse River Basin, conduct ecosystem restoration to improve biological integrity, hydrologic connectivity, wetland condition, and fish, oyster and mussel populations as measured by increases in functional units.

This objective is general in nature. In order to accomplish this overarching objective, more detailed site-specific objectives were developed to specifically address the varied array of problems and opportunities in the study area. These site-specific objectives are:

- Over the 50-year project life, improve connectivity and increase currently degraded in-stream habitat function in the lower degraded (2,500 foot reach) of Adkin Branch, which currently impairs connectivity between upstream reaches of Adkin Branch and the Neuse River, to a level that is comparable to upstream areas of the reach that have already had in-streams restoration, and which also currently provide a full array of functions and values.

- Restore functions within approximately 60 acres of highly eroded existing estuarine wetlands within Gum Thicket and Cedar Creek sub-estuaries, increasing estuarine wetland function over a 50-year period.

- Restore functions and improve connectivity between existing tracts of bottomland hardwood forest over a 50-year period by restoring 14.5 acres of bottomland hardwood forest at the Kinston East Wetland Complex.

- Restore wetland and stream function in approximately 3,700 feet of Ellerbe Creek and its associated riparian area and improve connectivity to already restored upstream and downstream portions of the stream over a 50-year period.

- Restore habitat connectivity for 46 miles of the upstream reaches of the Little River, which is currently cut off from its downstream reaches by the

Little River Dam to restore important spawning habitat for anadromous fish species.

- Restore up to 100 acres of oyster reef habitat in the Neuse River Estuary to address historic and projected habitat losses and protect the restored habitat areas.

Also, given the available level of project funding, the study will focus resources on detailed functional analysis of sites of the areas considered as being regionally or nationally significant, highly degraded and incapable of recover to a balanced and sustainable condition, and not being addressed by others.

3.4 Constraints

Planning constraints include legal and policy constraints that are applicable to all federal water resource planning projects. No planning constraints were identified for this study.

Table 3-4 includes potential site specific constraints that were considered in the evaluation of opportunities.

4.0 FUTURE WITHOUT-PROJECT CONDITIONS

The second step in the planning process is to inventory and forecast future conditions relevant to the problems in the Basin. Reasonably foreseeable actions by other were identified as listed in Table 3-1. These were considered in forecasting the Future Without Project Condition (FWPC). The USACE is also required to consider the option of no action as one of the alternatives (No Action Alternative) to comply with the requirements of the National Environmental Policy Act (NEPA). The No Action Alternative is the Future Without Project Condition absent a USACE project. The No Action Alternative forms the basis against which all other alternative plans are. These were considered in forecasting the Future Without Project Condition (FWPC). The No Action Alternative forms the basis against which all other alternative plans are measured.

A series of models and tools was used to predict conditions in a future without-project condition. The subsections that follow first describe the environmental benefits analysis (EBA) and then go on to define future without-project conditions for each of the potential six restoration areas or measures (identified in Section 3.2.2.4), which are 1) Adkin Branch, Kinston, North Carolina; 2) Gum Thicket and Cedar Creeks, Neuse River Sub-estuary near Oriental, North Carolina; 3) East Wetland Complex, Kinston, North Carolina; 4) Ellerbe Creek, Durham, North Carolina; 5) Low-head dam near Goldsboro, North Carolina; and 6) Oyster Reef Restoration in the Neuse River sub-estuary.

4.1 Environmental Benefits Analysis of Restoration Measures

Environmental Benefits Analysis (EBA) is used to measure the increase in both the quality and quantity of targeted ecosystem components associated with various proposed restoration measures and alternatives at a given site. For the Basin study, quality was measured in terms of a functional index. The functional index is multiplied by the area (number of acres) being restored to generate a functional unit (FU) output over the 50-year planning period.

An EBA was conducted on all six potential restoration areas. The analysis provided the input for subsequent development of project alternatives. The Basin study evaluated environmental benefits in three broad ecosystem habitat categories—wetland, stream, and oyster reef. These ecosystem components are believed to capture the primary sources of ecological output from the Basin. Three different models were used (one for each resource) because no existing single index model could be used to evaluate all three ecosystem components in the study area. The models were:

- Wetlands: North Carolina Wetland Assessment Method (NC WAM)
- Streams: North Carolina Stream Habitat Evaluation Method (NC SHEM)
- Oyster Reef: USFWS Habitat Evaluation Procedure (HEP) for oysters

4.1.1 Environmental Benefits Models

The following sections provide a brief description of each of the EBA models. The models used were selected on the basis of their development within and applicability to

North Carolina, and their sensitivity in being able to reflect changes to ecosystems on the basis of restoration activities. Applying the models in the field (determining variable scores under existing conditions) and in the office (predicting with and without project changes to variable scores over time) was done by a team of qualified biologists in the USACE Wilmington District with more than 70 years of combined experience. The models have received a recommendation for their approval for use in the study from the Ecosystem Restoration Planning Center of Expertise and from the HQ Model Certification Team.

4.1.1.1 North Carolina Wetland Assessment Method (NC WAM)

Environmental benefits resulting from wetlands restoration opportunities were assessed using NC WAM Version 2.0 (NCDENR 2009b), which is a rapid, reference-based functional assessment method. A state and Federal interagency team consisting of NCDOT, NCDENR, USEPA, USFWS, and the USACE developed NC WAM. The method provides functional ratings for up to 3 major functions and 10 sub-functions (Table 4-1), depending on the wetland type being assessed. Functions are evaluated using up to 22 field and GIS-based metrics, which include the soil, hydrologic, vegetative, and landscape characteristics of the assessment area. NC WAM data sheets are provided in Appendix K. Functional ratings are then determined on the basis of an iterative, Boolean logic process.

Table 4-1. Functions and sub-functions potentially measured in NC WAM

Function	Sub-function
Hydrology	Surface storage and retention
	Subsurface storage and retention
Water Quality	Pathogen change
	Particulate change
	Soluble change
	Physical change
	Pollution change
Habitat	Physical structure
	Landscape patch structure
	Vegetation composition

Three types of wetland are being assessed in this study—bottomland hardwood forest, estuarine woody wetland, and salt/brackish marsh. According to the assessment methodology, for bottomland hardwood forest sites, all functions and sub-functions (with the exception of the sub-function, pollution change) are measured by the assessment. For estuarine woody wetland, the hydrology main function and the habitat function and sub-functions are measured. For the salt/brackish marsh, only the hydrology and habitat main functions (no sub-functions) are measured.

The PDT made some modifications to the standard NC WAM outputs so that they could be useable in the EBA. The EBA requires that quality be measured numerically. NC WAM, however, does not provide numerical outputs; instead it gives each function and sub-function a rating of Low, Medium, or High. Therefore, the change the PDT made was to assign each function or sub-function rating an index score of 0.1 (Low), 0.5 (Medium), or 1.0 (High). A sensitivity, or risk, analysis of assigning numbers to qualitative factors in this study is presented in Section 6.4. For wetland classes that measure sub-functions, the sub-function scores are averaged to determine a score for the primary function. Because there was no clear scientific basis for differentially weighting sub-functions, each sub-function was given equal weight in determining the primary function score. For instance, the hydrology function consists of two sub-functions—surface storage and retention, and subsurface storage and retention. If, for instance, the scores for these sub-functions are 0.1 and 0.5, the score for the hydrology primary function will be 0.3. The primary functions scores are then averaged together to give a wetland functional index score for the site.

4.1.1.2 North Carolina Stream Habitat Evaluation Method (NC SHEM)

Stream restoration opportunities were assessed using the stream habitat evaluation procedure as outlined in the *Internal Technical Guide for Stream Work in North Carolina* (NCDENR 2001), which was developed for NCDWQ by an interagency team including NCDWQ, North Carolina Division of Land Resources, and USACE. The method constitutes a functional assessment approach to stream habitat quality. Each stream segment is evaluated on the basis of seven or eight variables (depending on ecoregion location). The variables capture aspects of riparian condition, channel modification, and in-stream habitat. Each variable is assigned a numerical score on the basis of field observations and measurements, and some variables have higher maximum scores than others.

Sample NC SHEM data sheets, which provide additional detail on the definitions and functional scoring of each variable, are in Appendix K. An aggregate functional score for a stream segment is calculated by adding the individual variable scores, with the highest possible total score equaling 100. For the purpose of the EBA, the total score was divided by 100 to generate a stream functional index score.

4.1.1.3 Habitat Evaluation Procedure for Oyster Reef Habitat

Estuarine reef restoration opportunities were evaluated using a USFWS HEP in which the quality of habitat is multiplied by the quantity of habitat to establish environmental benefit. The quality of habitat is defined by a Habitat Suitability Index (HSI) for the oyster. This species-specific model was chosen because a USACE approvedHSI model was available. The functions of the model represent both the oyster reef habitat and the organism. The eastern oyster (*Crassostrea virginica*), also known as the American oyster, is an appropriate target species because a healthy oyster population is considered a keystone indicator of the ecological health of the estuary (NCDMF 2001). In addition, healthy oysters are the ultimate driver of reef sustainability because they are the ecosystem's *engineers* that build reefs (Jones et al. 1994).

The *Gulf of Mexico American Oyster* HSI model (Cake 1983) was applied for this analysis. Although the USFWS developed the model for the Gulf of Mexico, it can be properly applied in Atlantic Coast habitats south of Cape Hatteras (Cake 1983). Relevant variables used in the model are shown in Table 4-2. The Neuse Estuary OGA is similar to the Gulf of Mexico in that it supports sub-tidal oysters, *Crassostrea virginica,* in waters that are less than 33 ft deep, and experiences a small mean tidal variation. All oyster life requisites in Table 4-2 were confirmed as appropriate through a review of literature regarding Atlantic Coast oyster populations (Kennedy et al. 1996).

This HSI model has both a larval and adult component and assesses six variables (V1–V6, Table 4-2) (Cake 1983). Those variables measure reef structure, water column conditions, and oyster abundance to determine site suitability for both adult oysters and larvae. Killing events (V5) were defined to address issues in the Basin such as low salinity and low dissolved oxygen events (Burkholder et al. 2004, Lenihan and Peterson 1998). Areas where no reefs exist will generate a habitat suitability of 0 despite acceptable water column conditions and oyster abundance. Where no reefs exist, it was assumed that with reef construction suitable cultch and hard substrate (V1 and V6) would be provided, that oyster abundance (V3) would be consistent with nearby reference reefs, and water column conditions would be consistent with model results for a given evaluation grid.

Table 4-2. Variables used in the oyster HEP

HEP function	Variable	Data source
Support oyster larvae	V:1 Percent suitable cultch	Neuse OGA July 2008 reef sampling (USACE 2008a) Proposed Reef Design
Support oyster larvae	V2: Mean summer salinity (in parts per thousand, or ppt)	Three-dimensional water quality model, Water quality Analysis Simulation Program (WASP) lower Neuse River Estuary, period of record 1998–2006 (USACE 2008b)
Support oyster larvae	V3: Mean abundance of living oysters per meter squared	Neuse OGA reef sampling July 2008 (USACE 2008a)
Support adult oysters	V4: Historic mean salinity (ppt)	WASP lower Neuse River Estuary, period of record 1998–2006 (USACE 2008b)
Support adult oysters	V5: Frequency of low salinity (ppt) and low dissolved oxygen (in milligrams per liter [mg/L]) events (killing events per period of record)	WASP lower Neuse River Estuary, period of record 1998–2006 (USACE 2008b)
Support adult oysters	V6: Substrate firmness (hard or soft)	Neuse OGA side-scan survey, August 2006 (USACE 2006) Proposed Reef Design

The habitat suitability for each variable, based on various site conditions (Cake 1983), is described in Appendix L. Measured site conditions were used to assign an index for each variable for both larvae and adult oysters.

For the purpose of this assessment, HSI and Habitat Units (HUs) as described in the HEP model will be referred to as the *Functional Index* and *Functional Units*, respectively. That naming convention was done for consistency between resources.

4.1.1.4 Total Benefits Output

For each No Action (Without Project) Alternative at each site, a total Average Annual Functional Unit (AAFU) was calculated as a quantified assessment of ecological outputs. Functional units are calculated as the number of ac multiplied by the functional index of that acreage. AAFU are calculated over the 50 year planning period of analysis.

For the stream elements of the ecosystem, acreage was calculated as the length of the stream multiplied by the bank to bank channel width (measured in the field at representative areas). Wetland areas were calculated based on measurements from geographic shapefiles. Oyster habitat areas were based on data collected in the field by USACE and proposed design drawings.

The Total AAFU was calculated as the sum of the AAFUs for the wetland, stream, and oyster components at each site. The different ecosystem components are given equal weight in this calculation, so as to not give *preference* for one type over another. Total AAFUs are calculated by determining the functional units at each project year, adding these together, and dividing by the period of analysis (50 years.) The total AAFU *benefit* for a future-with condition alternative is the difference between the AAFU calculated for that alternative (with project) and the AAFU calculated for the No Action Alternative (without project).

4.2 Future Without-Project Condition Environmental Benefits

Using the models described in the previous Section 4.1, AAFUs over 50 years for each area in a future without-project condition are presented in Table 4-3. The subsections to follow define conditions presented in Table 4-3 for:

1. Adkin Branch, Kinston, North Carolina
2. Gum Thicket and Cedar Creeks, Neuse River Sub-estuary
3. East Wetland Complex, Kinston, North Carolina
4. Ellerbe Creek, Durham, North Carolina
5. Low-head dam near Goldsboro, North Carolina
6. Oyster Reef Restoration Area, Neuse River Estuary

Table 4-3. Existing acres and AAFU for each possible No Action Alternative

No Action Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU	Stream AAFU	Oyster AAFU	Total ac	Total AAFU
Adkin Branch	0	2.15	0	0	0.99	0	2.15	0.99
Gum Thicket and Cedar Creeks	60.2[a]	0	0	30.2[b]	0	0	60.2	30.2
East Wetland Complex[c]	0	0	0	0	0	0	0	0
Ellerbe Creek	0	0.87	0	0	0.22	0	0.87	0.22
Low-head Dam near Goldsboro	0	297.1	0	0	265.2	0	297.1	265.2
Oyster Reef Restoration Area[d]	0	0	0	0	0	0	0	0

a. This is the number of ac that would be eroded away in the without project condition.
b. This is the AAFU of the original 60.2 ac as it erodes away over the 50 year period of analysis.
c. The restoration area is currently upland and provides no wetland benefits.
d. The Oyster Reef Restoration Area would be soft bottom material without structure to support oyster habitat, therefore oyster AAFU is zero.

4.2.1 Adkin Branch Restoration Opportunity Area

Riparian and aquatic habitat in the lower reach (~2,535 ft) of Adkin Branch has been historically degraded by channelization and streambank clearing activities. The site has 2.2 total stream acres with primarily sand substrate. The left bank has been filled and is unnaturally high and steep, with a trail paralleling it. The right bank has been armored with rock and concrete in many locations. The banks on the upper 200 ft of the reach and the left bank (facing downstream) on the lower 950 ft of the reach are very sparsely vegetated (Figure 4-1). The remaining riparian/floodplain area is bottomland hardwood forest, dominated by river birch (*Betula nigra*), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), willow oaks (*Quercus phellos*), and bald cypress (*Taxodium distichum*). However, the primary hydrologic source for the bottomland hardwood forest appears to be flooding from the Neuse River, rather than Adkin Branch.

Figure 4-1. Adkin Branch near road crossing.

Upstream of this location, additional measures are being implemented by City of Kinston to address stormwater runoff and local water quality improvement objectives. In addition, NCEEP is restoring an upstream section of Adkin Branch for others to use as mitigation credits.

No Action Alternative (Future Without-Project Condition). No entity has plans or intent to restore the site in the future and the reach is therefore expected to remain in its current degraded condition, with limited habitat connectivity for aquatic species attempting to move upstream from the Neuse River Estuary to the high-quality habitat in the restored reach upstream.

4.2.2 Gum Thicket and Cedar Creeks Restoration Opportunity Area

On the basis of field observations at Gum Thicket and Cedar Creek, transitional low marsh habitat linking open water and high marsh habitats in the estuary have eroded away, resulting in an actively eroding scarp feature along the shoreline. Surface sediments in the nearshore zone have been winnowed to a clay substrate in most areas. Estuarine beaches occur along the Gum Thicket and Cedar Creek shoreline. Remaining high marsh grasses appear weathered and pines are showing clear signs of salt stress, reducing their capacity to help stabilize the remaining shoreline.

The significance of wetland resources at this location is an important factor in plan selection. These locations provide one of the best and easiest opportunities for restoring emergent wetlands. Failure to stabilize the shoreline along Gum Thicket/Cedar Creek would also result in adverse effects associated with projected continued long-term erosion of a 240 ac wetland conservation easement in the project area. Adverse impacts in the form of direct marsh habitat loss at this 240 ac conservation easement area as well as adjacent marsh areas would be expected at Gum Thicket, without measures to reduce erosion.

The erosion rates used in the analysis were based on historic rates of sea level rise. Shoreline erosion rates under higher sea level rise scenarios would be expected to increase in without-project conditions, which in turn would result in greater loss of emergent wetlands. This is discussed in more detail in Section 6.6 of the report.

The shoreline erosion at Gum Thicket and Cedar Creek is also damaging cultural resources. Consultation with the North Carolina State Historic Preservation Office in 2009 revealed five known historic and prehistoric archaeological sites (state site numbers 31PM28, 31PM32, 31PM33, 31PM34, and GT 9) are along the shore in the Gum Thicket Creek and Cedar Creek area. Four of those sites were visited by an archaeologist with the North Carolina Office of State Archaeology in the late 1980s. The segments were described as heavily eroded and containing prehistoric and historic components. The fifth site, GT 9, was recorded in 2000, and it also was found to be heavily eroded. No cultural resource issues associated with the proposed project were identified during the 2009 consultation. Additionally, shoreline stabilization at these sites would provide incidental benefits to significant cultural resources.

No Action Alternative (Future Without-Project Condition). The respective erosion rates along Gum Thicket and Cedar Creek (9 ft/yr and 2 ft/yr) are expected to persist, reducing valuable marsh acreage. Figure 4-2 illustrates losses measured along the shoreline. Sediment fencing in the lower right corner of the image marks the previous year's shoreline. In addition to loss of cultural resources, emergent marsh and habitat protected by conservation easement will be lost. Erosion at Gum Thicket and Cedar Creek is encroaching on a wetland conservation easement. This conservation easement in the Neuse River Estuary was granted to the Neuse River Foundation, North Carolina Coastal Federation, and North Carolina so that the area would be conserved from future development of any kind. Further loss of shoreline would decrease the area's habitat value as emergent wetlands.

The erosion rates used in the analysis were based on historic rates of sea level rise. Shoreline erosion rates under higher sea level rise scenarios, although not measured for this study, would be expected to increase in without-project conditions, which in turn would result in greater loss of emergent wetlands.

Figure 4-2. Shoreline erosion at Gum Thicket.

4.2.3 Kinston East Wetland Complex Restoration Opportunity Area

The Kinston East Wetland Complex consists of approximately 30 ac in Kinston and it is located within the Neuse River floodplain. About 14.5 ac of this 30 ac property has been previously filled and is no longer functioning as a bottomland hardwood wetland area and no longer provides flood storage capacity. This earlier fill activity in this 14.5 ac tract resulted in the destruction of a bottomland hardwood wetlands that was vegetated with 30 to 60 year old blackgum (*Nyssa sylvatica*), elm (*Ulmus americana*), green ash (*Fraxinus* *pennsylvanica*), and cypress (*Taxodium distichum*). Currently the 14.5 ac previously disturbed area consists of 4.3 ac of open grassed area, 1.2 ac of an excavated pond, 9.0 ac of less than 10-year old (less than 3-inches DBH) loblolly pine (*Pinus taeda*) and sweeetgum (*Liquidambar styraciflua*). This 14.5 ac proposed restoration site is bordered on the east, west, and south by mature bottomland hardwoods wetlands within the Neuse floodplain. There are two shallow perimeter ditches on the east and west side of the tract. These two shallow perimeter ditches are connected to the river but don't affect the elevation of the water table of the adjacent bottomland hardwoods.

Figure 4-3. Kinston East filled area within the Neuse River floodplain

Figure 4-4. Flooded bottomland hardwood wetlands.

Figure 4-4 (above) shows flooded bottomland hardwood wetlands within 30 ac Kinston East wetland complex adjacent to the filled 14.5 ac tract. This functioning wetland area is located between the filled area and the main stem of the Neuse River.

No Action Alternative (Future Without-Project Condition). No entities have been identified with plans to restore this area of the Neuse River floodplain therefore it would remain in its upland condition and not provide wetland benefits and/or increased flood storage capacity. Under the No Action Alternative the East Wetland Complex is expected to remain in its current condition.

4.2.4 Ellerbe Creek Restoration Opportunity Area

In the 1960s, as part of a USACE flood risk management project, Ellerbe Creek was widened and straightened, and the excavated material was placed on the streambanks. The channel has since incised by up to 5 ft. No revetments exist along the banks of Ellerbe Creek, and the channel is generally sandy bottom with some shoaling. The banks of the creek must be maintained by the local municipality as part of the 1960s project agreement.

This reach of Ellerbe Creek is approximately 3,780 ft long. The morphology of the reach is a generally uniformly shaped trapezoidal channel that is approximately 10-ft wide with a largely homogeneous sandy substrate (Figure 4-5). A few pieces of wood and rock are in the channel, but generally the stream has been snagged and kept free of debris. The riparian/floodplain area varies along the extent of the reach. The left bank (facing downstream) contains areas of forested wetland of varying quality. Canopy vegetation in the wetland areas is young to middle-aged and ranges from portions that are oak- and sweetgum-dominated, to portions that are dominated by a mix of elm, box elder, green ash, sycamore, and maple with a few coniferous species such as cedar and pine interspersed. Also on the right bank, an approximately 20-ft-wide sewer right-of-way parallels most of the reach in the riparian area. The right bank of Ellerbe Creek does not contain wetland and appears to be connected to the stream only during extremely high-flow events.

Figure 4-5. Unrestored reach of Ellerbe Creek.

The City of Durham is conducting stream and wetland restoration on Ellerbe Creek upstream and downstream of this reach. Restoration by the city has not occurred along this reach because efforts have focused in other areas of the watershed. Restoring this reach of Ellerbe Creek would improve stream or wetland function and increase connectivity to the floodplain and the restored upstream and downstream reaches.

No Action Alternative (Future Without-Project Condition). The ecological condition of this reach in Ellerbe Creek is expected to stay in its degraded condition, because the surrounding areas is already extensively urbanized, and additional changes to areas that might affect the stream are not anticipated. Thus, for the analysis it is assumed the existing condition would be constant over the 50 years of the without project condition. The habitat along this reach would remain impaired and connectivity would be limited.

4.2.5 Low-head Dam Restoration Opportunity Area

Three dams (Cherry Hospital, Rains Mill, and Lowell) have been removed on the Little River, a tributary of the Neuse River (Figure 4-6). North Carolina removed Cherry Hospital and Rains Mill dams and Restoration Systems, Inc., removed Lowell Mill Dam. The low-head dam near Goldsboro, North Carolina, (FR5) (Figures 4-7 and 4-8) is the last major obstruction to fish passage on the mainstem of Little River. Data collected by North Carolina State University have confirmed this adverse effect on fish migration (Raabe and Hightower 2010). The presence of the dam affects the timing of migration and possibly spawning for anadromous fish species. Anadromous fish species in the Little River include American shad, hickory shad, and occasional striped bass (Raabe and Hightower 2010). Certain species, such as American shad, are also subject to higher predation risk as they pile up below the dam.

The Federally listed Endangered Dwarf wedge and Endangered Tar River spinymussel are known to reside in the area. Freshwater mussels have a complicated life history that is linked to fishes. The males release sperm into the water, which the females draw in. The fertilized eggs are brooded in the female's gills, where they develop into tiny larvae called glochidia. The glochidia are then released by the female mussels, which attach to fish gills or skin as temporary parasites. Over a few weeks to several months, the glochidia develop, or metamorphose, into juvenile mussels while attached to the host fish, detach from the host, fall to the lake or streambed, and begin their lives as free living mussels.

The low-head dam is downstream of the secondary water intake structure for the city's water treatment plant. The proposed low-head dam will be modified in such a way that it would allow anadromous fish to pass and also provide sufficient water for the City of Goldsboro's upstream secondary water intake. The service area for the secondary water intake is for the entire City of Goldsboro. The dam is less than 50 years old and is not a unique feature or been designated by the NC SHPO as a historic feature. No additional archaeological investigations are required at this project area.

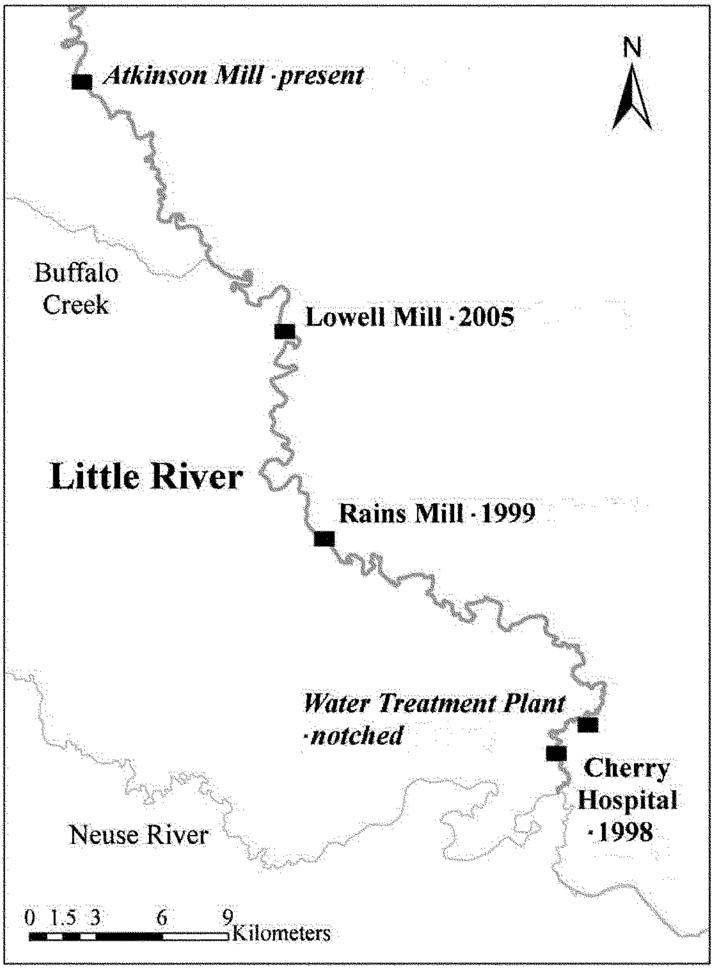


Figure 4-6. Little River obstructions removed (year), and present (*italics*). The low-head dam is at the water treatment plant near Goldsboro, NC.

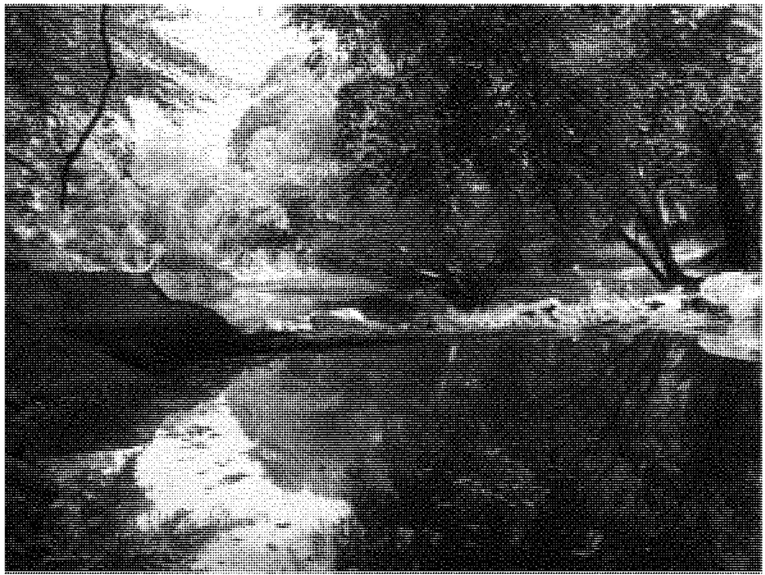


Figure 4-7. Low-head dam at Goldsboro.

Figure 4-8. Portion of the Little River upstream of Goldsboro low-head dam.

No Action Alternative (Future Without-Project Condition): It is anticipated the dam would remain an obstruction to upstream migration. Although there is potential for further urbanization in the watershed, current and projected state and local management activities are expected to ensure that the condition of the stream habitat is not significantly changed over the period of analysis.

4.2.6 Oyster Reef Restoration Opportunity Area

The ecological output, or functional habitat units, of reefs in the OGA are assumed to remain steady under future without-project conditions as described in Appendix L. The primary causes of the historical oyster decline in the Neuse River Estuary are the cumulative effects of pollution (Cooper et al. 2004, Pinckney et al. 1998), disease, and depletion of habitat from historical overfishing using destructive oyster dredges (Lenihan and Peterson 1998). Disease is not considered a planning constraint to existing oyster restoration however, because the presence of large oysters in the estuary today (> 100 mm or about 4 in) is an indicator of natural disease resistance (Encomio et al. 2005).

No Action Alternative (Future Without-Project Condition).

The footprint area proposed for oyster restoration is currently sand or mud softbottom, without structure to provide oyster habitat and therefore No Action would generate no additional oyster benefits. While natural reestablishment of displaced reefs is not expected to occur in the future without-project condition intervention, no additional displacement is expected over the 50-year period.

5.0 PLAN FORMULATION

Alternatives are combinations of management measures combined, as needed, to address the problem suite identified at each of the sites, and to address site-specific objectives. Environmental benefits derived from implementation of an alternative are defined as the increase in AAFUs gained from that alternative, when compared to the No-Action Alternative. Costs used for alternatives comparison all done to the same level of detail, and differ from those that are shown for the TSP, due to refinement of the details associated with the TSP, and the final results of the Cost-Effectiveness/Incremental Cost Analysis.

5.1 Adkin Branch Restoration Opportunity Area

The following restoration measures were identified as opportunities to improve biological integrity and restore damaged or eliminated natural riparian buffers.

Measure A - Revegetate banks

Banks that are sparsely vegetated or barren would be planted with appropriate riparian trees and shrubs. This measure would promote Bank Stability and enhance habitat value in this portion of the riparian zone. There are two distinct revegetation areas:

Measure A1 - This measure would revegetate both banks on the upper ~200 ft of the stream reach.

Measure A2 - This measure would revegetate the degraded left bank on the lower ~950 ft of the stream reach. The right bank of this segment is well vegetated and not in need of restoration.

The width of the riparian zone evaluated for revegetation is relatively narrow and would primarily benefit the stream rather than the entire riparian corridor and floodplain. Both Measures A1 and A2, benefits would increase over time and would not be fully realized until year 25, when the affected vegetation density and quality would be maximized.

Measure B - Add in-stream woody debris

This measure consists of the placement of large woody debris within the channel to restore degraded in-stream habitat in about 30 percent of the channel throughout the entire stream reach. To meet the objective of restoring habitat connectivity to upstream and downstream reaches, this measure would need to be implemented through the entire 2,535-ft stream length.

The benefits to stream ecological function from measure B are expected to be fully realized immediately following construction and maintained for the entire 50-year period of analysis. Additional measures do not contribute materially to environmental function, and were therefore, dropped from further consideration.

The locations of proposed measures at Adkin Branch are shown in Figure 5-1. Remaining restoration alternatives for this site are measures A1, A2, and B. Site alternatives can be individual measures or combinations of any of the three identified measures. Preliminary costs and benefits (AAFUs) from all the possible alternatives are shown in Table 5-1. As indicated in Section 4.1.1.4, AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details on calculation of benefits are contained in Appendix K. Of note, Table 5-1 indicates that the benefit from implementing measure A2 is greater than the benefit for implementing measure A1. Both of those measures provide a benefit over the No Action Alternative. Measure A1 provides a greater functional index lift because it is revegetating both banks, rather than just one bank as in A2; however, the total stream acreage being benefited by A2 is greater and leads to a greater total average annual functional unit benefit. Measure B benefits the largest amount of stream acreage; however, it also provides the lowest lift to the functional index. The output from this table was used in the cost-effective/incremental cost analysis presented in Section 6.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

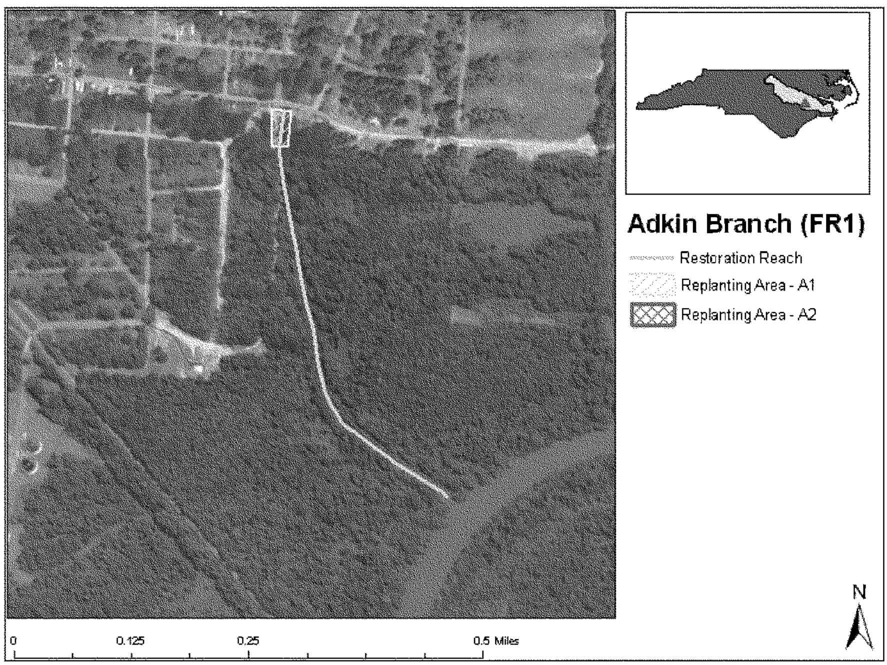


Figure 5-1. Location of Adkin Branch and proposed measures.

Table 5-1. Preliminary costs, Acres restored, and AAFU Benefits for each possible alternative at Adkin Branch

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A1	0	0.1	0	0	0.03	0	0.1	0.03	$91,700
A2	0	1	0	0	0.1	0	1	0.1	$97,200
B	0	2.2	0	0	0.18	0	2.2	0.18	$99,000
A1A2	0	1.1	0	0	0.13	0	1.1	0.13	$103,000
A1B	0	2.2	0	0	0.21	0	2.2	0.21	$104,705
A2B	0	2.2	0	0	0.28	0	2.2	0.28	$110,300
A1A2B	0	2.2	0	0	0.31	0	2.2	0.31	$116,000

Notes:
Ac refer to the number of ac being improved by the given alternative. The site contains 2.2 total stream ac.
Total AAFUs are rounded to the nearest tenth of a unit
.A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

5.2 Gum Thicket and Cedar Creeks Restoration Opportunity Area

Gum Thicket and Cedar Creek are separable segments that run along the shoreline within the Neuse River estuary. The following restoration measures were identified as opportunities to restore eroded emergent wetlands, improve biological integrity, and increase the quantity and quality of degraded oyster reef habitat.

Reach 1 - Gum Thicket

Gum Thicket is the approximately 4,300 ft southern segment of a larger 10,800 foot-long eroded estuarine ecosystem. It centers on Gum Thicket Creek, a valuable natural estuarine creek. The 2,200 ft of shoreline upstream of the Gum Thicket reach is currently protected by rock revetment and a rock sill along that portion of the shoreline.

Reach 2 - Cedar Creek

Cedar Creek is the 6,500 ft northern segment of the larger 10,800 foot-long eroded estuarine ecosystem. The wetlands in this reach are similar in quality to those in the Gum Thicket reach, although there is more extensive ditching present. Potential restoration measures at this candidate site are as follows:

Measure A1 - Parallel rock sill

This measure would consist of an approximately 3,500 foot-long straight rock sill parallel to the existing Gum Thicket shoreline (Measure 1A) or an approximately 5,200 foot-long rock sill parallel the Cedar Creek shoreline (Measure 2A). Optimization studies indicate that ecosystem output per unit cost is maximized at a distance of about 60 feet offshore (distance between the landward toe of the sill and the existing shoreline). An approximately 30 foot wide rock sill would stabilize the shoreline by attenuating wave action and reducing wave energy before reaching the shoreline. A sill would also provide benefits in improved water quality from decreased siltation, provide attachment substrate for shellfish, and provide resident and anadromous fish habitat. Enhanced environmental outputs from the rock sill would accrue from minimizing further degradation at approximately 59 acres of existing marsh (44 acres at Gum Thicket Reach and 15 acres at Cedar Creek), and incidentally protecting 12 acres of marsh and open water complex (5 acres in Gum Thicket Reach and 7 acres in Cedar Creek Reach).

Measure A2 - Marsh (high and low) planting

Marsh planting would create a *living shoreline* consisting of planted and open water areas, and increase nursery habitat for resident fish and shellfish.

Functional ratings for the existing marsh were measured using NC WAM and multiplied by the without-project eroding acreage to determine the environmental output from the rock sill. The functional rating was multiplied by marsh acreage to determine the benefit from planting.

Measure B1 - Meandering rock sill

This measure is conceptually similar to Measure A and functions in much the same manner; however, the rock sill plan design would be optimized to provide increased area for marsh planting and, for reach 1 only, additional oyster habitat. Rather than simply paralleling the shoreline, a more curved structure would create additional surface area along the sill where feasible, according to water depth. The meandering rock sill feature would be approximately 3,500 ft long in the Gum Thicket reach (Measure 1B) and 5,200 ft long in the Cedar Creek reach (Measure 2B). It would protect the same acreage of existing marsh as compared to Measure A, but create about 15 ac of new marsh-open water complex (6 ac in Gum Thicket Reach and 9 ac in Cedar Creek Reach).

Measure B2 - Marsh (high and low) planting

This measure would consist of planting suitable for implementation with Measure B1.

Measure C - Oyster bench

The measure adds rock cultch for oyster habitat to the shoreline, increasing the habitat available to shellfish. More oyster habitat can be built under the meandering rock sill than that under the parallel rock sill measure. This measure would be implemented only within in Gum Thicket (Measure 1C).

Measures A and B are mutually exclusive.

Alternatives for the site were built by generating different combinations of measures at each reach and assembling different combinations of reaches. Alternative 1A2B, for instance, consists of a parallel rock sill at Gum Thicket and a meandering rock sill at Cedar Creek. Expected wetland benefits would begin to be realized immediately following construction. Full oyster benefits are expected at year three.

The erosion rates used in the analysis of future without-project conditions were based on historic rates of sea level rise. Shoreline erosion rates under higher sea level rise scenarios, while considered for each alternative, would be expected to be higher for the future without-project condition, which in turn would result in higher environmental benefit outputs being produced by the various project alternatives. Therefore, the environmental benefit outputs presented in this section can be considered conservative.

Figure 5-2 shows the location of the area and proposed rock sill locations. Table 5-2 shows the preliminary costs and benefits of the alternatives. Measures are presented as providing benefits compared to the No Action Alternative. As indicated in Section 4.1.1.4, AAFUs are based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details on calculations of ecosystem benefits are contained in

Appendix K. Acres of oyster on the sill were computed as equal to the submerged surface area of the sill. The bench was to be totally submerged and computed as the surface area of the potential oyster bench. Wetland acreage consisted of additional wetland planting, shallow open water area created, and the number of acres that would have eroded over 50 yrs without a project in place. The differences in AAFUs shown in Table 5-2 are based on differences in acreage being benefited by each alternative, rather than differences in the functional index. The output from this table was used in the cost-effective/incremental cost analysis presented in Section 6.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

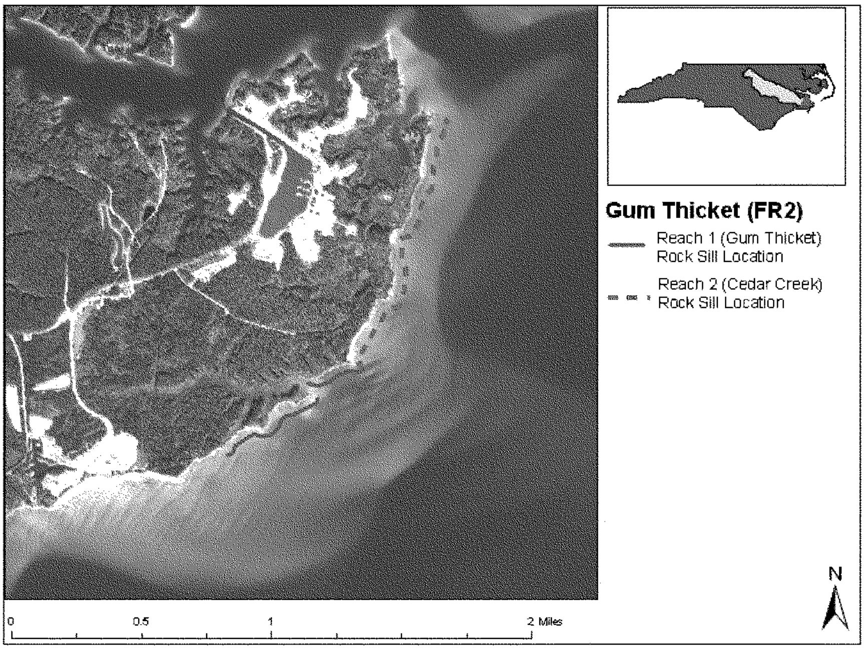


Figure 5-2. Location of Gum Thicket Creek and Cedar Creek and proposed rock sill alternatives.

Table 5-2. Preliminary costs and benefits from possible alternatives at Gum Thicket and Cedar Creek

Alternative	Wetland acres	Stream acres	Oyster acres	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total acres	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
1A	58.1	0	0.6	27.3	0	0.54	49.6	27.8	$7,044,000
1B	60.8	0	0.8	28.7	0	0.72	51.2	29.4	$8,997,000
1AC	58.1	0	1.3	27.3	0	1.17	50.3	28.5	$8,604,000
1BC	60.8	0	1.7	28.7	0	1.53	52.1	30.2	$9,603,000
2A	36.3	0	0	14.9	0	0	22.2	14.9	$10,514,000
2B	40.4	0	0	16.9	0	0	24.2	16.9	$13,628,940
1A2A	94.4	0	0.6	42.2	0	0.54	71.8	42.7	$17,558,000
1A2B	98.5	0	0.6	44.2	0	0.54	73.8	44.7	$20,672,940
1B2A	97.1	0	0.8	43.6	0	0.72	73.4	44.3	$19,511,000
1B2B	101.2	0	0.8	45.6	0	0.72	75.4	46.3	$22,625,940
1AC2A	94.4	0	1.3	42.2	0	1.17	72.5	43.4	$19,118,000
1AC2B	98.5	0	1.3	44.2	0	1.17	74.5	45.4	$22,232,940
1BC2A	97.1	0	1.7	43.6	0	1.53	74.3	45.1	$20,117,000
1BC2B	101.2	0	1.7	45.6	0	1.53	76.3	47.1	$23,231,940

Note:
Wetland ac are the expected difference in wetland acreage at the site between the with- and without-project (No Action) conditions at the end of the period of analysis.
A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

5.3 Kinston East Wetland Restoration Opportunity Area

The following potential restoration measures were identified as opportunities to restore damaged or eliminated natural riparian buffers along the Neuse River:

Measure A - Remove fill material and create hydrologic connections with surrounding bottomland hardwood forest

A volume of fill material that currently interferes with the hydrologic connectivity of the site to adjacent channel features would be excavated to match the elevation of the adjacent bottomland hardwood forest (4 ft). In the process of removing fill material from the previously filled flood plain, the contractor may remove a very small amount of natural soil. Removal of this natural soil would be considered insignificant. The fill will be excavated and disposed of to a nearby (within 24 miles) offsite commercial disposal area. Removal of this fill would restore floodplain functions by reconnecting the area hydrologically with the Neuse River, allowing overbank flows to flood the area periodically. This measure would restore hydrologic function to 14.5 ac of bottomland hardwood forest. Because it is adjacent to existing bottomland hardwood forest, the adjacent area is expected to eventually revegetate with appropriate species, with minimal seeding or planting of bare root stock. The functional ratings of this restored bottomland hardwood are assumed to eventually be the same as those of the existing adjacent forest; however, the habitat function rating would not reach this point until year 30 of the project. Functional ratings for the water quality and hydrology outputs are assumed static for the entire period of analysis.

Measure B - Plant vegetation

Once the restoration site was hydrologically restored to a condition suitable for habitat sustainability, the site could be planted with appropriate bottomland seedlings at a standard planting density. This measure is dependent on implementing Measure A as an initial implementation phase, due to a lack of current suitable hydrologic input. Planting vegetation would advance achievement of optimal ecosystem outputs by approximately 5 years over Measure A alone (no planting) (i.e., habitat function would maximize at year 25 rather than at year 30). Additionally, under Measure B, the *vegetation composition* habitat sub-function and *surface storage and retention* hydrology sub-function would score a 1.0 at year 0 (immediately following construction) and be maximized throughout the period of analysis. If the measure is not implemented, the sub-functions would score 0.1 and 0.5, respectively, at year 0 and maximize at a score of 1.0 at year 30.

The location of East Wetland complex is shown in Figure 5-3. Possible restoration measures for this site are Measure A or Measure A in combination with Measure B. Preliminary costs and benefits from all the possible alternatives are shown in Table 5-3. Benefits would begin to be realized immediately after construction, since normal hydrology would assume at that point. Measures are presented as providing benefits above the No Action Alternative. As indicated in Section 4.1.1.4, AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. The table indicates that measure B (planting vegetation) does not provide much additional AAFU benefit. The output from the table is used in the cost-effective/incremental cost analysis presented in Section 6.1, which is used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

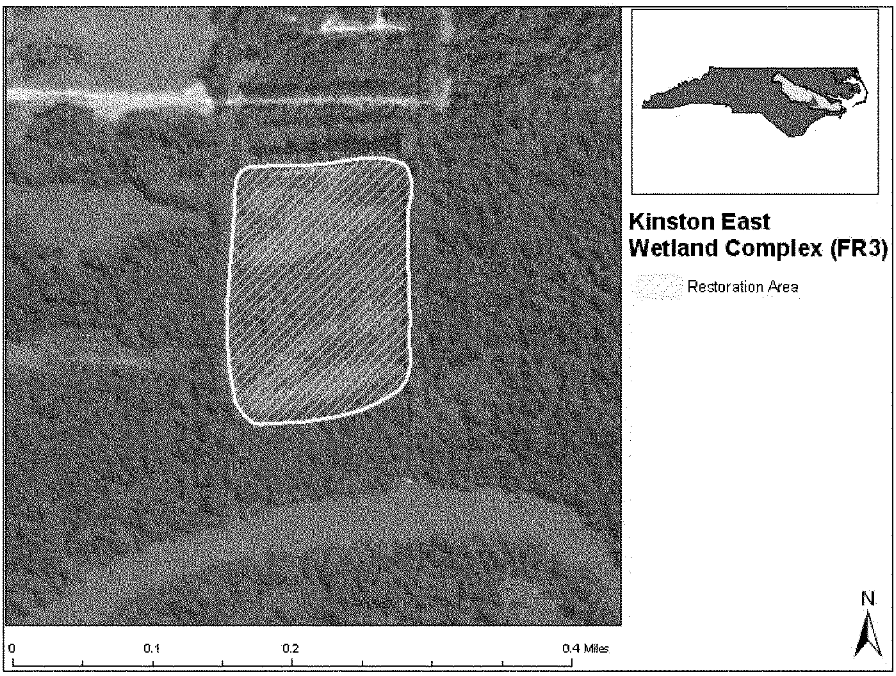


Figure 5-3. Location of Kinston East Wetland Complex restoration area.

Table 5-3. Preliminary costs and benefits from possible alternatives at Kinston East Wetland Complex

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A	14.5	0	0	11	0	0	14.5	11	$4,024,700
AB	14.5	0	0	11.2	0	0	14.5	11.2	$4,340,100

Note: Ac refers to the number of ac that are being improved by the given alternative.

A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

5.4 Ellerbe Creek Restoration Opportunity Area

The following restoration measures were proposed for this reach of Ellerbe Creek as an opportunity to improve biological integrity and restore damaged or eliminated natural riparian buffers:

Measure A - Excavate and revegetate banks

Streambanks would be excavated where feasible to a 3:1 slope or gentler, and a floodplain bench would be created to better connect the stream and existing floodplain. Existing vegetation in excavated areas would be replaced with appropriate riparian wetland vegetation.

Three distinct restoration sites suitable for excavation/replanting exist:

Measure A1 - This measure would excavate/replant approximately 6.2 acres on the left bank of the upstream portion of Ellerbe Creek. The material excavated from the site will be disposed of at a nearby (within 24 miles) offsite commercial disposal area.This area consists of medium-quality forested wetland, which would be supported by having overbank hydrology restored to a more natural state. Short-term impacts from initial vegetation removal would be surpassed by the long-term ecological enhancement after hydrologic connection with the channel.

Measure A2 - This measure would excavate/replant approximately 5.3 acres on the left bank of the downstream portion of Ellerbe Creek. The material excavated from the site will be disposed of at a nearby (within 24 miles) offsite commercial disposal area. This area consists of low- to medium-quality forested wetland, which would be supported by having overbank hydrology restored to a more natural state; more natural in that these areas would have hydroperiods more consistent with what would have occurred before the stream's earlier modifications. Short-term impacts from initial vegetation removal would be surpassed by the long-term ecological enhancement associated with hydrologic connection with the channel. Habitat quality would initially decline in the area from removing vegetation; however, it would eventually be improved over current levels during the period of analysis.

Measure A3 - This measure would excavate approximately 2.8 acres on the right bank of the downstream portion of Ellerbe Creek. The material excavated from the site will be disposed of at a nearby (within 24 miles) offsite commercial disposal area. The area is upland with a sparsely vegetated riparian layer. Infrastructure, including sewer lines, in the area would need to be removed or relocated. Excavation and replanting could restore this area to wetland.

For Measures A1, A2, and A3, functional unit benefits to stream and wetlands would increase over time and not be fully realized until year 25, when the functions and values of the area would be maximized. For simplicity, benefits are assumed to increase linearly until year 25.

Measure B - Create step pools

Boulders and woody debris could be placed in-stream to improve geomorphic and habitat functions by creating riffle and pool sequences. In order to establish sufficient density and functionality, it would have to be performed within at least 30 percent of the stream profile. To meet the goal of improving connectivity to upstream and downstream reaches, which would be accomplished by having a continuous area of suitable habitat for aquatic species, this measure would need to be implemented through the entire 3,780-ft stream length of this reach of Ellerbe Creek.

Measure C - Re-meander channel

The stream channel could also be re-graded to restore its natural stream meander wavelength through the reach. Re-establishing the natural meander sequence would create about 2,300 ft (0.5 ac) of additional stream habitat, with a corresponding 0.5 ac less of wetland restored in the excavated area. Existing vegetation in excavated areas would be replaced with appropriate riparian vegetation. This measure could be done only if Measures A1, A2, and A3 are all implemented.

The benefits to stream ecological function from Measures B and C are expected to be fully realized immediately following construction and maintained for the entire period of analysis.

The location of this reach of Ellerbe Creek and some of the proposed measures are shown in Figure 5-4. Possible restoration alternatives for this site could involve each of the individual measures alone or in combination with one another (with exceptions as noted in the description of measures above). Preliminary costs and benefits from all the possible alternatives are shown in Table 5-4. Measures are presented comparing each alternative to the No Action Alternative. As indicated in Section 4.1.1.4, AAFUs are based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 6.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

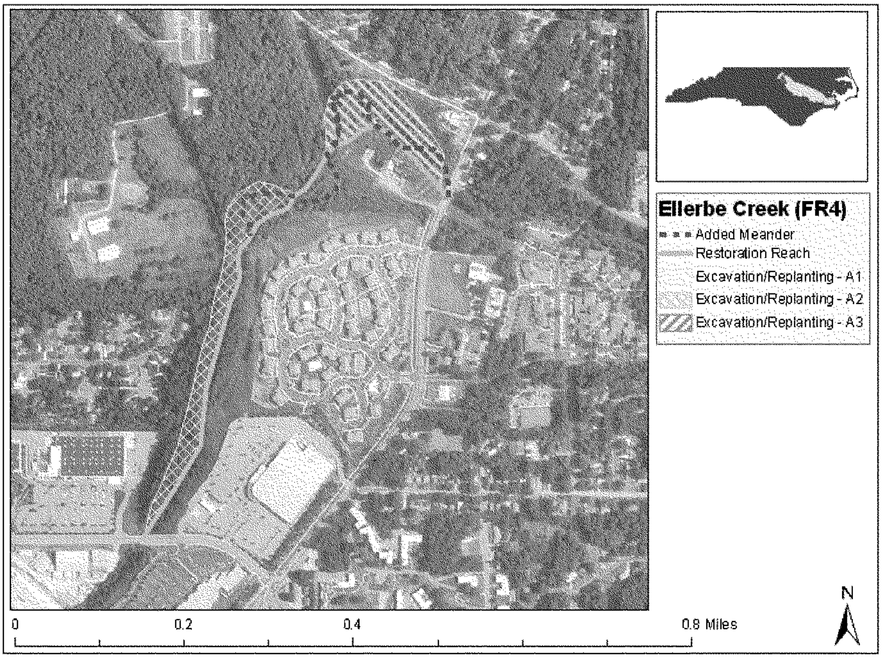


Figure 5-4. Location of Ellerbe Creek and proposed measures.

Table 5-4. Preliminary costs, acres restored, and AAFU Benefits for each possible alternative at Ellerbe Creek

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A1	6.2	0.6	0	1.78	0.08	0	6.8	1.9	$465,660
A2	5.3	0.3	0	1.84	0.06	0	5.6	1.9	$362,323
A3	2.8	0.3	0	2.15	0.06	0	3.1	2.2	$220,357
A1A2	11.5	0.9	0	3.62	0.14	0	12.4	3.8	$827,983
A1A3	9	0.9	0	3.93	0.14	0	9.9	4.1	$686,017
A2A3	8.1	0.3	0	3.99	0.06	0	8.4	4.1	$582,680
A1A2A3	14.3	0.9	0	5.77	0.14	0	15.2	5.9	$1,048,340
A1B	6.2	0.6	0	1.78	0.43	0	6.8	2.2	$481,422
A2B	5.3	0.3	0	1.84	0.41	0	5.6	2.3	$378,085
A3B	2.8	0.3	0	2.15	0.41	0	3.1	2.6	$236,119
A1A2B	11.5	0.9	0	3.62	0.49	0	12.4	4.1	$843,745
A1A3B	9	0.9	0	3.93	0.49	0	9.9	4.4	$701,779
A2A3B	8.1	0.3	0	3.99	0.41	0	8.4	4.4	$598,442
A1A2A3B	14.3	0.9	0	5.77	0.49	0	15.2	6.3	$1,064,102
A1A2A3C	13.8	1.4	0	5.58	0.39	0	15.2	6.0	$1,136,065
A1A2A3BC	13.8	1.4	0	5.58	0.73	0	15.2	6.3	$1,156,475
B	0	0.9	0	0	0.35	0	0.9	0.4	$15,762

Notes:
Ac refer to the number of ac that are being improved by the given alternative. The site contains 0.9 total stream ac and 11.5 wetland ac.
Total AAFUs are rounded to the nearest tenth of a unit.
A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

5.5 Little River Dam near Goldsboro Restoration Opportunity Area

A series of management measures was considered for this site. A reasonable estimate of fish passage efficiency around the dam, based on 2009 spring flow conditions, is 70 percent (Raabe and Hightower 2010). One potential measure would increase passage efficiency.

The potential measures for this site are as follows:

Measure A - Construct dam gate

An approximately 20 ft section of the existing 100 ft-wide, 4 ft-high concrete dam could be removed. Either a hydraulic gate or a stop log structure would be installed within the 20 ft opening. The gate in the existing dam would remain open during the anadromous fish migration season (i.e., about January to May). Only during low-flow conditions (i.e., July to September) would the City of Goldsboro close the gate to use the upstream (secondary) water intake structure. Fish passage efficiency for the measure was estimated to be 99 percent.

Measure B - Construct rock ramp

A six-tier rock ramp, constructed of large boulders at an approximately 20:1 slope could be built at the dam. The ramp would provide better passage under normal flow conditions but would not be as useful under low-flow conditions. Fish passage efficiency for this measure was estimated to be 80 percent.

Measure C - Remove dam

The existing dam could be removed. This measure would require modifications at the City of Goldsboro's secondary water intake area to maintain the city water supply after loss of the dam. Passage efficiency for this measure would be 100 percent because the dam would no longer obstruct fish passage.

The location of the Goldsboro low-head dam and the portion of the Little River that the location of the Goldsboro low-head dam and the portion of the Little River that would be affected by its removal are shown in Figure 5-5. Preliminary costs and benefits from all the possible site specific alternatives are shown in Table 5-5. Alternatives are presented in comparison to the No Action Alternative. Expected benefits would be realized immediately after construction. As indicated in Section 4.1.1.4, AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. In this case, Measure C resulted in the highest AAFU benefit because it provided the greatest increase in passage efficiency. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 6.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

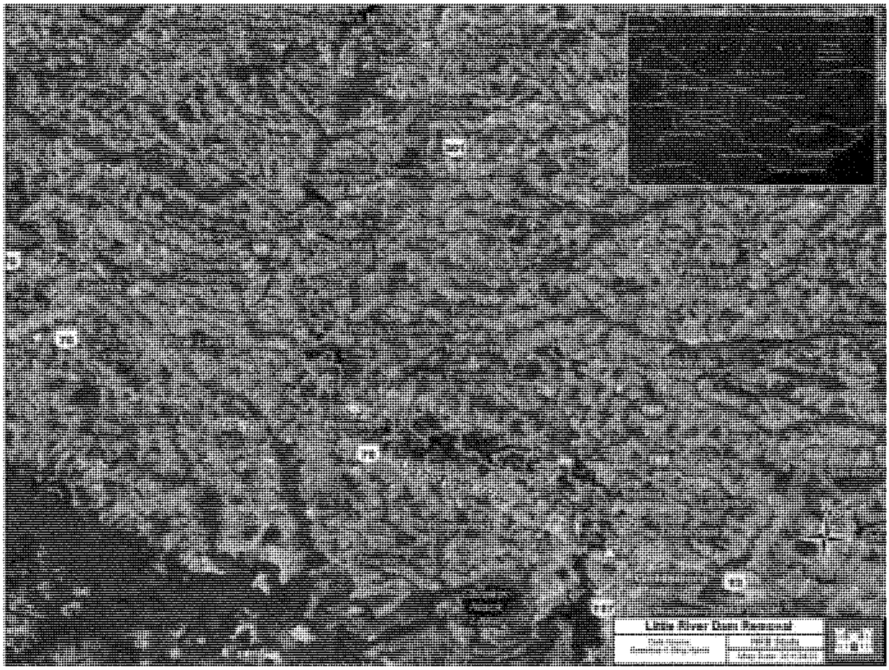


Figure 5-5. Location of Goldsboro dam and portion of the Little River that would be affected by dam removal.

Table 5-5. Preliminary costs, acres affected, and AAFU benefits for each possible site specific alternative at Little River/Goldsboro Dam

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A	0	509.2	0	0	109.9	0	509.2	109.9	$180,835
B	0	509.2	0	0	37.9	0	509.2	37.9	$240,650
C	0	509.2	0	0	113.7	0	509.2	113.7	$1,163,605

Note: Ac refer to the number of ac that are being affected by the given alternative.

A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

5.6 Neuse River Oyster Growing Area (OGA)

Building new deepwater reefs was determined to be the only method practicable to restore sustainable reef habitat and associated functional output. This measure would modify existing sandy soft bottoms that no longer support reefs, providing an opportunity to increase the quantity and quality of oyster reef habitat.

Potential sites were screened and selected as described in Appendix L. Gum Thicket (Site 2 in Figure 3-2) was also evaluated for oyster suitability so that an oyster measure could be considered as a component of alternatives formulated for that site.

Alternatives considered included: (1) Building new deep water reefs, (2) Restoring existing low output reefs by addition of new cultch, and (3) Designating existing high output reefs as sanctuaries to preclude impacts associated with harvest. Alternative is considered feasible. Alternative 2 was not considered technically feasible since low population reefs would not sustain suitable cultch and quickly revert to the previous degraded condition. For Alternative 3, existing NC sanctuary regulation only allows "Oyster Sanctuary" designation at previously low value bottoms where new reefs have been constructed. Therefore, alternatives 2 and 3 were eliminated from further detailed analysis.

A new NCDMF project, known as Little Creek Sanctuary, is to be located in the lower Neuse River in Pamlico Sound, NC, approximately 10 miles east of the town of Oriental and 108 miles north-west of Little Creek (N35° 02.616' W76°30.889'). This 10 acre site is proposed for construction and monitoring beginning early 2012 and includes alternate materials, in addition to conventional stone design. If the use of alternate materials is found to be as productive as and less costly than conventional designs, they will be incorporated in the design of the Recommended Plan during PED.

The proposed design was based on existing State methods and materials previously used for deepwater oyster reef construction. The proposed materials have been proven by extensive field application. The proposed reef architecture was modified to more closely match the form of nearby successful reference reefs. Alternative materials could be used if found to reduce cost without detracting from project outputs.

Potential Reef Sanctuary sites include the following and are illustrated in Figure 5-6.

(1) Mid River Reef Cells with FIs 1.0,

(2) Mid River Reef Cells with FIs 0.9,

(3) Mid River Reef Cells with FIs 0.7,

(4) North Shore Vicinity Reef Cell with FI 1.0, and

(5) South Shore Sanctuary FI 0.9.

New high-output reef areas could be constructed to be managed as sanctuaries by the State. This measure could add suitable cultch and provide firm substrate where soft bottom exists. Oyster density was assumed to be equal to that of nearby reference reefs by year three. Three development levels representing small, standard, and large areas were evaluated at each potential location:

(a) 20-ac reef service area,

(b) 30-ac reef service area, and

(c) 40-ac reef service area.

A one acre reef service area, including reef top, side slopes, and adjacent enhanced mud bottom, requires a productive 0.13 acre reef top area. This is consistent with the ratio of reef top to sanctuary area in the existing Neuse River Sanctuary. NCDMF would manage the measures defined in this study as sanctuaries. Sanctuaries would be identified by a series of buoys to preclude oyster harvest.

Benefits realized by restoration of former sites as new sanctuary reefs would not be fully realized until year three, when oyster recruitment and growth is expected to equal that of natural reefs. For simplicity, benefits were assumed to increase linearly until year three. Each Functional Index (FI) was applied over a project area and annualized, and an AAFU was computed.

The cost of constructed oyster reef is dependent on the amount of rock material. For planning purposes, the transportation costs to carry material to reef locations were found to be negligible between the various locations because both an upriver and downriver staging location was identified. Therefore, costs were assumed to be the same for areas of the same size.

A 4-ft reef height was proposed to allow 1 ft of settling and still provide three feet above the bottom substrate. If during PED, detailed geotechnical investigation identifies solid footing, the 1 foot allowance could be reduced or eliminated. Further, oyster restoration work in the Chesapeake Bay has found that one to two feet of elevation is sufficient to support sustainable oyster growth. Any reduction in reef height would reduce constructed cost.

As indicated in Section 4.1.1.4, AAFUs were based on the acreage being restored; reef top plus service area, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix L. In this case, Measures M2C and N3 resulted in the highest AAFU benefits, because the selected area provided the greatest increase in habitat quality (FI = 1.0) over the largest area (40 ac). Preliminary costs and benefits from all the possible alternatives are shown in Table 5-6. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 6.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs. Benefits from the construction of new sanctuary reefs would not be fully realized until year three, when oyster recruitment and growth is expected to equal that of natural reefs. For simplicity, benefits were assumed to increase linearly until year three.

NEUSE ESTUARY OYSTER GROWING AREA (OGA)
Round 3 Evaluation Areas for IWR Plan

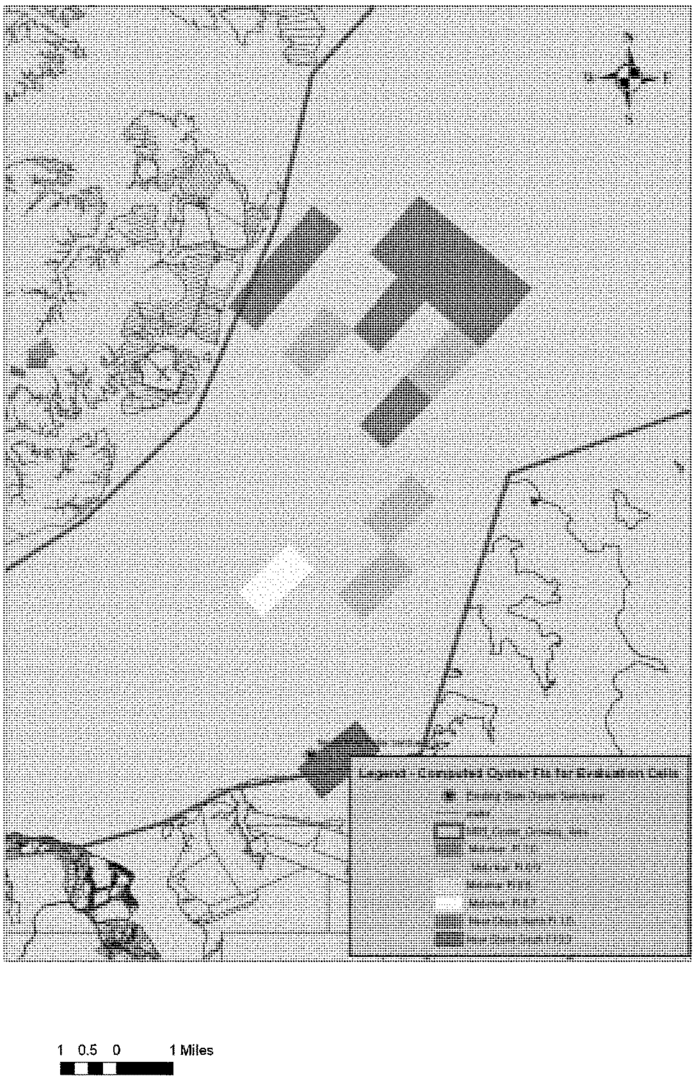


Figure 5-6. Neuse River Estuary oyster growing area.

Table 5-6. Preliminary costs, acres affected, and AAFU benefits for each possible alternative for Oyster Reef Habitat

Measures				Wetland Ac	Stream Ac	Oyster Ac	Wetland AAFU Benefit	Stream AAFU Benefit	Oyster AAFU Benefit	Total Ac	Total AAFU Benefit	Cost
New Mid-river Reef Sanctuary												
1) No Action				0	0	0	0	0	0	0	0	0
2) FSI =	1.0											
A1	a	20	Sanctuary Acres	0	0	20	0	0	19.4	20	19.4	$ 3,352,226
A2	b	30	Sanctuary Acres	0	0	30	0	0	29.1	30	29.1	$ 4,978,945
A3	c	40	Sanctuary Acres	0	0	40	0	0	38.8	40	38.8	$ 6,605,664
3) FSI =	0.9											
A4	a	20	Sanctuary Acres	0	0	20	0	0	17.5	20	17.5	$ 3,352,226
A5	b	30	Sanctuary Acres	0	0	30	0	0	26.2	30	26.2	$ 4,978,945
A6	c	40	Sanctuary Acres	0	0	40	0	0	34.9	40	34.9	$ 6,605,664
5) FSI =	0.7											
A7	a	20	Sanctuary Acres	0	0	20	0	0	13.6	20	13.6	$ 3,352,226
A8	b	30	Sanctuary Acres	0	0	30	0	0	20.4	30	20.4	$ 4,978,945
A9	c	40	Sanctuary Acres	0	0	40	0	0	27.2	40	27.2	$ 6,605,664
New North Shore Reef Sanctuary												
1) No Action												
2) FSI =	1.0											
B1	a	20	Sanctuary Acres	0	0	20	0	0	19.4	20	19.4	$ 3,352,226
B2	b	30	Sanctuary Acres	0	0	30	0	0	29.1	30	29.1	$ 4,978,945
B3	c	40	Sanctuary Acres	0	0	40	0	0	38.8	40	38.8	$ 6,605,664
Expand Existing South Shore Reef Sanctuary												
1) No Action		6	Sanctuary Acres	0	0	6	0	0	5.2	6	5.2	0
3) FSI =	0.9											
C1	a	14	Sanctuary Acres	0	0	14	0	0	12.2	14	12.2	$ 2,381,843
C2	b	24	Sanctuary Acres	0	0	24	0	0	20.9	24	20.9	$ 4,009,196
C3	c	34	Sanctuary Acres	0	0	34	0	0	29.6	34	29.7	$ 5,636,549

Note:
A detailed breakdown of costs that reflect cost of construction, E&D, S&A, Monitoring, and O&M are contained in Attachment A of the Economic Appendix (Appendix G)

6.0 PLAN SELECTION

The following sections compare the combinations of site alternatives presented in the previous section using cost-effective/incremental cost analysis (CE/ICA). First, CE/ICA was performed on the array of alternatives for each site, and the results were used to select a single alternative from each site for further consideration. Another CE/ICA was then performed on this final array of alternatives. These results, in combination with a comparison of alternatives in Section 6.2 using the four (4) accounts (national economic development, environmental quality, regional economic development, and other social effects), was used to establish the National Ecosystem Restoration plan (NER) as presented in Section 6.3.

6.1 Cost-Effectiveness/Incremental Cost Analysis (CE/ICA)

The environmental benefits and costs presented in the previous section were the inputs for a CE/ICA. The purpose of the analysis was to evaluate the effectiveness and efficiency of the site alternatives at producing environmental outputs. Guidance on the conduct of CE/ICA is in IWR Report #95-R-1, USACE, May 1995. The end product of a CE/ICA is the identification of a set of *best buy* plans. Best buy plans are the alternatives that provide the greatest increase in environmental output for the least increase in cost. Initially, all cost-effective alternatives (a cost-effective alternative is one where no other alternative can achieve the same level of output at a lower cost, or greater level of output at the same or less cost) are arrayed by increasing output to clearly show changes in cost (i.e., increments of cost) relative to changes in output (i.e., increments of output) of each cost-effective alternative plan compared to the without-project condition. The plan with the lowest incremental costs per unit of output of all plans is therefore considered the first best buy plan. After the first best buy plan is identified, all larger cost-effective plans are compared to the first best buy plan in terms of increases in (increments of) cost and increases in (increments of) output. The alternative plan with the lowest incremental cost per unit of output (for all cost-effective plans larger than the first best buy plan) is the second best buy plan. This process is continued until all the best buy alternative plans are identified.

The results of the initial analysis conducted to compare alternatives at each project area are presented in Figures 6-1 through 6-7. These figures display the incremental costs and benefits for the best buy plans at each of the sites (with the exception of the No Action Alternative, which is always a Best Buy Plan). The IWR Plan software was used to conduct the CE/ICA. Appendix G presents the complete results for each site.

Evaluation of the best buys from the initial analysis identified an array of best buy alternatives for comparison over the entire watershed. The PDT compared the best buys from each project area to determine whether the incremental environmental benefits justified the incremental costs. Based on this comparison, a single best buy alternative was selected from each project area, which was then used to create basin-wide alternatives.

At Adkin Branch, the CE/ICA identified only one best buy alternative (Figure 6-1). The best buy (A1A2B) at Adkin Branch is a combination of bank revegetation at the upper 200 ft of both banks and lower 950 ft of the left bank with the addition of in-stream woody debris.

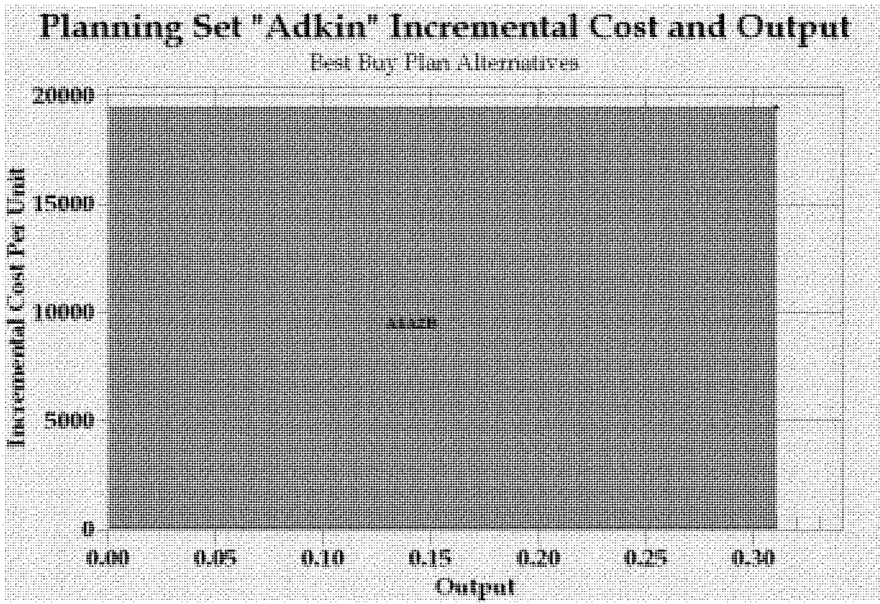


Figure 6-1. Incremental costs and benefits of Best Buy plans at Adkin Branch site. Alternative A1A2B is fully revegetating the stream banks and adding in-stream woody debris.

Five restoration alternatives were best buys in the Gum Thicket and Cedar Creek analysis (Figure 6-2). As shown in Figure 6-2, after the second best buy alternative (1A2A) the incremental benefits of the larger plans are minimal but the incremental costs per additional unit of output are relatively high. Therefore, the second best buy alternative (1A2A) is the recommended alternative from this site. The alternative consists of parallel rock sill and marsh plantings at both Gum Thicket and Cedar creeks.

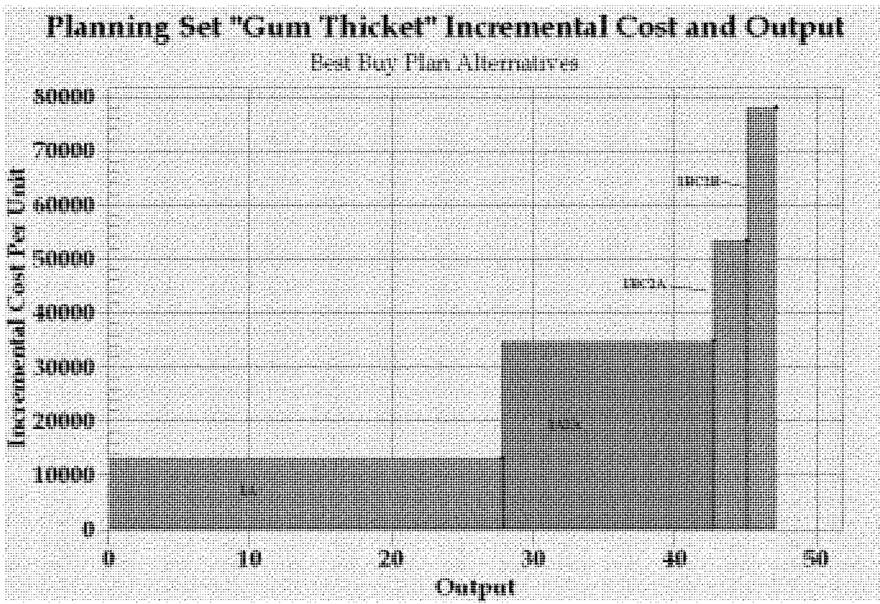


Figure 6-2. Incremental costs and benefits of Best Buy plans at the Gum Thicket/Cedar Creek site.

Descriptions of the plans are as follows: 1A = parallel sill at Gum Thicket Reach, 1A2A = parallel sills at Gum Thicket and Cedar Creek reaches, 1BC2A = meandering sill + added oyster habitat at Gum Thicket Reach, parallel sill at Cedar Creek Reach, 1BC2B = meandering sill + added oyster habitat at Gum Thicket Reach, meandering sill at Cedar Creek Reach.

At the East Wetland Complex in Kinston, both of the analyzed alternatives were best buy plans (Figure 6-3). The PDT did not feel that the best buy that maximized environmental benefits (alternative B) was justified because of the high incremental cost for a minimal additional output (0.2 habitat units [HU] at about $82,000 per unit of output). The restoration measure to excavate the site, without planting trees (alternative A) was selected as the preferred alternative from this site.

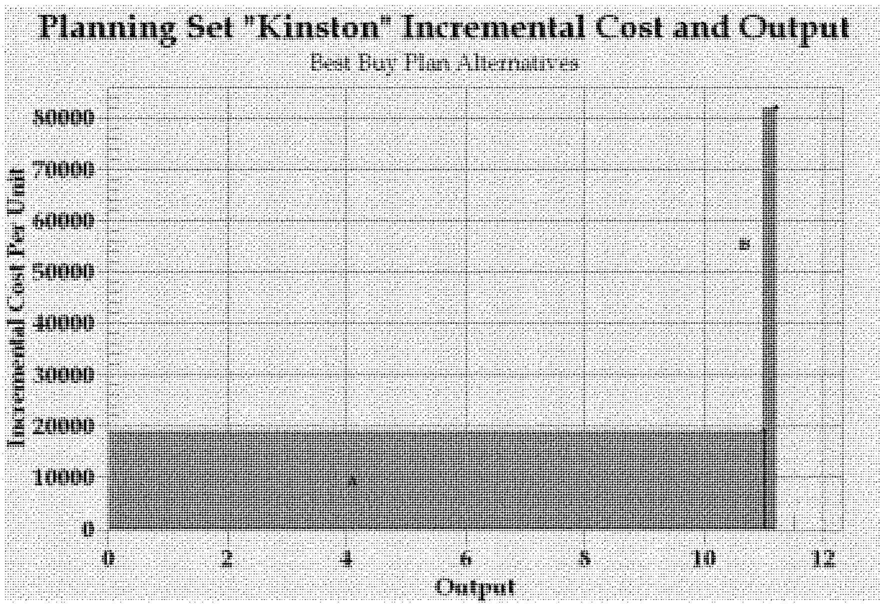


Figure 6-3. Incremental costs and benefits of Best Buy plans at Kinston site. Alternative A is excavating the site to its natural elevation, alternative B is excavating and planting trees at the site.

The smallest best buy (B) at Ellerbe Creek was selected because it did not adversely affect the riparian corridor. After site visits, it was determined that restoration measures to excavate the channel would potentially affect existing wetlands. As a result, the best buy with the least effect on the riparian corridor, creating step pools, was identified for further consideration.

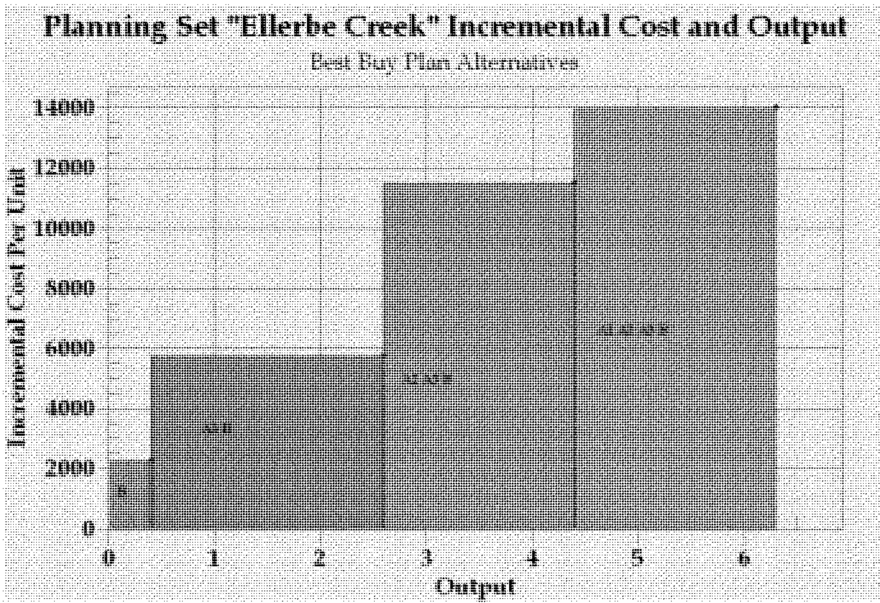


Figure 6-4. Incremental costs and benefits of Best Buy plans at Ellerbe Creek site. Alternative B is creating step pools, A3B is excavating and replanting reach 3 plus creating step pools, A2A3B is excavating and replanting reaches 2 and 3 plus creating step pools, and alternative A1A2A3B is excavating and replanting reaches 1, 2, and 3 and creating step pools.

There were two Best Buy plans at the Little River site (Figure 6-5). Relative to Alternative A (building a dam gate), the larger best buy plan (Alternative C - removing the dam) has a very high incremental cost for a relatively smaller benefit. Additionally, removing the dam would pose some risks to the city's secondary water supply. Therefore, Alternative A was selected as the recommended alternative from this site.

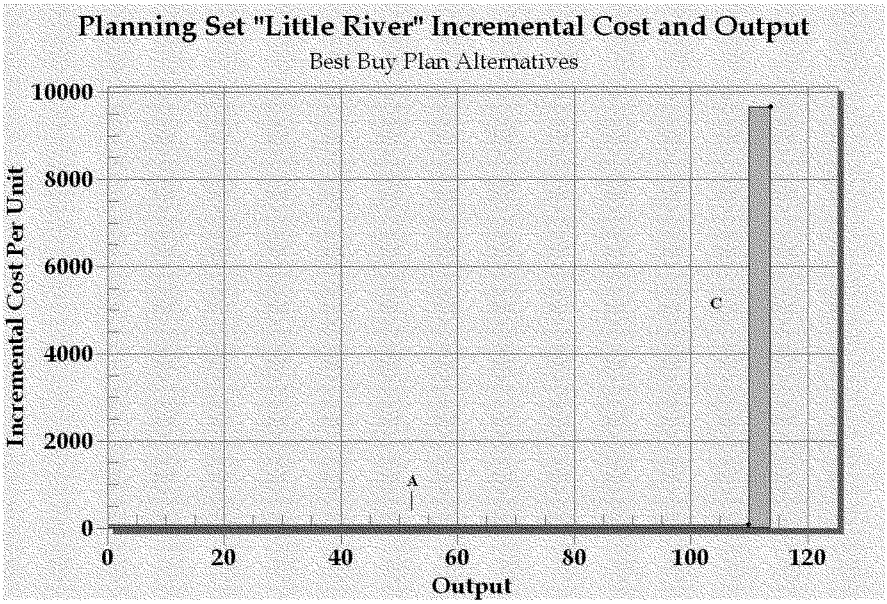


Figure 6-5. Incremental costs and benefits of Best Buy plans at Little River site. Alternative A is building a dam gate, Alternative C is removing the dam.

There were 5 best buy plans for the oyster growing area project, with relatively similar incremental costs (Figure 6-6). The recommended alternative was the best buy plan that came closest, when combined with existing sanctuary, to meeting the ORSC's goal of providing 100 ac of oyster sanctuary in the Neuse River Estuary. This is alternative A3B3, which creates 40 sanctuary acres at the Mid-River area and 40 sanctuary acres at the North Shore area.

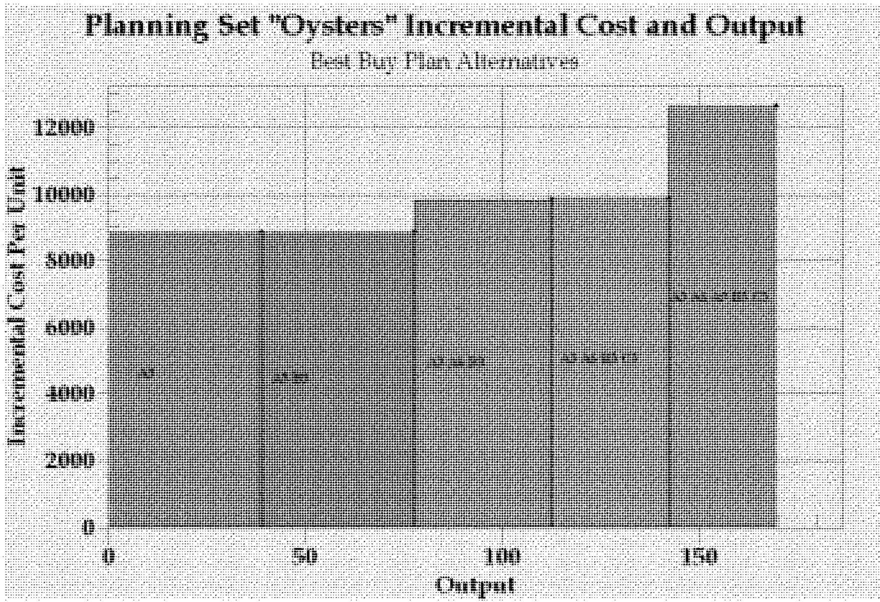


Figure 6-6. Incremental costs and benefits of Best Buy plans at Oyster Growing Area site.

Finally, the selected best buy alternatives (Table 6-1) were used to generate potential basin-wide alternatives. A letter code based on the site was used to represent each alternative. The basin-wide alternatives consist of every possible combination of one or more of the selected site alternatives. A CE/ICA was performed again on this array of Basin alternatives. The same costs and benefits that were used in the comparison of alternatives at each site were also used for this basin-wide alternatives CE/ICA. Figure 6-8 presents the best buy alternatives from this analysis.

Table 6-1. Basin-wide best buy alternatives (final array)

Site	Site Code	Description
Adkin Branch	A	Add in-stream woody debris, revegetate along 1,150 ft of bank length
Gum Thicket/ Cedar Creek	G	Build a 3,500 ft sill along Gum Thicket reach and 5,200 ft sill along Cedar Creek reach
East Wetland Complex at Kinston	K	Remove fill material from 14.5 ac of former bottomland hardwood forest
Ellerbe Creek	E	Create in-stream step pools through adding boulders and woody debris
Little River	L	Build a dam gate structure
Oyster Growing Areas	O	Create 40 ac of sanctuary in Mid-River site and 40 ac in North Shore site.

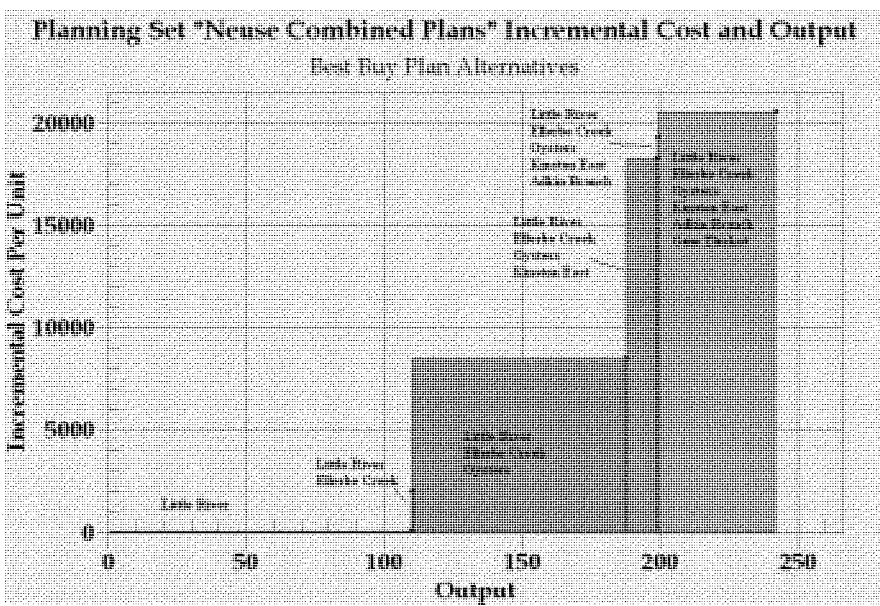


Figure 6-7. Final basin-wide best buy alternatives.

6.2 Comparison of Alternative Plans and Plan Selection

Further evaluation of the final array of best buy, basin-wide alternatives was used to demonstrate the positive and negative effects of various plans. The System of Accounts defined by the Principles and Guidelines (para. 1.6.2(c)) was used to compare plans. The four accounts used to compare proposed water resource development plans are the national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE) accounts.

The plans were compared with the planning opportunities and four formulation criteria suggested by the U.S. Water Resources Council. The criteria are completeness, effectiveness, efficiency, and acceptability.

- *Completeness*. Completeness is the extent to which an alternative plan provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. That could require relating the plan to other types of public or private plans if the other plans are crucial to achieving the contributions to the objective.
- *Effectiveness*. All the plans in the final array provide some contribution to the planning objectives. Effectiveness is defined as a measure of the extent to which a plan achieves its objectives.
- *Efficiency*. All the plans in the final array provide net benefits. Efficiency is a measure of the plan's cost-effectiveness expressed in net benefits.
- *Acceptability*. All the plans in the final array must be in accordance with Federal law and policy. Acceptability is defined in terms of acceptance of the plan by the non-Federal sponsor and the concerned public.

Table 6-2 presents a comparison of the system of accounts, planning opportunities, and formulation criteria for all the plans in the final array. The comparison in the table includes a modified Alternative 7. Alternative 7 was modified by removing the Ellerbe Creek and Adkin Branch components. The modified alternative is not a best buy, but it is a cost-effective plan. As shown in figure 6-7, the difference between Alternative 7 and modified Alternative 7 is negligible. The combined added benefit to the total output resulting from the selected alternatives at Ellerbe Creek and Adkin Branch is 0.7 habitat units. It was decided that less than one habitat unit of benefit would not meaningfully benefit the watershed or National Ecosystem Restoration goals. Additionally, the minimal size and costs of restoration at these sites could perhaps be adequately addressed at the local level. As a result, these two elements were not included as part of the TSP.

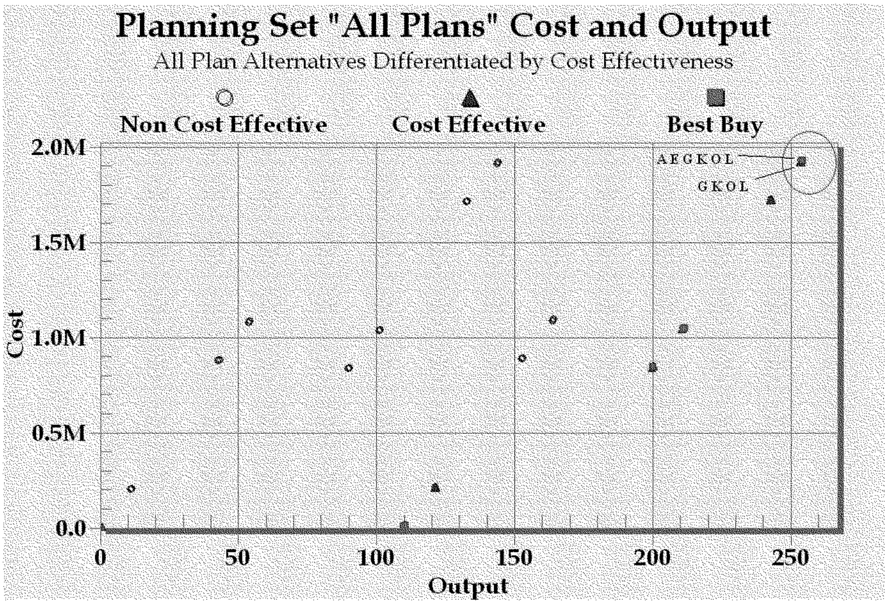


Figure 6-8. Scatterplot of all basin-wide alternatives considered.

Although plan GKOL (Gum Thicket/Cedar Creek, Kinston, Oysters, Little River) is not a best buy plan, it is a cost effective plan with slightly less cost and benefit output than AEGKOL (all the previous elements, plus Adkin and Ellerbe Creek sites), which is a best buy plan (figure 6-8).

Table 6-2. Neuse River Basin plan comparison. (Alternatives 1-7)

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 7modified
A. PLAN DESCRIPTION	No Action	Little River	Little River and Ellerbe Creek	Little River, Ellerbe Creek, and Oysters	Little River, Ellerbe Creek, Oysters, and Kinston East	Little River, Ellerbe Creek, Oysters, Kinston East, Adkin Branch	Little River, Ellerbe Creek, Oysters, Kinston East, Adkin Branch and Gum Thicket/Cedar Creeks	Little River, Oysters, Kinston East, and Gum Thicket/Cedar Creeks
	No Federal projects would be implemented.	The existing low-head dam (100-ft-wide, 4-ft-high concrete dam) on Little River near Goldsboro would be modified so that a section would be removed.	Alternative B and the creation of step pools at Ellerbe Creek using boulders and woody debris to create riffle and pool sequences.	Alternative C and expanding the existing Neuse Oyster Sanctuary by creating 40 sanctuary ac at the Mid-River area and 40 sanctuary ac at the North Shore The new reef would be constructed as elevated 4-ft-high flat plateau mounds with a minimum size of 1 ac. A 1-ac reef service area requires a 0.13-ac reef top area.*	Alternative D and restoration of a 14.5 ac riparian buffer on a site of a former bottomland hardwood that was filled	Alternative E and bank revegetation at the upper 200 ft of both stream banks and the lower 950 ft of the left bank and the addition of stream woody debris.	Alternative F, a rock sill approximately 7,200 ft long will be built at a distance of about 60 ft offshore of Gum Thicket Creek and Cedar Creek. Marsh planting would occur between the sill and the existing shoreline.	Alternative F minus Ellerbe Creek and Adkin Branch.
Totel area of wetlands restored (ac)	0	0	0	0	14.5	14.5	85.7	85.7
Total area of stream restored (ac)	0	509.2	510.1	510.1	510.0	512.3	512.3	509.2
Total oyster service area (ac)	0	0	0	80	80	80	80	80
Total area of constructed reef top (ac)	0	0	0	10.4	10.4	10.4	10.4	10.4
B. IMPACT ASSESSMENT								
1. Environmental Quality (EQ)								
Physical Environment								
Sediment and Erosion	The State's stream buffer rules are helping to stabilize stream banks in agricultural areas and in urban and suburban areas that will be developed in the future.	This altarnative would not influence sediment and erosion in the Neuse River Basin.	This alternative might decrease in-stream sediment transport in Ellerbe Creek.	This alternative might decrease in-stream sediment transport in Ellerbe Creek	This alternative might decrease in-stream sediment transport in Ellerbe Creek		This alternative might decrease in-stream sediment transport in Ellerbe Creek	This alternative would protect estuarine shoreline from erosion.
Flooding	Flood risks are thought to be low because of the FEMA buyouts that have already occurred. Nuisance flooding is expected to be managed by local agencies through stormwater programs.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.	Beyond Alternative A, no changes are expected from this alternative. The dam will be modified so that more water is passed during low flow periods. Additional components will not influence flooding.

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 7modified
Water Quality	The State's Nutrient Sensitive Waters Management Strategy and working being done by NCDWR would continue working to improve water quality.	None.	This alternative may have features that allow sediment to settle out into pools in Ellerbe Creek.	This alternative may have features that allow sediment to settle out into pools in Ellerbe Creek and the creation of oyster reef habitat will contribute to increased water clarity in the estuary.	This alternative may have features that allow sediment to settle out into pools in Ellerbe Creek and the creation of oyster reef habitat will contribute to increased water clarity in the estuary.	This alternative may have incidental benefits to water quality through features that allow sediment to settle out into pools in Ellerbe Creek and the creation of oyster reef habitat will contribute to increased water clarity in the estuary.	This alternative may have incidental benefits to water quality through protection of estuarine shoreline, features that allow sediment to settle out into pools in Ellerbe Creek and the creation of oyster reef habitat will contribute to increased water clarity in the estuary.	This alternative may have incidental benefits to water quality through protection of estuarine shoreline and the creation of oyster reef habitat (increasing the number of filter feeders in the estuary).
Biological Environment								
Freshwater Aquatic Habitat	Implementation of restoration by others might provide aquatic habitat where it does not currently exist.	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available.	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available.	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available and would create aquatic habitat in Ellerbe Creek (urban).	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available would create aquatic habitat in Ellerbe Creek (urban).	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available. would create aquatic habitat in Ellerbe Creek (urban) and Akin Branch streams.	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available, would create aquatic habitat in Ellerbe Creek (urban) and Akin Branch streams.	This alternative would allow access to 46 mi of potential spawning habitat during low flow periods where it is currently not available.
Riparian Habitat	Implementation of restoration by others might provide riparian habitat where it does not currently exist; riparian habitat is also likely to improve because of the State's stream buffer rules.	This alternative would not influence riparian habitat.	This alternative would not influence riparian habitat.	This alternative would not influence riparian habitat.	This alternative would not influence riparian habitat.	This alternative would improve riparian habitat along Adkin Branch.	This alternative would improve riparian habitat along Adkin Branch.	This alternative would not influence riparian habitat.
Wetland Habitat	Implementation of restoration by others might provide wetland habitat where it does not currently exist, but in many cases it might be used as mitigation to offset impacts in other areas.	This alternative would not influence wetland habitat.	This alternative would not influence wetland habitat	This alternative would not influence wetland habitat	This alternative would create wetland habitat at Kinston.	This alternative would create wetland habitat at Kinston	This alternative would protect wetland habitat in the estuary that might otherwise be eroded or change because of a change in salinity.	This alternative would protect wetland habitat in the estuary that might otherwise be eroded or change because of a change in salinity.
Estuarine Habitat	Little is expected to be done to protect or create estuarine habitat in this basin.	This alternative would not influence estuarine habitat.	This alternative would not influence estuarine habitat.	This alternative would create new oyster reefs that provide habitat for a variety of estuarine species.	This alternative would create new oyster reefs that provide habitat for a variety of estuarine species.	This alternative would create new oyster reefs that provide habitat for a variety of estuarine species.	This alternative would create new oyster reefs that provide habitat for a variety of estuarine species.	This alternative would protect estuarine habitat that might otherwise be eroded and would create new oyster reefs that provide habitat for a variety of estuarine species.
Cultural Environment								
Cultural Resources	Under the no action alternative, adverse impacts on cultural resources might occur at Gum Thicket and Cedar creeks because of the existing eroding shoreline.	No impacts on cultural resources are expected.	No impacts on cultural resources are expected.	No impacts on cultural resources are expected.	No impacts on cultural resources are expected.	No impacts on cultural resources are expected.	There could be a positive impact on cultural resources that otherwise would have eroded with the shoreline. Activities would be coordinated with the SHPO.	There could be a positive impact on cultural resources that otherwise would have eroded with the shoreline. Activities would be coordinated with the SHPO and North Carolina Underwater Archaeology Branch for oyster reef habitat.

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 7modified
Aesthetics	Aesthetics of the riparian corridor might improve in areas where others are conducting restoration.	No changes would occur with implementation of this alternative.	No changes would occur with implementation of this alternative.	No changes would occur with implementation of this alternative.	Aesthetics may improve as the bottomland hardwoods revegetate the Kinston East site.	Aesthetics may improve as the bottomland hardwoods revegetate the Kinston East site.	Aesthetics would improve because the shoreline would be intact at Gum Thicket/Cedar creeks and may improve as the bottomland hardwoods revegetate the Kinston East site.	Aesthetics would improve because the shoreline would be intact at Gum Thicket/Cedar creeks and may improve as the bottomland hardwoods revegetate the Kinston East site.
2. Regional Economic Development (RED)								
Impacts on employment	None.	None.	Construction costs might have a positive impact on employment	Construction costs might have a positive impact on employment	Construction costs might have a positive impact on employment.	Construction costs might have a positive impact on employment	Construction costs might have a positive impact on employment.	Construction costs might have a positive impact on employment.
Impacts on tax base	None.	None.	None.	None.	Potential.	Potential.	Potential.	Potential.
3. Other Social Effects (OSE)								
Create public facilities	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.	No public facilities would be created under this alternative.
Create opportunities for recreation and public access	No opportunities would be created under this alternative.	No opportunities would be created under this alternative.	No opportunities would be created under this alternative	No opportunities would be created under this alternative	No opportunities would be created under this alternative.	No opportunities would be created under this alternative.	No opportunities would be created under this alternative.	No opportunities would be created under this alternative.
Impact traffic and transportation	No impacts on traffic and transportation are expected.	No impacts on traffic and transportation are expected.	No impacts on traffic and transportation are expected.	No impacts on treffic and transportation are expected.	No impacts on traffic and transportation are expected.	No impacts on traffic and transportation are expected.	No impacts on traffic and transportation are expected.	No impacts on traffic and transportation are expected.
C. PLAN EVALUATION								
1. Environmental Outputs								
AAFU Benefit	0	110	110	188	199	199	242	241
2. Study Planning Objective								
Over the 50-year period of analysis, throughout the Neuse River Basin, conduct ecosystem restoration to improve biological integrity, hydrologic connectivity, wetland condition, and fish, oyster and mussel populations as measured by increases in functional units.	This alternative DOES NOT contribute to the study planning objective or meet any site specific objective.	This alternative DOES contribute to the study planning objective and meets 1 of 6 site specific objectives.	This alternative DOES contribute to the study planning objective and meets 2 of 6 site specific objectives	This alternative DOES contribute to the study planning objective and meets 3 of 6 site specific objective	This alternative DOES contribute to the study planning objective and meets 4 of 6 site specific objectives.	This alternative DOES contribute to the study planning objective and meets 5 of 6 site specific objectives	This alternative DOES contribute to the study planning objective and meets 6 of 6 site specific objectives	This alternative DOES contribute to the study planning objective and meets 4 of 6 site specific objectives.
3. Formulation Criteria								
Completeness	No.	Yes.	Yes	Yes	Yes.	Yes.	Yes.	Yes.
Effectiveness	No.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Efficiency	No	Yes.	Yes	Yes	Yes.	Yes.	Yes.	Yes.
Acceptability	No.	Yes.	Yes	Yes	Yes.	Yes.	Yes.	Yes.
Biodiversity Maintenance	None.	None.	None.	None.	None.	None.	None.	None.
Recreational Opportunities	None.	None.	None.	None.	None.	None.	None.	None.

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 7modified
Food	None.	None.	None.	None.	None.	None.	None.	None.
Fiber, Fuel, and other Raw Materials	None.	None.	None.	None.	None.	None.	None.	None.
Climate Regulation	None.	None.	None.	None.	None.	None.	None.	None.
Clean Air	None.	None.	None.	None.	None.	None.	None.	None.
Science and Education	Public education might be included as a component of the activities being handled by others.	None.	None.	There may be opportunities for public education, but none are planned at this time.	There may be opportunities for public education, but none are planned at this time.	There may be opportunities for public education, but none are planned at this time	There may be opportunities for public education, but none are planned at this time.	There may be opportunities for public education, but none are planned at this time.
Maintain Cultural Diversity	No changes would occur.	No changes would occur.	No changes would occur.	The location of oyster reefs and their designation as sanctuary should not impact existing local commercial and subsistence fishing practices; therefore unique coastal fishing communities should not be negatively impacted	The location of oyster reefs and their designation as sanctuary should not impact existing local commercial and subsistence fishing practices; therefore unique coastal fishing communities should not be negatively impacted	The location of oyster reefs and their designation as sanctuary should not impact existing local commercial and subsistence fishing practices; therefore unique coastal fishing communities should not be negatively impacted	The location of oyster reefs and their designation as sanctuary should not impact existing local commercial and subsistence fishing practices; therefore unique coastal fishing communities should not be negatively impacted	The location of oyster reefs and their designation as sanctuary should not impact existing local commercial and subsistence fishing practices; therefore unique coastal fishing communities should not be negatively impacted.
Aesthetics	Aesthetics of the riparian corridor might improve in areas where others are conducting restoration.	No changes would occur with implementation of this alternative.	Aesthetics may improve at Ellerbe Creek.	Aesthetics may improve at Ellerbe Creek and Kinston.	Aesthetics may improve at Ellerbe Creek and Kinston.	Aesthetics may improve at Ellerbe Creek and Kinston.	Aesthetics may improve at Ellerbe Creek, Kinston and, Gum Thicket/Cedar Creeks.	Aesthetics would improve at Kinston and, Gum Thicket/Cedar Creeks.
D. IMPLEMENTATION RESPONSIBILITY	None.	USACE with USFWS support.	USACE with USFWS support.	USACE, non-Federal sponsor, and potential local sponsor.	USACE, non-Federal sponsor, and potential local sponsor.	USACE, non-Federal sponsor, and potential local sponsor.	USACE, non-Federal sponsor, and potential local sponsor.	USACE, non-Federal sponsor, and potential local sponsor.
E. STATE OR OTHER NON-FEDERAL COORDINATION	None.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS and for cultural resources with the SHPO.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plan NCDWR.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plan NCDWR.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plan NCDWR.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plan NCDWR.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plen NCDWR.	Coordination has occurred throughout planning. Additional coordination would occur for threatened and endangered species with USFWS, Essential Fish Habitat with the NMF, cultural resources with the SHPO, water quality certification with the NCDWQ, and consistency with the Coastal Zone Management Plan NCDWR.
F. RISK EVALUATION								
Risk of Failure	None.	Little, because this is a modification to an existing structure.	Little. There is a level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	Little. There is a level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	Little. There is a level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	Little. There is a level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	Little. There is a level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	Little. Thera is e level of uncertainty regarding risk of failure because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decreese the potential for uncertainty.

Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 7modified
Residual Risk	None.	None.	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.	There is a level of residual risk because of the impact of catastrophic storm events; however, the experience of successful projects was considered in design to decrease the potential for uncertainty.
Reliability	None.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.	Yes. Successful project implementation was considered in design to account for potential for uncertainty.
Relative Sea Level Rise	None.	None.	None.	The guidance set forth in EC 1165-2-211 was used in the structural design, resiliency, and integrity of the engineering structures	The guidance set forth in EC 1165-2-211 was used in the structural design, resiliency, and integrity of the engineering structures.	The guidance set forth in EC 1165-2-211 was used in the structural design, resiliency, and integrity of the engineering structures	The guidance set forth in EC 1165-2-211 was used in the structural design, resiliency, and integrity of the engineering structures.	The guidance set forth in EC 1165-2-212 was used in the structural design, resiliency, and integrity of the engineering structures.
Risk of Ecosystem Damage	None.	None.	None	None	None.	None.	None.	None.
Risk to Life and Safety	None.	None.	None	None	None.	None.	None.	None.
Risk to Mental and Physical Health	None.	None.	None	None	None.	None.	None.	None.

6.3 Rationale for Designating the National Ecosystem Restoration Plan

The National Ecosystem Restoration (NER) Plan is the plan that reasonably maximizes ecosystem restoration benefits at an incremental cost [ER 1105-2-100 E-3b. (2)] and is acceptable to the USACE and local sponsor. On the basis of the comparison of alternatives in Table 6-2, that the modified alternative 7 maximizes beneficial ecosystem effects for the costs. That alternative creates opportunities to improve biological integrity, improve freshwater mussel populations, improve anadromous fish populations, restore emergent wetlands, and increase the quantity and quality of oyster reef habitat. The objectives that this alternative meets are the following:

- ***Gum Thicket and Cedar Creek Alternative.*** Prevent erosion of about 60 ac of existing estuarine wetland at the Gum Thicket and Cedar Creek sub-estuaries and create up to 6 ac of additional estuarine wetland in the area, thereby increasing estuarine wetland output (as measured by NC WAM) in the watershed over the 50-year project life. Stabilizing 3,500 ft of shoreline at Gum Thicket Creek and 5,200 ft of shoreline at Cedar Creek would restore estuarine shoreline and maintain coastal wetland conservation easement, where no development is allowed, that would otherwise be lost to erosion into the future.

- ***Kinston East Wetland Restoration Alternative.*** Improve wetland function in the watershed and improve connectivity between existing tracts of bottomland hardwood forest over the 50-year life of the project by restoring 14.5 ac of bottomland hardwood forest at the Kinston East Wetland Complex.

- ***Low-head dam on the Little River Alternative.*** Restore habitat connectivity for 46 mi of important spawning habitat for anadromous fish species between the Neuse River estuary and freshwater streams. Species that rely on habitat structure from the Neuse River Estuary upstream would be allowed access to additional features in the estuary and more than 100 mi upstream from the estuary into Little River, a tributary to the Neuse River. These opportunities would be provided through the modification to the low-head dam on Little River at Goldsboro. An additional 46 mi of in-stream habitat would be gained in the Little River.

- ***Oyster Reef Restoration Alternative.*** In the Neuse River Estuary, restore 80 ac of estuarine /oyster reef habitat (reef structure and benefited adjacent soft bottom as discussed in Section 8.3.2(3)). This alternative includes reef construction and protection of the restored habitat areas as state-designated sanctuary to preclude bottom disturbing fishing practices (oyster dredging and trawling). The goals set by the ORSC for the Neuse River Estuary would come close to being met by constructing approximately 10 ac of new oyster reef top (22 ac of reef bottom), supporting 80 ac of state managed oyster reef sanctuary.

6.3.1 The Locally Preferred Plan

The Locally Preferred Plan (LPP) is the plan that differs from the NER plan and, in the opinion of the state and local sponsors, best meets the needs of the local community. To date, the state and potential local sponsors have not identified an LPP.

6.3.2 Rationale for Designation of the Recommended Plan

The Recommended Plan is the NER plan. As defined by Table 6-2, a modification to Alternative 7 was selected as the NER Plan. Alternative 7 reasonably maximizes ecosystem restoration benefits and is cost-effective and justified to achieve the desired level of output; therefore, the TSP is the NER Plan. The TSP includes the following components:

- Modifying low-head dam on Little River near Goldsboro,
- Kinston East Wetland Restoration complex,
- Stabilizing Gum Thicket Creek and Cedar Creek, and
- Constructing new oyster reef habitat.

The TSP also addresses components of the CHPP (Street et al. 2005) by:

- Greatly expanding habitat restoration, by:
  - Constructing 80 ac of new oyster reef sanctuaries, and
  - Reestablishing stream hydrology by creating connectivity of 100 mi between the Neuse River Estuary and the Little River,
- Protecting SAV and 240 ac of wetland conservation easement in and adjacent to Gum Thicket and Cedar Creek by stabilizing estuarine shoreline to provide a protective buffer.
- Protecting fish habitat by stabilizing eroding estuarine shoreline. and
- Protecting and enhancing habitat for anadromous fishes by eliminating obstructions to fish movements.

6.4 Risk and Uncertainty

Areas of risk and uncertainty have been analyzed and are described so that decisions can be made with some knowledge of the degree of reliability of the estimated benefits and costs of alternative plans (ER 1105-2-100 para. E-4). Risk is defined as the probability or likelihood for an outcome. Uncertainty refers to a lack of knowledge. Uncertainty about the likelihood for an outcome results from a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes.

The PDT worked to manage risk in developing measures. It developed measures by expanding on and referencing successful similar work completed by the USACE Wilmington District and others on adjacent/nearby stream or shoreline segments or oyster reefs. The team used that experience from previous projects to identify possible risks and decrease uncertainty in plan formulation. No measures in the TSP are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed habitats.

Significant risk would be avoided by proper design, appropriate site selection, and correct seasonal timing of biotic applications. Risk associated with wetland revegetation would be reduced by using plant species common to the area from local sources. Unforeseen temporary perturbations during habitat establishment would be addressed by making allowances for replanting during the biotic establishment period. The dynamic and complex nature of coastal environmental processes is a principal source of uncertainty. The will continue to work to reduce the risk associated with oyster reef construction by refining the exact site selection to areas that contain existing sustainable reefs and with optimal water quality modeling conditions as identified through modeling efforts. Post-construction adaptive management would be used to address unplanned outcomes in the oyster restoration component.

For oyster reef restoration specifically, a contingency plan (adaptive management) would be developed for low spat set (oyster larvae that have settled on the reef) that includes additional seeded or unseeded cultch. If elevation concerns arise because of settling and the reefs are too low in the water column where they could be affected by water quality, more rock could be added. Sampling was conducted and assessment tools were developed to decrease uncertainty. Areas of the new oyster reef habitat were monitored or modeled or have existing sanctuary. The Mid-river sites have had extensive physical and biological sampling by the USACE, contain modeled reference reefs and, therefore, pose a low potential risk of failure. A potential concern is that local shrimpers could fish the Mid-river sites in the OGA. The proposed 40 ac Mid-river sanctuary site is less than 0.04 percent of the Neuse River Estuary OGA. The exact location of Mid-river oyster reef sanctuaries would be coordinated with local fishermen before finalizing this report to minimize conflicts with shrimp fishermen.

The North Shore site was identified after biological sampling. Modeling on the basis of water quality parameters indicates high potential for success in this area of the Neuse River Estuary. Additional sampling and side scan would be required during preconstruction engineering and design (PED) to identify reference sites, and confirm avoidance of existing reef and SAV.

As a result of low risk and uncertainty, no other opportunities for adaptive management have been identified at this time.

6.5 Risk and Uncertainty in the Environmental Benefits Analysis

The EBA relied on several simplifying assumptions, particularly with regards to the NC SHEM model, to forecast benefits over a 50-year time frame. Some of the assumptions may underestimate benefits, while others might overestimate benefits. Because of that, some level of risk and uncertainty is associated with the EBA. For instance, at the Ellerbe Creek site, modifying the channel by adding meanders was assumed to only affect the Channel Modification variable in NC SHEM. In reality, modifying the channel could also positively affect other variables, such as Pool Variety and Riffle Habitats, which would increase the benefits associated with the measure. On the other hand, with Adkin Branch and Ellerbe Creek, using a simple linear recovery rate and assuming that benefits would remain static once they are maximized could overestimate benefits. For instance, if habitat recovery occurs in a more stepwise fashion, or if the habitat quality again declines at some point (due to either project failure, which is common in stream restoration efforts, or other unforeseen circumstances), the benefits reported could be overestimated. A risk also exists that the methodology used to measure benefits at the Little River site could lead to an overestimation of benefits. The NC SHEM method measures general stream habitat quality; however, only anadromous fish are directly benefiting from the dam modification measures.

Some risk and uncertainty also exists with regards to the NC WAM methodology, which could affect the measurement of benefits for the Gum Thicket site. Because the PDT assigned numerical values to qualitative ratings (i.e. High = 1.0), there is a risk that benefits are overestimated if a high score actually corresponds to a numerical rating less than 1.0.

Even if all these factors were accounted for, they would not alter the formulation or selection of the TSP. To illustrate, Figure 6-9 shows a CE/ICA analysis where the benefits of the selected Adkin alternative are doubled (from 0.3 to 0.6), the benefits of the selected Little River alternative are halved (from 110 to 55). The benefits from Gum Thicket and Kinston were recalculated assuming a High rating of 0.8 rather than 1.0 in the benefits calculation, which reduced the benefits at each of those sites by about 20 percent (from 42.2 to 33.8 units at Gum Thicket and 11 to 9 units at Kinston). Benefits for the Ellerbe Creek site were not modified in this analysis, because there is less risk of the benefits of the selected plans being affected by the uncertainties described above.

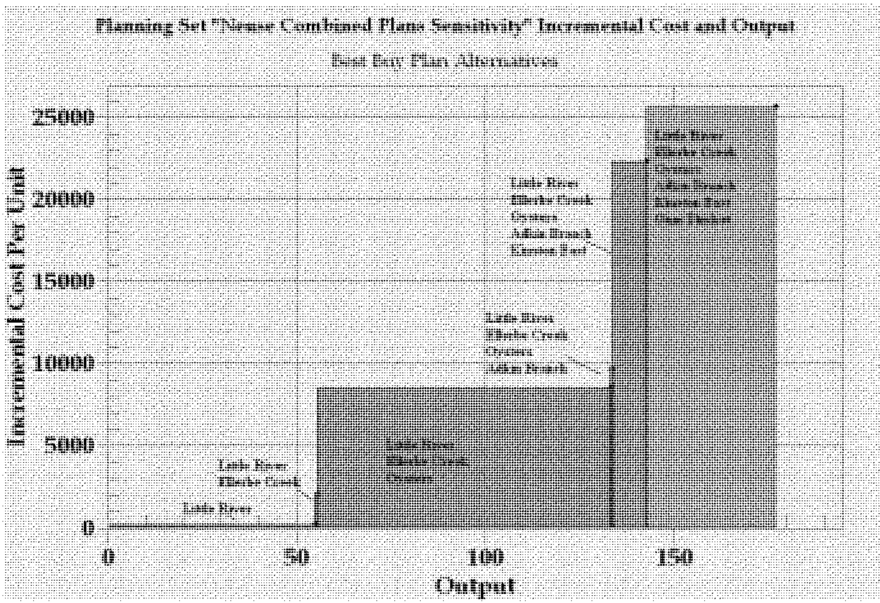


Figure 6-9. CE/ICA sensitivity analysis run on combined plans.

6.6 Risk and Uncertainty with Sea Level Rise

Accelerated sea level rise is expected to impact only one part of TSP, which is the Gum Thicket/Cedar Creek site. The potential effects of elevated sea level rise on erosion rates at the site are detailed in the preliminary design appendix (Appendix P) of this report. Currently, North Carolina's coastal wetlands are relatively stable. However, accelerated rates of future sea level rise may lead to drowning scenarios of North Carolinas tidal coastal wetlands. Predictions in this case can be inferred from wetland response to sea-level changes in the recent past (Spaur and Snyder, 1999). It is estimated in the without project condition, at the Gum Thicket reach up to 450 ft of erosion could occur under the historical rate of sea level rise, 671 ft of erosion could occur under curve 1 and up to 1,381 ft of erosion could occur under curve 3 over the 50 year period of analysis. At the Cedar Creek reach, 100 ft, 149 ft and 306 ft of erosion could occur under historical sea level rise and curves 1 and 3, respectively, over the 50 year period of analysis. Since the environmental benefits of the TSP were based on erosion occurring at the historical rate of sea level rise, this means that the environmental benefits from the plan would actually increase with the accelerated sea level rise scenarios. Average annual habitat benefits for the TSP at Gum Thicket/Cedar Creek under curve 1 are estimated at 52.7 habitat units (a 10.0 habitat unit increase as compared to the historical sea level rate). Under curve 3, the sill at its current design height would begin to be overtopped at around year 25 of the period of analysis, allowing for erosion to begin occurring again at the site. The amount of erosion that would occur at that stage cannot be quantified with the existing data on hand, although it would be less than the erosion rate in the absence of the sill. However, for the purposes of the benefit calculation, it was assumed that the erosion rate at year 25 would be the same as the without project rate. This provides a conservative estimate of benefits that would occur under curve 3. Average annual habitat benefits for the TSP at Gum Thicket/Cedar Creek under curve 3 is therefore estimated at 53.4 habitat units (a 10.7 habitat unit increase as compared to the historical sea level rate, and 0.7 increase compared to curve 1). The calculation of benefits under both curves is contained in Appendix K – Streams and Wetlands Environmental Benefits Analysis.

7.0 DESCRIPTION OF THE RECOMMENDED PLAN

The Recommended Plan includes restoration of various habitats throughout the Basin (Figure 7-1). The following description of plan components begins in the upstream portion of the Neuse River and moves downstream into the Neuse River Estuary. As previously stated, actions implemented throughout the watershed enhance the health of the overall Basin. Success in providing suitable aquatic habitat conditions in the overall watershed would begin by improving conditions for anadromous fish and freshwater mussels by removing obstructions and restoring connectivity to once-unavailable habitat and by providing habitat in the estuary for species to begin their journey upstream through restoring emergent wetlands and constructing oyster reef habitat.

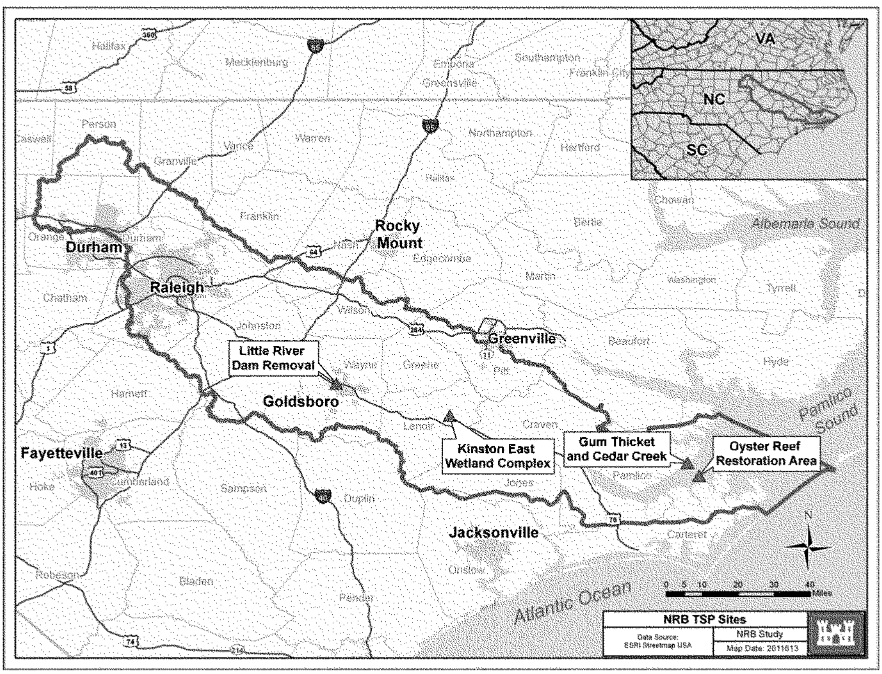


Figure 7-1. Components of the TSP.

Modifying Low-head Dam on Little River near Goldsboro. To restore connectivity, an approximately 20-ft section of the existing 100-ft-wide, 4-ft-high concrete dam would be removed. A hydraulic gate or a stop log structure would be installed in the 20-ft opening. The gate in the existing dam would remain open during the anadromous fish migration season (i.e., about January to May). During low-flow conditions (i.e., July to September), Goldsboro would close the gate to ensure sufficient water from their secondary water intake structure; design would ensure that the water intake structure and its ability to withdraw water is not impaired.

Kinston East Wetland Restoration Alternative. The Kinston East Wetland Complex consists of about 30 acres in Kinston and it is located within the Neuse River floodplain. About 14.5 acres of this 30 ac property has been previously filled and is no longer functioning as a bottomland hardwood wetland area and no longer provides flood storage capacity. This earlier fill activity in this 14.5 acre tract resulted in the destruction of a bottomland hardwood wetlands that was vegetated with 30 to 60 year old blackgum (*Nyssa sylvatica*), elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and cypress (*Taxodium distichum*). Currently the 14.5 acre previously disturbed area consists of 4.3 acres of open grassed area, 1.2 acres of an excavated pond, 9.0 acres of less than 10-year old (less than 3-inches DBH) loblolly pine (*Pinus taeda*) and sweeetgum (*Liquidambar styraciflua*). This 14.5 acre proposed restoration site is bordered on the east, west, and south by mature bottomland hardwoods wetlands within the Neuse River floodplain. There are two shallow perimeter ditches on the east and west side of the tract. These two shallow perimeter ditches are connected to the river but don't affect the elevation of the water table of the adjacent bottomland hardwoods.

Stabilizing Gum Thicket Creek and Cedar Creek. This component includes measures at both Gum Thicket and Cedar Creeks. The parallel-rock sills approximately 3,500 ft long at Gum Thicket Creek and 5,200 ft long at Cedar Creek would be built at distances of about 60 ft offshore. Constructing the rock sill would create new marsh after initial planting with *Spartina* species to create a living shoreline consisting of planted and open-water areas.

The rock sill would have a 30 ft bottom width. It would be mostly submerged with a 3.5 ft-wide top elevation set at about 2 ft above mean sea level. The structure would be made of limestone or granite rock, or both and would be pervious to fluctuating water levels. Openings would be provided every 100 ft along the sill length and at the creek mouth to facilitate movement of water, nekton, and plankton, in and around the project.

Constructing New Oyster Reef Habitat. This component includes constructing about 10 acre of new elevated reef top within an 80 acre service area that would be demarcated by corner buoys and managed as oyster sanctuary by the State of North Carolina. Two locations have been tentatively selected including a Mid-river site in the lower estuary and a site on Neuse Northern Shore. Reef development of those areas would contribute to ongoing state efforts to offset historic reef loss in the Neuse River and Albemarle Pamlico Estuary. Each site would contain a matrix of several flat-top plateaus about 4 ft high and 1 acre in size.

7.1 Design and Construction Considerations

The following design and construction considerations should be maintained throughout implementation of the Recommended Plan. Specific staging areas for the contractor's equipment (i.e., earth-moving equipment, stockpile of supplies, office trailer) are not currently known for all Recommended Plan areas. The Wilmington District will identify those areas that minimize environmental impacts during PED. Wilmington District will be responsible for obtaining any required clearances for the proposed staging sites. If the contractor does not want to use the staging area that the USACE, Wilmington District will identify adjacent to the project site, the contractor would be responsible for obtaining any required clearances for any new staging sites. However, the USACE, Wilmington District must approve the contractor's selected staging areas.

Modifying Low-head Dam on Little River near Goldsboro. Coordination with USFWS and state experts would be maintained throughout the design and construction of modifications to the low-head dam to ensure that fish would be able to migrate upstream during low-flow periods. Given the location of this site adjacent to the existing Goldsboro water treatment plant, the contractor would use a proposed 2 acre upland staging area, adjacent to the dam. A large portion of the proposed upland staging area is asphalt/concrete covered, with the remainder being grassed with lawn species (i.e., St. Augustine, bahia, etc.). No woody vegetation would be removed, cleared, or grubbed. Since no fill material will be placed in any waters of the Little River, borrow areas would not be required.

Design would also ensure that the city's upstream secondary water intake structure, and their ability to withdraw water, is not impaired. Under low-flow conditions, the height of the notched low-head dam provides sufficient water for the City's upstream secondary water intake. Removal or further lowering of the dam would impair the water intake during low-flow conditions. However, this modification with inclusion of a gate would be designed so that the upstream water intake has sufficient water during low-flow conditions.

The projected sea level rise for the 50 year project life would not affect this project. The dam site on the Little River is more than 60 mi upstream of the tidal saltwater influence at or just above New Bern (Giese et al. 1979). Moreover, the Goldsboro Dam (75 ft) is approximately 65 feet higher in elevation than the City of New Bern (10 ft).

Kinston East Wetland Restoration Alternative. The grade of the 14.5 acre site was apparently raised with hauled-in fill material in preparation for development, but the project did not go forward. The proposed measures consist of regrading the site to the approximate elevation of the adjacent bottomland hardwood forest and allowing natural revegetation of the site by bottomland hardwood species without replanting. The construction contract would be set up in sections. The contractor would be allowed to have limited portions of the site disturbed at any one time. Starting nearest the river and working north toward Lincoln Street, each area would be cleared, grubbed, and brought to final grade, and seeded with either permanent or temporary grass varieties depending on the time of year. During the regrading process and until stabilization with a permanent cover of grass is achieved, sediment control devices will be used to prevent sediment from leaving the site. During the next phase of work, a topographic survey of the proposed restoration area should be accomplished. While there is no indication of any soil contamination, this will be verified.

Stabilizing Gum Thicket Creek and Cedar Creek. Both the shoreline stabilization and marsh creation at Gum Thicket and Cedar Creeks would be affected by sea level rise. The project is designed based upon a historical rate of sea level rise.

In designing and constructing the rock sills, it was important to consider the height above high tide. If during the planting of *Spartina* species the rock sill is overtaken by waves, the planted marsh might be washed out. Fill material for shoreline restoration landward of the rock sills might be available from the adjacent landowner. To reduce risks from potential accelerated sea level rise on the plantings, marsh restoration would include both low and high marshes allowing upslope mitigation of low-lying marshes. The sill design accounts for the historical rate of sea level rise applied over 50 years. A land-based staging area would be necessary to temporarily store materials and transfer them from highway equipment to off-road construction equipment. The Gum Thicket/Cedar Creek shoreline stabilization project is adjacent to land under development where construction crews have already established a 3 acre staging area. Available use of this area would be expected for construction staging during the project. The majority of the staging area is currently cleared of vegetation and is being used as a sediment stockpile area for the development. No woody vegetation would be removed, cleared, and/or grubbed. A nearby existing commercial borrow area would be used for the proposed rock for the offshore sill and sand material that would be placed landward of the offshore sill for the planted marsh feature.

Constructing New Oyster Reef Habitat. The new oyster reefs will be designed and constructed as elevated, flat-top features to avoid bottom hypoxia and maximize the surface area of the management measure. Rock for proposed construction would come from commercial quarries.

Construction staging for the reefs would occur from barges in open water. Two staging areas are proposed for this component—the state's existing cultch staging facility at South River and existing state-owned lands under and adjacent to the western end of the New Hobucken Bridge. The bridge site has disturbed lands under the bridge and would incorporate the old road access to the replaced swing bridge. Land use for staging would not have unacceptable adverse impacts. A nearby existing commercial borrow area would be used for the proposed rock.

Sea level rise would not adversely affect this project. The deep water reefs would be at depths of 15-20 ft below the water surface in areas where salinity already fluctuates throughout the year. Salinity fluctuations at the depth of new reefs would be expected to increase on a yearly average but would not exceed acceptable levels.

7.2 Avoidance Measures or Environmental Commitments for the Recommended Plan

The Recommended Plan consists of the modifying the low-head notched dam on the Little River, stabilizing the shoreline of Gum Thicket and Cedar Creek, and constructing new oyster reef habitat.

Kinston East Wetland Restoration Alternative. Care will be taken to protect adjacent wetlands so that they are not impacted by during constriction. Avoidance measure would include installation of high visibility fence to identify clearing limits protecting adjacent bottomland forest. This project would require a sediment and erosion control plan. BMPs would be used during construction to minimize or eliminate any adverse environmental effects from runoff. Selected BMPs would be site-specific silt barriers, such as silt curtains. Excavated material will be hauled off site and disposed in approved commercial landfill or other appropriate, previously disturbed upland site.

Stabilizing Gum Thicket and Cedar Creek. During preconstruction engineering and design (PED), the Corps will conduct additional sampling and surveys at these sites to ensure that any existing oysters, SAV's and cultural resources are not adversely impacted by project design. Avoidance measures would include identification and protection of wetlands and other resources located in and adjacent to construction areas to the degree practical. BMPs would be used during construction to minimize or eliminate any adverse environmental effects from runoff. Selected BMPs would be site-specific silt barriers, silt curtains, floating silt curtain, or other silt protectors to contain sediment in water and overland. All fill material will be sand or rock.

Modifying Low-head Dam on Little River near Goldsboro. Impact avoidance measures include timing construction to avoid the anadromous fish spawning season, and use of BMPs during construction to minimize or eliminate any adverse environmental effects. Selected BMPs would be site-specific silt barriers, silt curtains, floating silt curtain, or other silt protectors to contain sediment in water and overland.

Constructing New Oyster Reef Habitat. Avoidance measures will require that placement areas are surveyed using side scan sonar prior to final site selection to assure avoidance of SAV or existing shell bottoms. BMPs would be used at staging areas during construction to minimize or eliminate any adverse environmental effects. Selected BMPs would be site-specific silt barriers, silt curtains, floating silt curtain, or other silt protectors to contain sediment in water and overland.

7.3 Real Estate Requirements

The requirements for lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERRDs) should include the rights to construct, maintain, and repair bank protection works and the right to construct new oyster reef habitat in the Neuse River Estuary. Components of the project can be constructed under the standard Temporary Work Area Easement, the standard Bank Protection Easement and the standard Borrow Area Easement. A Real Estate Plan is included as Appendix M. The real estate requirements at each geographic site follow.

All sites can be accessed by public roads. Eight landowners would be affected. It is estimated that real estate could be acquired within 12 months. Real estate cost including land value and administrative cost is estimated at $257,000.

Modifying Low-head Dam on Little River near Goldsboro. Project construction for modifying the low-head dam would be accomplished on property owned by the City of Goldsboro and used as a water treatment plant. Sufficient area for a staging area exists as well. The land requirement is .09 of an acre in Temporary Work Area Easement for this alternative.

Kinston East Wetland Restoration complex. The Kinston site construction would be on private lands for the project construction and will impact 27.50 acres of which 14.50 acres will be excavated. The full 27.50 acres will be subject to fee simple acquisition.

Staging will be on 2.40 acres of land owned by the City of Kinston.

Stabilizing Gum Thicket Creek and Cedar Creek. Stabilizing Gum Thicket and Cedar creeks would require approximately 23.7 acres in Bank Protection Easement, 6 acres in Borrow Area Easement and 1.5 acres in Temporary Work Area Easement for a staging area. The staging area would be in previously disturbed area associated with adjacent development and serve for construction of the project at Gum Thicket and Cedar Creek.

Constructing New Oyster Reef Habitat. For the new reef habitat, a permit would be required from North Carolina. A staging site of approximately 1.5 acres would be required for this alternative. Although all construction for this project component would take place in the water, a land-based staging area would be necessary to transfer materials from land to barge. Two staging areas are proposed for this component—the state's existing cultch staging facility at South River or existing, state-owned lands under and adjacent to the western end of the New Hobucken Bridge. The bridge site has disturbed lands under the bridge and would incorporate the old road access to the replaced swing bridge.

7.4 Operation, Maintenance, Repair, Replacement, and Rehabilitation Considerations

Specific OMRR&R requirements will be specified in an Operation and Maintenance Manual to be provided to the Sponsor upon completion of construction. The following discussion provides considerations for operation, maintenance, repair, replacement, and rehabilitation for the Neuse River Basin

Cost sharing for implementation of this ecosystem restoration project will be 65 percent Federal and 35 percent non-Federal. The Sponsor (State of North Carolina) will provide all lands, easements, relocations, rights-of-way, and disposal or borrow areas (LERRD) required for construction and subsequent maintenance. The non-Federal cost share is summarized in Table 10-2 (Section 10) and consists of credit for LERRD and sufficient cash and work-in-kind (WIK) credit to equal the 35 percent cost share. As shown in Table 10-2, no WIK has been negotiated with the Sponsor to date, but Sponsor capabilities and construction responsibilities may be pursued during detailed project design. If LERRD credit were to exceed the 35 percent cost share, the Sponsor would be reimbursed for the excess. However, for this project, estimated LERRD credit is less than one percent of estimated implementation costs.

The project will be monitored after construction to assure the project is performing as anticipated and is providing the intended benefits. Monitoring and adaptive management costs during this period (as needed and not to exceed ten years) are included in cost shared, implementation first costs discussed above.

The Sponsor will assume responsibility and all costs for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project. OMRR&R for the various project sites may be required as described below and at an estimated costs as shown in Table 7-1. OMRR&R requirements will be specified in an Operation and Maintenance Manual to be provided to the Sponsor upon completion of construction.

Modifying Low-head Dam on Little River near Goldsboro. Maintenance will be required on the low head dam to maintain sufficient depth for operation of the water treatment plant intake structure. Floating debris will need to be removed from the proposed water control system installed on the dam (stoplogs) to allow unimpeded operation of the stoplogs. Repair may be required on the proposed stoplogs or access walkway. For purposes of estimating maintenance costs, it is assumed that one third of the water control system and the access walkway would need replacement after 25 years.

Kinston East Wetland Restoration Complex. It is not expected to require any maintenance or repair.

Stabilizing Gum Thicket Creek and Cedar Creek. No long-term operational needs would be required.

Stone Sill – Maintenance may be required if deficiencies are found during Sponsor inspections that would compromise protection of the bank or vegetation. Maintenance would normally involve placement of additional stone or shifting of the existing stone to bring the top of sill up to an acceptable elevation. For the purposes of estimating maintenance costs, it is assumed that 400 linear feet of the stone sill would require an additional layer of 500 pound granite armor stone after 25 years.

Marsh Plantings – In certain conditions, the marsh plantings could become damaged to a point where natural recovery would not take place and shoreline is eroding. In some cases a small amount of earthen fill would be required to provide a substrate for the marsh plantings. For purposes of estimating maintenance costs, it is assumed that 0.2 acres of the marsh planting would require additional fill and plant replacement after 25 years. If Phragmites or other state listed noxious aquatic plants are found within the restoration areas during the vegetation establishment period, chemical control will be conducted as needed to allow appropriate establishment of target vegetation. Herbicides proposed for use would be registered by the U.S. Environmental Protection Agency. Application would be made in accordance with label restrictions by a licensed applicator.

Constructing New Oyster Reef Habitat. Oyster habitat is not expected to require any maintenance or repair, however marker buoys will require replacement every two years. The option of using 3-legged piles in lieu of buoys will be considered during PED. If incorporated in the plan, this option could reduce OMRRR costs.

Table 7-1. Cost Estimate for OMRR&R

Restoration Component	Cost for OMRR&R
Modifying Low-head Dam on Little River near Goldsboro	One time cost of $60,000 at year 25
Kinston East Wetland Restoration Complex	$0
Stabilizing Gum Thicket Creek and Cedar Creek	One time cost of $330,000 at year 25
Constructing New Oyster Reef Habitat	$12,000 every other year for 50 years for a total of $150,000

7.5 Monitoring and Adaptive Management

A feasibility level monitoring and adaptive management plan has been developed for the project (Appendix Q). This plan was developed to include a sufficient description of the proposed monitoring and adaptive management activities necessary to identify the nature of possible adaptive management needs and to estimate the costs and duration of the monitoring activities.

In accordance with Section 2039 of WRDA 2007, the Recommended Plan includes a monitoring plan to determine if the project outcomes are consistent with the original project goals and objectives. The monitoring plan (Appendix Q) provides a description of the monitoring activities, the criteria for success, the estimated cost and duration of the monitoring. Monitoring durations are habitat specific and allow for establishment target habitats and would continue until success criteria have been met. Monitoring costs would be considered a project cost for up to 10 years after project construction (or a component of a project). Any additional monitoring required beyond 10 years would be a non-Federal responsibility.

The monitoring also identifies specific monitoring components necessary to identify the need for adaptive management of specific project components. The power of this monitoring plan to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management. The primary incentive for implementing adaptive management is to increase the likelihood of achieving desired project outcomes in the face of uncertainties. Monitoring activities are summarized in Table 7-2 below.

Table 7-2. Summary of Project Monitoring Components

Site	Monitoring Component		
	Structural Persistence	Biological Persistence	Success Criteria
Oyster Reefs	Extent of reef mapped and quantified	Abundance of oysters Size class distribution of oysters* Percent coverage of fouling organisms* Presence of predators*	At least 25 oyster /m^2 at year 5 (combined all size classes) > 80% of the restored footprint at year 5
Kinston East Complex	Topography	Tree density and diversity DBH*	> 80% of the restored footprint at year 10. 260 trees per acres at year 10 with at least 5 species including a mix of Oaks, and or Cypress and or Gum present.**
Gum Thicket Cedar Creek	Topography	Species composition and percent cover Assessment of invasion by exotic non-native plants such as Phragmites*	80% cover of *Spartina alterniflora* and *S. patens* in appropriate landscape positions.
Little River Dam	Visual inspection of river connection		Retain 80% of the design cross section of 60 sq. ft. at year 5

Note: *Supporting metrics; ** Tree species and densities to be confirmed by survey of adjacent reference forest during PED.

For the Neuse River Basin an opportunity for possible adaptive management actions exists with the oyster restoration component of the plan.

Monitoring related to the uncertainties associated with the oyster reef component would include a three-year oyster establishment period and an additional two years of post-construction monitoring to ensure that the project is functioning as designed. The monitoring plan would include measureable success criteria and associated supporting metrics for spat set, oyster survival, and reef stability. It objectives are not being met, adaptive management could include placement of seeded cultch if natural spat attachment does not occur or numbers are too low to produce a sustainable population.

The cost estimate for monitoring is $312,000 and adaptive management activities is $354,000 (Table 7.3)

Table 7-3. Summary of Costs.

Monitoring Component	First Cost (Oct 2013) 10 years ($1,000s)
Oyster Reef Restoration	**$ 118.0**
Kinston East Wetland Complex	**$ 41.0**
Gum Thicket and Cedar Creek	**$ 147.0**
Little River Dam Removal	**$ 6.0**
Total Monitoring Cost	**$ 312.0**
Adaptive Management	**First Cost (Oct 2013) 10 years ($1,000s)**
Oyster Reef Restoration	**$ 354.0**

7.6 Cost Summary

The estimated total first cost for the Recommended Plan is $35,775,000 based on 2013 (October 2012) price levels. The fully funded project cost is $37,962, escalated from an estimated construction initiation date of FY15 (October 2014) (Table 7.4).

Table 7-4. Summary of Costs.

Item	First Cost ($1,000s)	Fully Funded ($1,000s)
PED	$ 2,960	$ 3,072
Construction Management	$ 3,001	$ 3,364
Lands & Damages	$ 254	$ 259
Fish and Wildlife Facilities		
Little River Dam near Goldsboro	$ 526	$ 556
Kinston East Wetland Complex	$ 3,885	$ 4,110
Gum Thicket and Cedar Creek	$ 13,930	$ 14,735
Oyster Restoration	$ 11,218	$ 11,866
Total Project Cost	$ 35,774	$ 37,962

8.0 ENVIRONMENTAL EFFECTS OF THE NO ACTION ALTERNATIVE AND THE RECOMMENDED PLAN AND ALTERNATIVES

This section describes the probable consequences (impacts and effects) of the No Action Alternative and the four components of the Recommended Plan on significant environmental resources in the Neuse River Basin. The four components of the Recommended Plan are:

- Modifying Low-head Dam on Little River near Goldsboro
- Kinston East Wetland Complex
- Stabilizing Gum Thicket Creek and Cedar Creek
- Constructing oyster reefs in the lower Neuse River Estuary

Table 8-1 summarizes the potential effects of the No Action Alternative and the four components of the Recommended Plan, or Preferred Alternative, on resources in the Basin.

Table 8.1. Summary of Significant In-Basin Resources Impacted.

	ENVIRONMENTAL EFFECTS								
							Other Significant Resources (Section 122 of Public Law 91-611)		
No Action	Physical Resources	Sea Level Rise	Water Resources	Biological Resources	Cultural Resources	Socioeconomic Resources	Air Pollution	Noise	Water Quality
Restoration Benefits Foregone	Status quo includes long-term erosion at Gum Thicket and Cedar Creek expected.	Current shoreline erosion rates at Gum Thicket / Cedar Creek would be expected to increase under higher sea-level rise scenarios.	No significant effects.	Present conditions at Gum Thicket/Cedar Creek mean that wetland and adjacent habitat utilized by flora and fauna will be lost by erosion. Obstruction at Little River adversely affects anadromous fishes spawning and nursery habitat.	Not stabilizing the shoreline at Gum Thicket and Cedar Creek will threaten 5 known cultural resource sites.	No significant adverse impacts.	No adverse impacts.	No adverse impacts.	No adverse impacts.
Beneficial Effects	No action avoids temporary construction impacts, but provides no significant benefits.								

	ENVIRONMENTAL EFFECTS								
							Other Significant Resources (Section 122 of Public Law 91-611)		
Modifying Low-head Dam on Little River near Goldsboro	Physical Resources	Sea Level Rise	Water Resources	Biological Resources	Cultural Resources	Socioeconomic Resources	Air Pollution	Noise	Water Quality
Adverse Effects	No significant effects.	Located approximately 60 miles inland - not affected by sea level rise.	No significant adverse effects. Minor temporary elevated turbidity during construction. No sediment found within upstream 0.1 ac impoundment.	No significant adverse impacts.	No adverse impacts. No historic properties identified at the Little River dam project area.	No significant adverse impacts.	Project located in an attainment area. No significant adverse impacts to air quality.	Not expected to result in significant noise impacts or violate any existing noise standards in the Neuse Basin. Construction equipment would only be in operation during daylight hours.	No significant adverse impact to existing water quality in the Neuse Basin. During in-water construction, temporary elevated turbidity levels may be experienced. No violation of state standards expected

Table 8.1. Summary of Significant In-Basin Resources Impacted (cont.)

Kinston East Wetland Complex	ENVIRONMENTAL EFFECTS								
							Other Significant Resources (Section 122 of Public Law 91-611)		
	Physical Resources	Sea Level Rise	Water Resources	Biological Resources	Cultural Resources	Socioeconomic Resources	Air Pollution	Noise	Water Quality
Adverse Effects	No significant effects.	Located approximately 30 miles inland - not affected by sea level rise.	No significant adverse effects.	No significant adverse impacts.	No adverse impacts. No historic properties identified at the project area.	No significant adverse impacts.	Project located in an attainment area. No significant adverse impacts to air quality.	Not expected to result in significant noise impacts or violate any existing noise standards in the Neuse Basin. Construction equipment would only be in operation during daylight hours.	No significant adverse impact to existing water quality in the Neuse Basin. No violation of state standards expected
Beneficial Effects	**Provides an additional 14.5 ac of restored riparian buffer and bottomland hardwood forest in the Neuse River floodplain.**								

Stabilizing Gum Thicket Creek and Cedar Creek	ENVIRONMENTAL EFFECTS								
							Other Significant Resources (Section 122 of Public Law 91-611)		
	Physical Resources	Sea Level Rise	Water Resources	Biological Resources	Cultural Resources	Socioeconomic Resources	Air Pollution	Noise	Water Quality
Adverse Effects	Not stabilizing the shoreline will adversely impact wetlands and 240 ac conservation easement.	Will not affect sea rise. The highest estimated sea level rise during the 50-year life of the project is 55cm (1.79 feet). The rock sill included in this alternative takes this rise into account and will be built to an appropriate height.	No significant adverse effects. Minor temporary elevated turbidity during construction.	No significant adverse impacts.	Not stabilizing the shoreline will adversely impact 5 known cultural resource sites	No significant adverse impacts.	Project located in an attainment area. No significant adverse impacts to air quality.	Not expected to result in significant noise impacts or violate any existing noise standards in the Neuse Basin. Construction equipment would only be in operation during daylight hours.	Increase in turbidity within water column since shoreline is not stabilized.
Beneficial Effects	**Stabilizing the shoreline at Gum Thicket and Cedar Creek will provide benefits to the existing wetlands and 240 ac conservation easement.** **Creation of new wetlands expected to provide beneficial wetland functions to water resources.** **Expected to provide benefits to shellfish and resident and anadromous fish habitat by creating new wetlands and estuarine habitat.** **Reducing existing shoreline erosion at Gum Thicket and Cedar Creek will preserve 5 known cultural resource sites.** **Reduce turbidity with the water column by stabilizing the shoreline.**								

Table 8-1. Summary of Significant In-Basin Resources Impacted (cont.)

Constructing Oyster Reefs in the Lower Neuse Estuary	ENVIRONMENTAL EFFECTS								
							Other Significant Resources (Section 122 of Public Law 91-611)		
	Physical Resources	Sea Level Rise	Water Resources	Biological Resources	Cultural Resources	Socioeconomic Resources	Air Pollution	Noise	Water Quality
Adverse Effects	No significant effects.	Will not affect sea rise; however, the highest estimated sea level rise during the 50-year life of the project is 55cm (1.79 ft). This rise in sea level is not expected to affect oyster health at the proposed project sites.	No significant adverse effects. Minor temporary elevated turbidity during construction.	No significant adverse impacts.	No adverse impacts. Locations for the construction of the Oyster Reefs will be coordinated with the NC Underwater Archaeology Branch to avoid known or suspected underwater cultural resources.	No significant adverse impacts.	Project located in an attainment area. No significant adverse impacts to air quality.	Not expected to result in significant noise impacts or violate any existing noise standards in the Neuse Basin. Construction equipment would only be in operation during daylight hours.	No significant adverse impact to existing water quality in the Neuse Basin. During in-water construction, temporary elevated turbidity levels may be experienced. No violation of state standards expected.
Beneficial Effects	**Creation of new oyster reefs may improve overall estuarine water quality through increased natural filtration.** **Increased oyster population and provides improved habitat for fish, shrimp and crabs.**								

8.1 Physical Resources

Physical resources are the non-living characteristics of a site such as, climate, sea level rise, geology and topography, stream geomorphology and dynamics, and soils and prime farmland. These physical resources could be affected by the No Action Alternative and the Recommended Plan; these effects are addressed below.

8.1.1 No Action Alternative

No adverse impacts to geology and topography, soils and prime farmland. No pronounced vulnerability to climate change or sea level rise. By not constructing the proposed Recommended Plan, the no-action alternative also avoids temporary construction impacts but provides no significant long-term benefits to the environment.

Under the No Action Alternative, the positive restoration benefits of the Recommended Plan would be forgone. By not modifying the low-head dam on the Little River in Goldsboro, anadromous fishes spawning and nursery habitat would continue to be adversely affected. By not restoring the previously filled Kinston East Wetland complex, about 14.5 acres of Neuse River floodplain and bottomland hardwood wetlands would remain adversely impacted. The continued shoreline erosion at Gum Thicket and Cedar Creek would adversely impact wetlands, cultural resources, and the adjacent 240 acre conservation easement. Failure to construct the oyster reefs would not increase oyster populations and improve habitat for fish, shrimp, and crabs in the lower Neuse Estuary.

8.1.2 Recommended Plan

If the Recommended Plan is constructed, the following physical effects are likely to occur.

8.1.2.1 Modifying Low-head Dam on Little River near Goldsboro

No adverse impacts to climate, sea level rise, geology and topography, stream geomorphology and dynamics, and soils and prime farmland.

The stream geomorphology and dynamics would be positively affected by removal of the obstruction which principally affects normal and low-flow conditions. Adverse impacts on physical resources during construction of the Little River Dam component of the project would be minimal and temporary, attributed to construction equipment in the contractor's staging area and concrete debris removed from the river channel. The staging area for this component would be within the confines of the existing Goldsboro water treatment facility immediately adjacent to the project site.

Sea level rise would not affect this project. The site on the Little River is more than 60 mi upstream of the tidal salt water influence at or just above New Bern (Giese et al. 1979). Additionally, there is a 65 ft elevation difference between the Goldsboro Dam (75 ft) and New Bern (10 ft).

No adverse long-term effects would be expected. Positive effects to stream geomorphology and dynamics expected as a result of removal of obstructions.

8.1.2.2 Restoration of Kinston East Wetland Complex

No adverse impacts to climate, sea level rise, geology and topography, stream geomorphology and dynamics, and soils and prime farmland.

Removal of the sediment within the existing Neuse River floodplain will provide additional flood water storage capacity and restoration of bottomland hardwood wetlands. Adverse impacts on physical resources during construction of the Kinston East Wetland component of the project would be minimal and temporary, attributed to construction equipment in the contractor's staging area, maintenance of haul road to the property, and vegetative debris/earthen material removed from the floodplain. The contractor's staging area for this component would be within the confines of the existing 30 acre tract.

Sea level rise would not affect this project. The restoration site on the Neuse River is more than 30 miles upstream of the tidal salt water influence at or just above New Bern (Giese et al. 1979). Additionally, there is a 25 ft elevation difference between Kinston (35 ft) and New Bern (10 ft).

No adverse long-term effects would be expected. Positive effects to the Neuse River floodplain and restoration of the bottomland hardwood forest wetlands are expected as a result of removal of the previously filled area.

8.1.2.3 Stabilizing the Shoreline at Gum Thicket Creek and Cedar Creek

No adverse impacts to climate, sea level rise, geology and topography, stream geomorphology and dynamics, and soils and prime farmland are expected. Positive effects to topography and stream geomorphology would be expected due to the measures to reduce erosion and loss of coastal wetland habitat at Gum Thicket and Cedar Creek.

Adverse effects on physical resources during construction of the Gum Thicket and Cedar Creek component of the project would be minimal, attributed to construction equipment in the contractor's staging area and temporary soil disruption associated with new marsh planting. Although much of the construction for the project component would take place in the water, a land-based staging area would be necessary to transfer materials from land to the construction site. This project is adjacent to land under development where construction crews have already established a 3 acre staging area. Available use of this area would be expected for construction staging during the project. The majority of the staging area is currently cleared of vegetation and is being used as a sediment stockpile area for the development. No woody vegetation would be removed, cleared, and/or grubbed. A nearby existing commercial borrow area would be used for the proposed rock for the offshore sill and sand material that would be placed landward of the offshore sill for the planted marsh feature. No dredging is proposed for construction access.

This component could be affected by sea level rise, as described in Section 2.1.1.1. USACE considered the structural design, resiliency, and integrity of the engineering structures at Gum Thicket using the guidance set forth in EC 1165-2-211 and predicted curves of sea level rise over the 50-year period of analysis. Those aspects were considered to ensure that the structures would not be compromised or produce unintended consequences under those potential sea level scenarios. The structural features would not pose a risk to public safety under any of the sea level rise scenarios, nor would their performance be adversely affected.

The substrate at the project site is composed of sandy soft-bottom material, where marshes are stable. Subsidence is not an issue at the project site. Site design would reduce the risk from potential sea level rise by integrating low and high marsh restoration areas, allowing for upslope migration of low lying marshes under varying tidal conditions. No anticipated adverse effects would be expected because the structure along the shoreline would be designed to withstand the high rate of sea level rise (i.e., 55 cm or 1.79 feet by 2065) if practical.

No adverse long-term effects adverse would be expected. Positive effects to topography and water-land dynamics are expected as a result of measures to reduce erosion and loss of coastal wetlands at Gum Thicket and Cedar Creek.

8.1.2.4 Constructing oyster reefs in the lower Neuse River Estuary

No adverse impacts to climate, sea level rise, geology and topography, stream geomorphology and dynamics, and soils and prime farmland. The oyster reef construction would alter the bathymetry and substrate characteristics over 10 acre oyster reef top (20 acre footprint) area.

Adverse effects on physical resources during construction of the oyster reef component of the project would be minimal and temporary, attributed to construction equipment in the contractor's staging area. Two staging areas for this component are proposed—the state's existing cultch staging facility at South River or existing, state-owned lands under and adjacent to the western end of the new Hobucken Bridge. The bridge site has disturbed lands under the bridge and would include the old road access to the replaced swing bridge. Although all construction for this project component would take place in the water, a land-based staging area would be necessary to transfer materials from land to barge.

This component would not be adversely affected by the highest estimate rate of sea level rise (i.e., 55 cm or 1.79 feet by 2065) because of the depth of the reefs in the water column.

No adverse long-term effects adverse would be expected. The oyster reef construction would alter the bathymetry and substrate characteristics over 10 acre oyster reef top area (20 acre fill footprint).

8.1.2.5 Kinston East Wetland Restoration

No adverse impacts to climate, sea level rise, geology and topography. Soils to be excavated are fill material. Positive effects to topography would be expected due to the restoration of wetlands hydrology by excavation of fill.

Adverse effects on physical resources during construction of the Kinston East Wetland Restoration component of the project would be minimal, attributed to construction equipment in the contractor's staging area. The staging area for the component would be on previously disturbed land adjacent to the project site. BMPs would be used during construction to minimize or eliminate any adverse environmental effects in adjacent areas. This component could be affected by sea level rise, as described in Section 2.1.1.1.

8.2 Water Resources

Water resources include surface water, groundwater, and navigation. The degree to which water resources might be influenced by the No Action Alternative and the Recommended Plan is stated below.

8.2.1 No Action Alternative

Under the No Action Alternative, existing habitat conditions would persist for water resources including groundwater and navigation. Continued erosion and associated sediment re-suspension at Gum Thicket and Cedar Creek may cause increased turbidity within surface waters of the Neuse estuary.

Under the No Action Alternative, potential benefits to water resources associated with implementing The Recommended Plan would be forgone.

8.2.2 Recommended Plan

8.2.2.1 Modifying Low-head Dam on Little River near Goldsboro

The NC Division of Water Quality (NCDENR 2009a) has designated the freshwater quality rating at the low-head notched dam as Water Supply III, or moderately developed Nutrient Sensitive Waters (NSW). Nutrient Sensitive Waters (NSW) are a Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation. No violations of water quality at the project site have been reported (NCDENR 2009a). Removal of the low-head notched dam is not expected to improve or adversely affect these water quality conditions.

The existing 4-ft-high notched concrete dam at Goldsboro has a very small ponding effect on the Little River. The dam is notched and impounds less than 0.1 acre (less than 500 square feet). A Tier 1 sediment evaluation was completed (see Appendix H) at this site and its current breached condition makes it a very ineffective sediment trap (Augsperger 2008). The Tier 1 evaluation concludes that "no further sediment characterization is recommended at this site". During high-flow conditions, the majority of the water goes over top of the structure. It is anticipated that modifying a portion of the dam would not cause an increase in flow through the dam and re-suspend any materials which might have an effect on water quality.

Removal or modification of the low-head notched dam would result in short-term minor increases in turbidity and suspended solids in the Little River. Significant increases in turbidity would not be expected outside the immediate construction area (turbidity increases of 25 nephelometric turbidity units (NTUs) or less are not considered significant in North Carolina). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) could be transported downstream of the dam. Turbidity levels would be expected to return to background levels in the project area after the project implementation.

Before construction, the contractor will be required to develop an Environmental Protection Plan, which thoroughly discusses that any hazardous material (fuel, hydraulic fluids, etc.) would be confined to high ground and within the proper containers. No hazardous materials are allowed to be placed, discharged, or allowed to erode into any waters of the Little River. If a discharge occurs, the contractor would stop all work and contact the USACE and the closest remediation company to resolve the issue. The contractor's Environmental Protection Plan would ensure that no fuel, hydraulic fluids or any other hazardous materials are discharged into any waters of the Little River.

Removing or modifying the Goldsboro Dam in the Little River would be authorized by the Regulatory Nationwide Permit (NWP) 27 Aquatic Habitat Restoration, Establishment and Enhancement Activities, and a Section 401 Water Quality Certificate would be obtained from NCDWQ. The USACE does not issue itself an NWP but would comply with all restrictions and conditions of the NWP 27 and the required 401 Water Quality Certificate from NCDWQ.

This component would not be expected to significantly reduce or improve small craft navigation (i.e., canoeing and kayaking).

The modification of the Little River Dam will not adversely affect surface water, groundwater, and navigation.

8.2.2.2 Kinston East Wetland Complex

The NC Division of Water Quality (NCDENR 2009a) has designated the freshwater quality rating at the Kinston East wetland restoration site as Water Supply III, or moderately developed Nutrient Sensitive Waters (NSW). Nutrient Sensitive Waters (NSW) are a Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation. No violations of water quality at the project site have been reported (NCDENR 2009a). Removal of the fill material placed in the Neuse River floodplain and previous bottomland hardwood wetland is not expected to improve or adversely affect these water quality conditions. All required erosion and sediment control BMPs will be in place and functioning prior to construction.

According to the U.S. Environmental Protection Agency (USEPA), Envirofacts Data Warehouse (http://oaspub.epa.gov/enviro/ef_home2.waste), no superfund sites pursuant to the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS), no reported hazardous waste activities in accordance with the Resource Conservation and Recovery Act (RCRA), or large hazardous waste generators are located near the Kinston East Wetland restoration site. There is no hazardous waste sites on the National Priorities List located in the project area. During earlier inspections of the 14.5 acre restoration site, there was no evidence of any HTRW contamination at this tract. There were no burn pits, used drums, discolored soils, oil sheen in the water, or any other indications that the site was used to deposit contaminated sediment. Moreover, according to Mr. Doug Roberts, Hydrogeologist with the Hazardous Waste Section, NC Division of Waste Management, NCDENR (Personal Communication 15 June 2011), he has no knowledge of any HTRW contaminated sites near the Lincoln Street tract in Kinston.

Removal of the fill material placed in the Neuse River floodplain would not result in either short or long-term increases in turbidity and suspended solids in the river. The required erosion and sediment control permits from the NC Division of Land Quality, NCDENR will be obtained prior to any construction. During the regrading process and until stabilization with a permanent cover of grass is achieved, sediment control devices will be used to prevent sediment from leaving the site. All equipment would be working from the upland portion of the 14.5 acre tract and the excavated material would be immediately placed in trucks and transported to an approved disposal area. Significant increases in turbidity is not be expected outside the immediate construction area (turbidity increases of 25 nephelometric turbidity units (NTUs) or less are not considered significant in North Carolina). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) would not be transported into the river since the required BMPs would be in place. Turbidity levels within the construction zone would be expected to return to background levels in the project area after the project implementation.

Removal of fill material from the Neuse River floodplain would not cause any adverse impacts to groundwater, in fact the proposed project would increase flood storage capacity. Additionally, the proposed action would not pump or discharge any water/sediment into the groundwater.

Before construction, the contractor will be required to develop an Environmental Protection Plan. Additionally, project plans and specifications will require all hazardous material (fuel, hydraulic fluids, etc.) be confined to high ground and within the proper containers. No hazardous materials will be allowed to be placed, discharged, or allowed to erode into any waters of the Neuse River. If a discharge occurs, the contractor would stop all work and contact the USACE and the closest remediation company to resolve the issue.

Removing fill material from the 14.5 acre site within the Neuse River floodplain would not require a Section 404 permit since no dredge or fill material will be placed in any waters and/or wetlands. A Section 401 Water Quality Certificate would not be obtained from NCDWQ, since no waters or wetlands would be filled as a result of this activity.

This component would not be expected to significantly reduce or improve small craft navigation (i.e., canoeing and kayaking) since the restoration site is located within the floodplain and not the main stem of the Neuse River.

The Kinston East wetland restoration site will not adversely affect surface water, groundwater, or navigation and while there is no indication of any soil contamination, this will be verified.

8.2.2.3 Stabilizing Gum Thicket Creek and Cedar Creek

The N.C. Division of Water Quality (NCDENR 2009a) has designated the estuarine water quality rating in this area as Saltwater C (SC) Nutrient Sensitive Waters (NSW). Class SC is all tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; fish and noncommercial shellfish consumption; aquatic life propagation and survival; and wildlife. Nutrient Sensitive Waters (NSW) are a Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.

Any adverse effects on water resources during construction of the Gum Thicket/Cedar Creek component of the project would be expected to be minimal and temporary. During marsh planting and sill construction, turbidity levels would be elevated in the immediate area. Placing the fill (i.e., sand and rock) material along the shoreline would result in short-term minor increases in turbidity and suspended solids in the nearshore zone. Significant increases in turbidity would not be expected to occur outside the immediate construction area (turbidity increases of 25 NTUs or less are not considered significant in North Carolina). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) could hug the nearshore and be transported with waves either northeast or southwest depending on wind and current conditions. Turbidity levels are expected to return to background levels in the nearshore zone after placement activities. Before any construction, the required Section 401 Water Quality Certificate from NCDWQ would be obtained, and all conditions/restrictions of this state certificate would be adhered to. If required by NCDWQ, floating turbidity or silt curtains would be used in the constructions site to reduce turbidity effects on adjacent waters. After construction, turbidity levels at the site would return to preconstruction levels. This project component would provide long-term benefits for water resources, including additional wetlands, both of which provide a natural means of water quality improvement.

The proposed offshore rock sill parallels the shoreline and would be placed about 60 feet offshore in shallow water and extend above the water surface. This component would not block access to Gum Thicket Creek and would be marked by either floats or USCG approved day markers to identify potential navigation hazards. No significant effects would be expected.

The shoreline stabilization of Gum Thicket and Cedar Creek will not adversely affect surface water, groundwater, and navigation. The proposed shoreline protection measures will protect wetlands of the Gum Thicket area and maintain the wetland functions which are beneficial to water quality.

8.2.2.4 Constructing oyster reefs in the lower Neuse River Estuary

The NC Division of Water Quality (NCDENR 2009a) has designated the estuarine water quality rating in this area as Saltwater C (SC) Nutrient Sensitive Waters (NSW). Class SC is all tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact; fish and noncommercial shellfish consumption; aquatic life propagation and survival; and wildlife. Nutrient Sensitive Waters (NSW) are a Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.

Construction of oyster reefs in the Neuse River can be expected to have a positive effect on water quality. Over the life of this project component, water quality in the immediate vicinity of the reef would improve because of the natural filtration offered by mature oyster populations at the created sites. Oysters are filter feeders. This means that they feed by pumping large volumes of water through their gills and filtering out plankton and other particles. As they filter water to get food, oysters also remove nutrients, suspended sediments and chemical contaminants. One oyster can filter more than 50 gallons of water per day.

Adverse effects on water resources during construction of the oyster reef component of the project would be expected to be minimal and temporary. During reef construction, turbidity levels would be elevated because of in-water material placement. If required by NCDWQ, floating turbidity or silt curtains could be required in the constructions site to reduce turbidity effects on adjacent waters. After construction is completed, turbidity levels at the site would return to preconstruction levels.

Mid-river sanctuaries would have at least 14 ft of navigational clearance and north and south nearshore reefs would have at least 7 ft of clearance. While the navigation channel occurs in ecologically suitable area for oyster growth, sanctuary footprint areas would avoid navigation channels as identified by navigation channel markers. While the area of potential hazard would be increased by about 20 acre (footprint), man-made reefs would provide less peril than that imposed by the array of unmarked existing natural reefs. Federal navigation channels are shown on Figure 8-1. All sites would be identified by buoys, and no significant hazard would be expected.

The oyster reef restoration will not adversely surface water, groundwater, and navigation. Positive affects to water quality are expected.

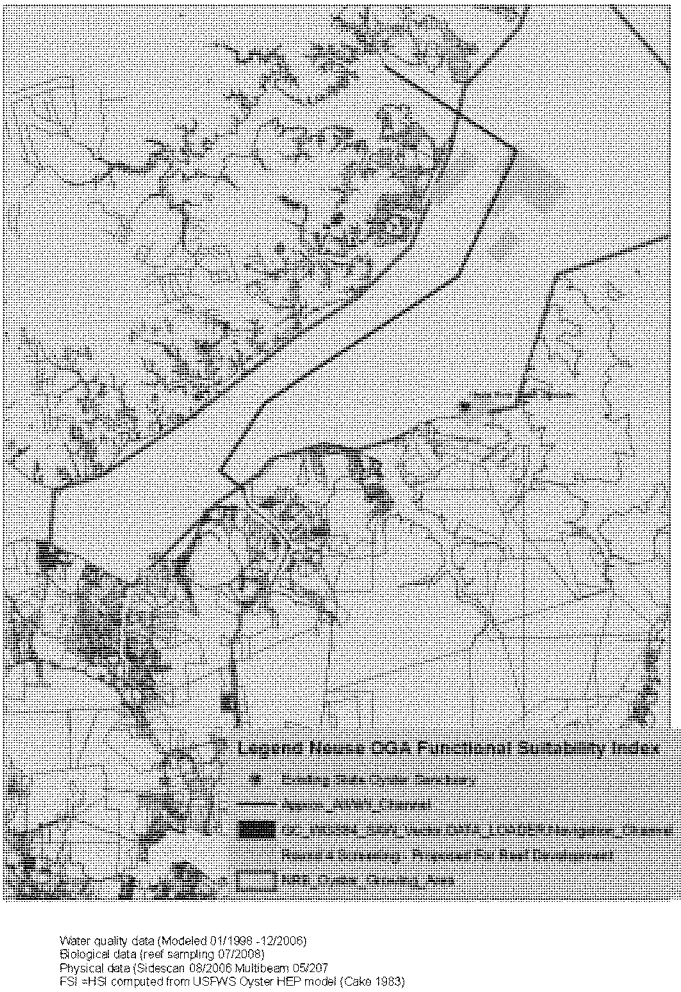


Figure 8-1. Neuse River Estuary Navigation Channel (AIWW) relative to the tentatively selected oyster reef habitat.

8.3 Biological Resources

Biological Resources include vegetation (includes tidal and freshwater wetlands), aquatic resources (macro-invertebrates, mussels, etc.), EFH, Fauna, and fish and wildlife resources (including Federally Threatened and Endangered Species as well as State Protected Species). The degree to which biological resources might be influenced by the No Action Alternative and the Recommended Plan is stated below.

8.3.1 No Action Alternative

The No Action Alternative would not adversely impact biological resources; however, potential environmental benefits from the Recommended Plan would be forgone. Ongoing natural and human affected processes are expected to continue to produce changes to biological resources. Additionally the following discuss site specific aspects of the No Action Alternative.

8.3.1.1 Modifying Low-head Dam on Little River near Goldsboro

The No Action Alternative would not alter existing conditions at this low-head dam. The existing low-head dam on Little River near Goldsboro dam limits fish passage upstream and access to spawning areas for anadromous fish, and this condition would continue. Additionally the existing structure may continue to reduce the habitat of Federally listed Endangered Dwarf wedge and Tar River spiny mussels in the Little River by limiting the movement of host fish for the mussel larvae.

8.3.1.2 Kinston East Wetland Complex

The No Action Alternative would not alter existing conditions at this site. The previously filled 14.5 acres of Neuse River floodplain and bottomland hardwood wetlands would continue to be the status quo. The No Action Alterative allows continued loss of both flood storage capacity and the number of acres of bottomland hardwood wetlands in the floodplains off the Neuse River.

8.3.1.3 Stabilizing Gum Thicket Creek and Cedar Creek

The Gum Thicket and Cedar Creek shorelines are eroding at a significant rate. This long-term erosion will affect existing about 60 acres of adjacent wetlands and brackish tidal marsh areas, which provide benefits for biological resources including providing nursery habitat for juvenile fishes and forage area for birds. The No Action Alternative allows continuation of loss of specific wetland areas and the function of those areas, as well as areas within the 240 acre conservation easement.

8.3.1.4 Constructing oyster reefs in the lower Neuse River Estuary

The No Action Alternative would not alter status quo with respect to oyster reefs in the Neuse Basin. No oyster reefs would be constructed as a result of this study but others may construct them as a part of other programs.

8.3.2 Recommended Plan

8.3.2.1 Modifying Low-head Dam on Little River near Goldsboro

The Little River Dam is located adjacent to Goldsboro's Water Treatment Plant. The upland portion of this property has been previously cleared and is currently paved and grassed. The proposed contractor's staging area is likely to occur in this cleared upland area. No native woody vegetation would, therefore, be affected or removed as a result of either the modification of the dam or the contractor's staging area. No Section 404 wetlands are located adjacent to the existing dam structure in the Little River or within the contractor's staging area. Therefore, no wetlands would be adversely impacted by this activity.

This action involves modifying an existing structure in the Little River; therefore, disturbance to nearby benthic resources, if any, would be expected to be minimal. The existing 4-ft-high notched dam at Goldsboro has a very small ponding effect on the Little River. The dam is notched and impounds less than 0.1 acre. During high-flow conditions, the majority of the water goes over top of the structure. It is anticipated that removing a portion of the dam would not cause any long-term adverse hydrogeomorphic induced change to benthic communities either upstream or downstream of the dam. No short- or long-term effects on benthic communities would be expected if the dam is modified to allow water to flow through the weir during lower flows. Freshwater benthic communities could experience temporary, elevated turbidity during modification of the dam on Little River. Similar or even higher levels of turbidity result from natural high flow events. Therefore, no adverse impacts to benthic resources are anticipated.

Long-term conditions may be improved for mussel species (including the Federally listed Dwarf wedge mussels and Tar River spinymussels) that require a fish host to complete their reproductive cycle. If the host movements are not restricted by the dam obstructions, the distribution of the mussels may be positively affected.

Anadromous and Resident Freshwater Fish. In average flow conditions, the existing notched low head dam passes about 70 percent of fishery resources in the Little River. After the proposed dam modification and/or gate are installed, USACE expects that up to 99 percent of fish would be able to pass the structure. Anadromous and resident freshwater fish could experience temporary effects from turbidity during modification of the dam, however, no explosives would be used and no fill material (sand or clay) would be placed in any waters of the Little River. No in-stream work would be done during the anadromous fish spawning season. Long-term conditions would be improved for anadromous fish spawning and improved stream connectivity would also benefit resident fish.

Fisheries. No adverse effects on resident freshwater fisheries would be expected. An increase in anadromous fish population is possible which may increase fishing opportunities in the project area.

In summary, the proposed modification of the low-head notched dam in Goldsboro will not adversely impact any Biological Resources in the Neuse River Basin. The proposed action would increase the efficiency of fish passage. This may increase anadromous fish and resident fish populations in the Little River by increasing movement within the stream. Additionally, long-term conditions may be improved for mussel species (including the federally listed Dwarf wedge and Tar River spinymussels) that require a fish host to complete their reproductive cycle.

8.3.2.2 Kinston East Wetland

The Kinston East Wetland Complex is located in the floodplain of the Neuse River, about 30 miles upstream of the tidal influence near New Bern, NC. This previously disturbed site is not located in any waters or on the main-stem of the river. The contractor's staging area would be located within the 30 acre site. No Section 404 wetlands would be adversely impacted by this activity. In fact, the proposed action would restore about 14.5 acres of bottomland hardwoods wetlands in the Neuse River floodplain. No benthic resources in the Neuse River or its tributaries would be impacted.

No elevated turbidities would enter the river, since the contractor would abide by the NC Land Quality, NC DENR erosion and sedimentation control permit. This state authorization would require that the necessary silt fences and other sedimentation control devices would be installed prior to construction. During the regrading process and until stabilization with a permanent cover of grass is achieved, sediment control devices will be used to prevent sediment from leaving the site. All stormwater runoff would be contained on the site. Therefore all sedimentation and any elevated turbidities would not be discharged into the river.

Estuarine Fish and Plankton. No adverse impacts since the site is located about 30 miles upstream of any tidally influences waters.

Anadromous and Resident Freshwater Fish. No adverse impacts are anticipated since all work will be on high ground not within any waters of the Neuse River. Moreover, all required erosion and sediment control measures will be in place throughout the construction process. No sediment or increased turbidities would be discharged from the site into the Neuse River.

8.3.2.3 Stabilizing Gum Thicket Creek and Cedar Creek

The proposed shoreline stabilization of Gum Thicket and Cedar Creek would impact the following areas:

1. Up to 6 acres of shallow water habitat would be filled with sand and planted in marsh, landward of the proposed rock sill.
2. About 6 acres of shallow water habitat would be filled as a result of the offshore rock sill footprint.

3. Approximately 6 acres of open water would be located landward of the rock sill and seaward of the planted marsh area.

The marsh creation and shoreline stabilization at Gum Thicket and Cedar Creek would be accessed from the water and an existing disturbed area would be used for staging. The sand placed landward of the proposed sill will be obtained from an existing commercial upland borrow area. By placing sand landward of the proposed rock sill, the existing estuarine beach will be converted to planted marsh. No mature trees would be cleared to implement this project.

Vegetated Section 404 wetlands (tidal salt marsh, freshwater marsh, forested wetlands, or SAVs) would not be filled or adversely impacted along the eroded shoreline of Gum Thicket and Cedar Creek.

The proposed rock sill would provide substantial biological benefits as follows:

1. Provide about 6 acres of planted marsh and protect hundreds of acres of adjacent marsh/wetlands in Gum Thicket and Cedar Creek project area.
2. Provide about 6 acres of protected shallow water habitat (landward of the rock sill).
3. Protect Gum Thicket and Cedar Creek wetlands and associated 240 acre conservation lands.

Placing sand and rock offshore of the eroded Gum Thicket and Cedar Creek would result in the loss of aquatic organisms in filled areas (up to 18 ac) particularly sessile or slow-moving forms. No threatened or endangered organisms are in this habitat. While no dredging is proposed for construction access, equipment movement during construction in shallow water areas near Gum Thicket and Cedar Creek could cause temporary disturbance as described in Section 8.1.

After construction, with the exception of the rock sill exposed above normal high-water, rapid recolonization of the site by aquatic organisms would be expected. However, changes in depth, tidal cycle and substrate would likely result in new inhabitants and different communities. Marine rock presents an attachment substrate new to the project area. Hard structure habitats typically develop a unique community assemblage of algae and animals, adding to the species diversity in previously soft or sandy bottom habitats. The upstream sill segment at Gum Thicket would be expected to support sustainable oyster growth within 3 years. While reduced in area and depth, shallow waters in the constructed habitat would be quiescent compared to the existing, high-energy environment and would therefore have an increased marsh/water interface. This would improve the site's habitat value for early life stages of estuarine animals. No adverse effects on primary nursery areas (PNAs) would be expected because the area footprint does not include PNAs as designated by the NCDMF.

Under existing conditions, the Neuse River Estuary shoreline within the project area, continues to lose high marsh and other wetlands. Historically common low marsh is generally absent, and SAV found in Gum Thicket are also at risk to future loss to erosion.

The projects would protect existing aquatic resources, including about 60 acres of wetlands that could be lost to erosion over the 50-year period of analysis. Implementing the project would be expected to result in a net increase in these resources, providing improved habitat for aquatic organisms. Long-term improved benthic conditions would be expected because the existing erosion would be stopped. That would offset any losses from modification of existing habitat including any minor temporary impacts during construction. After construction, rapid colonization by aquatic organisms would be expected.

Estuarine Fish and Plankton. Estuarine fish could experience temporary elevated turbidity levels during placement of fill material (sand, rock, and shell) at Gum Thicket and Cedar Creek. Placement of the fill (i.e., sand and rock) material along the Gum Thicket shoreline would be expected to result in short-term minor increases in turbidity and suspended solids in the nearshore zone. Significant increases in turbidity would not be expected outside the immediate construction area (turbidity increases of 25 NTUs or less are not considered significant in North Carolina). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) could hug the nearshore and be transported with waves either northeast or southwest depending on wind and current conditions. Turbidity levels would be expected to return to background levels in the nearshore zone after placement activities end. Before any construction, the required Section 401 Water Quality Certificate from NCDWQ would be obtained, and the USACE and contractors would adhere to all the conditions/restrictions of the state certificate. If required by the NCDWQ, floating turbidity or silt curtains would be used in the constructions site to reduce the effects of turbidity on adjacent waters.

Temporary losses of benthic food would require foraging in adjacent areas until benthic reestablishment occurs. Long-term conditions would be improved for estuarine fish once newly protected shallow-water, marsh, and reef communities are established.

Newly constructed marsh and shallow water habitat would provide important services including spawning, nursery and feeding areas for anadromous and resident fish, crabs, and shrimp. Studies in Louisiana have shown commercial in-shore shrimp harvest is directly proportional to the area of intertidal wetland (Turner 1977). Restoration and protection of these habitats would be expected to benefit fishery resources in the area. Phytoplankton is the primary carbon producer available under the without-project condition in unvegetated open water areas proposed for restoration. In North Carolina, primary productivity (measured in grams of carbon produced) of *S. alterniflora* falls in the range of 329 to 1,296 g dry wt/m^2/yr and *J. romerianus* production is between 560 and 1,960 g dry wt/m^2/yr (Peterson and Peterson 1979). That is about 3 to 18 times higher than the productivity (110 g carbon/m^2/yr) reported by Peterson and Peterson (1979), for North Carolina phytoplankton.

8.3.2.4 Constructing oyster reefs in the lower Neuse River Estuary

The proposed construction of oyster reefs in the lower Neuse River estuary would impact the following areas:

1. A total of about 20 acres of Neuse River estuary bottom would be filled. This would create a total of 10 acres of oyster reef top distributed over two 40-acre sanctuaries.
2. The proposed oyster reefs would be in the waters of the lower Neuse River Estuary about 11-20 ft deep.
3. Staging would affect about 1.5 acre of previously disturbed uplands and would not require clearing of mature vegetation.

A typical 40 acre sanctuary is shown on Figure 8-2. As described in Section 8.1, the likely staging site includes existing disturbed lands under the bridge. Any ground cover that is disturbed would be replanted and therefore any effects on terrestrial vegetation would be expected to be minor and temporary.

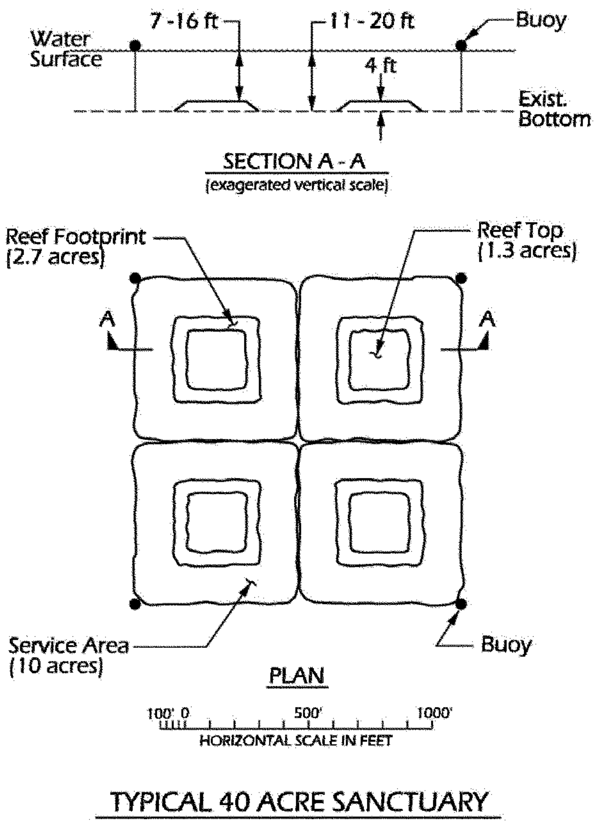


Figure 8-2 Typical 40 acre sanctuary design.

Proposed construction of a matrix of oyster reefs (at three locations) would provide a total habitat area of 80 acres that would serve as new oyster sanctuary upon state designation. This project would require constructing a total of about 20 footprint acres in existing soft-bottom areas, providing 10 acres of elevated stone and cultch reef top plateau. Only 74 acres of subtidal reef top were identified during project surveys. The proposed plan would expand the known reef top area in the Neuse OGA by about 13 percent. In addition to the reef top plateau, the footprint for individual structures includes reef side slopes and a buffer for misplaced or soughed stone. The highest oyster production would occur on the reef top with decreasing oyster populations on the reef side slopes. Studies have shown increases in the numbers of fish and species richness would also occur in adjacent soft bottom areas extending 50 to 100 meters away from the reef (dos Santos et al. 2010). The reef and adjacent soft bottom habitats and resident fauna, found within the sanctuary boundary, would be protected from future harvest and bottom disturbance. It is assumed that for every 0.13 acres of reef top, one acre of estuarine habitat would benefit. This relationship is consistent with the reef top, to sanctuary area, relationship measured at the existing NCDMF Neuse River Sanctuary.

Estuarine Benthic Resources. Project construction would be expected to result in the loss of aquatic organisms, particularly sessile, or slow-moving forms in rock and cultch placement areas. The footprint area of soft bottom that would be affected is about 25 acres for reef construction. The area would be permanently converted to hard structural reef habitat. Hard structure habitats typically develop a unique community assemblage of algae and animals, adding to the species diversity in previously soft or sandy bottom habitats. Rapid colonization of newly constructed reefs would be expected, and long-term beneficial effects on benthic resources would be expected to offset any short-term effects.

Estuarine Fish and Plankton. Estuarine fish could experience temporary elevated turbidity levels during construction of new reefs from disturbing bottom sediments; however, the construction materials (sand, rock, and shell), are not considered significant sources of turbidity. Reef building is a common NCDMF practice in a wide range of conditions throughout the Pamlico Sound, and turbidity during construction has not been a significant concern as described in Section 8.1. Effects on benthic food sources would cause fish to temporarily forage in other areas; however, the impact area is small, relative to nearby similar feeding areas. Rapid reef colonization would be expected over an increased surface area, providing replacement food resources over time. New elevated, structurally and biologically diverse oyster reefs would provide new habitat, feeding areas, and hypoxia refuge for reef residents including both migratory and transient fish species. Plankton would not be significantly affected by construction. However water filtration by new oysters would likely increase water filtration and have an unquantifiable localized benefit of reduced nutrients and turbidity.

Fisheries. Mid-river oyster reef construction will occur in areas fished by shrimp trawls. The proposed designation of newly constructed sites as oyster sanctuary would preclude future trawling in these areas. Discussions with local fishermen indicate that the proposed mid river reefs are located in areas that are heavily trawled and that numerous natural reefs in that area already require maneuvering to be avoided. If well marked, the proposed mid river reefs could be avoided without significant impact to fishing operations; however, they would cause inconvenience. The proposed North Shore reef area is not as heavily trawled and would be preferred. Opportunities to minimize impacts of a mid river reef by strategic reef placement have not been identified. Sanctuary reefs would not be available for oyster harvest but would provide a protected source of oyster larvae that would support natural oyster populations in nearby oyster harvest areas. Hook and line fishing is allowed on sanctuary reefs therefore, new reef construction would increase areas available for recreational fishing.

8.3.3 Essential Fish Habitat

8.3.3.1 No Action Alternative

The No Action Alternative would not adversely impact Essential Fish Habitat; however opportunities to benefit EFH by marsh and reef construction would be foregone. If the low head dam on the Little River in Goldsboro is not modified, anadromous fish migrations may continue to be reduced. No actions would be undertaken to affect EFH or managed species.

8.3.3.2 Recommended Plan

The modification of the low head notched dam at Goldsboro, Kinston East Wetland Complex, the shoreline stabilization project at Gum Thicket and Cedar Creek, and the oyster reef restoration would not cause significant adverse impacts EFH species or their habitats and benefit EFH once new habitats are established. Additionally, the Recommended Plan is expected to create and restore EFH and HAPC in the Neuse River Basin.

Modifying Low-head Dam on Little River near Goldsboro. No direct impacts to EFH. This component is not in the estuary and does not provide habitat for managed species. However, benefits for anadromous fish would accrue to the estuary. Increasing the spawning and nursery area for anadromous fish would be expected to increase production of juvenile anadromous fish. More juvenile anadromous fish would also benefit the Neuse River Estuary and Pamlico Sound by providing additional food resources.

Kinston East Wetland Complex. No direct impacts to EFH. This component is not in the estuary, is located about 30 miles upstream of any tidal influence, and does not provide habitat for managed species. Moreover the 14.5 acre restoration site is located in the Neuse River floodplain and not within the main stem of the river.

Stabilizing Gum Thicket Creek and Cedar Creek. No significant adverse effects on EFH or managed fish species would be expected from constructing or maintaining the Gum Thicket and Cedar Creek component. The proposed action would be expected to provide long-term beneficial effects on EFH and short-term minor negative effects during construction and establishment of proposed restored habitats as described in the following paragraphs.

Table 2-9 shows the categories of EFH and HAPC for managed species that were identified in the Fishery Management Plan Amendments of the South Atlantic Fishery Management Council and could occur in southeastern states. Those EFH categories that apply to the Gum Thicket/Cedar Creek portion of the proposed project are described below. Managed and forage fish species are highly mobile and should be able to avoid harm from construction activities. Any direct mortality would be expected to be low and less than significant. After the proposed marshes are established, it is expected that the habitat for fish would be improved.

Effects on EFH (identified by underlined and italicized text below) potentially present in the vicinity of the Gum Thicket/Cedar Creek portion of the proposed project are discussed below. Placing sandy material and rock during construction of this project could affect the *Estuarine Water Column* in the immediate vicinity of the activity, potentially adversely affecting estuarine fish and adjacent habitat. Those effects could include short-term minor suspended sediment plumes and related turbidity as described in Section 8.2. *Mud Bottoms* are in the project vicinity but do not occur in the project construction footprint, which NCDMF has mapped as Strata L (subtidal, hard, nonvegetated with no shell). Short-term minor effects, if any, would be expected. *Aquatic Beds*, of *Rangia* clams could be present in the vicinity of the project; however, these species are not of commercial importance in the Neuse Estuary. The salinities in the project area average about 12 ppt on the basis of water quality modeling and would not be expected to support significant populations of hard clam that require average salinities greater than 20 ppt for larval and juvenile development (Mulholland 1984). *Emergent and Forested Wetlands*, lost and restored or at risk to erosion, would be protected by the proposed project. *Submerged Aquatic Vegetation* is present in the Neuse Estuary but has not been mapped, nor is it expected within the project construction footprint because of the existing, high-energy environment. SAV is found in Gum Thicket Creek and would be protected from potential future impacts. Constructing the shoreline stabilization project would not adversely affect the abovementioned EFH resources because they are either not found in the project area or the USACE would ensure that all temporary short-term effects (i.e., turbidity, placement of rock and backfill material) would be confined to the project site. If required by the NCDWQ, floating turbidity/silt curtains would be used in the project area to confine any turbidity to the project area. *Oyster Reefs and Shellbanks* are present in the project vicinity but are not expected in the project construction footprint. Sill construction would expand oyster habitat. Any effects on existing oyster reefs or shell banks would be expected to be minor and temporary because no known shell banks are in the project area. *State-Designated Areas Important for Managed Species including PNAs* are present in the project vicinity but do not occur in the project construction footprint. Effects, if any, would be expected to be temporary and minor. Sill construction would be expected to provide beneficial staging areas for fish moving between nursery and adult habitats.

Constructing oyster reefs in the lower Neuse River Estuary. No significant adverse effects on essential fish habitat or managed fish species are expected from the construction or maintenance of this component as described below.

Table 2-9 shows the categories of EFH and HAPC for managed species that were identified in the Fishery Management Plan Amendments of the South Atlantic Fishery Management Council and could occur in southeastern states. Those EFH categories that apply to this component of the Recommended Plan are described below. Managed and forage fish species are highly mobile and should be able to avoid harm from construction activities. Any direct mortality would be expected to be low and insignificant. After the proposed reef features are established, habitat for fish would likely be improved.

Effects on EFH (identified by underlined and italicized font below) potentially present in the vicinity of proposed oyster reef project sites, are discussed below. Placing rock and cultch and potentially sandy material, during construction or maintenance of oyster reefs could affect the *Estuarine Water Column* in the immediate vicinity of the activity, potentially adversely affecting estuarine fish and adjacent habitat. Such effects could include minor short-term suspended sediment plumes and related turbidity. Because no violations of state standards would be expected, living estuarine resources dependent on good water quality would not be expected to experience significant adverse effects from water quality changes. The permanent presence of elevated structure would likely cause minor changes in currents in the vicinity of the structure but no significant hindrance to estuarine circulation. *Mud Bottoms* are in the project construction footprint. Potential reef sites would be in waters deeper than 11 ft, and includes areas that are periodically affected by hypoxia. The North Shore reef or expansion of the existing Neuse Sanctuary could occur in deep-water mud or on edges of strata that NCDMF has mapped as Strata L (subtidal, hard, nonvegetated with no shell). Converting soft bottoms to reef would be a permanent change. However losses of food resources provided by mud bottom would be expected to be minor because of the small scale of the loss, relative to the availability of this habitat type and the long-term replacement by alternative reef supported food resources once reefs become established. *Aquatic Beds, Emergent and Forested Wetlands, or Submerged Aquatic Vegetation* is not expected in proposed reef footprint areas. Efforts would be taken to avoid disrupting such resource areas if identified during construction, and any adverse effects would be expected to be short-term and minor. *Oyster Reefs and Shellbanks* are present in the project vicinity; however, reef placement would avoid existing reefs including an adequate protective buffer. Any adverse effects on existing oyster reefs or shell banks would be expected to be short-term and minor. Larvae production would help support oyster sustainability in nearby reefs. *State-Designated Areas Important for Managed Species including PNAs* are not present in the deep waters of the project vicinity. Short-term minor effects, if any, would be expected. Oyster reef construction would provide hypoxia refuge and naturally sustainable staging areas for fish moving between nursery and adult habitat, benefiting those species.

8.3.4 Fauna

8.3.4.1 No Action Alternative

Under the No Action Alternative, existing habitat conditions and trends for resident fauna would persist. No action at Kinston East Wetland Complex, Gum Thicket and Cedar Creek would result in continued future loss of wetland habitats and resultant impacts to associated fauna.

8.3.4.2 Recommended Plan

Wildlife (including birds) would not be expected to be adversely affected from implementing the Recommended Plan. Opossums, raccoons, rabbits, and foxes can be found in the upland portion of the project area. River otter and muskrat can be observed swimming along the river. Reptiles, amphibians, small nocturnal rodents, and white-tailed deer are also present. No known or existing bird rookeries or designated wildlife sanctuaries would likely be affected from implementing the Recommended Plan. Wildlife or birds using the project area are described in Section 2.3.2.2. Moreover, in Table 8-2 in Section 8.7 Compliance with Environmental Requirements, the USACE indicates that it will comply with the Migratory Bird Act.

Modifying Low-head Dam on Little River near Goldsboro. Little River Dam is adjacent to Goldsboro's water treatment plant in an area that is not expected to support significant numbers of wildlife. No clearing of woody vegetation would be expected at this site. The low-head notched dam is adjacent to Goldsboro's water treatment plant. This area is grassed with common lawn species (i.e., centipede, St. Augustine, Bahia, etc.). No woody vegetation would be cleared or removed from this site. Common bird species reside in this area such as cardinals, mockingbirds, sparrows, and morning doves. Additional species are described in Section 2.3.2.2. Those bird species are mobile and would avoid any construction activity. From observations at the site and discussions with on-site personnel, no resident bird species (ducks, wading birds, etc.) are using the 0.1 acre impounded water area upstream of the dam.

Kinston East Wetland Complex. The site was in the process of being developed for a subdivision and all of the mature bottomland hardwood vegetation has been removed. Since being cleared and filled, some young loblolly pines and sweetgum (all trees less than 3-inch DBH) have volunteered on the property. This predominantly disturbed tract is not expected to support significant numbers of wildlife. Common bird species reside in this area such as cardinals, mockingbirds, sparrows, and morning doves. There are no designated wildlife sanctuaries, migratory bird habitat, nesting, or rookeries in or near the project site. Additional species are described in Section 2.3.2.2. Those bird species are mobile and would avoid any construction activity. The proposed 14.5 acre restoration site is located within the Neuse River floodplain but not located adjacent to the main stem of the Neuse River. Staging would occur in previously disturbed upland areas within the 30 acre tract. Moreover, all restoration activities will be located on high ground and not within any waters of the Neuse River.

Stabilizing Gum Thicket Creek and Cedar Creek. Wildlife (birds) using this area is described in Section 2.3.2.2. North Carolina Wildlife Resources Commission has not designated any special bird nesting or rookery areas at or near the project site. Stabilizing the Gum Thicket shoreline would also benefit wading birds (i.e., egrets, heron, and ibis) and migratory shorebirds that frequent the shallow-water and estuarine shore habitat. Staging would occur in previously disturbed upland areas.

Constructing oyster reefs in the lower Neuse River Estuary. The proposed oyster reefs would be in waters of the lower Neuse River Estuary that are deeper than 11 ft. Direct adverse impacts to wildlife habitat are not expected as a result of construction of the oyster reefs. Staging would occur in previously disturbed upland areas. Any disturbed groundcover within these staging areas would be restored when construction has been completed.

8.3.5 Federally Threatened and Endangered Species and State-Protected Species.

8.3.5.1 No Action Alternative

Under the No Action Alternative, existing habitat trends for listed fauna would persist. The No Action Alternative would not affect federally endangered or threatened species or any State Protected species that may currently use or inhabit the Neuse River Basin study area.

8.3.5.2 Recommended Plan

As indicated in Section 2.3.2.5, coordination with the USFWS and the NMFS has been conducted to identify endangered and threatened species (as well as Federal species of concern) that might be present in the vicinity of the Neuse River Basin study area. Species that are federally listed as endangered or threatened (and FSC), could or do occur in the project area, and might be subject to effects from implementing the proposed projects are listed in Table 2-11. The table is based on a list of federally listed threatened and endangered species taken from the USFWS Draft Coordination Act Report dated August 11, 2008, and an e-mail from NMFS dated December 15, 2008. Table 2-11 provides an updated list of threatened and endangered species pursuant to Section 7 of the Endangered Species Act of 1973 (Public Law 93-205), as amended for the project area. Table 2-12 provides an updated list of those State Protected Species that may occur in the Neuse River basin and was provided by the North Carolina Natural Heritage Program (Personal Communication, John Finnegan, Information Systems Manager, North Carolina Natural Heritage Program, 21 October 2010). These species could be present in the project area on the basis of their historical occurrence or potential geographic range. However, the actual occurrence of a species in the project area depends on the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors.

The following Federally listed threatened or endangered species will not be affected by any component of the Recommended Plan.

American chaffseed (Schwalbea americana): American chaffseed is found in open pine flatwoods, savannas, and other open areas, in moist to dry acidic sandy loams or sandy peat barns. In North Carolina, it is found in Bladen, Hoke, Scotland, Moore, Pender, and Cumberland counties. Neither any staging areas or borrow areas would be in open pine flatwoods, savannas or in these counties, which are not in the Neuse River Basin. No adverse effects would be expected from any component of the Recommended Plan.

Michaux's sumac (Rhus michauxii): Michaux's sumac grows in sandy or rocky open woods in association with basic soils. Apparently, it survives best in areas where some form of disturbance has provided an open area. In North Carolina, the species is predominantly found in the Sandhills (Roberson, Scotland, Cumberland, and Moore counties), which is outside the Neuse River Basin. No adverse effects would be expected from any component of the Recommended Plan.

Rough-leaved loosestrife (Lysimachia asperulaefolia): This species generally occurs in the ecotones or edges between longleaf pine uplands and pond pine pocosins (areas of dense shrub and vine growth usually on a wet, peaty, poorly drained soil) on moist to seasonally saturated sands and on shallow organic soils overlaying sand. Rough-leaf loosestrife has also been found on deep peat in the low shrub community of large Carolina bays (shallow, elliptical, poorly drained depressions of unknown origin). The grass-shrub ecotone, where rough-leaf loosestrife is found, is fire-maintained, as are the adjacent plant communities (longleaf pine–scrub oak, savanna, flatwoods, and pocosin). Suppression of naturally occurring fire in these ecotones results in shrubs increasing in density and height and expanding to eliminate the open edges required by this plant. The proposed Recommended Plan project areas would not occur in any of the aforementioned rough-leafed loosestrife habitat. Therefore, no adverse effects would be expected from any component of the Recommended Plan.

Seabeach amaranth (Amaranthus pumilus): Seabeach amaranth is found growing the Atlantic Ocean beaches of North Carolina. The proposed staging or borrow areas would not be in ocean beach areas. No adverse effects would be expected from any component of the Recommended Plan.

Sensitive jointvetch (Aeschynomene virginica): *Aeschynomene virginica* is native to freshwater tidal marshes of the mid-Atlantic states (USFWS 1992). These marshes exhibit twice-daily tides but occur far enough upstream that they are nearly fresh or barely brackish in water chemistry. Salinity of one site in New Jersey ranges from 0.7 to 0.8 ppt with an average pH of 4.4. (NatureServe 2008). Only a small group of plants can tolerate this tidal inundation; thus, freshwater tidal marshes are home to many specialized and rare species. *A. virginica* grows low in the intertidal zone where soils might be mucky, sandy, or gravelly. *A. virginica* might perform best in areas of the marsh where competition with other plants is reduced—for example, newly accreting shores or openings created by wrack deposition or muskrat activity.

In North Carolina, *A. virginica* has been found in a few roadside ditches and wet corn fields, but these are not considered stable populations (Leonard 1986, USFWS 1992). Biological inventories of available freshwater tidal marsh habitat in North Carolina did not turn up additional populations, so the outlook for the taxon in North Carolina is uncertain.

As of the summer of 1990, *A. virginica* was extant in North Carolina in only two ditches connected to Lake Mattamuskeet in Hyde County. The sites in man-made habitats are very likely temporary and are not considered truly viable populations. All recent *A. virginica* records from North Carolina have been documented in only disturbed habitats such as roadside ditches and wet cornfields that are nearly tidal. It appears that *A. virginica* is exploiting moist, disturbed habitats where competing species such as smartweed and alligatorweed do not overtop the young seedlings (Leonard 1986). The plant also occurred historically (in the past 50 years) in Beaufort and Craven counties, and what was identified as Lenoir County. Several historical locations in North Carolina were field checked in 1985 (Leonard 1986), but *A. virginica* was not found and is presumed extirpated from those sites.

The Recommended Plan project areas are not located north of Lake Mattamuskeet in Hyde County and are not sited in a tidal freshwater wetland. Therefore the USACE does not anticipate any adverse effects on *A. virginica.*

Shortnose sturgeon (Acipenser brevirostrum). This species ranges along the Atlantic seaboard from southern Canada to northeastern Florida (USFWS 1999b). The shortnose sturgeon feeds on invertebrates and stems and leaves of macrophytes. From historical accounts, it appears that the species was once fairly abundant throughout North Carolina waters; however, many of those early records are unreliable because of confusion of this species with the Atlantic sturgeon (*A. oxyrhynchus*). Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low-salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults.

From June 2001 to September 2002, the Neuse River was sampled for both shortnose and Atlantic sturgeon (Oakley 2003). More than 200 hours of gill net surveys from the upstream obstruction of Millburnie Dam to Northwest Creek (south of New Bern) in the Neuse River were conducted in compliance with the NMFS shortnose sturgeon sampling protocol. No shortnose sturgeons were found in the Neuse River during the 2-year survey (Oakley 2003). However, four juvenile Atlantic sturgeons were encountered in the New Bern area (Oakley 2003).

Any component of the Recommended Plan would not be expected to adversely affect the shortnose sturgeon because they appear to be extirpated from the Neuse River Basin (Kynard 1997, Oakley 2003). Therefore, no anticipated adverse effects would be expected for the shortnose sturgeon or its habitat.

The following Federally listed threatened or endangered species may be affected but not significantly affected by any component of the Recommended Plan. Specific potential impacts for project components are discussed below.

Dwarfwedge mussel and Tar spinymussel. Both of these invertebrates are found in the Little River, about 15 mi upstream of the Rains Mill Dam that was demolished in 1999 (Personal comunication, Dale Sutter, Biologist, U.S. Fish and Wildlife Service, Raleigh Area Office, March 24, 2010). The Rains Mill Dam was on the Little River near Princeton, in Johnston County and was about 15 mi upstream of the existing notched low-head Little River Dam at Goldsboro.

The proposed action Little River Dam at Goldsboro would modify the existing notched low-head dam at Goldsboro by constructing a gate in the structure. No fill material would be placed in any water or wetlands. To provide additional stream access, the concrete debris found just downstream of the dam in the stream channel would be removed and placed on high ground. Any short-term turbidity caused by the project would be quickly dissipated downstream from the job site. Such short-term effects at Goldsboro would not cause any effects on the mussels more than 15 mi upstream of the existing dam. Therefore, no endangered mussel species would be adversely affected from implementing the proposed action. However, any increase in the number of potential fish hosts for glochidia transport would benefit mussels.

The proposed Kinston East wetland complex is located within the floodplain of the Neuse River. No work will take place in any waters of the Neuse River. Additionally, all sedimentation and runoff (turbidity) will be confined to the construction site. All restored floodplain would be stabilized and grassed after all work has been completed. Therefore, no endangered mussel species would be adversely affected from implementing the proposed action.

Sea Turtles and West Indian Manatee. Species listed in Table 2-11 including sea turtles and the West Indian Manatee can be found in the Neuse River Estuary and would only be found within the Gum Thicket/Cedar Creek shoreline stabilization project area and the Oyster Restoration Area. The construction activity could take place during the spring and summer months when these threatened and endangered sea turtles and the West Indian Manatee might be found in the estuary. Care will be taken to avoid impacts to these species.

The USACE would abide by all conditions and restrictions of the USFWS *Precautionary Measures for Activities in North Carolina Waters which May be Used by the West Indian Manatee* (2003). With these USFWS precautionary measures in place, the USACE does not anticipate any adverse effects on the West Indian Manatee and sea turtles.

Construction measures regarding threatened and endangered sea turtles were also coordinated with Dr. Matthew Godfrey, North Carolina Sea Turtle Coordinator, North Carolina Wildlife Resources Commission. Dr. Godfrey stated that with these construction measures in place, he would not anticipate any adverse effects on these threatened and endangered sea turtles (personal communication, Dr. Matthew Godfrey, North Carolina Sea Turtle Coordinator, North Carolina Wildlife Resources Commission, September 15, 2010).

Atlantic Sturgeon (Acipenser oxyrinchus oxyrinchus). Although specifics vary latitudinally, the general life history pattern of Atlantic sturgeon is that of a long-lived, late-maturing, estuarine dependent, anadromous species. The species' historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida (Murawski and Pacheco 1977, Smith and Clugston 1997). Atlantic sturgeons are found in the Gum Thicket and Oyster Reef construction areas in the lower Neuse Estuary (Oakley 2003).

Of the stressors evaluated, by catch mortality, water quality, lack of adequate state or Federal regulatory mechanisms, and dredging activities were most often identified as the most significant threats to the viability of Atlantic sturgeon populations. Additionally, some populations were affected by unique stressors, such as habitat impediments (e.g., Cape Fear and Santee-Cooper rivers) and apparent ship strikes (e.g., Delaware and James rivers).

The Gum Thicket and Cedar Creek and Oyster Restoration Area Recommended Plan components in the Lower Neuse Estuary would not be expected to cause any adverse effects on water quality and would not be considered a dredging activity. No excavation would take place at the sites. Any short-term turbidity created by these projects would be short term and quickly dissipate. In fact, the long-term stabilization of the shoreline (with the marsh creation) and the offshore oyster reef construction could benefit this species. No adverse effects on this species would be expected.

The following State listed protected species will not be affected by any component of the Recommended Plan.

The State Protected species found in Table 2-12, will not be adversely affected by any component of the Recommended Plan. These species could be present in the project area on the basis of their historical occurrence or potential geographic range. However, the actual occurrence of a species in the project area depends on the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors.

The USACE has discussed the Recommended Plan with representatives from the North Carolina Wildlife Resources Commission (NCWRC). For the proposed dam modification on the Little River and the Kinston East wetland restoration, Mr. Rob Nichols, Biologist, NCWRC stated that he did not anticipate any adverse impacts to any State protected species (Personnel Communication, 20 October 2010, Rob Nichols, Biologist, NCWRC). Also Ms. Maria Dunn, Biologist with the NCWRC stated that she did not anticipate any adverse impacts to any State protected species for either the proposed shoreline stabilization project at Gum Thicket and Cedar Creek and/or the oyster reef restoration sites (Personnel Communication, 21 October 2010, Maria Dunn, Biologist, NCWRC). The Corps will continue to coordinate closely with NCWRC and other State/Federal agencies to ensure that the Recommended Plan will not adversely impact these species. Therefore, the Corps does not anticipate any adverse impacts of the Recommended Plan to any State protected species listed in Table 2-12.

8.4 Cultural Resources

To meet the intent of the National Historic Preservation Act and ER 1105-2-100, a Cultural Resources Study Plan (CRSP) was coordinated with the North Carolina State Historic Preservation Office (SHPO).Because of the broad expanse of the study area; the cultural resources study plan was developed after identifying potential project alternatives. The CRSP includes the following:

- Section 106 guidelines, National Historic Preservation Act of 1966 (36 CFR Part 800) for applicable alternatives
- Defining the affected environmental setting (wetland, underwater, terrace, upland) of each alternative
- Listing known cultural resource sites by chronology and environmental setting
- Forecasting conditions at cultural resource sites

8.4.1 No Action Alternative

The No Action Alternative would not directly affect known cultural resources at Gum Thicket and Cedar creeks. Indirectly, no action and the continued shoreline erosion at

Gum Thicket and Cedar Creek would result in adverse impacts to cultural resources. Five known historic and prehistoric archaeological sites (state site numbers 31PM28, 31PM32, 31PM33, 31PM34, and GT 9) are along the shore in the Gum Thicket and Cedar Creek area. Four of those sites were visited by an archaeologist with the North Carolina Office of State Archaeology in the late 1980s. The segments were described as heavily eroded and containing prehistoric and historic components. The fifth site, GT 9, was recorded in 2000, and it also was found to be heavily eroded. Therefore, the continued erosion at Gum Thicket and Cedar Creek is damaging cultural resources and will have long-term adverse impacts on cultural resources.

No adverse effects on cultural resources would be expected at the Little River Dam, Kinston East Wetland Complex, and oyster reef restoration sites in the lower Neuse River Estuary under the alternative.

8.4.2 Recommended Plan

On the basis of the preliminary investigations and North Carolina SHPO consultation, the USACE has determined that the proposed action would likely have no effect on historic properties, in accordance with 36 CFR 800.4(d)(1). If unavoidable historic properties are found in the project's area of potential effect or previously undiscovered sites are located, work in that area would cease until the completion of further consultation and evaluation. We will continue coordination of the Integrated Feasibility Study with SHPO as the plan is finalized and the document distributed to the agencies and public.

8.4.2.1 Modifying Low-head Dam on Little River near Goldsboro.

No historic properties were identified at the Little River area. The proposed staging area is at Goldsboro's water treatment plant, and no borrow areas are required. No adverse effects would be expected.

8.4.2.2 Kinston East Wetland Complex.

No historic properties were identified at the Kinston East site, since it is located within the Neuse River floodplain. The proposed staging area would be located within the 14.5 acre project area and no borrow areas are required. No adverse effects would be expected.

8.4.2.3 Stabilizing Gum Thicket Creek and Cedar Creek

Constructing the proposed rock sills at Gum Thicket and Cedar Creek could have a positive effect on cultural resources by halting shoreline erosion. Five known historic and prehistoric archaeological sites (state site numbers 31PM28, 31PM32, 31PM33, 31PM34, and GT 9) are along the shore in the Gum Thicket Creek and Cedar Creek area and would be protected by this activity. On-shore activities associated with the measures would be coordinated with the North Carolina SHPO to ensure that there no effects on historic properties occur. No adverse effects would be expected.

8.4.2.4 Constructing oyster reefs in the lower Neuse River Estuary.

Locations for constructing the oyster reefs in the lower Neuse River Estuary would be coordinated with the North Carolina Underwater Archaeology Branch to avoid known or suspected underwater cultural resources. No adverse effects would be expected.

8.5 Socioeconomic Resources

8.5.1 No Action Alternative

Under the No Action Alternative, no adverse impacts on socioeconomic resources would be expected.

8.5.2 Recommended Plan

The Little River Dam modification, Kinston East wetland restoration, Gum Thicket/Cedar Creek shoreline stabilization, and oyster reef construction and the Kinston East Wetland Restoration components of the project would not be expected to affect socioeconomic resources. No adverse long-term effects would be expected.

8.5.2.1 Modifying Low-head Dam on Little River near Goldsboro.

No adverse effects on socioeconomic resources would occur during modification of the Little River Dam. Some short-term localized beneficial effects may occur during construction from job creation.

8.5.2.2 Kinston East Wetland Complex.

No adverse effects on socioeconomics resources would occur during the removal of sediment within the floodplain. Some short-term localized beneficial effects may occur during construction from job creation.

8.5.2.3 Stabilizing Gum Thicket Creek and Cedar Creek

No adverse effects on socioeconomic resources would be expected during the stabilization and marsh creation at Gum Thicket and Cedar creeks. Some short-term localized beneficial effects may occur during construction from job creation.

8.5.2.4 Constructing oyster reefs in the lower Neuse River Estuary

No adverse effects on socioeconomic resources would be expected during construction of the oyster reefs in the lower Neuse River Estuary. Some short-term localized beneficial effects could occur during construction from job creation.

8.6 Other Significant Resources (Section 122 of Public Law 91-611)

Section 122 of Public Law 91-611 identifies other significant resources that should be considered during project development. Such resources, and their occurrence in the study area, are described below.

8.6.1 No Action Alternative

The No Action Alternative would not adversely impact Air Quality, Noise, Water Quality, Displacement of People, Businesses, and Farms, and Community and Regional Growth.

8.6.2 Recommended Plan

8.6.2.1 Air Quality

The Little River Dam modification, the Kinston East Wetland complex, the stabilization and marsh creation at Gum Thicket and Cedar creeks, and constructing oyster reefs in the lower Neuse River and Estuary and Kinston East Wetland Restoration would not be expected to adversely affect air quality for the following reasons:

- The work sites are not within any nonattainment or maintenance areas for ozone or fine particle standards designated by the North Carolina Division of Air Quality.
- The proposed staging area at the Little River Dam is at the Goldsboro water treatment plant. No borrow areas would be required for the Little River Dam modification.

Short-term minor effects on air quality would be expected from implementing the proposed action. Emissions would result from operation of the water-based equipment (tugs, barge equipment, and such), land-based equipment, and any other support equipment that might be on or adjacent to the construction areas. The project area in Wayne County (Goldsboro), Lenior County (Kinston), and the Lower Neuse Estuary (Gum Thicket and the Oyster Reef construction) are in attainment with National Ambient Air Quality Standards parameters. The proposed action likely would not affect the attainment status of the project area or region. A State Implementation Plan conformity determination (42 *United States Code* 7506 (c) would not be required because the project area is in attainment for all criteria pollutants.

8.6.2.2 Noise

The Little River Dam modification, the Kinston East Wetland Complex, the stabilization and marsh creation at Gum Thicket and Cedar creeks, and constructing oyster reefs in the lower Neuse River Estuary and Estuary and Kinston East Wetland Restoration would not likely have adverse noise effects. The construction activities are not expected to cause excessive noise and construction equipment will be in operation only during daylight hours and within the 5-day work week. None of the counties or adjacent municipalities has enacted a noise ordinance.

8.6.2.3 Water Quality

The Little River Dam modification, the Kinston East Wetland Complex, the stabilization and marsh creation at Gum Thicket and Cedar Creeks, and constructing oyster reefs in the lower Neuse River Estuary would not be expected to adversely affect water quality. The proposed action could cause short-term turbidity; however, water flow, wind, and wave action would quickly dissipate such effects.

Significant increases in turbidity would not be expected to occur outside the immediate construction area (turbidity increases of 25 NTUs or less are not considered significant in North Carolina). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) might be transported adjacent to the worksite. Turbidity levels would be expected to return to background levels in the project area after the activity is completed. The USACE would comply with all conditions and restrictions of the required Section 401 Water Quality Certificate issued from NCDWQ. If required by NCDWQ, floating turbidity/silt curtains would be used at the construction site to reduce such effects.

8.6.2.4 Displacement of People, Businesses, and Farms

Implementing the components of Recommended Plan would not require the acquisition of any residential or commercial properties. No utility relocations would occur. No businesses or farms would be displaced.

8.6.2.5 Community and Regional Growth

No increase in the growth rate in the project area would be expected. The proposed restoration projects would enhance the quality of the Neuse River for residents and tourists.

8.7 Compliance with Environmental Requirements

The Recommended Plan is in compliance with all applicable laws, policies, and plans as summarized in Table 8-2. Additionally, the following information is provided for clarification: the Neuse River has not been designated as a "Wild and Scenic" river; the Recommended Plan will not adversely impact CBRA since it is not located within a designated CBRA boundary. Additionally, no known shipwrecks are located within the Recommended Plan.

Table 8-2. Compliance of the Recommended Plan with environmental requirements

Environmental requirement	Status
Federal laws and regulations	
Abandoned Shipwreck Act of 1987	C
Clean Water Act of 1977, as amended	C
Clean Air Act, as amended	C
Coastal Zone Management Act of 1972, as amended	C
Coastal Barrier Resources Act of 1982	C
Endangered Species Act of 1973, as amended	C
Estuary Protection Act of 1968	C
Fish and Wildlife Coordination Act of 1934, as amended	C
Fishery Conservation and Management Act of 1976	C
Hazardous and Toxic Materials Issues	C
Land and Water Conservation Act of 1964, as amended	C
Marine Protection, Research, and Sanctuaries Act of 1972, as amended	C
Marine Mammal Protection Act of 1972, as amended	C
Migratory Bird Treaty Act of 1918, as amended	C
National Historic Preservation Act of 1966, as amended	C
National Environmental Policy Act of 1969, as amended	C
Submerged Lands Act of 1953, as amended	C
Water Resources Development Act of 1986, Section 906	C
Watershed Protection and Flood Prevention Act of 1954, as amended	C
Wild and Scenic Rivers Act of 1968, as amended	C
Executive Orders, memoranda, etc.	
Executive Order 11593, Protection and Enhancement of the Cultural Environment	C
Executive Order 11988, Flood Plain Management	C
Executive Order 11990, Protection of Wetlands	C
Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	C
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	C
EO 13186, Protection of Migratory Birds	C
CEQ Guidance on Prime and Unique Farmlands	C
State laws and regulations	
Coastal Area Management Act (CAMA) of 1974	C
Neuse River Sensitive Waters Act	C

Note: C= Compliant

8.7.1 Executive Order 12898 (Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations) and Executive Order 13045 (Protection of Children from Environmental Health Risks and Safety Risks)

In compliance with these Executive Orders, an analysis has been performed to determine whether the proposed project would have a disproportionately adverse effect on minority or low-income population groups in the study area. The Executive Orders requires that minority and low-income populations and children not receive disproportionately high and adverse human health or environmental effects or safety risks. The EOs also requires that representatives of minority of low-income populations, who could be affected by the project, be involved in the community participation and public involvement process.

Population

The data obtained and analyzed is on a state, county, and Census tract basis and was collected through the 2008 partial Census (Bureau of Labor Statistics 2010). The Neuse River Basin is approximately 9 percent of the state's total area with 23 counties. The 23 counties are Beaufort, Carteret, Craven, Duplin, Durham, Edgecombe, Franklin, Granville, Greene, Harnett, Johnston, Jones, Lenoir, Nash, Onslow, Orange, Pamlico, Person, Pitt, Sampson, Wake, Wayne and Wilson. The major municipalities and population centers within the Basin are Durham, Raleigh, Cary, Smithfield, Goldsboro, Kinston, and New Bern.

The aggregated population of the Neuse Basin counties was 2,832,358, according to 2008 Census figures. Populations in the Neuse River Basin increased almost 50 percent during the 1990 to 2008 period. The population of North Carolina and the United States increased 16.6 percent and 13.1 percent, respectively, over the same period. Population in the Basin is expected to increase to more than 3.2 million residents by 2019, and nearly 3.7 million by 2029, a 40 percent growth over the 2008 population estimates.

Minority Populations

The minority populations in the Neuse River Basin include African-Americans, Hispanic, and Native Americans. North Carolina's African-American population is 2,026,000, which is 21.6 percent of the state's total population. In the Neuse River Basin, the African-American population is more than 600,000, about 30 percent of the Basin's population. The Basin has a significant portion of the population that claims Hispanic origin. Of the 2.8 million residents, approximately 7 percent are Hispanic, according to 2008 population estimates. Native American populations in the Basin are less than that of the state, at 0.5 percent and 1.3 percent, respectively. Percentages of minority populations within counties in the Neuse River Basin are shown in Figure 2-18.

Economy

Generally, strong wholesale and retail trade, government, and service sectors characterize North Carolina's economy. North Carolina's temperate weather and extensive coastline and mountains attract vacationers and other visitors and help make the state a popular destination for people all over the country. Agricultural production is also an important sector of the state's economy and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in North Carolina, but high-technology manufacturing has begun to emerge as a significant sector in the state over the past two decades.

The Neuse River Basin, like the rest of North Carolina, has seen a shift from an agricultural and manufacturing-based economy, to that of a service economy. Farm employment has decreased an average of 14 percent from 2000 to 2008 in the Basin, while nonfarm employment has increased an average of 10 percent during that same time. While declining, agriculture remains an important source of revenue for the Basin's and state's economy. In the entire Basin, agriculture (cultivated crops and pasture) accounts for approximately 29.5 percent of the land use (NCDENR 2009a), and in 2008, agriculture provided North Carolina with about 9.7 billion in revenues and in the Basin, more than $500 million in agricultural commodities was sold (USDA 2009).

The unemployment rate for North Carolina is 9.8 percent (Bureau of Labor Statistics 2010), while the unemployment rate for the Neuse Basin ranges from 7 to over 10 percent.

Percentages of people below poverty level within counties in the Neuse River Basin are shown in Figure 2-19. The percentage estimates in this figure represent characteristics of population and housing as of 2008 according to the U.S. Census Bureau. Similar to trends in minority populations, in general people below poverty level are at their highest incidence in counties geographically centered between the Neuse River's headwaters and estuary; Greene, Jones, Lenoir, Wayne, and Wilson counties each have populations of people below poverty level of over 16.2 percent.

8.7.1.1 No Action Alternative

Status quo conditions would continue.

8.7.1.2 Recommended Plan

The Recommended Plan is also the identified National Ecosystem Restoration Plan. The Recommended Plan would improve biological integrity, improve freshwater mussel populations, improve anadromous fish populations, restore emergent wetlands, and increase the quantity and quality of oyster reef habitat. The specific elements of the Recommended Plan include

Modification of the Low-head Dam on the Little River: This element would restore habitat connectivity for 46 miles of spawning habitat for anadromous fish species between the Neuse River estuary and upstream freshwater tributaries.

Kinston East Wetland Complex. This element would restore 14.5 acres of bottomland hardwoods wetlands in the Neuse River floodplain. Additionally, flood storage capacity within the Neuse River floodplains would be increased as a result of this activity.

Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creek: This element would minimize erosion on approximately 60 acres of existing estuarine wetland at the Gum Thicket and Cedar Creek sub-estuaries create approximately 6 acres of additional estuarine wetland, and protect about 6 acres of shallow water habitat (landward of the rock sill). Stabilizing 3,500 feet of shoreline at Gum Thicket Creek and 5,200 feet of shoreline at Cedar Creek would restore estuarine shoreline and maintain coastal wetland conservation easement, where no development is allowed, that would otherwise be lost to erosion into the future.

Neuse River Estuary Oyster Reef Restoration: This element would restore approximately 10 reef top acres supporting approximately 80 acres of oyster reef habitat, to address historic and projected future habitat losses, and protect the restored habitat areas as a state-designated sanctuary.

The Recommended Plan projects would provide benefits by improving the natural environment.

Approval and construction of the Recommended Plan should benefit all communities because the Recommended Plan projects contribute to Neuse River Basin environmental sustainability. The environmental benefits of the Recommended Plan projects would not adversely impact employment opportunities for minority and low-income populations in Neuse River Basin. All work would take place on private property or in the waters of the Neuse River Estuary. No private residences or businesses would be purchased or relocated as a result of implementing the activity. Any impacts of the Recommended Plan would not be disproportionate towards any minority or low-income population. The Recommended Plan actions do not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife." Therefore the Recommended Plan will not adversely impact minority or low-income populations.

After approval for public release, the Draft Integrated Feasibility Study and Environmental Assessment was widely distributed to State, Federal, and local agencies and governments, and stakeholders identified during the study. Special emphasis was made to distribute the draft report to the communities where the proposed project elements, and minorities and low income populations occur. Announcements were distributed to newspapers and television and radio stations including those that service minorities and low income populations. Additionally, the USACE coordinated specifically with the fishing industry to determine the acceptability of new oyster reef habitat locations and to identify any opportunities to minimize impacts on the local fishery. The USACE also coordinated the Draft Integrated Feasibility Study and Environmental Assessment with federally-recognized tribal governments.

Information gathered during the comment period has been incorporated, and the USACE will publish a Final Feasibility Study and EA.

8.7.2 Executive Order 11593 (Protection and Enhancement of the Cultural Environment)

This Executive Order states that the Federal Government shall provide leadership in preserving, restoring and maintaining the historic and cultural environment of the Nation. Agencies of the executive branch of the Government (hereinafter referred to as 'Federal agencies') shall (1) administer the cultural properties under their control in a spirit of stewardship and trusteeship for future generations, (2) initiate measures necessary to direct their policies, plans and programs in such a way that federally owned sites, structures, and objects of historical, architectural or archaeological significance are preserved, restored and maintained for the inspiration and benefit of the people, and (3), in consultation with the Advisory Council on Historic Preservation, institute procedures to assure that Federal plans and programs contribute to the preservation and enhancement of non-federally owned sites, structures and objects of historical, architectural or archaeological significance.

8.7.2.1 No Action Alternative

Both the Little River Dam modification, Kinston East Wetland Complex, and the Oyster Reef Restoration projects would not cause long-term adverse impacts to cultural resources. However, five known historic and prehistoric archaeological sites are along the shore in the Gum Thicket Creek and Cedar Creek area and would not be protected by the proposed shoreline stabilization. The No Action alternative would cause long-term adverse impacts to these 5 known sites at Gum Thicket and Cedar Creek.

8.7.2.2 Recommended Plan

Five known historic and prehistoric archaeological sites are along the shore in the Gum Thicket Creek and Cedar Creek area and would be protected by the proposed shoreline stabilization. Therefore, the Recommended Plan would not adversely impact cultural resources but would benefit cultural resources by protecting these sites.

8.7.3 Executive Order 11990 (Protection of Wetlands)

This Executive Order mandates each Federal agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. (b) This Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property.

8.7.3.1 No Action Alternative

By not stabilizing the Gum Thicket and Cedar shorelines up to 60 acres of adjacent wetlands and the 240 acre conservation easement would continue to be lost by erosion. Additionally, by not restoring the Kinston East wetland complex about 14.5 acres of bottomland hardwood wetlands would be permanently lost.

8.7.3.2 Recommended Plan

No wetlands would be adversely impacted by the Little River dam modification, Kinston East Wetland Complex, Gum Thicket and Cedar Creek shoreline stabilization, or the oyster reef restoration projects. Therefore, no long-term adverse impacts are anticipated. The Gum Thicket and Cedar Creek shoreline stabilization project would benefit about 60 acres of adjacent wetland and the 240 acre conservation easement by stopping further erosion along the shoreline. Additionally, at this site about 6 acres of newly planted marsh will be established landward of the rock sill. Also the Kinston East wetland restoration site would reestablish 14.5 acres of bottomland hardwood wetlands within the floodplain of the Neuse River.

8.7.4 Executive Order 11988 (Floodplain Protection)

This Executive Order states that each Federal agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing. and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

8.7.4.1 No Action Alternative

No anticipated long-term impacts are anticipated for the Little River Dam modification, Gum Thicket and Cedar Creek shoreline stabilization, and the oyster reef creation. However at the Kinston East wetland restoration site there would continue to have a 14.5 acre filled area within the floodplain of the Neuse River, which would reduce its overall flood storage capacity.

8.7.4.2 Recommended Plan

All four projects (Little River dam modification, Kinston East Wetland Complex, Gum Thicket and Cedar Creek shoreline stabilization, and the oyster reef restoration) are all located within the 1 percent flood plain (100-year). However, these beneficial environmental restoration projects are not anticipated to create any significant change to the 1percent flood plain (100-year). By restoring the 14.5 acres Kinston East bottomland hardwood wetlands in the floodplain of the Neuse River, additional flood storage capacity would be created.

Additionally, the Little River Dam modification is located within the floodway of the Little River. We do not anticipate any change to the floodway since we only plan to remove existing debris from the river channel and further expand the existing opening of the structure for anadromous fish and resident fish passage.

8.7.5 Executive Order 13045 (Protection of Children from Environmental Health Risks)

This Executive Order mandates Federal agencies to identify and assess environmental health and safety risks that may disproportionately affect children as a result of the implementation of Federal policies, programs, activities, and standards.

8.7.5.1 No Action Alternative

No anticipated long-term effects.

8.7.5.2 Recommended Plan

There are no schools, playgrounds, parks, or public access areas near of adjacent to the Recommended Plan. No anticipated long-term impacts are anticipated.

8.7.6 Executive Order 13186 (Protection of Migratory Birds)

This Executive Order mandates Federal agencies to protect and conserve migratory birds and their habitats.

8.7.6.1 No Action Alternative

No anticipated long-term effects at the dam on the Little River in Goldsboro, Kinston East Wetland Complex, and the oyster reef restoration projects. By not stabilizing the eroded shoreline at Gum Thicket and Cedar Creek habitat and shallow water feeding areas would be lost.

8.7.6.2 Recommended Plan

The Recommended Plan has been coordinated with State and Federal agencies to ensure that no migratory birds will be adversely impacted by the project. Gum Thicket and Cedar Creek shoreline stabilization and the Kinston East Wetland Complex will benefit migratory birds by protecting habitat and providing shallow feeding areas.

8.7.7 North Carolina Coastal Management Program

The Recommended Plan will take place in the designated coastal zone of the State of North Carolina. Pursuant to the federal Coastal Zone Management Act (CZMA) of 1972, as amended (P.L. 92-583), federal activities are required to be consistent to the maximum extent practicable with the federally approved coastal management program of the state in which their activities would be occurring.

8.7.7.1 No Action Alternative

No anticipated long-term effects.

8.7.7.2 Recommended Plan

The Corps has determined that the Recommended Plan is consistent with the North Carolina Coastal Management Program. Moreover, the Recommended Plan is also consistent with land classifications and policy statements found in the Oriental and Pamlico County Local Land Use Plan updates.

Based upon the information presented within this EA, the Recommended Plan is consistent with the North Carolina Coastal Management Program, the land use plans for Oriental and Pamlico County. This determination is being provided to the state for its review and concurrence.

9.0 CUMULATIVE EFFECTS

The Council on Environmental Quality defines *cumulative impact* as "the impact on the environment [that] results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). Whether cumulative impacts is a significant issue that should be addressed every time an Environmental Assessment is prepared. The analysis should be commensurate with the project's impacts and the resources affected. For example, small scale projects that have minimal impacts that are of short-duration would not likely contribute significantly to cumulative impacts.

Over the large Neuse River Basin area (the 6,235 sq mi) a number of reasonably foreseeable future actions by other Federal, state, and local agencies and by local landowners would be expected to occur. New construction and development would require implementing BMPs to limit the effect of such activities on the aquatic community and in the riparian corridor. The state's Basin-wide water quality planning efforts will continue to evaluate the condition of water quality on a 5-year basis. The state's water quality planning efforts will continue to identify improvement in areas and require reductions in areas not meeting water quality standards. Local municipalities, private dischargers, and landowners will continue to change the way they manage their activities to achieve pollutant reductions until all waterbodies meet water quality standards, including biological integrity.

As discussed in Section 8.0 of this Report, the Recommended Plan has minimal potential adverse impacts on environmental resources of the basin. While the Recommended Plan projects do occur in environmentally sensitive areas, the effects are shown to produce environmental benefits – otherwise they would not be carried forward or proposed. Accordingly, the incremental or cumulative adverse effects, effects of the proposed action plus effects of other reasonable foreseeable projects are not greater than those of the reasonably foreseeable projects alone.

9.1 Beneficial Cumulative Effects

During the initial inventory described in Section 3.2.2.4, a number of projects were identified as not being further evaluated because they were handled by others, recommended to be handled by others, or considered for preservation. Those projects work together to achieve the overall watershed goal, restoration of degraded aquatic ecosystems in the Neuse River Basin in support of increased Basin-wide environmental outputs. However, one critical project was identified in the initial stages of the study being implemented by others:

> ***Removal of Milburnie Dam.*** Moving upstream from the estuary, Milburnie Dam is the last obstruction on the mainstem of the Neuse River before Falls Lake Dam. Allowing fish passage upstream of that point would allow anadromous fish and other aquatic animal's access to the watershed over the maximum extent practicable. The landowner is moving forward with dam removal for the purpose

of establishing a mitigation bank. The landowner has started coordination with the Regulatory Branch of the USACE and communications with both parties indicate removal of the dam is moving forward. If the landowner is not able to proceed with removal the USACE would potentially include this as a Federal project in a reevaluation report.

Other projects recommended for implementation throughout the watershed include the following restoration projects:

- Little River and Buffalo Creek mitigation is being pursued by the city of Raleigh.
- Hominy Swamp is targeted by NCEEP for a future project.
- South River, Neuse Sub-estuary: land has been donated to the Coastal Federation, and restoration is being pursued.
- South Bay, Rattan Bay, and Turnagain Bay, Neuse Sub-estuary: NCEEP has targeted the watershed for restoration to be used as mitigation credits.
- Trent River at a railroad bridge crossing is targeted for implementation by NCEEP, to be used as mitigation for permitted impacts.
- Bay River, Neuse Sub-estuary, is being eroded and might be more appropriately addressed through authorities allowing the beneficial use of dredged material for marsh restoration.
- Little Lick Creek: NCEEP developed a watershed plan for this reach that identified reaches in fair condition (UNRBA 2006), and it is being handled by others.
- New Light Creek: NCEEP has already completed restoration, and the downstream reach is identified for mitigation.
- Swift Creek has been identified as a pursuit for future work by NCEEP.
- Little Contentnea Creek has a proposed greenway.
- Ledge Creek has a watershed management plan that will identify projects to be implemented.
- Reedy Branch is targeted by NCEEP.
- Mill Creek (in HUCs 03020201150040 and 03020201150050) was recommended for preservation after site visits to the area indicated pristine habitat conditions.

At the time of writing this report, the State does not have plans to increase the size of existing reefs or to build new reefs in the Neuse River Estuary. Constructing new oyster reef habitat as identified in the Recommended Plan would add nearly 100 acres toward meeting the goal of the ORSC's recommendations for construction of 500 acres of new marl reef as sanctuaries by 2018 (NCCF 2008).

In systems such as the Neuse Basin, where restoration may be conducted at a variety of sites, benefits of projects may add up to produce a greater system-wide benefit. Assessing cumulative positive effects of all the restoration actions of the proposed Recommended Plan and site-specific restoration actions proposed by others is very difficult particularly within a large and complex ecosystem like the Neuse River Basin. Intuitively, the addition of a series of positive effects is not expected to result in greater adverse impacts.

9.2 No Action Alternative

No adverse cumulative effects.

9.3 Recommended Plan

The proposed action would not produce a cumulatively significant adverse effect on the environment. Cumulative positive effects are likely considering the restoration efforts of many agencies. However, quantification of these cumulative effects on the large scale Neuse River basin ecosystem has not been accomplished.

10.0 PLAN IMPLEMENTATION

This project has been in the President's budget throughout the course of the study. After project authorization, if Congress appropriates Federal construction funds, the USACE and the non-Federal sponsor would enter into a Project Partnership Agreement (PPA). The PPA would define the Federal and non-Federal shares for implementing, operating, and maintaining the project.

Immediately after receiving project funding, finalizing plans and specifications, and execution of the PPA, the USACE would meet with the local sponsor with a formal notice to proceed with acquiring the necessary real estate interests and to discuss the real estate acquisition process. After a review of all real estate interests acquired by the local sponsor, the Real Estate Division would certify that the sponsor has acquired all real estate required for project construction. The USACE would then advertise the construction contract. After the sponsor acquisition is completed, the Real Estate Division would review all real estate-related costs for crediting purposes and provide a memorandum to the project manager for use in project closeout. The final acceptance and transfer of the project to the non-Federal sponsor would follow the completion of construction and the delivery of an operation and maintenance manual and as-built drawings. The estimated schedule for project implementation, shown in Table 10-1, assumes authorization in the proposed Water Resources Development Act of 2013.

Table 10-1. Project implementation schedule

Activity	Completion date
Project Engineering and Design start	2012
Plans and Specifications Complete	2014
Real Estate Acquisition Complete	2014
Construction Complete	2017

The Federal share for future costs is 65 percent, and the non-Federal share is 35 percent, with some portion from local sponsors.

10.1 Preconstruction Engineering and Design Phase

The PED phase would follow the feasibility study. The purpose of the phase would be to complete all the detailed, technical studies, and design needed to advertise and initiate construction. The phase would be complete with the finalization of detailed construction drawings and specifications.

PED costs would be initially funded between the USACE (75 percent) and the non-Federal sponsor (25 percent). Ultimately, all ecosystem restoration costs will be shared at 65 percent Federal / 35 percent non-Federal. Documents prepared during the PED phase would include the following:

- Updated Real Estate Plan
- PED agreement with the non-Federal sponsor
- First detailed construction drawings and specifications

- Draft Project Partnership Agreement

It is also anticipated that the geotechnical foundation of areas where rock would be placed would be evaluated during the PED phase of the study. Data would be collected to evaluate the potential for settlement and finalization of rock quantities.

10.2 Construction Phase

After Congress appropriates funds specifically for ecosystem restoration in the Basin, the PPA would be finalized and signed. The construction work would begin soon after the PPA is approved and executed, the real estate easements are acquired, and a construction contract is awarded. The construction phase would include the following:

- Appropriation of construction funds
- PPA approval and execution
- Construction contract advertised
- Construction contract awarded
- Phased construction of restoration features initiated
- Approval of operation and maintenance manual
- Construction completion
- Project acceptance and transfer to sponsor

Project construction can occur in phases at restoration sites throughout the Basin. It is estimated that construction would take two years to complete. Each construction element would be monitored for five years for physical and environmental performance after completing construction. The PDT recommends that work begin at the low-head dam on Little River near Goldsboro, then continue at Kinston East Wetland Complex, and then continue to Gum Thicket Creek and Cedar Creek, finishing with the construction of oyster reefs in the estuary. Phasing construction in such a way creates upstream habitat for anadromous fish before creating habitat staging areas in the estuary.

10.3 Project Monitoring Phase

A feasibility-level of detail Monitoring and Adaptive Management Plan can be found in Appendix Q. Monitoring will be used to address the project objectives and confirm project effectiveness. The USACE would use adaptive management techniques to correct any deficiencies found during monitoring that limit the environmental benefits of restoration. The costs associated with monitoring and adaptive management would be shared with the non-Federal sponsor in accordance with the cost-sharing requirements specified for project implementation.

10.4 Operation and Maintenance Phase

Responsibility for ongoing operation and maintenance, including repair, rehabilitation, and major replacement, would be turned over to the non-Federal sponsor following construction. The non-Federal sponsor's responsibilities in this phase would also include final certification of all necessary real estate and permit requirements for completing project operations and maintenance. Detailed operation and maintenance requirements would be specified in writing to the sponsor. The non-Federal sponsor would be responsible for 100 percent of the operation and maintenance requirements in this phase. The anticipated operation and maintenance requirements are described in Section 7.4.

10.5 Cost Allocation

All costs for this project have been allocated to the purpose of NER. Cost allocation is the practice of allocating the separable costs of a project to the project purpose that they serve.

10.6 Cost Apportionment

Cost-sharing for construction of this environmental ecosystem restoration project will be 65 percent Federal and 35 percent non-Federal. The Sponsor (State of North Carolina) will provide all lands, easements, relocations, rights-of-way, and disposal or borrow areas (LERRD) required for construction and subsequent maintenance. The non-Federal cost share is summarized in Table 10-2 below and consists of credit for LERRD and sufficient cash and work-in-kind (WIK) credit to equal the 35 percent cost share. As shown in Table 10-2, no work in-kind (WIK) has been negotiated with the Sponsor to date, but Sponsor capabilities and construction responsibilities may be pursued during detailed project design. If LERRD credit were to exceed the 35 percent cost share, the Sponsor would be reimbursed for the excess. However, for this project, estimated LERRD credit is less than one percent of estimated implementation costs.

The project will be monitored after construction to assure the project is performing as anticipated and is providing the intended benefits. Monitoring and adaptive management costs during this period (as needed and not to exceed ten years) are included in cost shared, implementation first costs discussed above.

Once construction is complete, the Sponsor will assume responsibility and all costs for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project. OMRR&R for the various project sites may be required as described in Section 7.4.

Table 10-2. Non-Federal Requirements ($1,000's)

Task	Cost
LERRD	$257
Cash	$13096.6
Work-In-Kind	$0

*escalated to midpoint of construction

11.0 PUBLIC INVOLVEMENT, REVIEW, AND COORDINATION

Throughout this study, stakeholders were actively involved in the planning process; some served as members of the PDT and workgroups. Ultimately, the USACE and stakeholders worked together to identify restoration measures that would add value to ongoing projects by other Federal, state, and local agencies and to recommend projects as the recommended plan.

Initial input was requested by a scoping letter dated March 31, 1999 This letter requested comments from agencies, interested groups and the public to identify needs and opportunities related to flood damages, water quality improvements, and ecosystem restoration in the Neuse River Basin, North Carolina. Information from this scoping activity was used during the preparation of the *Neuse River Basin, North Carolina Reconnaissance Report* (May 26, 2000).

On April 24, 2006, a second scoping letter was sent to Federal, state, and local agencies, interest groups, and the public to request identification of significant resources and issues of concern. The purpose of the scoping letter was to solicit comments from interested parties including various private, local, state, and federal agencies and any affected Indian tribes on this proposal to ensure that the development of a recommended plan considers the concerns of other agencies and the public. In response to the scoping letter, the public and review agencies expressed the following major concerns: fishery resources and habitats, wetlands, stream buffers, floodplains, storm water, water quality, aquatic life and habitat, endangered/threatened species, cultural resources, sediment control and erosion, and other natural resources. All concerns were considered and have been addressed in the recommended plan and in the integrated EA. Copies of the scoping letter and responses are found in Appendix D.

Letters were received from the agencies listed below and can be found in Appendix D.

Federal Agencies:

- U.S. Fish and Wildlife Service
- FEMA region IV

State Agencies:

- North Carolina Department of Administration
- North Carolina Department of Environment and Natural Resources
  - Division of Water Quality
  - Division of Marine Fisheries
  - Division of Environment Health
  - Division of Emergency Management
- UNC Chapel Hill
- North Carolina Department of Cultural Resources

- North Carolina Wildlife Resources Commission

Local Agencies:

- Upper Coastal Plain Council of Governments
- Franklin County Planning and Inspections
- County of Franklin, North Carolina
- Town Planner for Beaufort, North Carolina
- Town of Mount Olive, North Carolina

Individuals:

- Ben Bowditch, Oriental, North Carolina
- Randy Mundt

A Notice of Intent to prepare an Environmental Impact Statement was published in the Federal Register May 15, 2006 (Appendix D). The Recommended Plan is considered environmentally acceptable. The Recommended Plan is not expected to significantly affect the quality of the human environment. If this initial determination remains unchanged following circulation of the EA, an Environmental Impact Statement will not be required, and a Finding of No Significant Impact (FONSI) will be signed prior to the initiation of the proposed action.

Comments and concerns identified by the study scoping process were grouped into four broad focus areas. Workgroups were formed to collaborate and build upon the active efforts of other agencies and organizations working within these focus area to identify ecosystem and flooding issues and restoration opportunities throughout the Basin. The four workgroups include:

- Wetlands, Streams, and Riparian Buffer Restoration Workgroup
- Anadromous Fish Habitat Restoration Workgroup
- Estuarine Resources Workgroup
- Flood Risk Management Workgroup.

The workgroups consisted of various stakeholders in the region, including members of other Federal agencies, state agencies, local governments, and nongovernment environmental organizations, such as U.S. Fish and Wildlife Service (USFWS), North Carolina Division of Marine Fisheries (NCDMF), the city of Kinston, and North Carolina State University. In addition, each of the workgroups conducted meetings with state and local agencies to identify opportunities for partnerships in restoration.

Wetlands, Streams, and Riparian Buffer Restoration Workgroup

For the Wetlands, Streams, and Riparian Buffers workgroup, seven meetings were held between early November and mid-December 2007 with regional stakeholders to discuss restoration opportunities identified from reconnaissance efforts. Meetings addressing the following areas were held:

- City of Durham
- City of Kinston
- Upper Neuse (Raleigh and Wake County Areas)
- Little Contentnea Creek (Farmville)
- Wilson County: Contentnea Creek near Stantonsburg
- Craven County: Swift Creek
- Neuse Subestuaries (NC Division of Marine Fisheries)

Meeting participants:

- City of Durham: Stormwater Services; Durham contractor
- City of Kinston: City Manager; Planning Director; Executive Director and Waterfront Committee of Pride of Kinston
- City of Raleigh: Utilities Director; Upper Neuse Clean Water Initiative
- Wake County: Environmental Services; Parks and Recreation (Open Space); Facilities Design and Construction (Property Acquisition); Soil and Water Conservation District (SWCD)
- Upper Neuse River Basin Association (UNRBA) and Triangle J Council of Governments (TJCOG)
- Conservation Trust for North Carolina (CTNC)
- Town of Farmville; Town Manager
- Pitt County; Planning, Soil Erosion and Sedimentation Control, SWCD
- Greene County; SWCD
- Wilson County, County Manager; Resource Conservation, Soil and Water Conservation District (SWCD)
- U.S. Department of Agriculture; District Conservationist, Natural Resources Conservation Service (NRCS)
- North Carolina Department of Transportation (NCDOT) Highway, Division 4
- North Carolina Department of Marine Fisheries
- Wilson County: Natural Resources Conservationist, SWCD
- Craven County: Natural Resources Conservationist, SWCD; North Carolina State University Cooperative Extension Service
- North Carolina Coastal Federation

These public involvement meetings provided the means for identifying specific restoration opportunities. These Neuse River Basin meetings recognized local and state efforts and benefits of individual projects which could be linked to the study efforts, potentially providing opportunities for greater ecosystem benefits to the basin as a whole.

Estuarine Resources Workgroup

The Estuarine Resources Workgroup did not have assigned members but consisted of a liaison with other State, Federal agencies and organizations with similar ecological goals and areas of interest. Collaboration with a consortium of Neuse River and state oyster biologists identified survey needs and historically degraded reef sites.

The potential for oyster restoration in the Neuse Basin was presented at the *International Conference on Shellfish Restoration in 2004.* The study methods and preliminary data were discussed at a North Carolina Coastal Federation Oyster Forum in 2007. These venues provided opportunities for dialog with scientists, fishermen, and the conservation community early in our planning process to identify problems need and opportunities oyster restoration.

Periodic meetings and discussions were held throughout the study process to coordinate and update state oyster managers (NCDMF), university researchers from the University of North Carolina, Wilmington and North Carolina State University, North Carolina Coastal Federation, and The Nature Conservancy on the progress of the study. This group assisted with identification of need and potential restoration sites. The oyster reef and other resource data collected during the conduct of this study is being shared with a State and academic group that will identify Strategic Habitat Areas within the southern Pamlico Sound Region that includes the Neuse Estuary.

Anadromous Fish Habitat Restoration Workgroup

An initial team meeting for this area was held in April 2005. The following were invited: U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (EPA), National Marine Fisheries Service, N.C. State University, U.S. Geological Survey, N.C. Division of Water Resources, N.C. Division of Marine Fisheries, Triangle J Council of Governments, N.C. Division of Water Quality, N.C. Department of Transportation, N.C. Wildlife Resources Commission, Neuse River Keepers, Neuse River Foundation, N.C. Clean Water Management Trust Fund, and State Dam Safety Engineer, N.C .Division of Land Resources. Attending were USFWS, N.C. State University, U.S. Geological Survey. This meeting provided information on historic anadromous fish habitat in the Neuse Basin, databases showing the locations of dams and other obstructions (highway pipes/culverts, etc.) in the Neuse River Basin and discussion of the restoration opportunities of populations of sturgeon, shad, and/or striped bass in the Neuse River Basin Subsequently, workgroup site visits to potential restoration opportunity areas were made between July 2005 and March 2006. Using information from the site visits the workgroup identified restoration opportunities for the study to consider.

Other Coordination

The USACE has maintained ongoing coordination with agencies that would ultimately require specific consultation actions or clearances to meet Federal and state regulations: Threatened and endangered species coordination with USFWS.

- EFH coordination with the NMFS.
- Cultural resources coordination with the SHPO.
- Section 401 water quality certification with the NCDWQ. The Section 404(b) (1) analysis is in Appendix T.
- Consistency with the Coastal Zone Management Plan.
- Coordination mandated by the Fish and Wildlife Coordination Act.

Based on discussions with NMFS, they support the findings of this Study and the Recommended Plan (National Ecosystem Restoration Plan) which was determined to have the greatest net benefits to the Neuse River Basin in North Carolina. Several components of the selected plan would also benefit NMFS trust resources including essential fish habitat (EFH) for federally managed species. In the August 11, 2008 Draft Coordination Act Report, the USFWS indicated strong support for this restoration effort (USFWS 2008). Understanding that the goals of the proposed study would benefit fish and wildlife resources in the limited areas selected for work, and recognizing the large size of the overall Basin, the USFWS requested that sites be carefully selected to achieve the greatest benefits for anadromous fish, Federally listed species, and those rare or endemic species that could become listed if declines in habitat quality continue. USFWS has provided extensive input in selecting and evaluating protected sites.

Public Review

The proposed action and the environmental impacts of the proposed action were addressed in the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011. The Draft Integrated Feasibility Report and EA were made available to an extensive list of local, State and Federal regulatory agencies and the public on November 30, 2011 for a 30-day review and comment period. The Feasibility Report and EA were also placed on the Wilmington District Website.

Comments were received during the 30-day public review period. The comments were used in the preparation of the Final Feasibility Report and preparation of the FONSI. The FONSI documents the environmental considerations.

Review Plan

The Review Plan (Appendix) was originally developed in 2007 with the Ecosystem Planning Center of Expertise and the USACE Cost Engineering Center of Expertise in Walla Walla District and has been updated to reflect recent study activities (Feb 2012). Reviews include District Quality Control reviews and Agency Technical Reviews of the Feasibility Scoping, Alternative Formulation, and Final Reports. A policy review was conducted on the Alternative Formulation Briefings package. Additional reviews include cost engineering review and certification, legal review and certification, and model review and approval.

On the basis of the USACE peer-review guidance (EC 1165-2-209), this study does not meet the triggers for an independent external peer review (IEPR) because (1) an EIS is not included, (2) the Recommended Plan is not likely to have significant economic, environmental, or social affects to the nation, (3) the study is not likely to have significant interagency interest, (4) the study does not involve significant threat to human life, (5) the study is less than $45 million in total, (6) the study is not highly controversial, and (7) the study is not based on novel methods, does not present complex challenges for interpretation, does not contain precedent-setting methods or models, or present conclusions that are likely to change prevailing practices. Therefore, a request for exclusion from IEPR memorandum was submitted to USACE headquarters and the South Atlantic Division. The request was approved April 24, 2012.

12.0 RECOMMENDATIONS

The District Commander recommends that the *Neuse River Basin Restoration Plan* be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. For budgeting purposes FY13 price levels were used to express total project costs; the estimated first cost of the recommended plan is $35,774,000 at the FY13 price level and the estimated OMRR&R cost is $540,000. The Federal portion of the estimated first cost is $23,253,100 at the FY13 price level; the non-Federal sponsor's portion of the estimated first cost is $12,520,900 at the FY13 price level. The non-Federal sponsor must, before implementation, agree to perform the following items of local cooperation:

a. Provide 35 percent of total project costs allocated to nonstructural environmental protection and restoration and at least 35 percent but no more than 50 percent of total project costs allocated to structural environmental protection and restoration, as further specified below:

(1) Enter into an agreement that provides, before execution of the project partnership agreement, 25 percent of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the government to be necessary for the construction, operation, and maintenance of the project;

(4) Provide or pay to the government the cost of providing all retaining dikes, waste weirs, bulkheads, and embankments, including all monitoring features and stilling Basins, that might be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal the percent of total project costs allocated to nonstructural environmental protection and restoration and at least 35 percent but no more than 50 percent of total project costs allocated to structural environmental protection and restoration.

b. Give the government a right to enter, at reasonable times and in a reasonable manner, on land that the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

c. Assume responsibility of operating, maintaining, replacing, repairing, and rehabilitating the project or completed functional portions of the project, including mitigation features, without cost to the government, in a manner compatible with the project's authorized purpose and in accordance with applicable Federal and state laws and specific directions prescribed by the government in the OMRR&R manual and any subsequent amendments thereto.

d. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army may not begin construction of any water resources project or separable element thereof until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the government or the government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601–9675, that may exist in, on, or under lands, easements, or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the non-Federal sponsor will not perform such investigations on lands, easements, or rights-of-way that the government determines to be subject to the navigation servitude without prior specific written direction by the government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. Agree that, as between the Federal government and the non-Federal sponsor, the non-Federal sponsor will be considered the operator of the project for the purpose of CERCLA liability, and, to the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

j. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder operation or maintenance of the Project.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with that act.

l. Comply with all applicable Federal and state laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, titled *Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army*, and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of floodplain management plans.

m. Provide the non-Federal cost share of that portion of total cultural resource preservation mitigation and data recovery costs attributable to structural and nonstructural flood control that are in excess of one percent of the total amount authorized to be appropriated for structural and nonstructural flood control.

n. Inform affected interests, at least annually, regarding the limitations of the protection afforded by the project.

o. Publicize floodplain information in the areas concerned and provide that information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the floodplain and in adopting such regulations as necessary to ensure compatibility between future development and protection levels provided by the project.

p. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

q. Agree that any part of the project identified as approved for proposed advanced work for credit under Section 104 of Public Law 99-662 must be compatible with recommended flood risk management project, and that any credit granted will not relieve the non-Federal sponsor of its requirement to pay, in cash, 5 percent of total project costs allocated to structural flood control.

The recommendations here reflect the information available and departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels in the Executive Branch. Consequently, the recommendations could be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, before transmittal to Congress, the sponsor, the states, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

13.0 LETTERS OF SUPPORT AND FINANCIAL CAPABILITY

13.1 Completed, Current, and Future Work Eligible for Credit

No work is eligible for in-kind credit or expected to be eligible for credit. This section will be updated as the project progresses.

13.2 Institutional Requirements

The non-Federal sponsor will prepare a financial analysis before an agreement is signed for Federal construction of the cost-shared project. The analysis should include the following:

- The non-Federal sponsor's project-related yearly cash flows (both expenditures and receipts where cost recovery occurs), including provisions for major rehabilitation and operational contingencies and anticipated, but uncertain repair costs resulting from damages from natural events.
- The non-Federal sponsor's current and projected ability to finance its share of the project cost and to carry out project implementation, operation, maintenance, and repair/rehabilitation responsibilities.
- The means for raising additional non-Federal financial resources including special assessment districts.
- The steps that the non-Federal sponsor will take to ensure that it will be prepared to execute its project-related responsibilities at the time of project implementation.

In addition, as part of any Project Cost-Sharing Agreement, the non-Federal sponsor will be required to undertake to save and hold harmless the Federal government against all claims related to environmental restoration, and other activities, associated with this project.

13.3 Sponsorship Agreements

The non-Federal sponsor will provide a Letter of Intent acknowledging sponsorship requirements. Before the start of construction, the non-Federal sponsor will enter into a Project Partnership Agreement (PPA) with the USACE.

14.0 POINT OF CONTACT

The point of contact for this project is Tomma Barnes, Lead Planner, Wilmington District (910)251-4728 or 69 Darlington Ave, Wilmington, NC 28403

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16.0 LIST OF PREPARERS

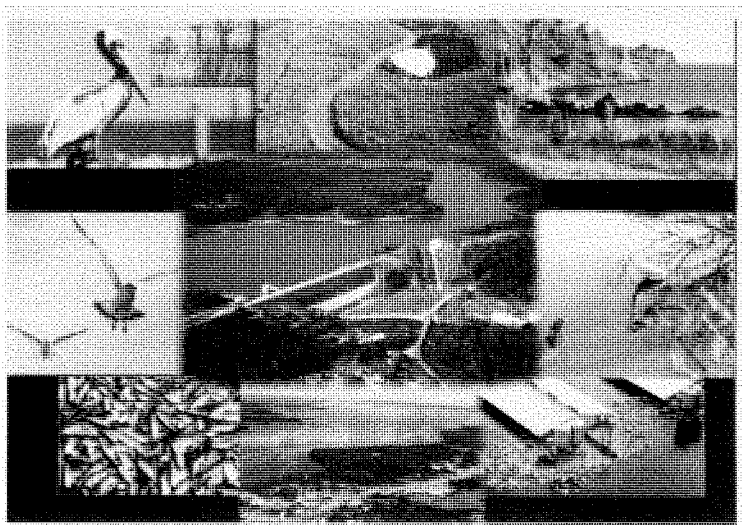
The people listed in Table 16-1 provided major support in developing and preparing this *Integrated Feasibility Report and Environmental Assessment for the Neuse River Basin, North Carolina.*

Table 16-1. List of preparers

Name	Role
Tomma Barnes	Lead Planner
Philip Payonk	Chief, Environmental Resources Section
Elden Gatwood	Chief, Planning Branch
Hugh Heine	NEPA preparation
Chuck Wilson	Environmental benefits analysis and NEPA preparation
Jeff Lin	Environmental benefits analysis and planning
John Mayer	Cultural Resources
Chris Graham	Economics
Justin Bashaw	NEPA preparation
Doug Wall	Engineering
Pam Castens	Project Management
Belinda Estabrook	Real Estate
Kristin Olsen	Cost estimator
Jamie Childers	Water resource planning, Tetra Tech

Neuse River Basin Integrated Feasibility Report and Environmental Assessment

Appendices A-F



IN COOPERATION WITH

NCDENR

PREPARED BY:

US Army Corps of Engineers
Wilmington District

November 2012

Appendix A: Consistency Determination for Compliance With CAMA

NORTH CAROLINA CONSISTENCY DETERMINATION

FOR WILMINGTON DISTRICT, US ARMY CORPS OF ENGINEERS (USACE)

In accordance with Section 307 (c)(1) of the Federal Coastal Zone Management Act of 1972, as amended, the US Army Corps of Engineers, Wilmington District (USACE) has determined that all described components of the Tentatively Selected Plan (TSP) are consistent, to the maximum extent practicable, with North Carolina's coastal management program. This determination is based on the review of the proposed project against the enforceable policies of the State's coastal management program, which are principally found in Chapter 7 of Title 15A of North Carolina's Administrative Code. The proposed TSP complies with the relevant enforceable policies of North Carolina's approved coastal management program and will be conducted, to the maximum extent practicable, in a manner consistent with the State's coastal management program. The following supportive narrative provides the details of the consistency determination. Drawings of the TSP are also provided.

The USACE requests that the North Carolina Division of Coastal Management concur with this consistency determination.

I. Project Description

The TSP is also the identified National Ecosystem Restoration Plan. The TSP would improve biological integrity, improve freshwater mussel populations, improve anadromous fish populations, restore emergent wetlands, and increase the quantity and quality of oyster reef habitat. Construction of the four components of the TSP is anticipated to occur within applicable environmental windows.

The specific components of the TSP are shown in Figure 1 and are described below.

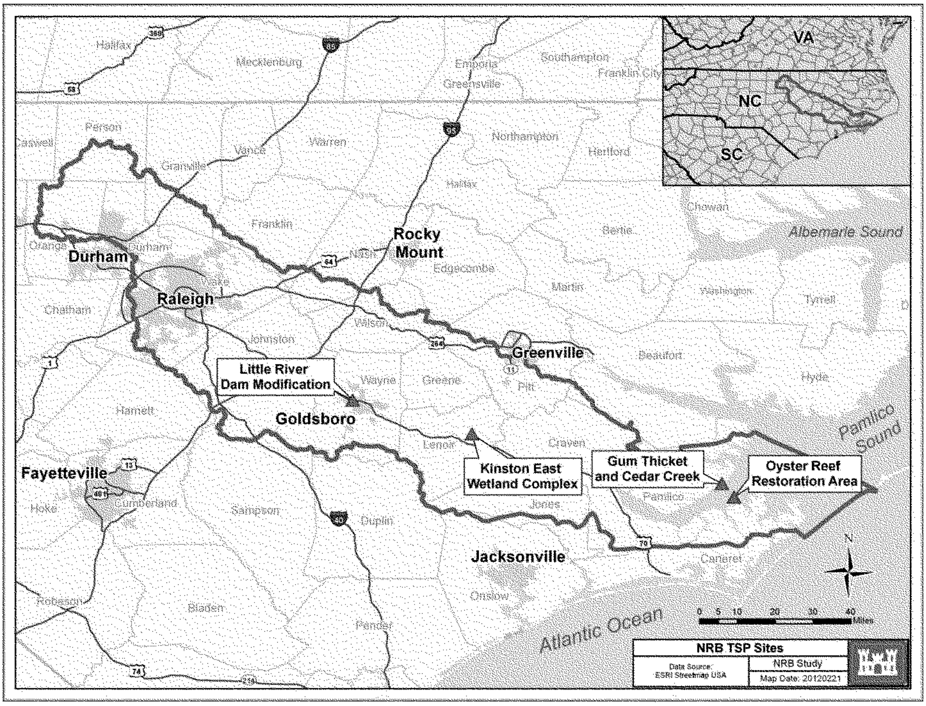
Modification of the Low-head Dam on the Little River in Goldsboro (Wayne County): This component would restore habitat connectivity for 46 miles of important spawning habitat for anadromous fish species between the Neuse River estuary and upstream freshwater tributaries. Species that rely on habitat structure from the Neuse River Estuary upstream would be allowed access to the Little River, a tributary to the Neuse River. Forty-six miles of in-stream habitat would be made accessible by re-connection of the Little River to its mainstem, the Neuse River. In order to reduce impacts to anadromous fish and their spawning habitat, no in-stream work will occur from 15 February to 30 September of any year. Additionally, all erosion and sediment control measures will be in place, prior to any work on the dam modification.

Kinston East Wetland Complex (Lenoir County): This component would restore approximately 14.5 acre of damaged or eliminated riparian buffer where a former bottomland hardwood forest adjacent to the Neuse River was filled. Restoration of this area would result in a reconnection to the adjacent floodplain. All erosion and sediment control measures will be in place, prior to any work on this 14.5 acre tract.

Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creek, near Oriental (Pamlico County): This component would reduce erosion on approximately 59 acre of existing estuarine wetland at the Gum Thicket and Cedar Creek sub-estuaries and create approximately 42 acre of additional estuarine wetland. Stabilizing 3,500 feet of shoreline at Gum Thicket Creek and 5,200 feet of shoreline at Cedar Creek would restore estuarine shoreline and maintain coastal wetland conservation easement, where no development is allowed, that would otherwise be lost to erosion in the future. All erosion and sediment control measures will be in place, prior to any work on this component of the TSP.

Neuse River Estuary Oyster Reef Restoration in Pamlico and Carteret Counties: This component would restore approximately 10 acre of new oyster reef top, supporting 80 acre of estuarine habitat that would be managed by the state as oyster reef sanctuary, where oyster harvesting would be prohibited.

Figure 1. Components of the TSP.



II. Background

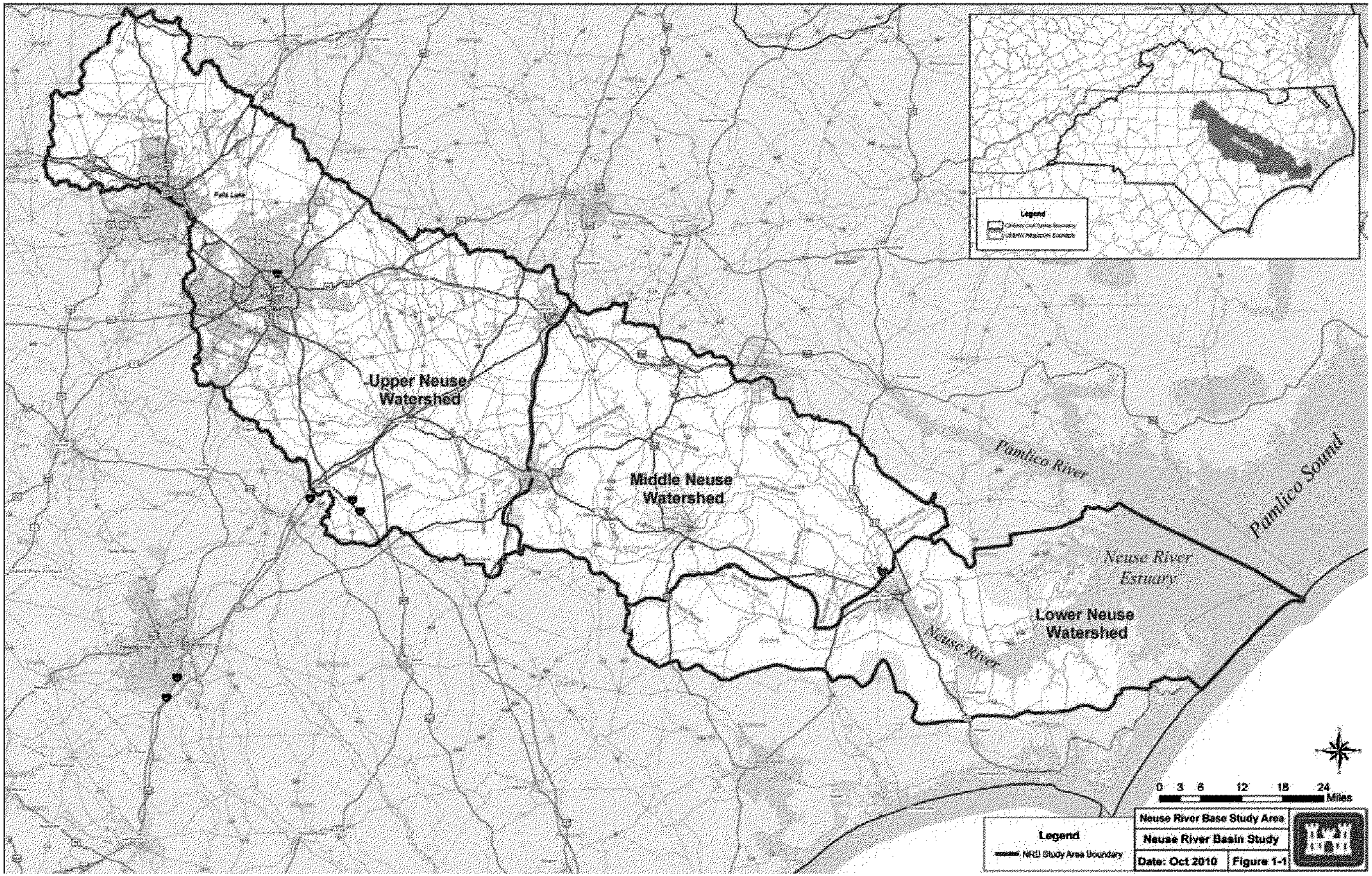
The <u>*Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, North Carolina, dated October 2011*</u> was coordinated with the public, Federal, State, and local agencies by letter dated November 30, 2011. This report was prepared as a partial response to the Congressional Resolution which requested recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin. The Corps partnered with the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) to conduct the study. This study encompassed the Neuse River Basin, a total area of 6,234 square miles and the third-largest river basin in North Carolina. The study team focused its resources on identifying areas of critical need within the Neuse river basin, performing functional assessments on those areas, developing solutions to area-specific problems, and identifying the most cost-effective means for restoration. The feasibility report contains a recommendation for later pursuit of follow-on studies directed at less critical problem areas and areas with rapidly changing land-uses.

The Neuse River Basin study evaluated environmental benefits in three ecosystem habitat categories—wetland, stream, and oyster reef. Analyses of existing and future "without-project" conditions, and projected future "with-project" conditions under numerous alternative restoration plans were conducted. After consideration of the costs, benefits, and environmental consequences of the proposed and alternative actions, a Tentatively Selected Plan (the National Ecosystem Restoration (NER) Plan) that had the greatest net benefits was selected. No Locally Preferred Plan was suggested.

III. Existing Conditions

The study area encompasses the Neuse River Basin, the third-largest river basin in North Carolina. The Basin contains a total area of 6,234 square miles (sq mi) (Figure 2), and it is one of only four watersheds entirely within the state. The Neuse River originates at the confluence of the Eno and Flat Rivers in north-central North Carolina near the city of Durham (in Person and Orange counties) and flows southeasterly until reaching tidal waters near State Highway 43, upstream of the city of New Bern, North Carolina. At New Bern the river broadens dramatically and changes from a unidirectional freshwater regime to a mixed tidal regime of the Neuse River Estuary. The Neuse River then flows through the estuary and out into Pamlico Sound before reaching the Atlantic Ocean. The upper one-third of the Basin is in the Piedmont physiographic province, while the lower two-thirds lie in the Mid-Atlantic Coastal Plain physiographic province. Elevations in the Basin range from 905 feet (ft) in the western part of the Basin to sea level where the Neuse River Estuary joins Pamlico Sound.

Figure 2. Neuse River Basin Study Area.



The Neuse River feeds one of the nation's largest and most productive coastal estuaries (Albemarle-Pamlico). The Albemarle-Pamlico estuary system is a nursery for 90 percent of the commercial seafood species caught in North Carolina. The rivers and streams of the Neuse River Basin are spawning areas for shad, herring, striped bass, and other anadromous fish—species that live as adults in the ocean but migrate upriver to spawn. Other important recreational and commercial species include catfish, bass, flounder, blue crabs, shrimp, and oysters.

State and Federal agencies recognize the significance of potential anadromous fish spring migrations on the Neuse River. The Neuse River produced more catches of shad than any other river in North Carolina at the beginning of the 20th century. Since 1997, the state, USFWS, and USACE have worked together to remove four dams on the Neuse River allowing migrating species to access 90 percent of their original spawning grounds (NCOEE 2010).

The Neuse has received national recognition from the American Rivers, a Non–Governmental Organization (NGO) focused on conservation. In addition, a call for protection of the Basin is supported by a number of local NGOs including Riverkeepers. In 1995, 1996, 1997, and 2007, American Rivers designated the Neuse River and Estuary as one of the most threatened rivers in North America. The Neuse River Foundation was created in 1980, one of the first water quality groups to be created in eastern North Carolina. Their mission has been "to protect, restore and preserve the Basin through education, advocacy and enforcement, to provide clean water for drinking, recreation and enjoyment to the communities that it serves." The Neuse River Foundation supports two Riverkeepers: the Lower Neuse Riverkeeper based in New Bern and the Upper Neuse Riverkeeper based in Raleigh.

The Neuse River Basin is home to 17 species of rare freshwater mussels and a rare snail species. Two of these mussels, the dwarf wedge mussel and Tar River spinymussel, are federally listed as endangered. The largest known population of the dwarf wedge mussel is found in the Connecticut River, but North Carolina has the greatest distribution of this mollusk, with tiny populations in small streams throughout 12 counties.

IV. Alternatives Analysis

The alternatives investigated during plan formulation and the benefits are found in the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011 (USACE 2011).

Ecosystem restoration is one of the primary goals of the USACE Civil Works Program. The USACE objective in ecosystem restoration planning is to contribute to national ecosystem restoration (NER). NER contributions include increases in the net quantity and/or quality of desired ecosystem resources. NER measurements are changes in ecological resource quality as a function of improvement in habitat quality and/or quantity. The units are expressed quantitatively in physical units or indexes that are not based on monetary units. Net changes are measured in the study area and in the rest of the Nation. Single-purpose ecosystem restoration plans are formulated and evaluated in terms of their net contributions to increases in NER output.

In Section 3.0 (USACE 2011), the USACE began the plan formulation process by clearly defining problems and opportunities for aquatic ecosystem restoration and flood risk management in the Neuse

River Basin. First, through clearly understanding the problems presented in Section 2 (USACE 2011), opportunities are identified that address the problems. The opportunities were then used to identify management measures. Opportunities were identified, in part, by looking to other's work in the watershed. Using screening factors that considered partnership opportunities, technical feasibility, implementation by other stakeholders, and sustainability, the management measures have been screened down to actions and sites in the Basin at which restoration activities will provide an overall systemic benefit to the Neuse River ecosystem that will complement other watershed activities currently being undertaken and planned for the future by other organizations.

Within Section 3 (USACE 2011), the USACE carried the planning process forward. Section 4 (USACE 2011) defines the future without-project condition. Understanding the future without-project condition, the management measures were refined to meet the opportunities of various sites, and the environmental benefits for future with-project conditions were quantified (Section 5 in USACE 2011). The environmental benefits and associated costs were the inputs for a cost effective/incremental cost analysis (Section 6.1 in USACE 2011). The purpose of the analysis was to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs. Ultimately, a final array of best buy, basin-wide alternatives was compared to display positive and negative effects. The comparison was used to select the TSP presented in Section 6.3 (USACE 2011).

Feasible alternatives investigated (including the No-Action Alternative) during plan formulation and the benefits are found in the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011. Table 1 below summarizes the potential effects of the No Action Alternative and the four components of the TSP, or Preferred Alternative, on resources in the Neuse River Basin.

There has been no change from the TSP described in the referenced EA dated October 2011 and the FONSI.

V. Resource Agency Coordination

Throughout this study, stakeholders were actively involved in the planning process; some served as members of the PDT and workgroups. Ultimately, the USACE and stakeholders worked together to identify restoration measures that would add value to ongoing projects by other Federal, state, and local agencies and to recommend projects as the tentatively selected plan.

Scoping was continued during the Feasibility Study. A scoping letter was distributed on April 24, 2006 to a USACE-maintained mailing list of approximately 500 stakeholders, which included Federal, state and local agencies, interest groups, and the public. A Notice of Intent (NOI) was also published in the *Code of Federal Regulations* dated May 15, 2006. All copies of the scoping letter (including comments) as well as the NOI are found in Appendix D in the *Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, North Carolina, dated October 2011.* The participation of all known affected Federal, state, and local agencies; any affected American Indian tribes; and other interested parties was requested. The USACE used the comments received to determine the scope of the EA and the significant issues to be analyzed in depth. At the time of the notices, the various stakeholders expressed no interest in holding public meetings.

The Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011 was coordinated with the public, local, State and Federal agencies by letter dated November 30, 2011 for a 45-day comment period. All comment letters and memoranda are found in Attachment B. The USACE's responses to these comment letters are found in Attachment A.

Public involvement was essential to obtaining relevant and available study information and citizen concerns. Section 11.0 *Public Involvement, Review, and Coordination* (found in the referenced feasibility report dated October 2011) summarizes the public involvement to date for this study.

VI. Mitigation

The TSP is identified as the National Ecosystem Restoration Plan. The proposed TSP would improve biological integrity, improve freshwater mussel populations, improve anadromous fish populations, restore emergent wetlands and protect them from future erosion, and increase the quantity and quality of oyster reef habitat. Because any environmental impact would be minimal and short-lived, it is USACE's opinion that no mitigation is required for any of the four components of the TSP. Work will be implemented within the environmental windows discussed in Section 1 or requested by the agencies during the NEPA and/or State consistency determination review.

VII. Analysis of Conformance of the Proposed Project With North Carolina's Coastal Management Program

Areas of Environmental Concern. That portion of the TSP located in an area of environmental concern (AEC) as defined by Section 113A-113 of the North Carolina Coastal Area Management Act (CAMA). Specifically, these components of the proposed TSP will be occurring in the estuarine waters and the shoreline of estuarine and public trust waters AECs.

Surface Water Classification. NC Division of Water Quality (NCDWQ) classifies waters within the lower Neuse River estuary (at the shoreline stabilization at Gum Thicket/Cedar Creek and the oyster reef restoration area) as SA, High Quality Waters (HQW) and Nutrient Sensitive Waters (NSW). Definitions of these terms are found in Table 2, below.

Table 2. Primary and Supplemental surface water classifications in the Neuse River Basin.

Class	Best use
C and SC	Aquatic life propagation/protection and secondary recreation.
B and SB	Primary recreation and Class C uses.
SA	Waters classified for commercial shellfish harvesting.
WS	*Water Supply watershed.* There are five WS classes ranging from WS-I through WS-V. WS classifications are assigned to watersheds on the basis of land use characteristics of the area. Each water supply classification has a set of management strategies to protect the surface water supply. WS-I provides the highest level of protection, and WS-IV provides the least protection. A Critical Area (CA) designation is also listed for watershed areas within one-half mile and draining to the water supply intake or reservoir where an intake is.
Sw	*Swamp Waters*: Recognizes waters that will naturally be more acidic (have lower pH values) and have lower levels of dissolved oxygen.
HQW	*High-Quality Waters*: Waters possessing special qualities including excellent water quality, Native or Special Native Trout Waters, Critical Habitat areas, or WS-I and WS-II water supplies.
ORW	*Outstanding Resource Waters*: Unique and special surface waters which are unaffected by pollution and have some outstanding resource values.
NSW	*Nutrient Sensitive Waters*: Areas with water quality problems associated with excessive plant growth resulting from nutrient enrichment.

Primary Nursery Areas. North Carolina Division of Marine Fisheries (NCDMF) defines Primary Nursery Areas (PNAs) as those areas of the estuarine system where initial post larval development takes place. Such areas are within the uppermost sections of the estuarine system where populations are uniformly very early juveniles (Deaton et al 2010). The estuarine system includes tidal saltwater marsh (including adjacent, shallow, open water areas) that provide essential habitat for the early development of commercially important fish and shellfish such as ocean spawning estuarine dependent spot, Atlantic croaker, brown shrimp, and southern flounder and estuarine spawning, red drum, spotted seatrout and blue crab. NCDMF has identified a total of 80,144 ac of PNAs statewide. According to the NCDMF, approximately 2,835 ac of primary nursery are in the Neuse River Estuary (Trish Murphey, NCDMF, personal communication, May 16, 2007). Figure 3 depicts the location of PNAs in the project area.

No components of the TSP are located within a designated NCDMF PNA. No adverse impacts to PNAs are anticipated.

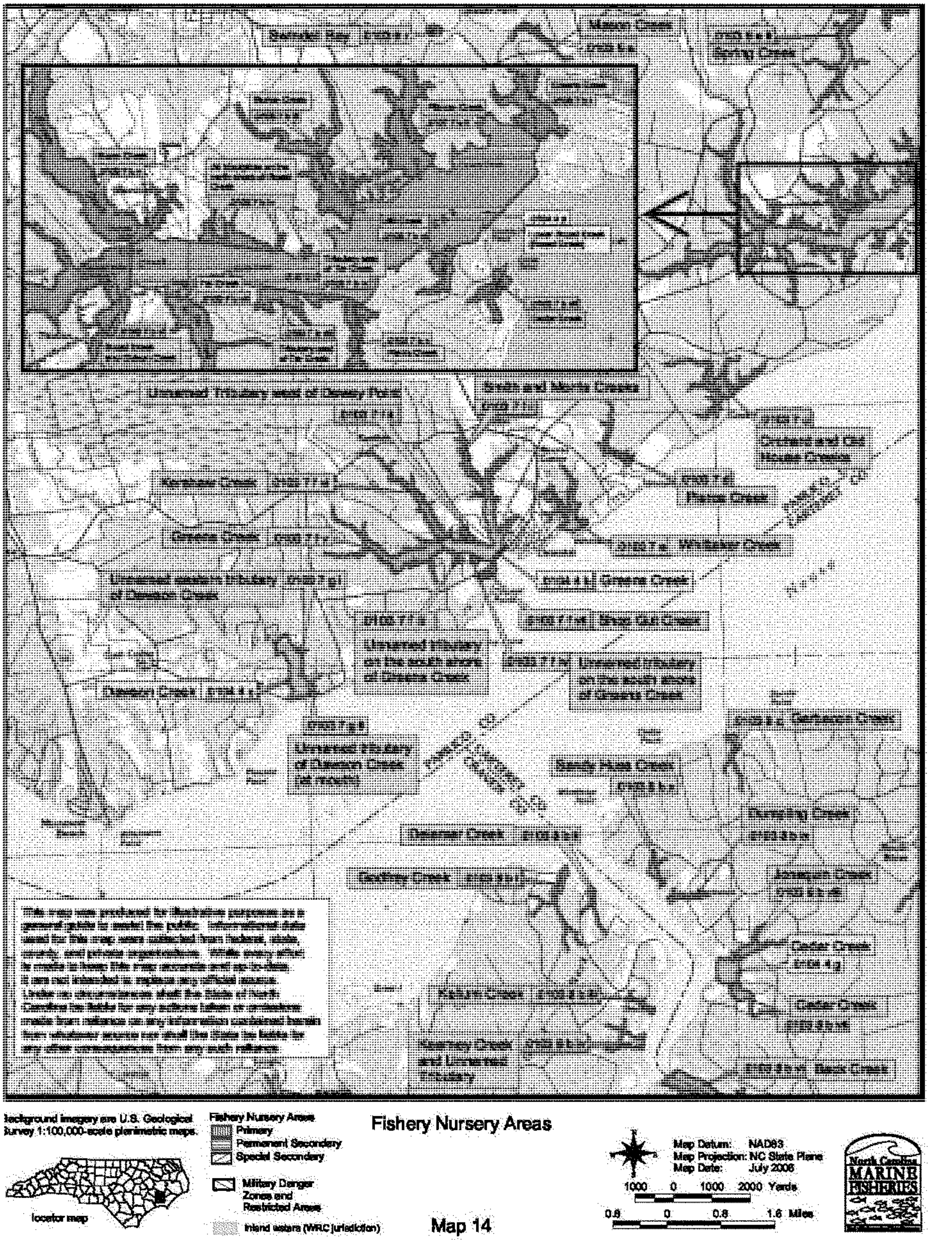
Inland Primary Nursery Areas. In 2000 North Carolina Wildlife Resources Commission (NCWRC) designated the main stem of the Neuse River from Pitchkettle Creek (near Grifton, North Carolina) upstream to Milburnie Dam, including Craven, Pitt, Lenoir, Wayne, Johnston, and Wake counties, as *Inland Primary Nursery Areas* (15A NCAC 10C .0503).

None of the four components of the TSP are located within the NCWRC designated inland primary nursery area. No adverse impacts to the NCWRC designated inland primary nursery area are anticipated as a result of the TSP.

Outstanding Resource Waters. The North Carolina Environmental Commission has designated certain waters within North Carolina as Outstanding Resource Waters (ORW). This designation is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance. Three areas of Carteret County are designated: (1) Western Bogue Sound, (2) Core and Back Sounds, and (3) Southeast Pamlico Sound. In Pamlico County only PNAs are designated as ORW. None of the components of the TSP in Pamlico and/or Carteret Counties are located in Outstanding Resource Waters (ORW), as defined by NCDWQ. No adverse impacts are anticipated to ORW.

Submerged Aquatic Vegetation. Submerged aquatic vegetation (SAV) has not been identified in waters adjacent to the TSP (15A NCAC 07H .0208(a)(6)). It is unlikely that any SAV are present within the areas adjacent to the low head dam on the Little River in Goldsboro and the filled floodplain at the Kinston East Wetland Complex. On 7 and 8 February 2012, a SAV survey was completed along the shoreline of Gum Thicket and Cedar Creek, in Pamlico County. No SAVs were found along the highly eroded shoreline. The proposed oyster reef restoration sites in the lower Neuse Estuary are at a depth (-20 foot) which does not provide suitable habitat for SAVs. However, prior to construction a side scan survey will be completed to verify this matter. No adverse impacts are anticipated to SAVs.

Figure 3. Neuse River estuary primary nursery areas.



Shellfish beds. *Rangia* clams could be present in the vicinity of the TSP project along the shoreline of Gum Thicket and Cedar Creek; however, these species are not of commercial importance in the Neuse Estuary. The salinities in the project area average about 12 ppt on the basis of water quality modeling and would not be expected to support significant populations of hard clam that require average salinities greater than 20 ppt for larval and juvenile development (Mulholland 1984). Recent field surveys by Corps biologists including visual inspection and probing along 5 perpendicular and 25 parallel shoreline transects found no oyster beds in the immediate project area along the shoreline of Gum Thicket and Cedar Creek, (15A NCAC .0208(a)(2)). However, along the shoreline there are scattered beds of small (less than 1- inch in size) mussels in wave up-rush areas that could be impacted by the proposed planting of marsh, landward of the rock sill. However once all work has been completed, they should repopulate the area to pre-project levels.

The proposed oyster reef restoration sites in the lower Neuse Estuary are at a depth (-20 foot). Prior to construction a side scan survey will be completed to verify that the proposed oyster reef restoration sites would not adversely impact existing shellfish beds. No adverse impacts are anticipated to shellfish beds.

Natural and Cultural Resources Area. The project site is not designated as a "Natural and Cultural Resources Area". (15A NCAC 07H .0501). Although the project is not likely to impact cultural resources, the contract will be conditioned to ensure that care is taken during all aspects of the work. Any cultural resources encountered will be protected and coordination with the USACE and the NC Department of Cultural Resources will occur.

No adverse impacts are anticipated to cultural resources. By letters dated September 15, 2011 and December 15, 2011 (copies in Attachment B), the North Carolina Department of Cultural Resources, State Historic Preservation Office concurred with this determination.

15A NCAC 07H .0203 identifies the Management Objective of the Estuarine and Ocean System: *It is the objective of the Coastal Resources Commission to conserve and manage estuarine waters, coastal wetlands, public trust areas, and estuarine and public trust shorelines, as an interrelated group of AECs, so as to safeguard and perpetuate their biological, social, economic, and aesthetic values and to ensure that development occurring within these AECs is compatible with natural characteristics so as to minimize the likelihood of significant loss of private property and public resources. Furthermore, it is the objective of the Coastal Resources Commission to protect present common-law and statutory public rights of access to the lands and waters of the coastal area.*

The TSP will not result in the loss of coastal uses. Construction of this project will not impact coastal resources or prohibit access to coastal resources by the public. The shoreline stabilization at Gum Thicket/Cedar Creek will reduce the overall lose of coastal wetlands/marshes from wind and wave erosion. The oyster reef restoration project would increase shellfish and fish habitat and contribute to water quality in the Neuse estuary.

15A NCAC 07H .0206 identifies the Management Objective of Estuarine Waters: *To conserve and manage the important features of estuarine waters so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and utilizing estuarine waters so as to maximize their benefits to man and the estuarine and ocean system.*

This section also identifies the Use Standards for Estuarine Waters: *Suitable land/water uses shall be those consistent with the management objectives in this Rule. Highest priority of use shall be allocated to the conservation of estuarine waters and their vital components. Second priority of estuarine waters use shall be given to those types of development activities that require water access and use which cannot function elsewhere such as simple access channels; structures to prevent erosion; navigation channels; boat docks, marinas, piers, wharfs, and mooring pilings.*

The TSP complies with the management objective and use standards for estuarine waters in that the shoreline stabilization at Gum Thicket/Cedar Creek and the oyster reef restoration in the lower Neuse estuary would ***"safeguard and perpetuate their biological"*** values.

<u>15A NCAC 07H .0207</u> identifies the Management Objective of Public Trust Waters: *To protect public rights for navigation and recreation and to conserve and manage the public trust areas so as to safeguard and perpetuate their biological, economic and aesthetic value.*

The proposed TSP will not result in the loss of coastal uses. Construction of this project will not adversely impact coastal resources or prohibit access to coastal resources by the public. The shoreline stabilization at Gum Thicket/Cedar Creek and the oyster reef restoration in the lower Neuse estuary would not adversely impact the public right for navigation and recreation.

<u>15A NCAC 07H .0208 (b) (1) c</u> identifies Use Standards for maintenance of existing navigation channels: *Spoil from maintenance of channels and canals through irregularly flooded wetlands shall be placed on non-wetland areas, remnant spoil piles, or disposed of by a method having no significant, long term wetland impacts. Under no circumstances shall spoil be placed on regularly flooded wetlands.*

The TSP proposes to place fill material sand and rock for the offshore sill for the stabilization of the Gum Thicket/Cedar Creek. Additionally, the oyster reef restoration area would place sand and rock to increase shellfish and fish habitat in the lower Neuse estuary. Both these activities would benefit the ecosystem by reducing the loss of coastal marsh/wetlands and increase shellfish and fish habitat.

<u>15A NCAC 07H .0209 (c)(2)</u> identifies the Management Objectives for Coastal Shorelines: *The management objective is to ensure that shoreline development is compatible with the dynamic nature of coastal shorelines as well as the values and the management objectives of the estuarine and ocean system. Other objectives are to conserve and manage the important natural features of the estuarine and ocean system so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and utilizing these shorelines so as to maximize their benefits to the estuarine and ocean system and the people of North Carolina.*

The proposed TSP project meets the listed management objectives. The project has been designed to minimize/avoid adverse environmental impacts, as addressed above.

B. <u>15A 07M .1100 Policies of beneficial use and availability of material resulting from the Excavation or Maintenance of Navigation Channels.</u>

Not Applicable. The TSP is not proposing to perform any maintenance dredging of any new and/or existing channels in the Neuse River estuary.

C. North Carolina's Dredge and Fill Law

North Carolina's Dredge and Fill Law: It is the understanding of the USACE that North Carolina's Dredge and Fill Law, NCGS 113-229, applies to those entities seeking permits from NCDCM, and not to federal agencies making determinations of consistency with the enforceable policies of the CAMA. Specifically, federal agencies are not identified in section (m) of the law as entities which are subject to these provisions; the law specifically identifies "State government or local governments," but not the federal government, as entities which must comply.

VIII. Project Conformance with Pamlico County and Carteret County Coastal Area Management Act (CAMA) Land Use Plans

The North Carolina Coastal Area Management Act of 1974 was passed in accordance with the Federal Coastal Zone Management Act. It requires each of the 20 coastal counties to have a local land use plan in accordance with guidelines established by the NC Coastal Resources Commission.

Each land-use plan includes local policies that address growth issues such as the protection of productive resources (i.e., farmland, forest resources, and fisheries), desired types of economic development, natural resource protection and the reduction of storm hazards.

Pamlico County's CAMA land use plan was approved by the Coastal Resources Commission in November 2004. The county strongly supports protection and conservation of its coastal wetlands, due to the essential role that they play in protecting water quality and providing food and habitat for fish and wildlife. By stabilizing the shoreline along Gum Thicket and Cedar Creek, the wind and wave erosion of coastal marsh/wetlands would be reduced. The proposed TSP is consistent with all aspects of the Pamlico County Land Use Plan. Compliance with recommendations from the NCDCM Consistency Concurrence will further ensure compliance with the Plan.

Carteret County's CAMA land-use plan was approved by the Coastal Resources Commission in April 2009. The plan identifies the county's awareness of the importance to maintain, protect, and where possible, enhance water quality in the County's public trust waters, including shellfishing areas. The proposed TSP is consistent with all aspects of the Carteret County Land Use Plan. Compliance with recommendations from the NCDCM Consistency Concurrence will further ensure compliance with the Plan.

X. Other Required Approvals

Neuse River Riparian Buffer Protection Rule. Effective August 1, 2000, North Carolina adopted the Neuse River Riparian Buffer Protection Rule for maintaining and protecting existing riparian buffers in the Basin (15A NCAC 2B .0233). That strategy consists of a series of rules to protect and preserve existing riparian buffers to maintain their nutrient-removal functions in the Basin. The main rule, called the Neuse River Riparian Buffer Protection Rule, requires that existing vegetated riparian buffers in the Basin be protected and maintained on both sides of intermittent and perennial streams, lakes, ponds, and estuarine waters.

All of the four components of the TSP are located within the existing Neuse River Riparian Buffer. The required riparian buffer permits will be obtained prior to construction.

Section 401 Water Quality Certificate. Prior to the construction of the TSP, the USACE will obtain the required Section 401 Water Quality Certificate from the NCDWQ. No work will be initiated on the TSP until this required authorization is obtained.

No other permits, authorizations, or approvals are necessary at this time for the proposed project.

All agency coordination will be satisfactorily concluded prior to the beginning of work associated with this project.

XI. Conclusions

The proposed TSP project conforms to the management objectives of 15A NCAC 07H .0203, 15A NCAC 07H .0206, 15A NCAC 07H .0207, 15A NCAC 07H .0208, and 15A NCAC 07H .0209 as it will result in reducing the wind and wave erosion along the shoreline of Gum Thicket/Cedar Creek and increase oyster/shellfish and fish habitat in the lower Neuse River estuary while minimizing adverse impacts to Estuarine Waters and Public Trust Areas.

The proposed TSP will not affect any wildlife recognized by the State as species of concern, will not adversely impact water quality, and will result in at most minimal, temporary and short-lived impacts to fisheries and the aquatic species. This action promotes effective use to protect and enhance the coastal ecosystem. The proposed project will be undertaken in compliance with all conditions of the NC Division of Land Resources sediment and erosion control permit and the required NCDWQ Section 401 Water Quality Certificate. Adherence to these conditions and recommendations will further minimize adverse biological and environmental impacts to the maximum extent practicable

Appendix B: Flood Risk Management

North Carolina Cooperating Technical State Floodplain Mapping Program
Table 1. Community Information

Community Name	County	Participation Status	Date of Current NFIP Map
Unincorporated Areas	Beaufort	Regular/Participating	2/4/87
Unincorporated Areas	Carteret	Regular/Participating	11/6/98
Unincorporated Areas	Craven	Regular/Participating	12/5/97
Bridgeton	Craven	Regular/Participating	5/4/87
Cove City	Craven	Not Participating	N/A*
Dover	Craven	Not Participating	N/A*
Havelock	Craven	Regular/Participating	5/4/87
New Bern	Craven	Regular/Participating	5/4/87
River Bend	Craven	Regular/Participating	8/19/86
Trent Woods	Craven	Regular/Participating	9/8/99
Vanceboro	Craven	Regular/Participating	8/4/88
Unincorporated Areas	Duplin	Regular/Participating	7/4/89
Unincorporated Areas	Durham	Regular/Participating	3/21/00
Durham	Durham	Regular/Participating	3/21/00
Unincorporated Areas	Edgecombe	Regular/Participating	8/3/81
Unincorporated Areas	Franklin	Regular/Participating	1/19/01
Youngsville	Franklin	Regular/Participating	N/A*
Unincorporated Areas	Granville	Regular/Participating	9/28/90
Butner	Granville	Not Participating	N/A*
Creedmoor	Granville	Regular/Participating	9/28/90
Stem	Granville	Not Participating	9/28/90
Unincorporated Areas	Greene	Regular/Participating	1/6/83
Hookerton	Greene	Regular/Participating	1/20/82
Snow Hill	Greene	Regular/Participating	1/20/82
Walstonburg	Greene	Regular/Participating	N/A*
Unincorporated Areas	Harnett	Regular/Participating	4/16/90
Unincorporated Areas	Johnston	Regular/Participating	10/20/00
Benson	Johnston	Regular/Participating	10/20/00
Clayton	Johnston	Regular/Participating	10/20/00
Four Oaks	Johnston	Not Participating	10/20/00
Pine Level	Johnston	Not Participating	N/A*
Selma	Johnston	Regular/Participating	10/20/00
Smithfield	Johnston	Regular/Participating	10/20/00
Wilson's Mills	Johnston	Not Participating	10/20/00
Unincorporated Areas	Jones	Regular/Participating	8/16/88
Pollocksville	Jones	Regular/Participating	8/16/88
Trenton	Jones	Regular/Participating	8/16/88
Unincorporated Areas	Lenoir	Regular/Participating	1/6/83
Kinston	Lenoir	Regular/Participating	6/15/82

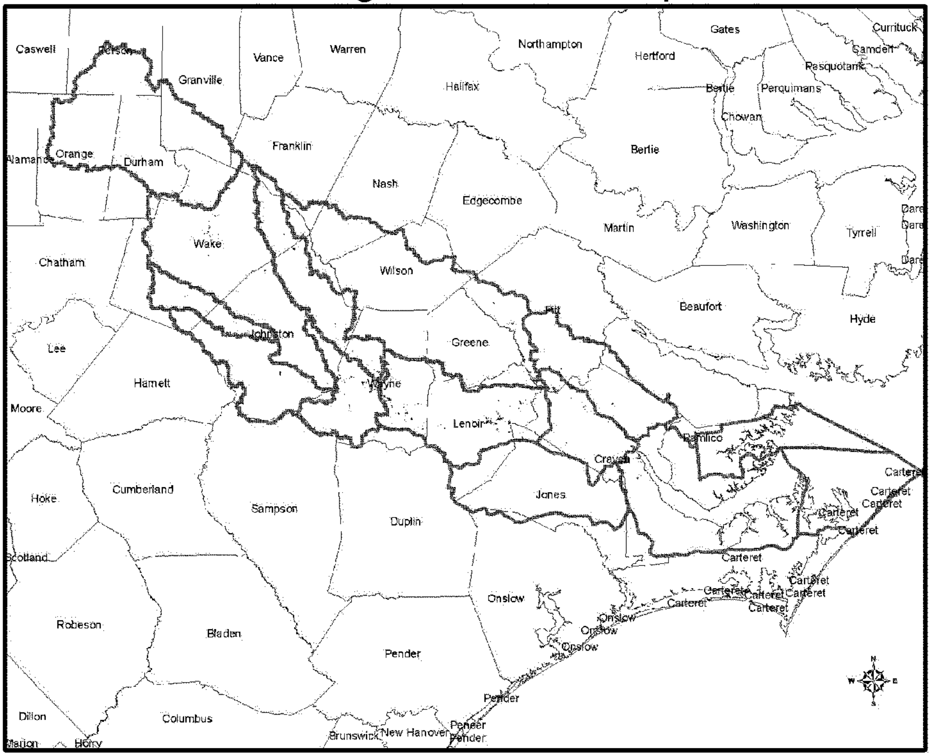
North Carolina Cooperating Technical State Floodplain Mapping Program
Table 1. Community Information (Continued)

Community Name	County	Participation Status	Date of Current NFIP Map
La Grange	Lenoir	Not Participating	N/A*
Pink Hill	Lenoir	Not Participating	N/A*
Unincorporated Areas	Nash	Regular/Participating	1/20/82
Bailey	Nash	Not Participating	N/A*
Middlesex	Nash	Regular/Participating	1/20/82
Unincorporated Areas	Onslow	Regular/Participating	11/4/92
Unincorporated Areas	Orange	Regular/Participating	3/16/81
Hillsborough	Orange	Regular/Participating	5/15/80
Unincorporated Areas	Pamlico	Regular/Participating	9/4/85
Alliance	Pamlico	Regular/Participating	8/5/85
Arapahoe	Pamlico	Not Participating	N/A*
Bayboro	Pamlico	Regular/Participating	12/4/85
Grantsboro	Pamlico	Not participating	9/4/85
Hollyville	Pamlico	Not Participating	N/A*
Mesic	Pamlico	Regular/Participating	9/4/85
Minnesott Beach	Pamlico	Regular/Participating	8/5/85
Oriental	Pamlico	Regular/Participating	12/4/85
Stonewall	Pamlico	Regular/Participating	12/4/85
Vandemere	Pamlico	Regular/Participating	12/4/85
Unincorporated Areas	Person	Regular/Participating	9/14/90
Roxboro	Person	Regular/Participating	9/14/90
Unincorporated Areas	Pitt	Regular/Participating	9/14/90
Ayden	Pitt	Regular/Participating	8/4/87
Farmville	Pitt	Regular/Participating	4/17/89
Fountain	Pitt	Not Participating	N/A*
Greenville	Pitt	Regular/Participating	4/30/86
Grifton	Pitt	Regular/Participating	11/20/98
Winterville	Pitt	Regular/Participating	2/24/78
Unincorporated Areas	Sampson	Regular/Participating	7/16/91
Unincorporated Areas	Wake	Regular/Participating	11/20/98
Apex	Wake	Regular/Participating	12/5/96
Cary	Wake	Regular/Participating	12/5/96
Fuquay-Varina	Wake	Regular/Participating	12/5/96
Garner	Wake	Regular/Participating	12/19/97
Holly Springs	Wake	Regular/Participating	12/5/96
Knightdale	Wake	Regular/Participating	12/19/97
Morrisville	Wake	Regular/Participating	12/5/96
Raleigh	Wake	Regular/Participating	11/20/98
Rolesville	Wake	Regular/Participating	12/5/96

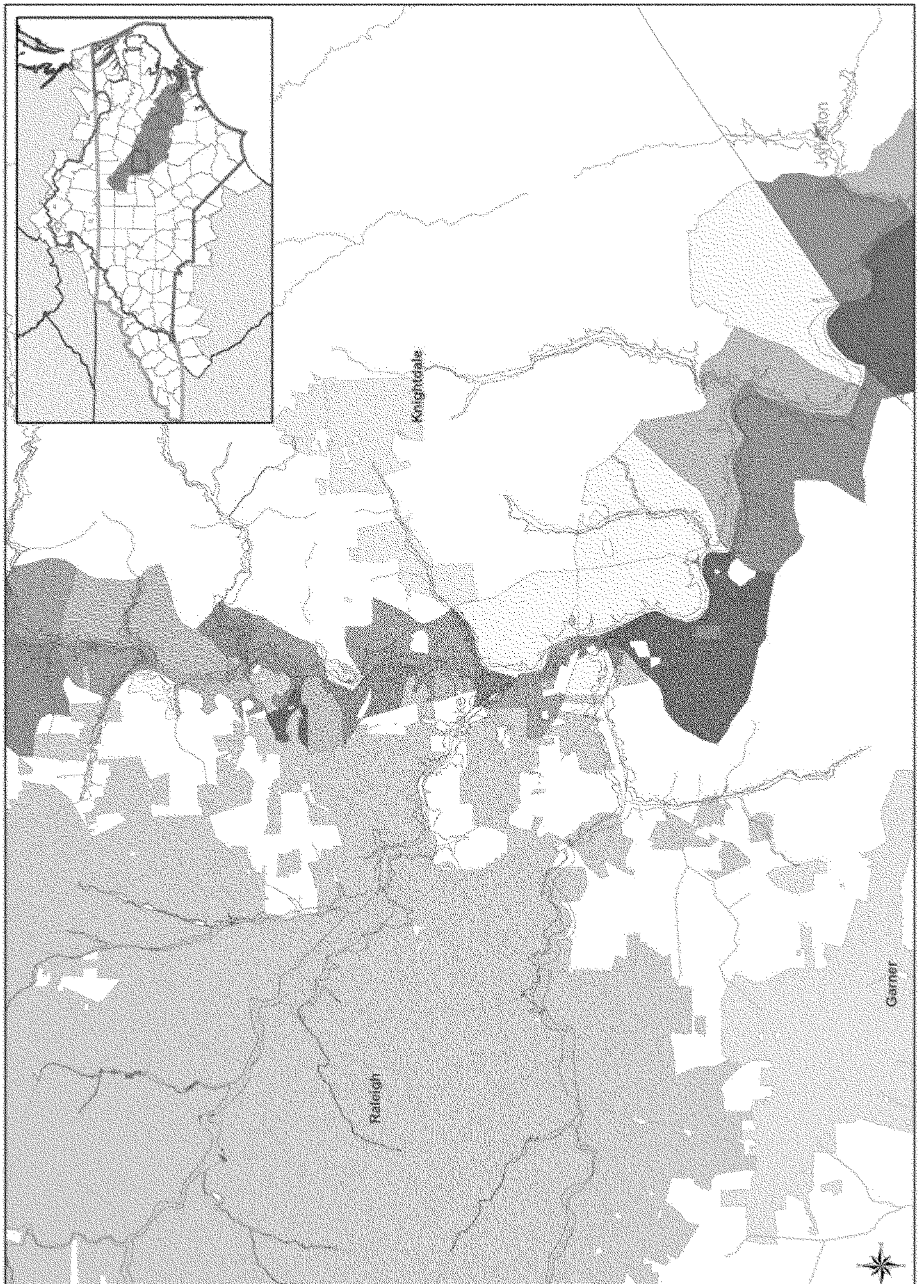
North Carolina Cooperating Technical State Floodplain Mapping Program
Table 1. Community Information (Continued)

Community Name	County	Participation Status	Date of Current NFIP Map
Wake Forest	Wake	Regular/Participating	12/5/96
Wendell	Wake	Regular/Participating	12/5/96
Zebulon	Wake	Regular/Participating	12/5/96
Unincorporated Areas	Wayne	Regular/Participating	3/16/98
Eureka	Wayne	Not Participating	N/A*
Fremont	Wayne	Regular/Participating	9/30/83
Goldsboro	Wayne	Regular/Participating	3/16/98
Mount Olive	Wayne	Regular/Participating	2/17/82
Pikeville	Wayne	Regular/Participating	4/1/82
Seven Springs	Wayne	Regular/Participating	2/17/82
Walnut Creek	Wayne	Regular/Participating	9/30/83
Unincorporated Areas	Wilson	Regular/Participating	1/6/83
Black Creek	Wilson	Not Participating	N/A*
Kenly	Wilson	Not Participating	10/20/00
Lucama	Wilson	Emergency/Participating	N/A*
Saratoga	Wilson	Not Participating	N/A*
Sims	Wilson	Not Participating	1/12/79
Stantonsburg	Wilson	Regular/Participating	9/1/89
Wilson	Wilson	Regular/Participating	7/19/82

Hazard Mitigation Grant Properties



NEUSE RIVER BASIN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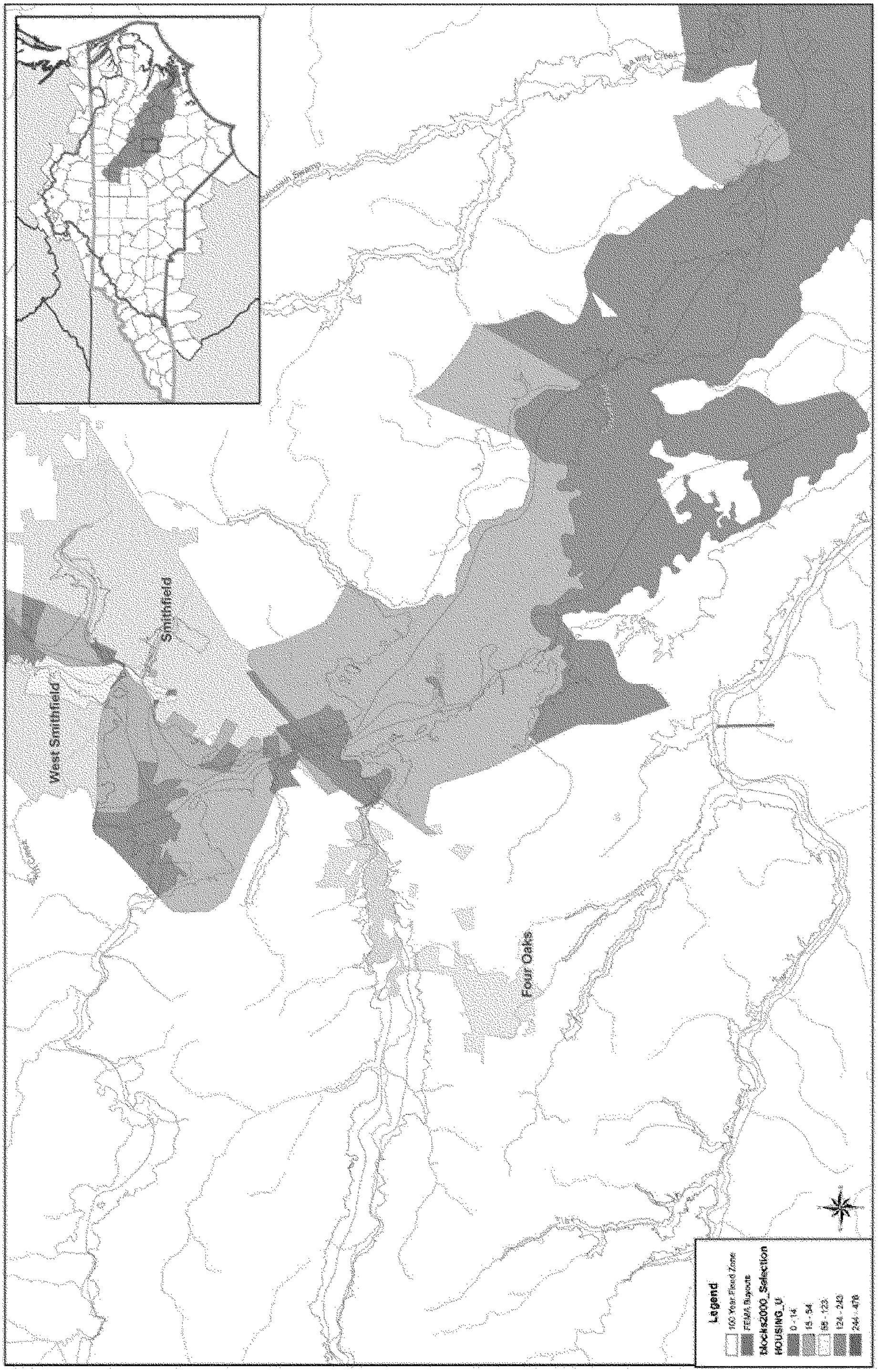
Garner
Legend
100 Year Flood Zone
FEMA Buyouts
blocks2000_Selection
HOUSING_U
0 - 14
15 - 54
55 - 123
124 - 243
244 - 476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Smithfield
Four Oaks
Legend
100 Year Flood Zone
FEMA Buyouts
blocks2000_Selection
HOUSING_U
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124 - 243
244 - 478


Lenoir
Wayne
Duplin
Legend
100 Year Flood Zone
FEMA Buyouts
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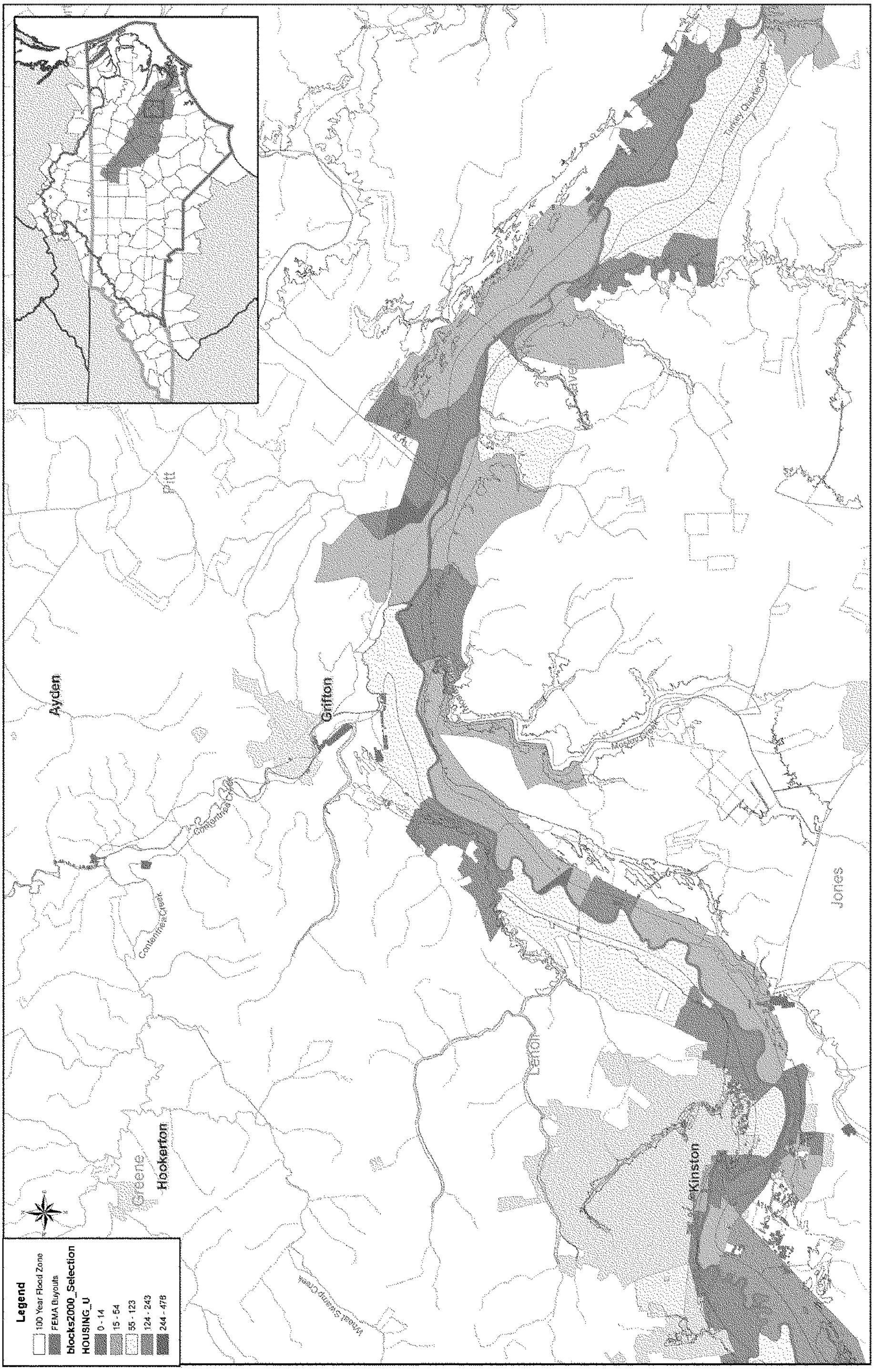
124 - 243
244 - 476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FEMA Buyouts
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0 - 14
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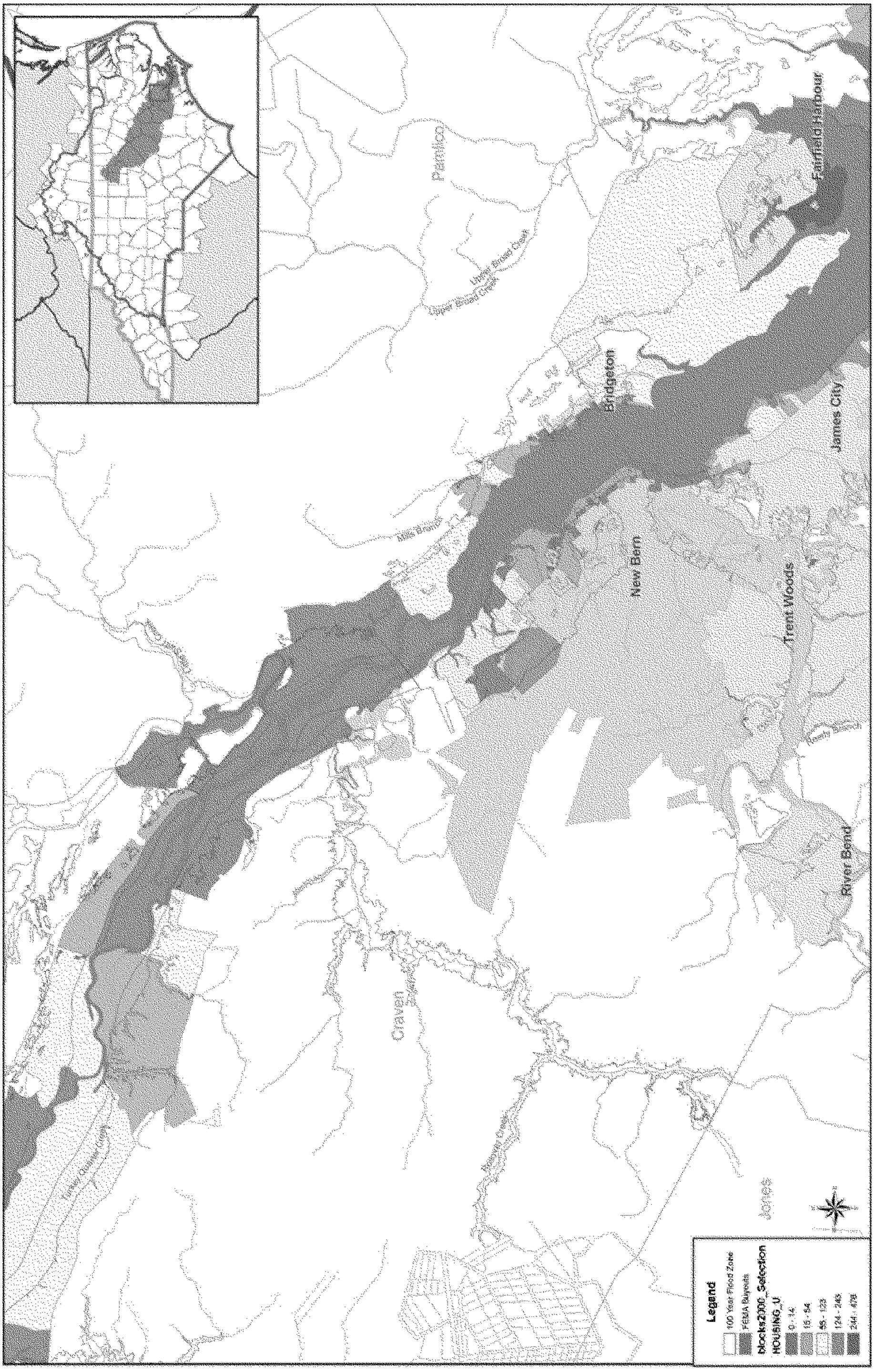
244 - 478
Ayden
Grifton
Hookerton
Greene
Kinston
Lenoir
Jones
Pitt
Contentnea Creek
Wheat Swamp Creek


Pamlico
Upper Broad Creek
Fairfield Harbour
Bridgeton
James City
New Bern
Trent Woods
River Bend
Craven
Jones
Legend
100 Year Flood Zone
FEMA Buyouts
blocks2000_Selection
HOUSING_U
0 - 14
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55 - 123
124 - 243
244 - 478

Appendix C: Studies Conducted by Others

*Related Studies, Reports, Water Resource Projects, and Initiatives**

Many of the related and ongoing studies in the Neuse River Basin are collaborative efforts among stakeholders. The following outline summarizes previous and ongoing studies, reports, projects, and initiatives in the Neuse River Basin.

1. USACE Historic Studies
   a. **Improvement and Development of Neuse River, North Carolina**. May 1932. This letter report recommended no action to improve the basin for power development, navigation, or irrigation because of unfavorable economics. It also did not recommend construction of flood control reservoirs at the time because of costs exceeding that assessed against benefited lands. It recommended flood control consisting of clearing and snagging by the Federal government and additional measures by local and state government.
   b. **Neuse River, North Carolina, Johnston County Line to New Bern**. August 1941. This report recommended the Goldsboro Cut-off channel, which was completed in December 1947. The channel provides flood control by increasing overall flow capacity. The channel uses sheet piling to divert water into the existing Neuse River channel. During times of high flow, water can flow over the sheet piling and through the Cut-off channel. The USACE is conducting planning studies to update the existing sheet piling. Local authorities have reported that the existing structure leaks. The Goldsboro primary water intake is located in the Neuse River's natural channel and depends on the sheet piling to maintain baseflows at their intake.
   c. **Neuse River, North Carolina, Smithfield to Wayne County Line, Survey Report**. December 1949. The report investigated reservoirs and levees and clearing and snagging to reduce Johnston County flooding. No alternative was found to be economically feasible, and no improvements were recommended.
   d. **Preliminary Report on Neuse River Basin**. October 1957. This 35-page reconnaissance-level report determined a Federal interest in conducting a comprehensive survey of the Neuse River Basin, including tributaries.
   e. **Neuse River Basin, North Carolina, Survey Report**. December 31, 1963. This report laid the ground work for construction of Falls Lake and recommended Wilson Mills Reservoir on the Neuse River, Buckhorn Reservoir on Contentnea Creek, and Beulahtown Reservoir on Little River. The survey also recommended nine smaller lakes. Local protection measures for flooding were considered unnecessary if Falls and Wilson Mills reservoirs were completed.
   f. **Hominy Swamp, Wilson County, North Carolina, Detailed Project Report**. May 1968. This report recommended measures to reduce flood damages, including 5 miles of channel widening, two bridge replacements, and one culvert. The project was discontinued near the end of the Plans and Specifications phase.
   g. **Neuse River Basin, North Carolina Interim Report on Buckhorn Project**. October 1970. The report recommended Buckhorn Reservoir on Contentnea Creek for water supply, flood control, water quality, recreation, and conservation.

* Denotes sections required for EIS/NEPA compliance.

It noted prior clearing and snagging on Contentnea Creek and navigation roughly to Snow Hill. It discussed other reservoirs in the Neuse River Basin. This is a very thorough report, but it is now dated.

h. **Neuse River, North Carolina, Channel Extension to Streets Ferry, Detailed Project Report**. 1971. This report proposed a project to increase the channel to 9 feet deep by 120 feet wide upstream from New Bern, North Carolina, 9 miles upstream to the Weyerhaeuser Paper Company. The project was recommended with a benefit-to-cost ratio of 1.9. A final environmental statement was issued in 1974. The project was not constructed because only a single user would benefit.
i. **Reconnaissance Report, Neuse River Basin, North Carolina**. May 1984. The conclusions and recommendations identify the primary problem as the flooding of the Neuse River at Goldsboro. However, a feasibility study was never funded through Congress. A feasibility study of Buckhorn Reservoir on Contentnea Creek was recommended. The report recommended local protection feasibility studies under Section 205 of the Flood Control Act of 1948 for Adkin Branch in Kinston, Hominy Swamp and Toisnot Swamp in Wilson, and Crabtree Creek in Raleigh. It also recommended a feasibility study of hydropower addition to Falls Dam. Specific feasibility studies at Hominy Swamp, Adkins Branch, Buckhorn Reservoir, and Falls Lake Dam Hydropower have continued. The follow-up Section 205 study of Crabtree Creek in Raleigh did not result in a favorable recommendation for flood risk management measures.
j. **Buckhorn Dam, Detailed Feasibility Study**. 1987. This site on Contentnea Creek was evaluated as a multipurpose reservoir project. The report concluded that under the existing Federal policy, there were not sufficient flood damages to justify continued Federal involvement. The policy required that a minimum of 10% of the total project benefits be for flood risk management; however, the majority of the benefits were for water supply. The Regulatory Division of the USACE developed the *Final Environmental Impact Statement for the Buckhorn Reservoir Expansion, City of Wilson* (June 1996), which evaluated the cumulative effects of the reservoir. The city of Wilson developed the site for water supply.
k. **Falls Lake Storage Shortage Reconnaissance Study**. October 1987. This report recommended investigating solutions to storage shortage by developing a Supplement to General Design Memorandum No. 3.
l. **Falls Lake, Neuse River Basin, North Carolina, Water Storage Shortage, Supplement No. 1, General Design Memorandum No. 3**. November 1988. This report evaluated four alternatives for increasing actual as-built storage to storage as planned according to original topographic mapping and area-storage curves. The recommended plan was to restore only flood control and water supply storage (not water quality and sediment storage).
m. **Detailed Project Report and Environmental Assessment on Flood Damage Reduction, Adkin Branch, Kinston, NC**. December 1991. The channel improvement project was determined to be feasible and recommended for construction. It involved construction of a 26-foot to 31-foot bottom-width channel for a distance of 8,700 feet.
n. **Detailed Project Report and Environmental Assessment on Flood Damage Reduction, Hominy Swamp, Wilson, North Carolina**. October 1997. The

channel improvement project was determined to be feasible and recommended for construction. It consisted of 0.9 mile of clearing and snagging, installation of an additional culvert, and construction of a 25-foot bottom-width channel for a distance of 1.2 miles. The project was proposed but did not receive a Section 401 permit from the North Carolina Division of Water Quality (NCDWQ).

o. **Reconnaissance Report, Neuse River Basin, North Carolina**. July 1999. Conclusions and recommendations resulted in identifying basin-wide improvements to flood risk management, water quality, environmental restoration, and related purposes. Environmental restoration opportunities include stream restoration, oyster habitat restoration, and anadromous fish habitat. After the reconnaissance report was completed, there was sufficient support from the non-Federal sponsor to justify this feasibility study.

p. **Environmental Assessment (EA) and Finding of No Significant Impact (FNSI) for the Demolition and Removal of the Pleasant Green Road Dam, on the Eno River, in Orange County, North Carolina**. October 2005. Duke Power Company constructed the structure in 1915 to provide cooling water for a steam power generation plant. Duke retired the power plant and removed the equipment in 1958. The existing dam impound is a 21.8-acre lake on the Eno River, which extends about 1.5 miles upstream of the structure. The existing 122-foot-long Pleasant Green Road concrete dam is about 10 to 12 feet in height and has two adjustable weir gates on the southern end. Under Section 22 of the Water Resources Development Act of 1974, as amended (Planning Assistance to States), the North Carolina Division of Water Resources, North Carolina Division of Parks and Recreation, U.S. Fish and Wildlife Service, and the USACE, Wilmington District, completed the State Environmental Policy Act (SEPA) environmental assessment and a finding of no significant impact (FNSI). The dam removal was complete in 2007.

2. Other Federal Agency Initiatives
   a. U.S. Fish and Wildlife Service (USFWS)
      i. **Environmental Assessment and Finding of No Significant Impact for the Demolition and Removal of the Rains Mill Dam, on the Little River, in Johnston County, North Carolina**. October 1999. The NCDWR and USFWS demolished and removed the 250-foot-long, 12-foot-high Rains Mill Dam and its attendant structures on the Little River, near Princeton, in Johnston County, North Carolina. Rains Mill Dam impounded up to a 28-acre lake. Removal opened up 151 miles of suitable spawning and rearing habitat for diadromous fish. Eliminating the associated 28-acre impoundment also allowed reoccupation of this section of river by two species of endangered freshwater mussel (dwarf wedge mussel (*Alasmidonta heterodon*) and Tar River spiny mussel (*Elliptio steinstansana*)). The NCDWR removed the dam in November 1999. As of April 2, 2005, Mike Wicker, USFWS, had caught American and hickory shad at the base of Lowell Dam, about 11 miles upstream of the old Rains Mill Dam site. Under Section 22, the USACE's role was to complete the SEPA documents (EA/FNSI) and to coordinate with the

North Carolina Department of Water Quality (Section 401 water quality certification) and develop the necessary permits for the dam removal.

ii. **Planning Aid Letter and Report**. June 25, 2003. Appendix D.

iii. **Coordination Act Report**. August 11, 2008. Appendix D.

b. U.S. Environmental Protection Agency (USEPA)

i. **Clean Water Act Section 319 Nonpoint Source Management Program**. To help states and local nonpoint source efforts, the Federal government amended the Clean Water Act in 1987 to establish the Section 319 Nonpoint Source Management Program. Under Section 319, grant money is available to support activities to decrease the contribution of nonpoint source pollution. In fiscal year 2008, $2.6 million in grant money was made available in the state of North Carolina.

ii. **Albemarle-Pamlico National Estuary Program (APNEP)**. The Program's mission is "to identify, restore and protect the significant resources (including natural, economic, recreational, and aesthetic values) of the Albemarle-Pamlico estuarine system." Formerly known as the Albemarle-Pamlico Estuarine Study (APES), it was among the first National Estuary Programs established by the U.S. Environmental Protection Agency (USEPA) in 1987. Unlike traditional regulatory approaches to environmental protection, the APNEP is a cooperative effort jointly sponsored by the North Carolina Department of Environment and Natural Resources (NCDENR) and USEPA that targets a broad range of issues and engages local communities in the process. The Program focuses not only on improving water quality in the region's estuaries but also on maintaining the integrity of the whole system—its chemical, physical, and biological properties, as well as its economic, recreational, and aesthetic values. Important components of the APNEP are the consideration of water quality, fisheries resources, land and water habitats, and the interaction of humans with the natural resources of the estuarine system. The APNEP is designed to encourage local communities to take responsibility for managing the resources in their respective jurisdictions.

c. **Natural Resources Conservation Service (NRCS)**

i. **Environmental Quality Improvement Program** (EQIP). EQIP provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. Cost sharing is provided through several state agencies.

ii. **Conservation Partnership Initiative Awards**. In 2005 the Center for Agricultural Partnerships received $66,000 to reduce nutrient and pesticide loadings in the Neuse River Basin.

d. **U.S. Geological Survey (USGS)**. This Federal agency studies and monitors water resources in the Neuse River Basin. Several publications have been written to document conditions in the basin. Many are available online at http://nc.water.usgs.gov/cgi-bin/pubs?keyword=Neuse&author=&date=&date1=&date2=. *The most recent studies were published in 2008 and document nutrient conditions in the estuary and costal area; Factors affecting nitrate delivery to streams from shallow ground water in the North Carolina Coastal Plain,* by S.L. Harden and T.B. Spruill and *Estimation of groundwater and nutrient fluxes in the Neuse River estuary,* by T.B. Spruill and J.F. Bratton.

3. North Carolina State Studies and Initiatives
   a. **NCDWQ**. Identifies and regulates impaired waters and designated uses.
      i. **Neuse River Total Maximum Daily Load (TMDL) for Nitrogen**. The TMDL for nitrogen was finalized in 1999. Reductions of 30% from both point and nonpoint sources were identified to meet the allowable load of 6.76 million pounds per year of nitrogen at New Bern, North Carolina. See Appendix E.
      ii. **Neuse River Basin Wide Water Quality Plan 2009**. The plan recommends basin-wide water quality planning as a nonregulatory, watershed-based approach to restoring and protecting the quality of North Carolina's surface waters. The causes and sources of pollution for individual streams are provided to facilitate local restoration efforts. Implementing, restoring, and protecting water quality is a coordinated effort of many agencies, local governments, and stakeholders. An update to this plan is being finalized by NCDWQ.
      The 2009 basin-wide plan summarizes water quality in the Neuse River Basin from 2002 to 2007. The plan indicates that although the Neuse River Nutrient Sensitive Waters Management Strategy has been fully implemented, additional reductions are likely needed in areas that were not completely covered by the initial set of management rules to achieve the TMDL goal of a 30% reduction in total nitrogen loading at Fort Barnwell and the reduction of chlorophyll *a* standard violations within the Neuse River Estuary. Stormwater retrofits on existing development, better stormwater controls on new development throughout the basin, and other management strategies are suggested as measures to help reduce nitrogen and phosphorus loading to the estuary.

      Several water quality improvements were noted in the Neuse River basin between 2002 and 2007. The freshwater (river TMDL segment) and upper portion (about half of the upper TMDL segment) of the Neuse River Estuary were removed from the 2008 Clean Water Act Section 303(d) list of impaired waters, and 27 miles of the Nahunta Swamp in subbasin 03-04-07 and 15.4 miles of Core Creek in subbasin 03-04-08 were removed from the 2008 impaired waters list (they had been listed for impaired biological integrity). The macroinvertebrate community improved from fair to good-fair after the Agriculture Cost Share Program provided over $108,000 and $106,000 for implementing agricultural best management practices (BMPs) in Nahunta Swamp and Core Creek, respectively.

During this assessment period several new impairments were identified: Falls Lake for chlorophyll *a* and turbidity standard violations and the expansion of the chlorophyll *a* violation farther downstream into the estuary.

Stormwater is the number one source of pollutants/stressors (sediment, nutrients, heavy metals, chemicals, bacteria) that contribute to impaired and impacted waters in the Neuse River basin. Stormwater runoff is a primary carrier of nonpoint source pollution in both urbanized and rural areas. http://h2o.enr.state.nc.us/basinwide/Neuse/2008/NeuseRiverBasinPlanDRAFT.htm

iii. **Nonpoint Source Management Program—Neuse River Sensitive Waters Management Plan**. In 1997 the North Carolina Environmental Management Commission (NCEMC) adopted the state's first mandatory plan to control both point and nonpoint source pollution in the basin. The plan, backed by data in the Neuse River TMDL, calls for a mandatory 30% reduction in nitrogen from point, urban, and rural sources by 2003. The NCEMC worked with the appropriate nonpoint source agencies to target the implementation of BMPs to reduce sediment and nutrient runoff throughout the basin. Between 1996 and 2003, half the croplands enrolled in the program implemented BMPs such as buffers, contour planting, no-till planting, and creek fencing. Data for 2003 show that the Neuse River Basin's agricultural community achieved a 42% nitrogen reduction, exceeding the 30% goal set by the NCEMC and Neuse River TMDL. A continuous monitoring system was established in the lower portion of the basin, near the Neuse River Estuary. Using flow-adjusted nitrogen concentrations, long-term nutrient data show a 27% in-stream nitrogen reduction in 2003 as compared to the average flow-adjusted concentrations from the 1991 to 1995 baseline. This decrease, along with point source reductions, was accomplished by installing BMPs, implementing fertilizer management plans, and removing cropland from production. The new agricultural practices also led to lower phosphorus levels and slowed erosion, while farmers benefited from savings on fertilizer. The BMPs prevented more than 480,000 tons of soil from being washed away by erosion. Available online at http://www.epa.gov/nps/success/state/nc_neu.htm

b. **NCDWR**. This agency is responsible for water quantity permitting and regulation, water conservation, and basin planning for water supply.

    i. **Neuse River Basin Hydrologic Modeling**. This effort started in 2008 for management of water quantity using the OASIS model.

c. **NCDENR Ecosystem Enhancement Program (NCEEP)**. This in-lieu fee mitigation program was designed to provide advanced mitigation at the watershed level for wetland and water impacts permitted by the USACE primarily for North Carolina Department of Transportation (NCDOT) projects. The mission of the NCEEP is to "restore, enhance, preserve and protect the functions associated with wetlands, streams and riparian areas, including but not limited to those necessary for the restoration, maintenance and protection of water quality and riparian habitats throughout North Carolina." NCEEP and its partners have completed projects on more than 75 stream reaches in North Carolina.

d. **NCDENR Center for Geographic Information and Analysis (CGIA)**
    i. **Streams Mapping Project**. This project maps water bodies throughout the state.
e. **NCDENR Division of Coastal Management (NCDCM)**. NCDCM developed a database that includes restored, created, enhanced, and preserved wetlands and submerged aquatic vegetation constructed and planted for mitigation, shoreline stabilization, conservation, and research.
f. **NCDENR Division of Marine Fisheries (NCDMF)**
    i. **North Carolina Coastal Habitat Protection Plan (CHPP)**. In accordance with the North Carolina Fisheries Reform Act of 1997, the CHPP was developed to protect habitats, including wetlands, spawning areas, threatened and endangered species habitat, primary and secondary nursery areas, shellfish beds, submerged aquatic vegetation, and Outstanding Resource Waters. The CHPP was written to "1) Document the ecological role and function of aquatic habitats for coastal fisheries. 2) Provide status and trends information on the quality and quantity of coastal fish habitat. 3) Describe and document threats to coastal fish habitat, including threats from both human activities and natural events. 4) Describe the current rules concerning each habitat. 5) Identify management needs. 6) Develop options for management action using the above information." Within the Neuse River Basin in 2005, the CHPP found approximately 596 miles of streams that are partially or totally obstructed by dams, 154 miles of streams that are partially or totally obstructed by roadway pipe culverts, and 219 miles of streams that are partially or totally obstructed by reinforced concrete box culverts (Street 2005). The CHPP was used in the development of a restoration project to identify opportunities in the basin.
g. **NCDENR Division of Soil and Water Conservation**
    i. **Agriculture Cost Share Program**. Established in 1984 to help reduce the sources of agricultural nonpoint source pollution to the state's waters, this program helps owners and renters of established agricultural operations improve their on-farm management by using BMPs. The BMPs include vegetative, structural, or management systems that can improve the efficiency of farming operations while reducing the potential for surface water and groundwater pollution. This voluntary program reimburses farmers up to 75% of the cost of installing an approved BMP with a $75,000 annual cap. http://www.enr.state.nc.us/dswc/pages/agcostshareprogram.html
h. **North Carolina Cooperative Extension**
    i. **Watershed Education for Communities and Local Officials (WECO)**. The WECO program is dedicated to building local capacity for sustainable watershed management in North Carolina and facilitating watershed partnerships. WECO initiated a watershed assessment of

Hominy Swamp and is conducting a watershed study on Stoney Creek; both are within the Neuse River Basin. As of 2010, no work has been completed on these projects.

i. **NCDEM**
   i. NCDEM is responsible for the acquisition and demolition of more than 1,000 residential structures following hurricanes Fran, Bonnie, and Floyd in coordination with FEMA.
   ii. NCDEM is updating flood insurance rate maps.

j. **North Carolina Wildlife Resources Commission** (NCWRC). NCWRC manages wildlife regulations, including identifying threatened and endangered species and issuing hunting and fishing licenses.

k. **North Carolina Water Management Trust Fund**. Created in 1996 by the General Assembly (Article 18; Chapter 113A of the North Carolina General Statutes), the Fund offer grants to local governments, state agencies, and conservation nonprofits to help finance projects that specifically address water pollution problems. In August 2008, $40.6 million in grants were awarded to protect water quality and conserve open space.

l. **NCDOT**. *1997 Stream Crossing Guidelines for Anadromous Fish Passage*. In response to permit questions raised by the natural resources community concerning anadromous fish use of culverts, a multidisciplinary committee was established to review this issue. The committee consisted of representatives from the USFWS, National Marine Fisheries Service, NCWRC, NCDMF, North Carolina Division of Environmental Management, and NCDOT. By a memorandum dated May 12, 1997, NCDOT circulated these guidelines to the agencies. NCDOT used the document as a uniform policy on handling the anadromous fish passage issue. The guidance applies to projects in the coastal plain for perennial and intermittent streams. NCDOT projects are to avoid activities during the spring spawning period and to establish a preference for constructing bridges and other channel-spanning structures.

4. Academic Studies and Initiatives

a. **Duke University**
   i. **Ecology and Conservation Lab**. The Lab conducts ongoing research projects with the primary goal of understanding the mechanisms and processes by which changes in water quality and management affect the fish community.

b. **East Carolina University**
   i. Masters students at the University have worked with NCEEP to develop site specific methods and applications for ecological assessments through habitat scoring.
   ii. ***Mapping of Neuse River Estuary*** by Dr. Riggs. The Freshwater, Wetlands, Streams, and Riparian Buffer Restoration Workgroup used this work in establishing areas of erosion in the estuary used in initial screening of watershed subbasins.

c. **North Carolina State University (NCSU)**
   i. **Neuse River Education Team**. The Team informs citizens, agencies, and industry about the Neuse River Basin. http://www.neuse.ncsu.edu/

ii. **College of Design**. The NCSU Department of Landscape Architecture partnered with the City of Kinston and others to develop *The Kinston Waterfront–Now!*, a plan outlining conceptual designs for flood hazard mitigation properties and other land along the Neuse River in Kinston. Pride of Kinston, a nonprofit organization, is working toward implementing the designs. http://www.downtownkinston.com/aboutus.html

d. **University of North Carolina** (Chapel Hill and Wilmington)

i. **Neuse River Estuary Modeling and Monitoring Project** (ModMon). ModMon is funded by the NCDWQ, the Lower Neuse Basin Association (LNBA), and the Neuse River Compliance Association (NRCA). NRCA is a nongovernmental organization that holds the discharge permit for several municipalities with wastewater discharges into the Neuse River. ModMon is the main source of data for models being used for the Neuse River Estuary TMDL and Estuarine Workgroup for the USACE Neuse River Basin Feasibility Study (this study). The monitoring data collected by this project was used in the modeling effort for this study.

5. Nonprofit Organization Studies and Initiatives

a. **The Nature Conservancy**. This organization established a 30-acre oyster habitat sanctuary at Crab Hole near Roanoke Island in coordination with the NCDMF. The Nature Conservancy is continuing its oyster reef restoration work in the Pamlico Sound including holding volunteer events to bag oyster shells and build reef.

b. **North Carolina Coastal Land Trust**. Formed in 1992, the Land Trust acquires open space and natural areas for conservation education and promoting good land stewardship. It has 16 projects in the Neuse River Basin in Craven, Pamlico, and Carteret counties.

c. **The Conservation Trust for North Carolina**. The Conservation Trust is a nonprofit, statewide conservation organization with the mission "to protect our state's land and water through statewide conservation and cooperative work with land trusts to preserve our natural resources as a legacy for future generations." It works directly with landowners, local land trusts, and government agencies to protect the land and water resources most important to local communities throughout the state.

d. **The Conservation Fund (TCF)**. TCF works to protect land and waterways throughout the United States by using conservation and community-based programs. In 2001, as part of its Green Infrastructure Leadership Program, TCF worked with the City of Kinston, Lenoir County, and the University of North Carolina's Department of City and Regional Planning to develop the *County Green Infrastructure Plan for the Neuse River Floodplain*, which includes recommendations for conservation and recreational uses on flood hazard mitigation properties. In 2002 TCF and its partners also developed a related plan entitled *Linking Natural and Historic Assets: Green Infrastructure As Economic Development in Lenoir County, NC*.

e. **The Pride of Kinston**. Established in 1984, this organization is working to revitalize downtown Kinston, including land within the Neuse River floodplain.
f. **Neuse River Foundation (River Keepers)**. This foundation employs two River Keepers (for the lower and upper portions of the basin), who patrol the waterways, monitor conditions, investigate pollutant sources, provide educational outreach, and work to protect and restore the natural functions of the basin. http://www.neuseriver.org
g. **Ellerbe Creek Watershed Association**. The Association is working with NCSU and NCEEP to restore sections of Ellerbe Creek. http://www.ellerbecreek.org
h. **Upper Neuse River Basin Association**. The Association develops and maintains programs to protect the Neuse River Basin upstream of Falls Lake and manage growth within this drainage area. http://www.unrba.org
i. **Lower Neuse River Basin Association**. The Association supports ModMon in the Neuse River Estuary.
j. **North Carolina Coastal Federation**. The Federation develops and maintains programs to protect coastal resources along the North Carolina coast. Its efforts within the basin include maintaining conservation easements and developing strategies for reducing estuarine shoreline erosion and protecting/enhancing oyster habitat. http://www.nccoast.org
    i. **North Carolina Oyster Restoration Steering Committee (ORSC)**. *Oyster Restoration and Protection Plan for North Carolina: A Blueprint for Action* (Draft 2003–2008). This five-year plan summarizes agreements and outlines a plan of action to "1) Restore & protect North Carolina's native oyster populations, and habitat so that estuaries are again robust, diverse, & resilient ecosystems. 2) Build broad public awareness & support for the value of estuarine conservation & sustainable fisheries. 3) Work with a strong coalition to make significant, demonstrable & meaningful progress toward oyster restoration in the next 3 - 5 years." The ORSC is made up of members from various Federal and state agencies. They have identified the Neuse River Estuary as a water body containing sites of high priority for oyster restoration.

Appendix D: Public Coordination

Dated: May 8, 2006.

Todd A. Stevenson,

Secretary, Consumer Product Safety Commission.

[FR Doc. E6–7292 Filed 5–12–06; 8:45 am]

BILLING CODE 6355–01–P

COORDINATING COUNCIL ON JUVENILE JUSTICE AND DELINQUENCY PREVENTION

[OJP (OJJDP) Docket No. 1454]

Meeting of the Coordinating Council on Juvenile Justice and Delinquency Prevention

AGENCY: Coordinating Council on Juvenile Justice and Delinquency Prevention.

ACTION: Notice of meeting.

SUMMARY: The Coordinating Council on Juvenile Justice and Delinquency Prevention (Council) is announcing the June 2, 2006, meeting of the Council.

DATES: Friday, June 2, 2006, 9:15 a.m.–12:30 p.m.

ADDRESSES: The meeting will take place at the Department of Health and Human Services, 200 Independence Ave, SW., Room 800, Washington, DC 20201.

FOR FURTHER INFORMATION CONTACT: Robin Delany-Shabazz, Designated Federal Official, by telephone at 202–307–9963 [**Note:** this is not a toll-free telephone number.], or by e-mail at *Robin.Delany-Shabazz@usdoj.gov.*

SUPPLEMENTARY INFORMATION: The Coordinating Council on Juvenile Justice and Delinquency Prevention, established pursuant to Section 3(2)A of the Federal Advisory Committee Act (5 U.S.C. App. 2) will meet to carry out its advisory functions under Section 206 of the Juvenile Justice and Delinquency Prevention Act of 2002, 42 U.S.C. 5601, *et seq.*

Documents such as meeting announcements, agendas, minutes, and interim and final reports will be available on the Council's Web page at *http://www.JuvenileCouncil.gov.* (You may also verify the status of the meeting at that Web address.)

Although designated agency representatives may attend, the Council membership is composed of the Attorney General (Chair), the Secretary of Health and Human Services, the Secretary of Labor, the Secretary of Education, the Secretary of Housing and Urban Development, the Administrator of the Office of Juvenile Justice and Delinquency Prevention (Vice Chair), the Director of the Office of National Drug Control Policy, the Chief Executive Officer of the Corporation for National and Community Service, and the Assistant Secretary for Homeland Security, Immigrations and Customs Enforcement. Nine additional members are appointed by the Speaker of the House of Representatives, the Senate Majority Leader, and the President of the United States.

Meeting Agenda

The agenda for this meeting will include: (a) A review of the past meeting and written public comments; (b) remarks from Michael Leavitt (invited), Secretary, Health and Human Services, and Susan Orr, Associate Commissioner, Children's Bureau and other Children's Bureau staff concerning child and family service reviews and the implications of the reviews for member agencies; (c) an update on mentoring activities; (d) discussions of various opportunities to coordinate federal work addressing juveniles and youth who are disadvantaged or at-risk; and (e) other business and announcements.

For security purposes, members of the public who wish to attend the meeting must pre-register by calling the Juvenile Justice Resource Center at 301–519–6473 (Daryel Dunston), no later than Friday, May 26, 2006. [**Note:** these are not toll-free telephone numbers.] Additional identification documents may be required. To register online, please go to *http://www.JuvenileCouncil.gov/meetings.html.* Space is limited.

Note: Photo identification will be required for admission to the meeting.

Written Comments

Interested parties may submit written comments by Friday, May 26, 2006, to Robin Delany-Shabazz, Designated Federal Official for the Coordinating Council on Juvenile Justice and Delinquency Prevention, at *Robin.Delany-Shabazz@usdoj.gov.* The Coordinating Council on Juvenile Justice and Delinquency Prevention expects that the public statements presented will not repeat previously submitted statements. Written questions and comments from the public may be invited at this meeting.

Dated: May 10, 2006.

Michael Costigan,

Acting Administrator, Office of Juvenile Justice and Delinquency Prevention.

[FR Doc. E6–7355 Filed 5–12–06; 8:45 am]

BILLING CODE 4410–18–P

DEPARTMENT OF DEFENSE

Department of the Army; Corps of Engineers

Intent to Prepare a Draft Environmental Impact Statement for the Neuse River Basin Feasibility Study, NC

AGENCY: Department of the Army, U.S. Army Corps of Engineers, DoD.

ACTION: Notice of intent.

SUMMARY: The Neuse River Basin is the third largest basin in North Carolina, encompassing a total area of about 6,235 square miles. The Neuse River originates in north central North Carolina and flows southeasterly until it reaches tidal waters of Pamlico Sound. Water quality in the Neuse River Basin has become degraded from multiple causes, including: Rapidly expanding urban growth with increasingly rapid runoff from storm events; deforestation; expanding high-density livestock operations; and aging wastewater infrastructure. Fish and wildlife populations have suffered declines in diversity and vigor; and waterborne fish diseases have now become apparent, especially *Pfiesteria.* The U.S. Army Corps of Engineers, Wilmington District, in cooperation with the State of North Carolina Division of Water Resources has initiated the Neuse River Basin Feasibility Study in North Carolina. The purpose of the feasibility study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish passage, wetlands, stream, riparian buffer, and oyster habitat. We will also investigate flood damage reduction. The focus of this study is to identify resource problems, needs, and opportunities and develop solutions. The feasibility study is being carried out under the Corps of Engineers General Investigation Program and is being conducted in response to a congressional resolution adopted July 23, 1997.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and DEIS can be answered by: Mr. Hugh Heine; Environmental Resources Section; U.S. Army Engineer District, Wilmington; P.O. Box 1890; Wilmington, NC 28402–1890; telephone: (910) 251–4070.

SUPPLEMENTARY INFORMATION: This study will investigate the following alternatives: No action alternative, restoration of wetland and stream habitats as well as riparian buffers which serve as natural filtering systems, oyster habitat restoration, removal or modification of low head dams and culverts to restore anadromous fish

Comment Response by Agency and Subject

	NCWRC	NCDWQ	NCDMF	NCDENR	NCDCR	UNC	UCPCG	FCPI	County of Franklin	FEMA regIV	B.Bowditch, Oriental, NC	Randy Mundt, AICP, CFM	Town of Beaufort	NCDEM	Town of Mt. Olive, NC	NCDA	NCDEH	USFWS
Urban Growth	yes																	
Deforestation	yes																	
Wetlands	yes															yes		yes
Stream buffers	yes															yes		yes
Floodplains	yes			yes						yes		yes				yes		yes
Storm water	yes							yes					yes		yes			
Point and non point runoff	yes																	
Water quality	yes	yes	yes				yes	yes					yes	yes		yes		yes
Aquatic habitat	yes		yes															yes
Anadromous fish	yes		yes													yes		yes
Rare/threatened/endangered species	yes					yes												yes
Oyster habitat	yes		yes													yes	yes	yes
Fisheries	yes					yes												yes
Nongame fauna	yes																	
Infrastructure	yes																	yes
Erosion	yes														yes			yes
Sediment control	yes																	yes
Habitat loss	yes																	
Riparian zone	yes																	yes
Construction impacts	yes																yes	
Cumulative impact	yes																	
Nutrients in the water		yes																yes
Nursery areas			yes															
Cultural resources					yes													
Public education							yes											
Drinking water								yes	yes								yes	
Rule enforcement											yes			yes				yes
Pest control																	yes	
Terrestrial wildlife																		yes
Water based recreation																		yes
Aquatic vegetation																		yes

March 31, 1999

Planning and Environmental Branch

Dear Sir or Madam:

The Wilmington District, U.S. Army Corps of Engineers, in cooperation with the state of North Carolina Division of Water Resources and the Division of Water Quality, is conducting a reconnaissance study to identify needs and opportunities related to flood damages reduction, water quality improvements, and ecosystem restoration in the Neuse River Basin, North Carolina. The focus of this stage will be to identify resource problems, needs, and opportunities; to develop a study plan to identity solutions; and to develop a cost sharing agreement between Federal and non-Federal interests for the conduct of the study.

Water quality in the Neuse River Basin has become degraded from multiple causes, including: rapidly expanding urban growth with increasingly rapid runoff from storm events; deforestation; expanding high-density livestock operations; and aging wastewater infrastructure. Fish and wildlife populations have suffered declines in diversity and vigor; and waterborne fish diseases have now become apparent, especially Pfiesteria. The State of North Carolina has designated water quality improvements in the Neuse River as an issue of highest priority and has taken action to reduce nitrogen loading to the estuary.

Flow in the Neuse River has been regulated since 1983 through controlled releases from Falls Lake. The lake is owned and operated by the U.S. Army Corps of Engineers and is used for flood control, water supply, wildlife habitat, recreation, and downstream flow augmentation. Since Falls Lake controls less than one third of the Neuse River drainage basin, considerable flooding has occurred during and after major storm events below Smithfield where the flood plain is broad and flat. Other concerns in the Neuse River Basin in recent years have been water supply, navigation, and recreation.

Water resources improvements will require a cooperative effort among local, State, and Federal governments, and the public. Some potential measures to improve basin water quality may include flow modifications, restoration of riparian buffers and wetlands, treatment, and land use management. Possible solutions to reduce flooding damages include both structural measures such as dams, levees, and channel modifications, and include nonstructural measures such as relocation, flood proofing, and flood plain management.

At this time, we are requesting comments from agencies, interest groups, and the public to identify significant water resource issues and concerns. Please give serious attention to your comments, as they will be used to help develop the plan. Please provide written comments within 30 days from the date of this letter. Comments should be addressed to:

U.S. Army Corps of Engineers, Wilmington District
Attention: Mr. Doug Greene
Post Office Box 1890
Wilmington, North Carolina 28402-1890

If you have any questions concerning this matter, please call Mr. Greene, Planning Services Section, at (910) 251-4553. We appreciate your attention and assistance.

Sincerely,

Ron Fascher
Chief, Planning and Environmental Branch

April 24, 2006

Environmental Resources Section

Dear Sir or Madam:

The U.S. Army Corps of Engineers, Wilmington District, in cooperation with the State of North Carolina Division of Water Resources has initiated the Neuse River Basin Feasibility Study in North Carolina (see enclosed figure). The purpose of the feasibility study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish, wetlands, stream, riparian buffer, and oyster habitat, and flood damage reduction. The focus of this study will be to identify resource problems, needs, and opportunities to develop a plan to identity solutions. The feasibility study is being carried out under the Corps of Engineers General Investigation Program and is being conducted in response to a congressional resolution adopted July 23, 1997. The purpose of this scoping letter is to solicit any comments you may have on this project.

The Neuse River is formed by the confluence of the Eno and Flat Rivers approximately 8 miles north of Durham then passes through Falls Lake; a Corps of Engineers multiple purpose reservoir near Raleigh. As it continues downstream from Falls Lake the major tributaries are Crabtree Creek, Little River, Contentnea Creek, and the Trent River. The study area is located in the eastern portion of North Carolina in parts of the 1st, 2nd, 3rd, and 4th Congressional Districts. The Neuse River Basin consists of approximately 11 percent of the area of North Carolina including all or portions of 19 counties. The basin is approximately 180 miles long with a maximum width of about 46 miles. It has a drainage area of approximately 6,235 square miles. The basin is primarily an agricultural region, but contains many small towns and several cities that are important commercial centers. These municipalities include Durham, Raleigh, Smithfield, Goldsboro, Wilson, Kinston, and New Bern.

Water quality in the Neuse River Basin has become degraded from multiple causes, including: rapidly expanding urban growth with increasingly rapid runoff from storm events; deforestation; expanding high-density livestock operations; and aging wastewater infrastructure. Fish and wildlife populations have suffered declines in diversity and vigor; and waterborne fish diseases have now become apparent, especially *Pfiesteria*. The State of North Carolina has designated water quality improvements in the Neuse River as an issue of highest priority and has taken action to reduce nitrogen loading to the estuary. Considerable flooding has occurred during and after major storm events below Smithfield where the flood plain is broad and flat.

This study will investigate the following alternatives: no action alternative, restoration of wetland habitats and riparian buffers which serve as natural filtering systems, oyster habitat restoration, modification of operation of Falls Lake to accommodate preferred flow targets, removal or modification of low head dams and culverts to restore anadromous fish passages, and flood reduction. The final outcome of the study would be a feasibility report and an Environmental Impact Statement (EIS), which would recommend projects for construction authorization.

All private interests and federal, state, and local agencies that have an interest in the project are invited to comment at this time and to identify any concerns and issues that should be addressed or considered by the U.S. Army Corps of Engineers during project planning and engineering. An EIS will be prepared in accordance with the requirements of the National Environmental Policy Act of 1969, as amended, and will address the project's relationship to all applicable federal and state laws and Executive Orders. The EIS would describe the environmental effects of the proposed action on socioeconomic resources, hazardous, toxic, and radiological wastes, natural resources, endangered and threatened species, wetlands, floodplains, Neuse River Basin "Riparian Buffer Rules", cultural resources, air quality resources and cumulative impacts. The EIS is currently scheduled for distribution to the public in the fall/winter of 2007.

No formal scoping meetings are planned at this time. However, based on the responses to this letter, scoping meetings may be held with specific agencies as required.

Please send your written comments to arrive within 30 days from the date of this letter in order that they may be considered during our evaluations and decision process. Questions about the proposed action should be addressed to Mr. Hugh Heine, Environmental Resources Section, e-mail address hugh.heine@usace.army.mil or telephone (910) 251-4070.

Sincerely,

W. Coleman Long
Chief, Planning and Environmental Branch

Enclosure

CESAW-TS-PE/Heine/bw/4070
CESAW-TS-PE/Yelverton
CESAW-TS-PE/Adams
CESAW-PM-C/Hall
CESAW-TS-P/Long/s/
Return to Brenda for mailing
CESAW-TS-PE Files

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North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

MEMORANDUM

TO: Melba McGee, Environmental Coordinator
Office of Legislative and Intergovernmental Affairs

FROM: Shari L. Bryant, Piedmont Region Coordinator
Habitat Conservation Program

DATE: 26 May 2006

SUBJECT: Neuse River Basin Feasibility Study, Carteret, Durham, Johnston, Lenoir and Wake Counties. DENR Project No. 06-0316.

Biologists with the North Carolina Wildlife Resources Commission (NCWRC) have reviewed the subject document and we are familiar with the habitat values of the area. Our comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), North Carolina Environmental Policy Act (G.S. 113A-1 through 113A-10; 1 NCAC 25), and North Carolina General Statutes (G.S. 113-131 et seq.).

The U.S. Army Corps of Engineers (Corps) in cooperation with the N.C. Division of Water Resources (DWR) has initiated the Neuse River Basin Feasibility Study in North Carolina. The purpose of the feasibility study is to develop and evaluate basin wide alternatives to improve water quality; restore anadromous fish, wetlands, stream, riparian buffer, and oyster habitat; and reduce flood damage.

The Neuse River basin contains many miles of significant high quality aquatic habitat for anadromous fish; rare, threatened and endangered species; and important recreational and commercial fishery resources. The NCWRC has expended significant monies to restore, enhance, and conserve these resources for the citizens of North Carolina. Our biologists work to assess and manage fish populations; survey for listed species and other non-game fauna; comment on environmental documents and development permits to minimize impacts; work with other state and federal agencies to identify and protect important natural areas; provide public access areas for fishing and boating; and manage lands to protect water quality and enhance aquatic and terrestrial wildlife habitat.

The study will investigate the following alternatives: no action alternative, restoration of wetland habitats and riparian buffers, oyster habitat restoration, modification of operation of Falls Lake to accommodate preferred flow targets, removal or modification of low head dams and culverts to restore anadromous fish passage, and flood reduction. The final outcome of the study would be a feasibility

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

report and an Environmental Impact Statement (EIS) that would recommend projects for construction authorization.

We request the Corps and DWR consider the following in the study and development of the feasibility report and EIS.

- Many portions of the Neuse River basin are experiencing rapid urban growth with increases in deforestation; impacts to wetlands, streams, riparian buffers and floodplains; increases in impervious surfaces and stormwater runoff; and increases in point source discharges. Point and non-point source discharges have led to degradation of water quality and aquatic habitat in the Neuse River basin and we recommend that project alternatives should include measures to address point and non-point sources discharges. NCWRC's *Guidance Memorandum to Address and Mitigate Secondary and Cumulative Impacts to Aquatic and Terrestrial Wildlife Resources and Water Quality* (August 2002) which is located on the web at: http://www.ncwildlife.org/pg07_WildlifeSpeciesCon/pg7c3_impacts.pdf details measures to minimize impacts to aquatic and terrestrial wildlife resources in developing landscapes. In addition, the Coastal Habitat Protection Plan (CHPP) may be helpful in addressing some of these issues.

- Measures or projects to improve anadromous fish habitat and passage including, but not limited to, modification in the operation of Falls Lake to accommodate preferred target flows, and removal or modification of low head dams (e.g., Milburnie dam) and culverts.

- Measures or projects to protect or improve aquatic habitat for rare, threatened or endangered species. Several streams within the Neuse River basin support federal and state listed species including the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*) and Tar spinymussel (*Elliptio steinstansana*).

- Measures or projects to restore oyster habitat.

- Projects to restore natural stream conditions (e.g., de-channelization of Little Contentnea Creek).

- We are concerned that formal scoping meetings are not proposed. We suggest an interagency Project Development Team (PDT) be formed to discuss alternatives, gather public ideas, and work with agencies to develop an appropriate document for review.

- We are concerned about the negative effects that extensive flood control projects can have on watersheds. Protection of floodplains and wetlands as a flood control strategy is of the highest importance. Moving residents from flood prone areas and re-establishing riparian buffers will surely reduce loss of property. Data should be gathered that can reasonably predict the effects of any measures proposed on the sensitive resources within the Neuse River basin. This includes hydrologic models that address in-stream flow, water needs within the basin, and water quality effects; field surveys for listed species, anadromous and diadromous fish as well as local fish populations; recreational use surveys with participation by user groups; economic analysis comparing the property damage that may be alleviated by any proposed measures to the cost of the measure and loss of recreational or commercial value of the resources eliminated by the measure.

Thank you for the opportunity to provide input in the planning stages for this project. We look forward participating in a PDT, if one is formed, and to reviewing the feasibility report and EIS. If you need additional information please contact our office at (336) 449-7625.

cc: Linda Pearsall, NHP
Howard Hall, USFWS

ec: Steve Everhart, WRC
Maria Tripp, WRC

North Carolina Wildlife Resources Commission

Charles R. Fullwood, Executive Director

GUIDANCE MEMORANDUM TO ADDRESS AND MITIGATE SECONDARY AND CUMULATIVE IMPACTS TO AQUATIC AND TERRESTRIAL WILDLIFE RESOURCES AND WATER QUALITY
(August 2002)

Mailing Address: **Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721**
Telephone: **(919) 733-3633** • Fax: **(919) 715-7643**

Executive Summary

Thousands of acres of land are developed each year in North Carolina, and this development consists of many individual and often unrelated projects. Without proper safeguards, the cumulative effects of land development can transform the landscape and negatively impact the environmental character and natural functions of the ecosystems. North Carolina projects a population increase of more than 3 million new individuals by the year 2020 (N. C. Progress Board 2001); therefore, it is imperative that coordinated measures be implemented to protect wildlife resources and their habitats.

When development is conducted in an unplanned and amorphous or ambiguous pattern it can have more serious impacts on ecosystem function. Rapidly developing landscapes can result in stream degradation due to increases in stormwater runoff, sedimentation and other pollutants, and riparian habitat losses. Some of the greatest impacts of development, both land-based and near-water development, occur on water quality in our streams and rivers. Many of our native species of aquatic organisms have become highly imperiled as a result. The decline in freshwater species is a direct reflection of declining quality of our streams and rivers, and rare and sensitive species are particularly affected by secondary and cumulative impacts associated with urban development due to their sensitivity to slight habitat alterations.

A more comprehensive approach to project review is necessary if we are to effectively protect the environmental resources of the State. This approach should scrutinize the cumulative and secondary impacts (CSI) associated with all projects subject to State Environmental Policy Act (SEPA) requirements as closely as direct impacts. Cumulative effects are defined as effects resulting from the incremental impact of the proposed activity when added to other past, present, and probable future activities in the area. Cumulative effects can occur from individually minor but collectively significant activities taking place over a period of time. Secondary effects are defined as probable effects caused by and resulting from the proposed activity although they are later in time or further removed in distance.

Presently, cumulative and secondary impacts are often not fully addressed in an environmental review. The Department of Environment and Natural Resources (DENR), has identified as part of the 2000 strategic plan the need to develop a policy for evaluating and mitigating the cumulative and secondary impacts. Identification of measures to mitigate for secondary and cumulative impacts was determined to be an important component of addressing impacts.

This document was primarily authored by biologists with the N. C. Wildlife Resources Commission and the N. C. Division of Parks and Recreation. Significant contributions were provided by the CSI Working Group, which includes representatives from numerous state agencies concerned with the conservation of natural resources. The U. S. Fish and Wildlife Service, which supports these recommendations, also provided constructive review of the document.

This document is intended to serve as a guidance memorandum for local governments to assist with addressing secondary and cumulative impacts associated with public projects. Implementation of these recommendations will assist in the mitigation of impacts to water quality, to fish and wildlife and their habitat generally, and in situations where federally threatened and endangered species exist. Alternatives to these measures will be examined on a case-by-case basis, provided that the same level of protection is afforded. The recommendations provided herein are intended to be applied to new developments or to existing developments for which significant modifications or expansions are proposed. Incorporation of the measures that are outlined throughout the document by local governments will alleviate the concerns of the natural resource agencies and will provide for a smoother and more timely review of environmental documents and permits.

The recommendations presented in this document to avoid or mitigate these impacts are based on the best available science and were obtained by a synthesis of scientific information in journals, publications, reference books, and personal communication with professionals familiar with North Carolina aquatic species and other natural resources. However, the recommendations may be revised as more information becomes available about species' habitat requirements and measures necessary to protect aquatic and terrestrial habitat and water quality. It is envisioned that through the active participation and initiative of local governments in partnership with State resource and regulatory agencies, the concerns regarding impacts of significance will be alleviated and the review of environmental documents and permits will be more efficient and effective.

Recommendations include measures regarding:

- Forested buffers
- Stream and wetland resources
- Infrastructure locations
- Floodplains
- Impervious surfaces and stormwater treatment
- Erosion and sediment control

Preface

This document is intended to serve as a guidance memorandum for local governments to assist with addressing secondary and cumulative impacts associated with public projects. Implementation of these recommendations will assist in the mitigation of impacts to water quality, to fish and wildlife and their habitat generally, and in situations where federally threatened and endangered species exist. Alternatives to these measures will be examined on a case-by-case basis, provided that the same level of protection is afforded. The recommendations provided herein are intended to be applied to new developments or to existing developments for which significant modifications or expansions are proposed. Incorporation of the measures that are outlined throughout the document by local governments will alleviate the concerns of the natural resource agencies and will provide for a smoother and more timely review of environmental documents and permits.

Agencies, municipalities, landowners, and the public share a responsibility to protect and conserve fish and wildlife, which are public resources. Efforts to minimize secondary and cumulative impacts may not show immediate rewards, however such efforts are important to prevent future damage to riparian and stream systems and to rebuild degraded areas. These efforts will also help meet the anti-degradation standard established in Rule 15A NCAC 02B .0201, which provides for the maintenance, protection, and enhancement of existing uses.

During the fall of 2001 and through 2002 the N. C. Department of Environment and Natural Resources (DENR) established and guided a Cumulative and Secondary Impact (CSI) Working Group. This group was made up of a variety of staff from Divisions within DENR. The CSI Working Group undertook the task of identifying, drafting, and developing a system and protocol for ensuring that cumulative and secondary impacts are adequately addressed during the review of documents required under the N. C. Environmental Policy Act. Identification of mitigation measures effective in reducing potential negative impacts associated with projects was a major component of this endeavor; therefore, a "mitigative measures" subgroup was formed. This document was developed as a result of that effort.

This document was primarily authored by biologists with the N. C. Wildlife Resources Commission (NCWRC) and the N. C. Division of Parks and Recreation, and significant contributions were provided by the mitigative measures subgroup. The document includes comments, ideas, and suggestions from the entire CSI Working Group, which includes representatives from the N. C. Division of Coastal Management, N. C. Division of Environmental Health, N. C. Division of Land Resources, N. C. Division of Marine Fisheries, N. C. Division of Parks and Recreation, N. C. Division of Water Quality, N. C. Division of Water Resources, N. C. Office of Legislative and Intergovernmental Affairs, and the NCWRC. Constructive comments from many of these agencies improved the document. The U. S. Fish and Wildlife Service (USFWS), which supports these recommendations, also provided constructive review of the document.

The NCWRC and the Division of Parks and Recreation recognize that ongoing development and change to the natural landscape will continue and that continued economic development is critical to the citizens of the state. Furthermore, a healthy state is dependent upon a healthy economy and a healthy natural environment, both of which are integrated components. How and where change to the landscape occurs makes all the difference in the future of a sustainable economy and healthy natural environment. The assembled information consists of recommendations, that when implemented by a local government, will simultaneously work to maintain or improve water quality, protect aquatic habitat, permit economic expansion, and preserve the character of the land.

Introduction

Thousands of acres of land are developed each year in North Carolina, and this development consists of many individual and often unrelated projects. Without proper safeguards, the cumulative effects of land development can transform the landscape and negatively impact the environmental character and natural functions of the ecosystems. North Carolina projects a population increase of more than 3 million new individuals by the year 2020 (N. C. Progress Board 2001); therefore, it is imperative that coordinated measures be implemented to protect wildlife resources and their habitats. Most citizens want a clean environment and a healthy economy, therefore measures must be implemented statewide to allow economic growth without significant and irretrievable impacts to North Carolina's environment.

Some of the greatest impacts of development, both land-based and near-water development, occur on water quality in our streams and rivers. Many of our native species of aquatic organisms have become highly imperiled as a result. Approximately one-third of North American freshwater fish species (Williams et al. 1989) and 72% of freshwater mussel species (Williams et al. 1993) qualify for classification as "endangered", "threatened", or "special concern" at the federal level, and habitat loss is a primary culprit, particularly for mussels. In North Carolina, 21% of freshwater fishes and 53% of freshwater mussel species are designated endangered, threatened, or of special concern at the state level (LeGrand et al. 2001). The decline in freshwater species is a direct reflection of declining quality of our streams and rivers. Federally endangered and threatened species are particularly affected by secondary and cumulative impacts associated with urban development due to their sensitivity to slight habitat alterations. A high proportion of listed species occurs within areas of the state that are developing the most rapidly; some have lost major reaches of their habitats within the past few decades, others are in danger of being extirpated from entire river basins, and one species has been extirpated from the state, and thus is extinct (Carolina Elktoe, *Alasmidonta robusta*).

When development is conducted in an unplanned and amorphous or ambiguous pattern it can have more serious impacts on ecosystem function. Rapidly developing landscapes can result in stream degradation due to increases in stormwater runoff, sedimentation and other pollutants, and riparian habitat losses. Measures that may mitigate these impacts include preservation of forested stream buffers of appropriate size, reduction of impervious surfaces, and effective stormwater treatment.

The recommendations presented in this document to avoid or mitigate these impacts are based on the best available science and were obtained by a synthesis of scientific information in journals, publications, reference books, and personal communication with professionals familiar with North Carolina aquatic species and other natural resources. However, the recommendations may be revised as more information becomes available about species' habitat requirements and measures necessary to protect aquatic and terrestrial habitat and water quality.

General Mitigation Measures for All Watersheds (more extensive measures apply to watersheds that support federal endangered and threatened species)

Although riparian zones constitute a small percentage of the landscape, they frequently perform important ecological functions and contain a disproportionately high number of wildlife species in comparison to most upland habitats (Fischer et al. 2000; Knutson and Naef 1997). As a matter of policy, the American Fisheries Society strongly urges that riparian areas be considered unique and distinctly valuable habitats, and that such areas be declared of critical environmental concern (AFS 1985). Riparian areas perform many functions that are essential to maintaining water quality, aquatic species survival, and biological productivity.

With regards to the measures required to protect streams from pollutants, the further the intervention occurs from the source, the greater the costs to society (Reeves et al. 1991); resulting in a gradient from prevention to interdiction to restoration (Waters 1995). Watershed protection has been the most successful method of habitat rehabilitation (Reeves et al. 1991); however, given the difficulty of totally preventing or eliminating pollutants (e.g. sediment) at the source, interdiction such as the use of riparian buffers is an important tool in reducing damage to streams (Waters 1995). The functions of riparian zones are well documented and convey sometimes subtle but critical benefits to society. These functions are listed below.

<u>Forested riparian area functions</u>

- Reduce pollutants and filter runoff
- Improve air quality and lower ozone levels
- Maintain stable water flows
- Help sustain natural channel morphology
- Help maintain water and air temperature by providing shade
- Stabilize stream banks
- Provide most of the organic carbon and nutrients to support the aquatic food web
- Provide sources of large woody debris for the stream channel
- Help reduce the severity of floods
- Facilitate the exchange of groundwater and surface water
- Provide critical wildlife habitat

Numerous studies have evaluated buffer widths needed for stream protection. Often these have focused on a single parameter, which has resulted in a large variation in recommended buffer widths (Appendix A). For a buffer to effectively perform for all riparian processes, wider contiguous buffers (100–300 feet) are recommended (Knutson and Naef 1997; May and Horner 2000; Martin et al. 2000; Palik et al. 2000; Richards and Hollingsworth 2000; Stewart et al. 2000). Effective buffer sizes depend upon specific site conditions, such as slope and soil type. Although variable widths may be more applicable in some circumstances, they are often more difficult to understand, implement, and enforce. Therefore, we offer generalized recommendations of minimum buffer widths for predictable application across the North Carolina landscape. Because specific conditions differ, some deviations from the general recommendation may be acceptable, however deviations should be kept to a minimum. Discussions regarding buffers or riparian corridors refer to forested buffers where the dominant vegetation consists of native trees and shrubs.

Streams with wide, forested riparian corridors in developed areas are essential for the protection of water quality and aquatic habitats. Natural riparian corridors are diverse, dynamic, and complex biophysical habitats (Naiman et al. 1993), and riparian ecosystems have the greatest vulnerability to alteration (Knutson and Naef 1997; and references therein). The maintenance of riparian habitat may yield the greatest gains for aquatic and terrestrial wildlife across the landscape while involving the least amount of area.

Numerous significant and negative consequences can result when headwater streams are lost (Meyer and Wallace 2001), and the effects of degradation accumulate; therefore, the condition of the stream in the lower reaches is closely dependent on the condition in the headwaters (Vannote et al. 1980). In addition, headwater streams can significantly reduce nutrient export to rivers (Alexander et al. 2000; Peterson et al. 2001).

1. We recommend the maintenance or establishment of a minimum 100-foot native forested buffer along each side of perennial streams and 50-foot native forested buffer along each side of intermittent streams and wetlands throughout the present and future service areas or the entire municipal jurisdiction (EPA 2000; Stewart et al. 2000). We additionally encourage the implementation of buffers on ephemeral streams due to the important functions that they provide as headwater streams (Alexander et al. 2000; Peterson et al. 2001). Buffers should be measured horizontally from the edge of the stream bank (Knutson and Naef 1997), which may result in wider buffers on higher gradients, and must be provided over the entire length of stream, including headwater streams. Further, we recommend leaving 30% of the development area as greenspace, which would include buffers and wetlands and ensure that the greenspace is connected to natural resources.

   Wide, contiguous riparian buffers have greater and more flexible potential than other options to maintain biological integrity (Horner et al. 1999) and could ameliorate many ecological issues related to land use and environmental quality (Naiman et al. 1993). As expansion of developed areas continues into the watershed, wildlife habitat can change, become fragmented, and even disappear. Riparian buffers provide travel corridors and habitat areas for wildlife displaced by development. In addition, riparian buffers serve to protect water quality by stabilizing stream banks, filtering capacity of stormwater runoff, and provide habitat for aquatic and fisheries resources.

2. We recommend that delineation of streams be conducted for the municipal service area according to U. S. Army Corps of Engineers (USACOE) or N. C. Division of Water Quality (NCDWQ) methodology. This information can be found at http://h2o.enr.state.nc.us/ncwetlans/strmfrm.html (accessed May 2002). U. S. Geological Survey (USGS) maps underestimate the extent of streams. Recent research has shown that USGS maps can underestimate total stream length in the Piedmont of North Carolina by 25 % (Gregory et al. in press).

3. We recommend that sewer lines, water lines, and other utility infrastructure be kept out of riparian buffer areas (Knutson and Naef 1997; and references therein). All utility crossings should be kept to a minimum, which includes careful routing design and the combination of utility crossings into the same right-of-way (provided there is not a safety issue). Discontiguous buffer segments can impair riparian functions disproportionate to the relative occurrence of the breaks in the buffer (May and Horner 2000; Van Sickle 2000), and multiple crossings can result in cumulative impacts. The directional bore (installation of utilities beneath the riverbed, avoiding impacts to the stream and buffer) stream crossing method should be used for utility crossings wherever practicable, and the open cut stream crossing method should only be used when water level is low and stream flow is minimal. Manholes or similar access structures should not be allowed within buffer areas. Stream crossings should be near perpendicular (75° to 105°) to stream flow and should be monitored at least every three months for maintenance needs during the first 24 months of the project and then annually thereafter. Sewer lines associated with crossing areas should be maintained and operated at all times to prevent the discharge to land or surface waters. We recommend a minimum 50–100 feet setback on all streams, lakes, and wetlands for these structures, which falls in line with the recommended buffer widths. In circumstances where minimum setbacks cannot be attained, sewer lines shall be constructed of ductile iron or other substance of equal durability. Further, pesticides

(including insecticides and herbicides) should not be used for maintenance of rights-of-way within 100 feet of perennial streams and 50 feet of intermittent streams, or within floodplains and wetlands associated with these streams.

4. Avoid the removal of large trees at the edges of construction corridors. Re-seed disturbed areas with seed mixtures that are beneficial to wildlife. Avoid fescue based mixtures because fescue is invasive and provides little benefit to wildlife. Native, annual small grains appropriate for the season are preferred and recommended (See http://www.esb.enr.state.nc.us/wetplant/wetland_plants.htm, and http://www.co.mecklenburg.nc.us/coeng/Storm/services/vegetation/vegetation.htm). Where feasible, use woody debris and logs from corridor clearing to establish brush piles and downed logs adjacent to the cleared right-of-way to improve habitat for wildlife. Allowing the corridor area to revegetate into a brush/scrub habitat would maximize benefits to wildlife. For areas adjacent to residential areas, a native shrub/grass option may also be beneficial. Minimize corridor maintenance and prohibit mowing between April 1 and October 1 to minimize impacts to nesting wildlife. We suggest a maintenance schedule that incorporates only a portion of the area —one third of the area, for example—each year instead of the entire project every 3 or 4 years. Herbicides and pesticides should never be used in wetland areas or near streams, as described above in item 3.

5. We recommend that the local governments prohibit commercial or residential development within the 100-year floodplain. Undeveloped floodplains strongly influence aquatic systems, support a combination of riparian and upland vegetation used by aquatic and terrestrial wildlife, supply a rich source of food to aquatic communities (Junk et al. 1989), and provide an important sediment trapping function (Palik et al. 2000). The filling of floodplains increases the potential for flooding of adjacent properties and interferes with the natural hydrologic process of the waterways. It also disrupts the continuity of migration corridors for wildlife. Instead, we recommend that developers set aside a portion of the land to be developed as green space and concentrate these areas along the streams and rivers (see Item 1 above). In addition we encourage "infill" (new development in unused or underutilized land in existing urban areas) development in urbanized portions of the jurisdiction and recommend the site practices for infill and brownfield development issued by the U. S. Environmental Protection Agency (EPA) (http://www.epa.gov; accessed May 2002) and the Center for Watershed Protection (http://www.cwp.org/; accessed May 2002). Floodplain maps may need to be updated to reflect development of the watershed. Floodplain remapping studies in Charlotte showed that buildout conditions would result in a floodplain width change from an average of 429 feet to 611 feet (http://www.co.mecklenburg.nc.us/coeng/storm/floodinfo/floodmaps.htm; accessed May 2002)

6. We recommend that the local government limit impervious surfaces to less than 10% of the watershed (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000; Paul and Meyer 2001). The construction of roadways and other impervious surfaces in new neighborhoods can produce short-term direct impacts as well as long-term cumulative effects. Multiple studies have shown that stream degradation occurs at approximately 10% coverage by impervious surfaces (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000; Paul and Meyer 2001). Likewise, the Wake County Watershed Management Plan Task Force performed a correlation

analysis of impervious surfaces to watershed classification based on water quality data, and they found that watersheds of unimpaired streams averaged 8% imperviousness, impacted streams averaged 11%, and degraded streams averaged 24% (http://projects.ch2m.com/WakeCounty/; accessed May 2002).

We also recommend that the local government provide for sufficient open space to effectively reduce impervious surface so that predevelopment hydrographic conditions are maintained, limit curb and gutter in new developments, and prevent direct discharges of stormwater into streams. To achieve no net change in the hydrology of the watershed, we recommend installation of grassed swales in place of curb and gutter and on-site stormwater management (i.e. bioretention areas or other attenuation measures). These designs often cost less to install (Kwon 2000) and significantly reduce environmental impacts from residential development. Information regarding financing stormwater management can be found at http://stormwaterfinance.urbancenter.iupui.edu/ (accessed May 2002).

Many of these recommendations have been applied in Maryland to protect the Chesapeake Bay from water quality degradation (MDE 2000). Suggested examples to accomplish the <10% impervious goal are using conventional designs at a level of <10% imperviousness or using conservation clusters with higher densities, with dedicated open space and other stormwater control measures to mimic the hydrograph consistent with an impervious coverage of less than 10%. Reduction of road widths is one method to reduce overall impervious surface coverage. The N. C. Department of Transportation (NCDOT) has issued road guidelines that allow for the reduction in street widths when compared to standard secondary road guidelines. This material can be found at http://www.doh.dot.state.nc.us/operations/tnd.pdf (accessed May 2002). In addition, there are site planning practices that, when incorporated with the above mentioned road building guideline, can further reduce the amount of impervious surface within a site (see recommendations in the document Better Site Design (Center for Watershed Protection; http://www.cwp.org/; accessed May 2002).

7. Use bridges for all permanent roadway crossings of streams and associated wetlands to eliminate the need to fill and culvert, where practicable. If culverts must be used, the culvert should be designed to allow passage of aquatic organisms. Generally, this means that the culvert or pipe invert is buried at least one foot below the natural streambed. If multiple cells are required, the second and/or third cells should be placed so that their bottoms are at stream bankfull stage. This will allow sufficient water depth in the culvert or pipe during normal flows to accommodate movements of aquatic organisms. If culverts are long and sufficient slope exists, baffle systems are recommended to trap gravel and provide resting areas for fish and other aquatic organisms. If multiple pipes or cells are used, at least one pipe or box should be designed to remain dry during normal flows to allow for wildlife passage. In addition, culverts or pipes should be situated so that no channel realignment or widening is required. Widening of the stream channel at the inlet or outlet of structures usually causes a decrease in water velocity causing sediment deposition that will require future maintenance. Finally, riprap should not be placed on the streambed.

8. We recommend that municipalities incorporate the elements listed below into their erosion and sediment control plans (see Brown and Caraco 2000 for additional information). Sediment is considered the most important cause of water pollution in the

United States (Waters 1995), and construction is considered the most damaging phase of the development cycle to aquatic resources (Brown and Caraco 2000).

a) Minimize clearing and grading and only perform these operations in the context of an overall stream protection strategy.
b) Protect waterways by preventing clearing adjacent to waterways, and stabilize drainage ways.
c) Phase construction for larger construction sites (≥25 acres) to reduce the time and area that disturbed soils are exposed.
d) Stabilize soils as rapidly as possible (<2 weeks) by establishing a grass or mulch cover.
e) Protect steep slopes, and avoid clearing or grading existing steep slopes as much as possible.
f) Establish appropriate perimeter controls at the edge of construction sites to retain or filter concentrated runoff from relatively short distances before it leaves the site.
g) Employ advanced settling devices that contain design features which include greater wet or dry storage volume, perforated risers, better internal geometry, use of baffles, skimmers and other outlet devices, gentler side-slopes, and multiple cell construction.
h) Implement a certified contractors program so that trained and experienced contractors are on-site.
i) Sedimentation impacts should be minimized by regular inspection of erosion control measures, and sediment control devices should be maintained in good and effective condition at all times. Erosion and sediment controls should be reassessed after storms. The incorrect installation of erosion control structures and those not properly maintained can result in sedimentation impacts to nearby streams and wetlands.

Specific Mitigation Measures for Waters Containing Federally Listed Species

Federally endangered and threatened species are particularly affected by secondary and cumulative impacts associated with urban development due to their sensitivity to habitat degradation and resulting high probability of extirpation. A high proportion of listed species occurs within portions of the state that are developing the most rapidly; some have lost major reaches of their habitats within the past few decades, others are in danger of being extirpated from entire river basins, and one species has been extirpated from the state, and thus is extinct (Carolina Elktoe, *Alasmidonta robusta*). It is not just single species that are in danger of being lost in some systems, but entire faunas and communities.

For those watersheds that support federally endangered and threatened species, the following additional conditions shall be followed. These measures provide a higher degree of protection and also serve to protect the state-listed species and the general biotic integrity of these systems. The natural resource agencies' concerns regarding indirect effects to threatened and endangered species will be alleviated by adoption of these measures. The attached map (Appendix B) shows the location of NCDWQ designated 14 digit hydrologic unit code (HUC) drainage basins that support federally endangered and threatened species, and provide an indication of where the more extensive measures will apply. This map may be updated, as more information becomes available.

<u>Stormwater</u>

1. Permits for new developments exceeding 6% imperviousness shall be required to include stormwater controls designed to replicate and maintain the hydrographic condition at the site prior to the change in landscape and at a minimum include provisions that satisfy WS II-HQW minimum standards (WSII-HQW waters as precedent; Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Horner 2000; Stewart et al. 2000). This can be achieved through a variety of measures (see Item 6 above).

2. Insufficient information exists in the literature for the minimum buffer widths necessary to ensure the continued survival of federally endangered and threatened aquatic species. Therefore, the following minimum buffer recommendations are based on the best scientific information available and the opinion of biologists most familiar with the species in the state. The minimum recommended buffer widths may actually need to be more or less stringent; and therefore, recommended widths may be modified as more information becomes available. A 200-foot native, forested buffer on perennial streams and a 100-foot forested buffer on intermittent streams, or the full extent of the 100-year floodplain, shall be required for new developments. Detailed studies have resulted in recommendations of 200-foot buffers and wider for protection of priority habitats in the U. S. (Knutson and Naef 1997, and references therein; Martin et al. 2000; Richards and Hollingsworth 2000). If wooded buffers do not exist, then these areas shall be revegetated or allowed to naturally revegetate (so long as the area is pervious) to increase the functionality of a forested buffer. (Knutson and Naef 1997, and references therein; 200-foot buffers on Randleman Lake; 200-foot buffers associated with protection of aquatic endangered species habitats required for Buckhorn Reservoir Expansion Project in 1995 – City of Wilson).

3. Grassed swales shall be used in place of curb and gutter for new developments, except in areas with >5% slope. Check dams, level spreaders, and other associated best management practices shall be used to minimize the effect of stormwater runoff entering the riparian buffer areas. In areas where slopes exceed 5%, stormwater collected in piped conveyance systems shall be directed away from surface waters and best management practices shall be employed at both the intake and the outlet areas. Curbs and gutters may be used in combination with sidewalks in areas where clustering of uses increases the net local density to a level greater than 4 dwelling units per acre. This will separate the pedestrian portion of a street-scape from the automobile portion and will encourage greater pedestrian mobility within the cluster development (see recommendations in Pedestrian Facilities Users Guide at http://www.walkinginfo.org/insight/features_articles/userguide.htm; accessed May 2002). Clustering development away from riparian areas will also allow for greater stream protection.

4. We recommend that that direct discharges of stormwater to streams not be allowed. Effective energy dissipation at the pipe outlet shall be accomplished to prevent scour of the stream channel and buffer. Stream habitats are maintained most effectively when stormwater runoff is dispersed through a vegetated or grassed buffer zone prior to entering the riparian buffer. The ditching or piping of stormwater except when used in combination with grassed swales, level spreaders and check dams shall not be allowed in the riparian buffer. At no time should any mandated vegetated buffer zone be used for these engineered devices. In addition, the use of trees—particularly evergreen species—can be an effective component of an integrated stormwater management plan and can reduce the amount of surface water runoff by as much as 7% on a site due to interception, transpiration, and other processes (see http://www.sustainable-

communities.agsci.ubc.ca/bulletins/TB_issueforest.pdf, and http://wcufre.ucdavis.edu/urban.htm; accessed May 2002).

5. Emergency management procedures shall provide for the containment of runoff from fighting residential, commercial, or industrial fires and for the removal and clean up of any hazardous spills that may endanger nearby streams, instead of flushing contaminants into waterways.

Wastewater Infrastructure

1. Force mains shall be used to the greatest extent practicable. Gravity sewer lines shall be installed to follow along the outside of the100-year floodplain contour unless topographic features, existing development, or other conditions restrict this technique.

2. Public and private sewer lines adjacent to streams shall parallel streams and be sited as far as practicable from stream and tributary corridors (Knutson and Naef 1997; and references therein). A minimum 200-foot buffer shall be provided for perennial streams and a 100-foot buffer for intermittent streams to maintain the integrity of the buffer or the full extent of the 100-year floodplain. Sewer lines close to streams shall be constructed of ductile iron or other substance of equal durability, similar to the guidance under the general mitigation measures item number 3.

3. No new sewer lines or structures shall be installed or constructed in the 100-year floodplain or within 50 feet of wetlands associated with a 100-year floodplain (Knutson and Naef 1997; and references therein).

4. Septic tanks, lift stations, wastewater treatment plants, sand filters, and other pretreatment systems shall not be located in areas subject to frequent flooding (areas inundated at a 10-year or less frequency) unless designed and installed to be watertight and to remain operable during a 10-year storm. Mechanical or electrical components of treatment systems shall be above the 100-year flood level or otherwise protected against a 100-year flood (As per rule 15A NCAC 18A .1950 – Location of Sanitary Sewage Systems).

5. Only aerial crossings elevated sufficiently to reduce the risk of flood damage or directional boring stream crossings shall be allowed. The placement of these crossings will be limited to major stream or creek confluences. Manholes or similar access structures shall not be allowed within buffer areas. Stream crossing areas shall be monitored once a quarter for maintenance needs.

Water and Utility Infrastructure (Electricity, Telecommunications, and Gas)

1. All water lines and utilities shall follow roads or meet the requirements associated with sewer line placements (Killebrew 1993; Knutson and Naef 1997; and references therein). Stream crossing guidance is presented under the general mitigation measures item number 3.

Maintenance of Rights-of-Ways

1. Insecticides and herbicides shall not be used within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein) except when needed to protect native flora and fauna from exotics and when using appropriately labeled products, such as biopesticides (http://www.epa.gov/pesticides/biopesticides/; accessed May 2002).

2. Native, forested plant communities shall be maintained within 200-foot buffer area of streams, floodplains, and associated wetlands. A closed canopy will be maintained over streams. Emphasis will be placed upon trimming trees, instead of tree removal, within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein).

Sediment and Erosion Control

1. In addition to the items listed under the general mitigation measures, locally enforced stringent erosion and sedimentation control requirements shall be developed and implemented for all construction. The development of these requirements shall be fully coordinated with the state and federal agencies involved in aquatic endangered species protection. These measures shall be state-of-the-science and significantly exceed state minimum requirements for sediment and erosion control. Local ordinances shall be developed to prevent "forestry exemptions" from turning into development opportunity without meeting the conditions identified in this memorandum.

2. Fill or buildings shall not be allowed in the 100-year floodplain (as described in previous sections).

Additional Recommendations for Federally Listed Species

1. The local government shall solicit assistance and concurrence from resource agencies such as NCDWQ, N. C. Division of Land Resources, NCWRC, N. C. Natural Heritage Program, and USFWS during the initial development and assessment of best management practices for stormwater management, sediment and erosion control, utility placement, etc.

2. Maps shall be developed of the anticipated construction lines of utilities associated with expanded service areas. This information shall become part of a Geographic Information System (GIS) database housed and maintained by the local government. Surveys or reviews will use maps and field determinations, when necessary, in conjunction with USACOE and NCDWQ delineation criteria for wetlands and waters. As infrastructure or development is planned or developed, field surveys should be conducted to assess impacts and means to avoid impacts. Field surveys (delineation) or intensive map reviews (including soil surveys, National Wetland Inventories (NWI) maps, USGS maps, watershed protection maps of all wetlands and waters) shall be completed and mapped with GIS technology. All GIS databases and associated files shall be provided to state and federal agencies upon request.

3. Local governments shall encourage and offer incentives for new developments, as part of the subdivision review process, to use low impact development technique for stormwater control (*Low Impact Development;* EPA Document # 841– B-00-002 and 841-B-00-003), and reduce impediments to implementing the plan. Proposed projects that are subject to NCEPA review shall identify as a part of the subdivision review process anticipated impervious surface amounts prior to plat approval.

4. Developers and builders, including land-clearing operators, shall be required to participate in a local government stormwater and sediment erosion control education program. Certification and bonding is recommended.

5. Infiltration practices (e.g., reduced road widths, rain gardens, parking lot bioretention areas, increased sheet flow instead of ditching, and disconnect impervious areas) to maintain predevelopment hydrographic conditions shall be emphasized over detention ponds. Condition information should include the base flow for low flow conditions.

6. Conservation Reserve Program lands and restoration of prior converted wetlands shall be encouraged to help manage overall stormwater impacts as part of a regional integrated stormwater management plan.

7. Site gas stations, car washes, and other "spill" land uses at least 200 feet from streams and wetlands.

8. The local government shall provide an environmental check-off list that a developer must complete before the issuance of development approvals to ensure protection of aquatic habitats for threatened and endangered species and that proper state and federal permits have been obtained. This shall preclude the issuance of any subdivision plan, building, and utility permits without inclusion of pertinent protective measures. This process shall ensure that land clearing does not occur without a site plan, including erosion control.

9. A watershed impact evaluation board shall be established to review projects within the service area with aquatic, endangered species. The board would ensure compliance, preview infrastructure and development plans, and be eligible to seek funding for conservation initiatives designed to protect and preserve aquatic, endangered species.

10. We encourage local governments to consider retrofit options, including abandonment of chronic problem areas especially where projects exist in floodplains and are on failing septic systems. These areas should not be candidates for sewer service. Local governments should explore all buyout opportunities of these areas prior to exploration of providing sewer services to these areas. In addition, this should apply to schools and other public institutions. These public facilities should be relocated to more suitable areas. Local governments are encouraged to strengthen local land development codes to ensure that privates lands donated to the public for usage of schools and other public facilities (i.e. fire, police, or medical facilities) are located outside of the 100-year floodplain so as to avoid future problems.

11. We recommend the use of conservation easements, public ownership, or deed restrictions to ensure the perpetual conservation of natural buffer areas.

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Appendices

Appendix A. Minimum riparian habitat buffer widths needed to retain various riparian habitat functions as reported in the literature.

Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Nutrients (General)	36(118)	Young et al. 1980 (MN)
Filter Nitrogen	18(59) retention of only 20–50% of surface ammonium and 50% of nitrite and nitrate	Daniels and Gilliam 1996 (NC)
	9(29) grass	Dillaha et al. 1989 *in* Osborne and Kovacic 1993
	30(98)	Doyle, et al. 1977 *in* Osborne and Kovacic 1993
	31(102) 94% reduction in ground water nitrate	Hanson et al. 1994
	30(100) 78% reduction in groundwater nitrate	Hubbard 1997 (GA)
	16(52)	Jacobs and Gilliam 1985 (NC)
	10(32)	James, et al. (in press) *in* Osborne and Kovacic 1993
	55(180)	Jordan et al. 1993 (MD)
	25(82)	Lowrance, et al. 1984
	10–40(33–131)	Lowrance 1992 (GA)
	16(52) or 39(127) grass	Osborne and Kovacic 1993 (IL)
	19(62) ~70–80% reduction	Peterjohn and Correll 1984 (MD)
	50(164) 80–90% reduction	Peterjohn and Correll 1984 (MD)
	30(98)	Pinay and Decamps 1988 *in* Osborne and Kovacic 1993
	27(88) grass	Schnabel 1986 *in* Osborne and Kovacic 1993
	30(98)	Spruill 2000 (NC)
	17–20(56–66) or 31(100) to produce lowest simulated outputs	Williams et al. 2000 (GA)
	21(70) reduced surface N by 67% and ammonium by 71% [recommended 40m (118)]	Young et al. 1980 (MN)
	27(88) grass	Young, et al. 1980 *in* Osborne and Kovacic 1993

Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Sediment/Phosphorus	10(32)–20(65)	Aubertin and Patric 1974 *in* Osborne and Kovacic 1993 (WV)
	Nearly 50% of ^{137}Cs labeled sediment moved over 100m(328) in riparian area	Cooper et al 1987 (NC)
	16(52)	Cooper and Gilliam 1987 *in* Osborne and Kovacic 1993
	6–18(20–59)	Daniels and Gilliam 1996 (NC)
	9(30) (grass filter)	Dillaha et al. 1989 (VA); Dillaha et al. 1988 (VA); Magette et al. 1989 (MD)
	9(29)	Haupt and Kidd 1965 *in* Osborne and Kovacic 1993 (ID)
	55(180)	Jordan et al. 1993 (MD)
	Most sediment deposited within 1st 30(98) of buffer but extends 80(262) in riparian buffers	Lowrance et al. 1988 (GA)
	30(98) removed 75-80% from storm water in logged areas	Lynch et al. 1985
	28(92) for 81% efficiency	Mander et al. 1997 (Estonia)
	16(52) or 39(127)grass	Osborne and Kovacic 1993 (IL)
	19(62) trapped 90% of sediment	Peterjohn and Correll 1984 (MD)
	50(164) trapped 94% of sediment	Peterjohn and Correll 1984 (MD)
	50(164) for 84% total and 73% soluble P removal efficiency	Peterjohn and Correll 1984 (MD)
	15(49)–45(147)	Trimble and Sartz 1957 *in* Osborne and Kovacic 1993 (NH)
	30(100) recommended for trapping sediment	Wenger 1999
	17–20(56–66) or 28(92) to produce lowest simulated outputs	Williams et al. 2000 (GA)
	21(69) for 67% total and 69% soluble P removal efficiency	Young et al. 1980 (MN)
	27(90) removed 93% sediment from feedlot; 23(75) removed only 33% from dairy farm runoff	Young et al. 1980 (MN); Horner and Mar 1982 in Castelle et al. 1994

Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Filter Contaminants	9(30) (fecal coliform/grass filter)	Coyne et al. 1998 (KY)
	15–80 (49–262) adequate for nonpoint source pollution	Phillips 1989 (NC)
Erosion Control	55(180)	Jordan et al. 1993 (MD)
	30(100)	Raleigh et al. 1986 *in* Knutson and Naef
Stream Type Maintenance (Rosgen 1996)	20x bankful width each side (E channel type streams >10 ft wide at bankfull and <5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
	10x bankfull width each side (other channel type streams >10 ft wide at bankfull and <5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
	Entire floodplain + ≥30(100) (For identifiable floodplain and terrace slopes)	Llhardt, et al. 2000 (Eastern U.S.)
	≥61(200) (>5% slope)	Llhardt, et al. 2000 (Eastern U.S.)
Large Woody Debris	>30(100)	Fetherston, et al. 1995 (Pacific NW)
	Majority of recruitment within 45(148)	Knutson and Naef 1997 (review)
	46(150)	Robinson and Beschta 1990
Water Temperature Control	10(32)–20(65)	Aubertin and Patric 1974 *in* Osborne and Kovacic 1993 (WV)
	≥30(100) provides shading of old growth forest	Beschta et al. 1987 *in* Castelle et al. 1994 and Knutson and Naef
	10(32)	Brazier and Brown 1973 *in* Osborne and Kovacic 1993 (OR)
	12(39)	Corbett, et al. 1978 *in* Osborne and Kovacic 1993 (NC)
	31(101)	Lynch and Corbett 1990 *in* Osborne and Kovacic 1993 (PN)
Microclimate Influence	>45(148) and up to 300(985)	Brosofske, et al. 1997 (WA)
	61–122(200–399)	Chen et al. 1990 *in* Knutson and Naef

Riparian habitat function	Perpendicular distance from stream in meters (feet in parentheses)	Source
Food Resources	>30(100) particulate organic matter (POM)	Palik, et al. 2000 (Eastern U.S.)
Instream habitat and aquatic resources	73–275(240–902) semi-aquatic resources	Burke and Gibbons 1995 (SC)
	≥30(100) to minimize short-term logging impacts on streams	Davies and Nelson 1994 (Australia)
	15–30(50–100) for minimum maintenance	Johnson and Ryba 1992 *in* Knutson and Naef
	>30(100)	May and Horner 2000 (WA) ; Martin et al. 2000 (MI, VA) ; Stewart et al. 2000 (WI)
	>61(200)	Richards and Hollingsworth 2000 (Eastern U.S.)
	164(534) semi-aquatic resources	Semlitsch 1998 (multi state)

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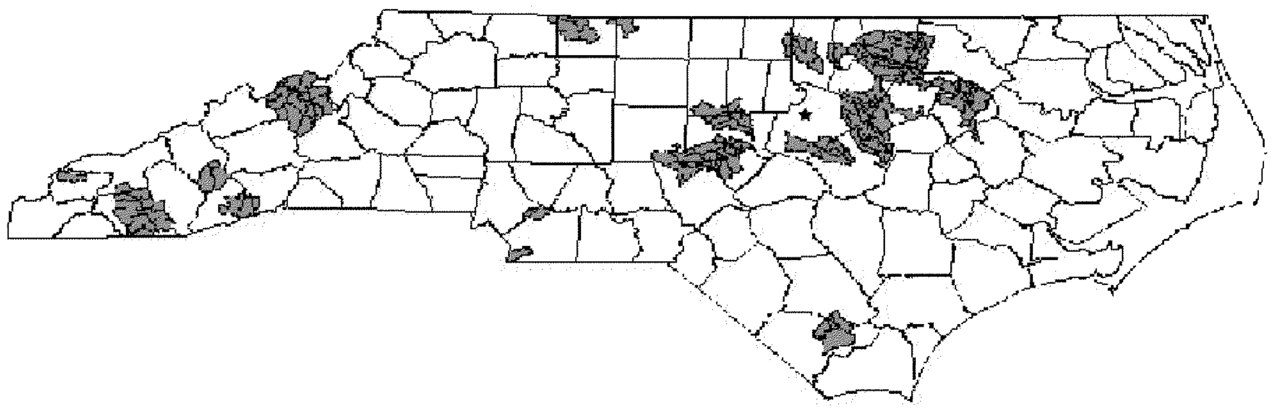

Appendix B. N. C. Division of Water Quality designated 14 digit hydrologic unit code (HUC) drainage basins that support federally endangered and threatened species. (July 2002: Map maybe updated as more information is acquired)

Michael F. Easley, Governor

William G. Ross Jr., Secretary
North Carolina Department of Environment and Natural Resources

Alan W. Klimek, P.E. Director
Division of Water Quality

25 May 2006

TO: Melba McGee, Department of Environment and Natural Resources

FROM: Alex Marks, AICP

SUBJECT: Scoping: Neuse River Basin Feasibility Study, DWQ #13678, SCH #06-0316

The Division of Water Quality (Division) has reviewed the subject environmental scoping notice from the Army Corps of Engineers (ACOE) for its proposed Neuse River Basin Feasibility Study. According to the document reviewed, the Study will be coordinated with the DENR Division of Water Resources. Following are the Division's comments:

1. The Division's Basinwide Planning Unit would like to assist the ACOE in their efforts and help identify specific project locations to enhance or restore water quality. We can provide the ACOE with information as the Neuse River Basinwide Water Quality Plan is developed for 2007 and would in turn value their input during the fall 2006 interim review period. Further communication regarding the Basinwide Plan should be directed to Nora Deamer, Neuse River Basinwide Planner (919) 733-5083 ext. 374 or Darlene Kucken, supervisor for the Basinwide Planning Program at ext. 354.

2. The Division's Modeling & TMDL Unit is also supportive of this study. Due to North Carolina Senate Bill 981, the Division is scheduled to develop a nutrient management strategy for Falls of the Neuse Reservoir by 2008. Any modification to the operation of Falls Lake dam (or to habitats upstream of the dam) could have an impact on the spatial distribution of nutrients in the reservoir. Thus, we recommend that the Corps keep informed of the progress of the strategy development as well as keep the Unit informed of progress with the feasibility study. There is the potential for collaboration to support both of these efforts. Please contact Pam Behm at (919) 733-5083 ext. 506 should you have any questions regarding this matter.

Thank you for the opportunity to review this material. I may be contacted at 919.733.5083 x555 for additional information or further assistance.

EC: Coleen Sullins
Alan Clark
Darlene Kucken
Pam Behm
Nora Deamer

Secretary's Office
DOA

MAY 31 2006

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NCDENR

North Carolina Department of Environment and Natural Resources
Division of Marine Fisheries

Michael F. Easley, Governor
William G. Ross Jr., Secretary

Preston P. Pate Jr., Director

25 May 2006

Mr. Hugh Heine, Environmental Resources Section
U.S. Army Corps of Engineers, Wilmington District
P.O. Box 1890
Wilmington, NC 28402-1890

Dear Hugh:

In response to the notice of 26 April 2006 concerning the proposed Neuse River Basin Feasibility Study, the North Carolina Division of Marine Fisheries (DMF) has the following comments:

We have conducted a number of sampling programs in the Neuse River Basin over the last 30 years, from the estuary upstream to the Raleigh area. We have considerable data available for use in the upcoming study. Our data include life history information on many finfish and invertebrate species, bottom type mapping, water conditions at sampling sites, and commercial fisheries data. The data are public record, and they are available on request.

We have many interests related with this study, especially water quality and flow, and fish habitat. We have identified anadromous fish spawning and nursery areas, and primary and secondary nursery areas for estuarine-dependent species, as well as shellfish habitat in the lower estuarine area. We want to assure that water quality and quantity needs of fish are fully considered as the Basin develops over the coming decades, especially as requests to withdraw surface water for human uses in the Basin increase.

Mr. Sean McKenna of our Washington, NC office will be the principal contact in the DMF for this study. Please contact him at the NC Department of Environment and Natural Resources Washington Regional office at NC Division of Marine Fisheries, 943 Washington Square Mall, Washington, NC 27889. His telephone number is 252-975-3716, and his email address is Sean.McKenna@ncmail.net.

Thank you for the opportunity to participate in this program.

Sincerely,

Michael W. Street, Chief
Habitat Protection Section

cc: Sean McKenna
Katy West
Mike Marshall
Melba McGee

3441 Arendell Street, P.O. Box 769, Morehead City, North Carolina 28557
Phone: 252 726-7021 \ FAX: 252 726-0254 \ Internet: www.ncdmf.net

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NCDENR

North Carolina Department of Environment and Natural Resources

Michael F. Easley, Governor

William G. Ross Jr., Secretary

Secretary's Office
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MEMORANDUM

TO: Chrys Baggett
State Clearinghouse

FROM: Melba McGee
Project Review Coordinator

RE: 06-0316 Neuse River Basin Feasibility Study, Multi Counties

DATE: May 31, 2006

The Department of Environment and Natural Resources has reviewed the proposed project. The attached comments are a result of this review. More specific comments will be provided during the environmental review process.

Thank you for the opportunity to respond. If during the preparation of the environmental document, additional information is needed, the applicant is encouraged to notify our respective divisions.

Attachments

1601 Mail Service Center, Raleigh, North Carolina 27699-1601
Phone: 919-733-4984 \ FAX: 919-715-3060 \ Internet: www.enr.state.nc.us/ENR/

From: rmundt@ncem.org
Sent: Tuesday, May 30, 2006 9:50 AM
To: Heine, Hugh SAW
Subject: Neuse River Basin Feasibility Study

Hello,
I'm working w/ NC Emergency Management on the updating of FEMA's NFIP Flood Insurance Rate Maps (FIRMs). As such I would be interested in learning more about how we can provide input to the above referenced as it relates to flood damage reductionfrom the varied perspectives of what we are doing, what we are aware local jurisdictions are doing, and what the USACE is doing or proposes to do.

Please let me know how I can best contribute.

thank you
rpm

Randy Mundt, AICP, CFM

NORTH CAROLINA STATE CLEARINGHOUSE
DEPARTMENT OF ADMINISTRATION
INTERGOVERNMENTAL REVIEW

MAY

STATE NUMBER: 06-E-0000-0316
DATE RECEIVED: 05/01/2006
AGENCY RESPONSE: 05/29/2006
REVIEW CLOSED: 06/01/2006

MS RENEE GLEDHILL-EARLEY
CLEARINGHOUSE COORD
DEPT OF CUL RESOURCES
ARCHIVES-HISTORY BLDG - MSC 4617
RALEIGH NC

CH 06- 1243

A- DAH 5/19/06

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DEPT OF TRANSPORTATION
EASTERN CAROLINA COUNCIL
TRIANGLE J COG

PROJECT INFORMATION

APPLICANT: Dept. of the Army/Corps of Engineers

TYPE: National Environmental Policy Act

ERD: Scoping

DESC: The purpose of the Neuse River Basin Feasibility Study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish, wetlands, stream, riparian buffer, oyster habitat & flood damage reduction

The attached project has been submitted to the N. C. State Clearinghouse for intergovernmental review. Please review and submit your response by the above indicated date to 1301 Mail Service Center, Raleigh NC 27699-1301.
If additional review time is needed, please contact this office at (919)807-2425.

AS A RESULT OF THIS REVIEW THE FOLLOWING IS SUBMITTED:

☐ NO COMMENT

☒ COMMENTS ATTACHED

SIGNED BY: Renee Gledhill-Earley

DATE: 5/22/06

MAY 10 2006

North Carolina Department of Cultural Resources

State Historic Preservation Office

Peter B. Sandbeck, Administrator

Michael F. Easley, Governor
Lisbeth C. Evans, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

May 24, 2006

Hugh Heine
Environmental Resources Section
Department of the Army
Wilmington District, Corps of Engineers
PO Box 1890
Wilmington, NC 28402-1890

Re: Neuse River Basin Feasibility Study in North Carolina, CH 06-E-0000-0316, Multi-County, CH 06-1243

Dear Mr. Heine:

We have received notification from the State Clearinghouse concerning the above project.

Many hundreds of historic properties are located within the Neuse River basin. While many of these resources are listed in the National Register of Historic Places, many more have yet to be evaluated for their eligibility. Large portions of the basin have never been surveyed in order to locate and evaluate historic properties. Development of a feasibility study should have no effect upon such resources, however implementation of the resulting plan is likely to have an effect upon eligible or listed historic properties. Consideration of such resources should be included in your environmental document. We look forward to working with you and your staff on this study.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, please contact Renee Gledhill-Earley, environmental review coordinator, at 919/733-4763. In all future communication concerning this project, please cite the above referenced tracking number.

Sincerely,

Renee Gledhill-Earley
for Peter Sandbeck

cc: State Clearinghouse

THE UNIVERSITY
of NORTH CAROLINA
at CHAPEL HILL

INSTITUTE OF
MARINE SCIENCES

3431 ARENDELL STREET
MOREHEAD CITY, NC 28557

T 252.726.6841
F 252.726.2426

3 May 2006

Mr. Noel Clay
Acting Chief, Planning and Environmental Branch
Department of the Army
Wilmington District Corps of Engineers
Box 1890
Wilmington, NC 28402-1890

Dear Mr. Clay:

Be advised of several species in the Neuse River that should be considered during our Neuse River Basin study. They are: *Manatee* that go into Trent River and just north of New Bern. *Carolina mudpuppy* that is in the Neuse River and Tar to Pitch Kettle. *Dwarf mudpuppy* in Tar and Neuse Rivers to deeper waters along the fall line; catfish and freshwater mussels should be of concern. Also *Rangia* at New Bern. I append a paper on the Manatees for your information.

Sincerely,

Frank J. Schwartz
Professor

FJS:lw

Enclosure

cc: Dr. R. A. Luettich

Florida Manatees, *Trichechus manatus* (Sirenia: Trichechidae), in North Carolina 1919–1994

FRANK J. SCHWARTZ
Institute of Marine Sciences
University of North Carolina
Morehead City, North Carolina 28557

ABSTRACT—Florida manatees, first reported in 1919 from North Carolina, are now known to have frequented 59 sites (68 individuals) during the period of 1919–1994. All but two have been subadults of about 1.8–2.4-m lengths. Only seven deaths have been recorded. Eleven coastal counties have harbored manatees. Four occurrences have been at inlets and six in the open ocean. Pelletier Creek, a Carteret County tributary of Bogue Sound, along with the Atlantic Ocean have been the most frequented sites (6); eight manatees occurred at a lush vegetation site in the Trent River (Craven County), a tributary of the Neuse River. Four records came from Wrightsville Beach and Sound, three manatees entered the state from Chesapeake Bay via the canal and Intracoastal Waterway into Currituck Sound. Farthest inland river penetrations have been 94.4 km, 6.4 km north of Wilmington; 92 km, Neuse River at Fort Barnwell Bridge, 33 km northeast of New Bern (Craven County); and one each penetrated the Tar River at Washington (58 km, Beaufort County) and Greenville (88 km, Pitt County). The increased frequency of occurrences in later years may be the result of an increased public awareness of the federally-protected species rather than a seemingly increasing population.

The Florida manatee, *Trichechus manatus*, can attain a size of 4.1 m, 1,620 kg, and ranges from Maryland (Chester River, Chesapeake Bay) to Louisiana in the northern Gulf of Mexico (C. Beck, National Biological Service, personal communication; Jefferson et al. 1993). Northernmost manatee records in North Carolina have been in Currituck Sound (Dare County) (Brimley 1905, 1946; Brimley 1931; Caldwell and Golley 1965) (Table 1, Fig. 1). My study summarizes early records, adds 44 new records (total 59) and comments on where, when, and what size manatees have occurred in North Carolina.

There are more recent records.

Table 1. Occurrences of manatees in North Carolina 1919–1994 by year, locality, number, status alive (A) or dead (D), size (meters), literature reference, and county.

	Date	Locality	N	Status	Approx. Size	County	Reference or Authority
1919	11 September	Masonboro Sound near Wilmington	1	A	2.2	New Hanover	Brimley 1931, 1946
1934	mid-October	Currituck Sound near Duck (Duck Sound)	1	A	3.0	New Hanover	Brimley 1946
1936	8 October	Cape Lookout	1	D	3.3	Carteret	Rathbun et al. 1981
1952	Summer	Southport	1	A		Brunswick	Rathbun et al. 1981
1960		Wrightsville Beach	1	A		New Hanover	Smith 1960
1970	14 December	Wrightsville Beach	1	D		New Hanover	Rathbun et al. 1981
1972	September	Near Southport	1	A		Brunswick	Rathbun et al. 1981
1972	Fall	Wrightsville Beach	2	D		New Hanover	Rathburn et al. 1981
1975	25 June	Cape Hatteras, Pamlico Sound	1	A		Dare	Rathbun et al. 1981
	25 June	3.2 km north of Cape Lookout in Barden's Inlet	1	A		Carteret	Clark, NCMNS[1]
	Summer	Calabash River	2	A		Brunswick	Rathbun et al. 1981
1976	13 July	Ocean Isle Beach	1	A		Brunswick	Rathbun et al. 1981
	6-9 August	Cape Fear River near CPL Power Plant	1	A		Brunswick	Rathbun et al. 1981
	August	Carolina Beach - Ocean	2	A		New Hanover	Rathbun et al. 1981
	Fall	Wrightsville Beach Jetty	1	A		New Hanover	Rathbun et al. 1981
		Lower Cape Fear River	1	A		New Hanover	Lee 1976
1980	August	Minnesott Beach Yacht Basin, Neuse River	3	A	1.4-2.0	Pamlico	This study
1981		Silver Lake, Ocracoke	1	A	1.5	Hyde	This study
	4 August	Pelletier Creek, tributary to Bogue Sound, Morehead City	1	A	1.6	Carteret	This study
	30 September	Pelletier Creek	1	A		Carteret	This study
1982	29-30 June	Avalon Fishing Pier, Altantic Ocean, Kill Devil Hills	1	A	2.4	Dare	C. Beck[1]
	10 July	Trent River	1	A		Craven	Clark[1]
	August	Ocean off Bogue Banks	1	A	2.0	Carteret	This study
	August	Neuse River near Oriental	1	A	2.0	Pamlico	This study
	9 October	Pelletier Creek	1	A	1.8	Carteret	This study
	18-19 October	Pelletier Creek	1	A	1.8	Carteret	This study

Table 1. Continued.

	Date	Locality	N	Status	Approx. Size	County	Reference or Authority
1983	24 June	Ocracoke Island	1	A	2.0	Hyde	This study
	August	Ocean off Shackleford Banks opposite Bottle Run Point in Back Sound	1	A	1.8	Carteret	This study
	10-15 September	10-15 km North of Cape Hatteras near Rodanthe, Pamlico Sound	1	A		Dare	This study
	15 September	8 km North Roanoke Island, Albemarle Sound	1	A	3.0	Dare	This study
	30 September	North end Wanchese Harbor	1	A	3.8	Dare	This study
		Davis Harbor, Core Banks, Davis	1	A	1.5	Carteret	This study
	23 October	Stumpy Point, Pamlico Sound, Later died off Pungo River	1	A-D	S	Dare/Beaufort	This study
	24 October	12.9 km North Roanoke Island	1	A	3.0	Dare	This study
	2 November	Tar River, Greenville	1	A		Pitt	This study
1984	5 January	Wade Point, Pamlico River near Pungo River	1	A	2.75	Beaufort	Beck[1]
	6 January	Pamlico River, Pamlico Beach	1	D		Beaufort	Beck[1]
1985	20 September	Tar River 0.3 km upstream of Washington	1	A	1.4	Pitt	Beck[1]
1986	11 March	Cape Fear River near Marker 50 west side Channel	1	D	2.2	Brunswick	Beck[1] NCMNS5252
	September-October	Collington Bay near Kitty Hawk	1	A	1.8	Dare	This study
1987	9 September	Ft. Macon Coast Guard Harbor, Beaufort Inlet, Morehead City	1	A	2.0	Carteret	This study
	9 September	South side Hatteras Island creek near Rodanthe, South end	1	A	2.1	Dare	This study
	24 September	Ft. Macon Coast Gnard Harbor	1	A		Carteret	Clark[1]
1990	22 January	Pamlico Sound 3.2 km NNE of Ocracoke-Gap Point	1	A-D	2.1	Hyde	Beck[1] NCMNS6211
	30 September	Pelletier Creek	1	A	1.6	Carteret	This study
	2 October	Pelletier Creek	1	A	1.6	Carteret	This study
	3 October	Neuse River at Fort Barnswell Bridge	1	A	1.5	Craven	This study

Table 1. Continued.

	Date	Locality	N	Status	Approx. Size	County	Reference or Authority
1992	Summer	Pamlico Sound, Brant Island Shoals	1	A	2.0	Hyde	This study
	29 July	Wrightsville Beach, Airlie Marina & Route U.S. 74	1	A	3.0	New Hanover	This study
	18 November	Back Sound, off Harkers Island	1	A	1.4	Carteret	This study
1993	11 July	Northeast Cape Fear River, 6 km North of NC 210	1	A	1.5	Pender[2]	This study
	24 August	Trent River 1.6 km upstream of U.S. 70, New Bern	1	A	1.5	Craven	This study
	August-September	Elizabeth River - Intracoastal Canal to Currituck Sound	3	A	1.4-1.6	Currituck	This study
	1 September	Davis Harbor, Core Sound, Davis	1	A	1.5	Carteret	This study
1994	7 July	Cape Fear River at south end Wilmington port facility, east side at Wilmington Center Marina	1	A	1.8	New Hanover	This study
	14 July	Trent River 1.6 km west of Trent River Bridge, U.S. 70	1	A	1.8	Craven	This study
	30 August	Trent River, Lawson Park, just north of US 70 Bridge over river	1	A	1.8	Craven	This study
	17 September	Trent River, Sheraton Hotel Marina, New Bern	3	A	1.4-1.8	Craven	This study
	22 September	Trent River, Sheraton Hotel Marina, New Bern	1	A	1.8	Craven	This study

[1] Personal communication. [2] Wilmington Morning Star 7/20/93.

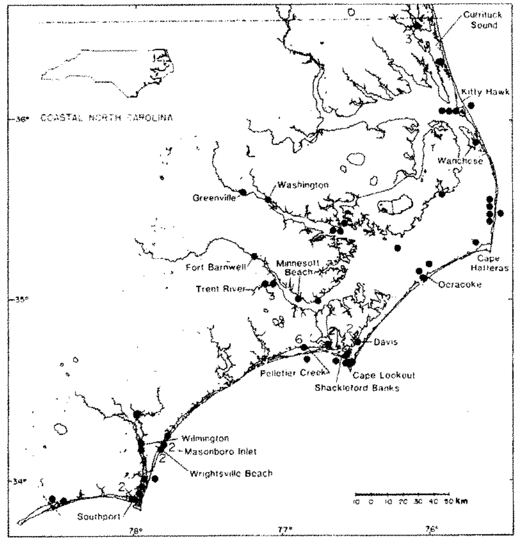

Fig. 1. Locations for 68 manatee sightings in North Carolina during the years 1919-1994.

EARLY LITERATURE OBSERVATIONS

Fifteen live and three dead manatees were reported (16 sites) from North Carolina between 1919 and 1976 by Brimley (1931, 1946), Lee (1976), Rathbun et al. (1981), and Smith et al. (1960). The specimen from Currituck Sound near Duck (Brimley 1946) was about 3 m loug. None was weighed, although a Wrightsville Sound specimen and the Currituck specimens were estimated to weigh 450 kg (Brimley 1931, 1946). Clark (National Marine Fisheries Service, personal communication) recorded a live manatee near Cape Lookout 25 June 1975.

RECENT NORTH CAROLINA OBSERVATIONS

Manatees are now known (68 individuals from 59 sites) to frequent nearly all North Carolina ocean and inland waters (Table 1, Fig. 1). From 1977 to 1994, C. Beck (National Biological Service, personal communication) reports three live and three dead manatees from six sites between 1982 and 1990; Clark adds two additional live individuals in 1982 and 1987 and the remaining 42 specimens (41 sites) are from my study (Table 1). All but four occurrences have been of live specimens. Recent manatee sightings have been of subadults or young about 1.8–2.4 m long (Table 1). None has been weighed. Manatees have been recorded from 11 coastal North Carolina counties (Table 1); 15 occurrences have been in Carteret County, nine each in Dare and New Hanover, and eight in Craven County. Most sightings occurred in 1983 and 1994 (nine), five in 1976, and two to four sightings during most other years. Sightings have occurred during nine months of the year, mostly in September (14), followed by eight in August and October (Table 1). Most often frequented localities have been: Pelletier Creek (six), a tributary to Bogue Sound at Morehead City (Carteret County), various localities in the Atlantic Ocean (6), four at Wrightsville Beach and Sound (New Hanover County), and the Trent River near New Bern, North Carolina (8) (Craven County). While Rathbun et al. (1981) noted that open ocean habitat occurrences are rare, four North Carolina records have been from inlet-ocean sites and six in the open ocean. Of the latter, three ocean occurrences were off Shackleford Banks (Carteret County), one off Wrightsville Beach (New Hanover County), and one each off the Outer Banks off Avon and Kitty Hawk (Dare County) (Fig. 1). Most sightings have been of single individuals; the largest groups sighted for several days before disappearing were three at Minnesott Beach Yacht Basin, a tributary to the Neuse River (Pamlico River) in August 1980, and three in the Trent River at the Sheraton Yacht Harbor, New Bern (Craven County) in September 1994.

Although six records are of manatees frequenting Pelletier Creek, the area seems an unlikely manatee habitat as the short 0.8 km creek is plied by many boats, pollution is heavy from numerous boat works and marinas, and considerable runoff occurs from the densely built houses and condominiums lining the shoreline. Yet manatees have spent several days in the creek during each visit. In 1993 to 1994 two (once) to six separate manatees frequented the same general area of the coffee-colored Trent River, tributary to the Neuse River, 2 km southwest of New Bern (Craven County) and fed on dense aquatic vegetation. Three specimens frequented the river 0.2 km west of New Bern, at Lawson Park or the Sheraton Hotel Yacht Basin in 1994. The 1993 specimen was followed downstream in the Neuse along its western shore for 13 km before vanishing. The July 1994 specimen did not linger in the Trent River prior to its next (presumed) sighting in the lower Neuse River opposite Oriental in late July. August-September 1994 specimens lingered and fed on the lush vegetation of the Trent River even as late as 24 September 1994. Bottom and surface salinities 17 September 1994 were 14 and 7 ppt respectively.

INLAND PENETRATIONS

Manatees are known to penetrate inland freshwater such as the St. John's River of Florida for 224 km to Lake Monroe (Volusia County; D. Odell, Sea World Inc., personal communication). Farthest inland river penetrations by manatees in North Carolina have been: Cape Fear River (one) for 94.4 km-6.4 km above Route 210 and north of Wilmington (Pender County) 11 July 1993, and one for 92 km in the Neuse River to the Fort Barnwell Bridge (Craven County) in October 1980, 33 km northeast of New Bern (Fig. 1). Two other manatees occurred in the Tar River system of the upper Pamlico River, a tributary of Pamlico Sound: one for 88 km to Greenville (Pitt County) in November 1989 and the other for 58 km to just upstream of Washington (Beaufort County) (Fig. 1) in September 1985. The most peculiar movements have been of three manatees that traversed south from the lower Chesapeake Bay in late summer of 1993 via the canal and Intracoastal Waterway into Currituck Sound (Fig. 1). While most manatee sightings have been at localities which could have been reached via the Intracoastal Waterway and sounds, the four inlet and six ocean occurrences also suggest travel north from Florida to North Carolina may have been via those avenues. In any event, observations seem to indicate many more young manatees are expanding their range into North Carolina, perhaps as a result of an increased public awareness of Florida's manatees rather than a real population increase.

ACKNOWLEDGMENTS—Thanks are extended to the many interested people of North Carolina who called or commented on manatee occurrences in North Carolina. Others, elsewhere, who were also helpful in supplying information were: C. Beck, National Biological Service, Sirenia Project, Gainesville, FL (occurrences, sizes, and Rathbun et al. 1981 reference); D. Odell, Sea World Inc., Orlando, FL, (St. John's River occurrence, file data, and review of manuscript; R. Dove, Neuse River Keeper (1994 Trent River observations); J. Wolfenberger, (Minnesott Beach Yacht Basin observations); New

Hanover Public Library (Cape Fear River stories); J. Oakley, Carolina Biological Lab, Burlington (early Brimley references); M. Nabinetts, Washington Daily News (Pamlico River stories), N. Winfrey, Oriental News (comments on lower Neuse River observations); M. Clark provided the three North Carolina State Museum of Natural Sciences records and checked the Museum overall occurrence records. D. Lee of the North Carolina State Museum of Natural Sciences reviewed the paper, as did C. Potter, National Marine Fisheries Service, Division of Mammals (North Carolina data). D. Webster, University of North Carolina, Wilmington, noted the 29 July 1992 record. L. White typed the text; R. Barnes produced Figure 1.

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Smith, E. R., J. B. Funderberg, and T. L. Quay. 1980. A checklist of North Carolina mammals. North Carolina Wildlife Resource Commission, Raleigh.

Received 13 October 1994
Accepted 10 February 1995

From: Wyatt McGhee [wmcghee@ucpcog.org]
Sent: Friday, May 26, 2006 2:57 PM
To: Clay, Noel C SAW
Cc: Heine, Hugh SAW; Greg Godard; Dennis Patton
Subject: Comments to Neuse River Basin Feasibility Study

Attachments: Neuse River Basin Feasibility Study, 25 May '06 final written comments.doc
Ms. Clay:

It was a pleasure to speak with you over the phone. Please accept the attached letter that contains our comments on this study. Feel free to contact me if you have any questions.

Wyatt L. McGhee IV
Wyatt L. McGhee IV, AICP/CFM
Upper Coastal Plain Council of Govemments
1309 S. Wesleyan Blvd (27803)
Mailing address: PO Drawer 2748
Rocky Mount, NC 27802
Phone: (252) 446-0411, ext 227
Fax: 446-5651
Email: wmcghee@ucpcog.org

Heine, Hugh SAW

From:	Wyatt McGhee [wmcghee@ucpcog.org]
Sent:	Friday, May 26, 2006 2:57 PM
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Cc:	Heine, Hugh SAW; Greg Godard; Dennis Patton
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Upper Coastal Plain Council of Governments
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Phone: (252) 446-0411, ext 227
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Email: wmcghee@ucpcog.org

Edgecombe
Halifax
Nash
Northampton
Wilson
Counties

UPPER COASTAL PLAIN
COUNCIL OF GOVERNMENTS

1309 S. WESLEYAN BLVD.
P.O. DRAWER 2748
ROCKY MOUNT, NORTH
CAROLINA 27082-2748
TELEPHONE (252) 446-0411
FAX (252) 446 5651

25 May 2006

Noel Clay, Acting Chief
Planning and Environmental Branch
Environmental Resources Section
Department of the Army
Wilmington District, Corps of Engineers
PO Box 1890
Wilmington, NC 28402-1890

Re: Comments to Neuse River Basin Feasibility Study

Dear Ms. Clay:

Thank you for the opportunity to submit comments on this project. On behalf of the Director of the Department of Planning & Development Services of the Upper Coastal Plain Council of Governments this letter is being sent to voice our support for your effort to "develop a plan to identify solutions" to water quality and other concerns in the Neuse River Basin. By adequately evaluating the issues that were identified in your letter, this study has the potential to be a truly comprehensive study that could greatly benefit the Neuse basin.

We would also like to encourage that additional consideration be given to holding some public meetings regarding this project, throughout the process. Such meetings could serve the multiple purposes of public input and education.

Thank you again for the opportunity to provide input regarding this study. Please continue to include our agency in any public notices that are distributed regarding the study, so that we may have the opportunity for further participation. We will be looking forward to the results of this effort.

Sincerely,

Wyatt McGhee

Wyatt McGhee, AICP/CFM
Planning & Development Services

c: Greg Godard, Executive Director, Upper Coastal Plain Council of Governments
Dennis Patton, Director of Planning & Development Services

Franklin County Planning & Inspections

"Working Today to Help Build a Better Tomorrow"

May 25, 2006

Mr. Hugh Heine
Environmental Resources Section
Department of the Army
Wilmington District
Corps of Engineers (USACOE)
Post Office Box 1890
Wilmington, North Carolina 28402-1890

Re: Neuse River Basin Feasibility Study in North Carolina
Franklin County, North Carolina Comments

Dear Mr. Heine:

This letter is in response to USACOE's attached April 26, 2006 solicitation of comments regarding the aforementioned proposed project. Franklin County, North Carolina strongly supports the proposed project and its intent of identifying basin wide alternatives to improve water quality, reduce flood damage and improve environmental conditions in the Neuse River Basin.

Over 51.4 square miles of Franklin County are located within the Neuse Basin, reflecting over 10 percent of the County's total land area. Significantly, the portion of Franklin County in the Neuse Basin directly abuts fast growing Wake County and is thus experiencing significant development pressure.

As such, the County is very concerned about ensuring that urban growth does not significantly degrade water quality in the Neuse. This concern is heightened by the fact that Franklin County is currently evaluating a site in the Upper Neuse River Basin near Wake Forest, North Carolina as a potential source of public water supply.

As expressed in the attached April 27, 2006, letter to the North Carolina Environmental Management Commission, Franklin County is particularly concerned about efforts to relax or remove current development restrictions required by water supply watershed laws and/or regulations in the Neuse Basin, due to the likely negative impact such relaxation of current regulations would have on environmental quality and potential to use waters of the Neuse Basin for future public water supply.

215 E. Nash Street • Louisburg, NC 27549 • (919) 496-2909, 496-2281 • FAX (919) 496-2637

Therefore, Franklin County would strongly suggest that USACOE thoroughly evaluate the sufficiency of current State Water Supply Watershed laws and regulations as a primary mechanism for protecting water quality. Franklin County believes that, in general, existing development restrictions found in State Water Supply Watershed laws and regulations, stormwater management requirements, and site-specific best management practices (BMPs) to control stormwater runoff are the most cost-effective manner in which to control water quality degradation. As such, these measures should be supported as authorized by current law.

Franklin County would also support any other alternatives that will help preserve the Neuse basin as an environmental resource and a potential source of future public water supply, especially for communities downstream of Falls Lake. Actions that result in flow restriction downstream of Falls Lake or additional impoundment of water at this facility would likely not be supported by the County, as such action would likely have a deleterious impact on environmental quality and public water supply availability downstream of Falls Lake.

Please consider this letter my request to consult with County Public Utilities Director Bryce Mendenhall and myself as this important project proceeds. Mr. Mendenhall can be reached via telephone at (919) 494-5415 and I can be reached at (919) 496-2909.

Thank you for the opportunity to comment on this project and do not hesitate to contact me with any questions or concerns.

Sincerely,

Patrick O. Young, AICP
Director of Planning and Inspections

cc: Franklin County Board of Commissioners
Chris Coudriet, County Manager
J. Bryce Mendenhall, Public Utilities Director

County of Franklin

North Carolina

Board of County Commissioners
113 Market Street
Louisburg, NC 27549
Telephone: (919) 496-5994
Fax: (919) 496-2683

April 28, 2006

Dr. David H. Moreau
Chairperson
North Carolina Environmental
Management Commission (EMC)

Ms. Elizabeth Kountis
Environmental Specialist III
North Carolina Division of
Natural Resource (DENR)
North Carolina Division of
Water Quality (DWQ)

c/o EMC Recording Clerk
Directors Office
Division of Water Quality
1617 Mail Service Center
Raleigh, NC 27699-1617

Re: Request for Reclassification - Upper Neuse River (Richland Creek/Unnamed Tributaries)

Dear Dr. Moreau and Ms. Kountis:

This letter is a follow-up to a telephone conversation April 26, 2006 between Ms. Elizabeth Kountis of DWQ and Mr. Bryce Mendenhall, Public Utilities Director for Franklin County, North Carolina.

Franklin County has recently begun the process of evaluating alternative sources of potable water supply for its public water system. The county is experiencing significant population growth and the current potable water source appears to be inadequate to meet medium-to-long term demand for potable water. One of the public water supply sources under consideration by the county is the former Burlington Industries/Wake Finishing Plant water treatment facility located on the Upper Neuse River in Wake Forest, North Carolina.

Dr. David H. Moreau
Ms. Elizabeth Kountis
April 28, 2006
Page 2

As such, the county is requesting that the EMC delay consideration of the City of Raleigh's request to reclassify a segment of the upper Neuse River watershed (Richland Creek/Associated Unnamed Tributaries) from Class WS-IV and WS IV CA to a WS-V classification. The county is requesting a delay for a period of six (6) months, i.e., through November 10, 2006. The EMC is currently scheduled to consider the City of Raleigh's reclassification request at its May 11, 2006 meeting.

The site is located on the segment of the Neuse River referenced above, and the requested reclassification would permanently and significantly diminish the potential for cost-effective public water supply use at this facility or other locations along the referenced segment of the Neuse River if granted by the EMC at its May 11, 2006 meeting.

The county will thoroughly assess the feasibility of public water supply withdrawals from the aforementioned water treatment facility in the upper Neuse River basin over the coming months and will communicate the results of this analysis to the EMC no later than November 10, 2006. If the analysis indicates that the water treatment facility, or similar facility along the segment of the upper Neuse River basin referenced above, is unsuitable for public water supply use by the county, we will withdraw our request to delay the reclassification action requested by the City of Raleigh.

Thank you in advance for your consideration and action on this matter and please do not hesitate to contact me at (919) 496-5994 with any questions or concerns regarding this matter. You may also contact Public Utilities Director Bryce Mendenhall at (919) 494-5414 or Planning and Inspections Director Patrick Young at (919) 496-2909 with any questions or concerns.

Sincerely,

Chris Coudriet
County Manager

cc: N.C. Environmental Management Commissioner (EMC) Members
Franklin County Board of Commissioners
Becky Heron, Chair, Board of Directors, Upper Neuse River Basin Association
Senator Doug Berger
Representative Lucy Allen
J. Bryce Mendenhall, Public Utilities Director, Franklin County
Patrick O. Young, Planning and Inspections Director, Franklin County
G. Eugene Boyce, Boyce & Isley
J. Russell Allen, City Manager, City of Raleigh
Dale Crisp, Public Utilities Director, City of Raleigh

Heine, Hugh SAW

From: Beck, Charles [Charles.Beck@dhs.gov]

Sent: Wednesday, May 03, 2006 2:18 PM

To: Heine, Hugh SAW

Cc: Straw, William; Inmula, Prasad; Shirk, Donald

Subject: Neuse River Basin Feasibility Study

Mr. Hugh Heine:

Thank you for letting FEMA, Region IV, know of the Wilmington Corps' planned study of potential environmental and flood damage reduction projects in the Neuse River Basin. We have no specific comment at this time except to note that we, of course, share the Corps' concern with protecting the environment and minimizing flood damage.

Charles Beck
Environmental Specialist

Heine, Hugh SAW

From: Ben Bowditch [benbowditch@yahoo.com]
Sent: Thursday, May 04, 2006 8:15 AM
To: Heine, Hugh SAW
Subject: Neuse River Basin Study

There are widespread violations of setback requirements in my area. Many individuals are unaware of the rules, and many developers don't care . Responsible agencies are swamped with permit applications, leaving no enforcement resources available. Complaints from citizens aren't even followed up upon. Exceptions to setback requirements are granted routinely without investigation. Penalties for violations, in the few instances where they are formally discovered, are miniscule and are viewed by some as a nominal cost of doing business.

I would be happy to take anyone on a boat ride on my creek, and they could see for themselves what I am talking about. And from what I hear from other Oriental citizens, it's going on everywhere in this area.

Ben Bowditch
292 Headwaters Drive
Oriental, NC 28571

Heine, Hugh SAW

From: rmundt@ncem.org
Sent: Tuesday, May 30, 2006 9:50 AM
To: Heine, Hugh SAW
Subject: Neuse River Basin Feasibility Study

Hello,
I'm working w/ NC Emergency Management on the updating of FEMA's NFIP Flood Insurance Rate Maps (FIRMs). As such I would be interested in learning more about how we can provide input to the above referenced as it relates to flood damage reductionfrom the varied perspectives of what we are doing, what we are aware local jurisdictions are doing, and what the USACE is doing or proposes to do.

Please let me know how I can best contribute.

thank you
rpm

Randy Mundt, AICP, CFM

Heine, Hugh SAW

From: Rob Will [bftplanner@beaufortnc.org]
Sent: Wednesday, May 03, 2006 8:53 AM
To: Heine, Hugh SAW
Subject: Neuse River Feasibility study

Mr. Heine,

Good morning, my name is Robert Will and I am the Town Planner for Beaufort, NC. Although the proposed Neuse River EIS doe not include the town of Beaufort, we may be directly impacted by the water quality degradation that may or may not to be determined. Currently the town is undertaking drainage studies and has received grant money to address storm water runoff through development controls. I think that the findings of the Neuse River study may be useful to Beaufort and I would like to keep track of it's progress.

I would appreciate if I could be notified when significant milestones of the study are made. Thanks for your consideration of this matter.

Rob Will

Robert Will
Town Planner
Town of Beaufort, North Carolina
(252) 728-2141 phone
(252) 728-3982 fax

Heine, Hugh SAW

From: JCrew@ncem.org
Sent: Monday, May 08, 2006 1:56 PM
To: Heine, Hugh SAW
Cc: smtp-msprayberry; SPowers@ncem.org; JPflaum@ncem.org
Subject: Neuse River Basin Feasibility Study in North Carolina

Mr. Heine:

I received notice of the COE's general investigation of possible actions to improve water quality in the Neuse River basin.

Following Hurricanes Fran, Bonnie and Floyd, the Hazard Mitigation Section of the NC Division of Emergency Management presided over the acquisition and demolition of over 1000 residential structures in the Neuse River basin (principally in Wilson, Wayne, Lenoir, Duplin and Craven Counties) under the auspices of the FEMA Hazard Mitigation Grant Program and also under the State Acquisition and Relocation Fund program. Properties thus acquired have been deeded as public open space in perpetuity with restrictions on future development and use.

NCEM has significant interest in the area, and has significant experience in working with the local governments and residents in the watershed.

If I may be of service to the study, please do not hesitate to contact me.
Please keep this office apprised of any scoping meetings pursuant to development of the Draft EIS.

Chris Crew, CFM
State Hazard Mitigation Officer
NC Division of Emergency Management
(919) 715-8000 x 277

Heine, Hugh SAW

From:	Sherry Hawley [secretary@townofmountolivenc.com]
Sent:	Tuesday, May 09, 2006 10:21 AM
To:	Heine, Hugh SAW
Subject:	Input on Neuse River Basin
Attachments:	U.S. Army Corps of Engineers Memo.doc

U.S. Army Corps of Engineers M...

Dear Mr. Heine,

I am attaching a memo from Mayor Huggins with regards to your request for our input on the Neuse River Basin.

Should you have any questions or need any additional information, please do not hestitate to contact my office at 919-658-9539.

Thank You,

Sherry Hawley
Administrative Assistant

Memorandum

To: Hugh Heine, US Army Corps of Engineers
From: B.R. "Ruff" Huggins, Mayor
Date: 6/5/2006
Re: Input on Neuse River Basin

This is in response to your request for input on the Neuse River Basin.

About one half of our Town of Mount Olive drains into Falling Creek, a tributary of the Neuse River. The area drained is estimated at 50 plus acres.

As a result of development over the years and an increase in Beaver population, coupled with Hurricanes Fran and Floyd, Falling Creek has become a swamp instead of a defined stream. The area between Smith Chapel Road and NC 55 west has been congested with erosion from the approx. 50 acres. The reduction of the flow of storm water in this area causes flooding along the smaller streams or ditches in our Town.

Very definitely, the area of Falling Creek between Smith Chapel Road and N.C. 55 west needs to be cleaned out to increase the flow of storm water and reduce the normal level of drainage. Our Town has and is improving the flow of storm water in our Town. We need the U.S. Army Corps of Engineers to help with the drainage outside our Town limits and down stream from the areas where storm water is a problem.

June 5, 2006

North Carolina
Department of Administration

Michael F. Easley, Governor | Britt Cobb, Secretary

June 8, 2006

Mr. Hugh Heine
Dept. of the Army/Corps of Engineers
Environmental Resources Section
P.O. Box 1890
Wilmington, NC 28402-1890

Dear Mr. Heine:

Re: SCH File # 06-E-0000-0316; Scoping; The purpose of the Neuse River Basin Feasibility Study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish, wetlands, stream, riparian buffer, oyster habitat & flood damage reduction

The above referenced environmental impact information has been submitted to the State Clearinghouse under the provisions of the National Environmental Policy Act. According to G.S. 113A-10, when a state agency is required to prepare an environmental document under the provisions of federal law, the environmental document meets the provisions of the State Environmental Policy Act. Attached to this letter for your consideration are **additional** comments made by agencies in the course of this review.

If any further environmental review documents are prepared for this project, they should be forwarded to this office for intergovernmental review.

Should you have any questions, please do not hesitate to call.

Sincerely,

Chrys Baggett/S?

Ms. Chrys Baggett
Environmental Policy Act Coordinator

Attachments

cc: Region J
Region P

Mailing Address:
1301 Mail Service Center
Raleigh, NC 27699-1301

Telephone: (919)807-2425
Fax (919)733-9571
State Courier #51-01-00
e-mail Chrys.Baggett@ncmail.net

Location Address:
116 West Jones Street
Raleigh, North Carolina

NCDENR

North Carolina Department of Environment and Natural Resources

Michael F. Easley, Governor

William G. Ross Jr., Secretary

JUN 2006 RECEIVED Secretary's Office DOA

MEMORANDUM

TO: Chrys Baggett
State Clearinghouse

FROM: Melba McGee
Project Review Coordinator

SUBJECT: 06-0316 Neuse River Basin Feasibility Study

DATE: June 6, 2006

The attached comments were received by this office after the response due date. These comments should be forwarded to the applicant and made a part of our previous comment package.

Thank you for the opportunity to respond.

Attachment

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH

Project Number
06-0316
County **Carteret, Durham, Johnston, Lenoir & Wake**

Inter-Agency Project Review Response

Project Name **US Army Corps of Engineers & Div. Of Water Resources**

Type of Project **Purpose of the Neuse River Basin Feasibility Study is to develop & evaluate basin wide alternatives to improve water quality, restore anadromous fish, wetlands, stream, reparian buffer, oyster habitat & flood damage reduction.**

☐ The applicant should be advised that plans and specifications for all water system improvements must be approved by the Division of Environmental Health prior to the award of a contract or the initiation of construction (as required by 15A NCAC 18C .0300et. seq.). For information, contact the Public Water Supply Section, (919) 733-2321.

☐ This project will be classified as a non-community public water supply and must comply with state and federal drinking water monitoring requirements. For more information the applicant should contact the Public Water Supply Section, (919) 733-2321.

☐ If this project is constructed as proposed, we will recommend closure of ______ feet of adjacent waters to the harvest of shellfish. For information regarding the shellfish sanitation program, the applicant should contact the Shellfish Sanitation Section at (252) 726-6827.

☐ The soil disposal area(s) proposed for this project may produce a mosquito breeding problem. For information concerning appropriate mosquito control measures, the applicant should contact the Public Health Pest Management Section at (919) 733-6407.

☐ The applicant should be advised that prior to the removal or demolition of dilapidated structures, a extensive rodent control program may be necessary in order to prevent the migration of the rodents to adjacent areas. For information concerning rodent control, contact the local health department or the Public Health Pest Management Section at (919) 733-6407.

☐ The applicant should be advised to contact the local health department regarding their requirements for septic tank installations (as required under 15A NCAC 18A. 1900 et. sep.). For information concerning septic tank and other on-site waste disposal methods, contact the On-Site Wastewater Section at (919) 733-2895.

☐ The applicant should be advised to contact the local health department regarding the sanitary facilities required for this project.

☐ If existing water lines will be relocated during the construction, plans for the water line relocation must be submitted to the Division of Environmental Health, Public Water Supply Section, Technical Services Branch, 1634 Mail Service Center, Raleigh, North Carolina 27699-1634, (919) 733-2321.

☒ For Regional and Central Office comments, see the reverse side of this form.

Jim McRight	PWSS	05/08/06
Reviewer	Section/Branch	Date

S:\Pws\Angela W\Clearinghouse\Review Response Pgs 1 and 2 for input.doc

RECEIVED
MAY 22 2006
PUBLIC WATER SUPPLY SECTION

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF ENVIRONMENTAL HEALTH
Inter-Agency Project Review Response

Project # 06-0316
County: Lenoir/Wayne, et.al.

Project Name: US Army Corps of Engineers Div. of Water Resources

Type of Project: Neuse River Basin feasibility study to develop & evaluate basin wide alternatives to improve water quality, restore anadromous fish, wetlands, stream, ripiarian buffer, oyster habitat & flood damage reduction.

Comments provided by:

- [ ] Regional Program Person
- [x] Regional Supervisor for Public Water Supply Section
- [ ] Central Office program person

Name: Fred Hill-WaRO Telephone #: (252) 946-6481 Date Rec'd: 05-10-06
Other DEH regional & central staff Date Rev'd: 05-19-06

Program within Division of Environmental Health:

- [x] Public Water Supply
- [ ] Other, Name of Program____

Response (check all applicable):

- [x] No objection to project as proposed
- [ ] No comment
- [ ] Insufficient information to complete review
- [ ] Comments attached
- [x] See comments below

JUN 2006 RECEIVED

1. Utility companies that operate water &/or wastewater systems that are dependent on the Neuse River & tributaries should be contacted regarding this project and to solicit their comments.
2. During any in-stream or riverbank activities, diligence must be exercised to avoid contact and potential damage with utility structures, including submerged intake piping supplying river water to drinking water treatment facilities.

Return to :
Public Water Supply Section
Environmental Review Coordinator
for the

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

June 19, 2006

RECEIVED EXECUTIVE OFFI
06 JUN 23 09

Colonel John E. Pulliam
District Engineer, Wilmington District
U. S. Army Corps of Engineers
P. O. Box 1890
Wilmington, NC 28402-1890

Routed: 27 June 2006 kj
Action: TSD
Susp Date:
CF: Cdr, DX, DP, REG Bill Adams, Env.

Attention: Mr. Hugh Heine, Environmental Resources Section

Dear Colonel Pulliam:

This provides comments on the Notice of Intent (NOI) to prepare a Draft Environmental Impact Statement (DEIS) for the Neuse River Basin Feasibility Study. The NOI was published in the Federal Register (Vol. 71, No. 93) on May 15, 2006. The purpose of the feasibility study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish passage, wetlands, stream, riparian buffer, and oyster habitat. The study will also investigate flood damage reduction.

By letter dated June 24, 2003, the Service provided the Wilmington District with a Planning Aid Letter (PAL) for the proposed project. Our earlier comments and those contained in this letter are submitted in accordance with the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661-667d). Our review of the NOI indicates that the scope of the proposed work has not changed and we recommend that the environmental recommendations provided in our PAL continue to be incorporated in your planning process.

At this time the Service suggests that the forthcoming DEIS consider the Conservation Reserve Enhancement Program (CREP) of the U. S. Department of Agriculture (USDA). The USDA, Commodity Credit Corporation (CCC), and the State of North Carolina have implemented the North Carolina Conservation Reserve Enhancement Program (CREP), administered by Farm Service Agency (FSA) of USDA. The CREP is a component of the FSA's Conservation Reserve Program (CRP), which targets the specific environmental needs of each State. The CRP reduces soil erosion, protects the Nation's ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices.

The CREP in North Carolina is intended to provide agricultural producers with financial incentives to voluntarily remove their lands from agricultural production for periods of 10-15 years and voluntarily install FSA approved conservation practices (CPs). Through CREP, producers receive annual rental payments and cost-share assistance to establish long term, resource-conserving covers on eligible land. The two primary objectives of North Carolina's CREP are to: (1) coordinate federal and non-federal resources to address specific conservation objectives in a cost-effective manner; and (2) improve water quality, erosion control, and wildlife habitat related to agricultural use in specific geographic areas.

The North Carolina CREP seeks to enhance the water quality of the four watersheds that have been classified as nutrient-sensitive waters (NSW). These watersheds are the Chowan River Basin, Neuse River Basin, Tar-Pamlico Basin, and B. Everett Jordan Reservoir Watershed. These NSWs encompass a portion or all of 44 counties in North Carolina, primarily in the northeastern part of the state.
North Carolina's CREP enrollment period runs from the agreement signing in 2004 through 2007. A Programmatic Environmental Assessment (PEA) for the North Carolina program is available via the internet at < http://www.fsa.usda.gov/dafp/cepd/epb/pdf/FINAL%20PEA%203-82.pdf >.

The PEA notes (p. 1-3) that implementation of CPs is designed to improve the water quality of discharges coming from agricultural land. The primary goal of the North Carolina CREP agreement is to provide an opportunity, through financial and technical assistance, for eligible producers in the CREP area to voluntarily establish buffers, through the implementation of CPs such as "filters, strips, grass waterways, hardwood tree plantings, wildlife habitat, wetlands, that improve the water quality of agricultural non-point discharges." Other, secondary goals of implementing CREP are:

- protecting and conserving the diversity of aquatic life, including threatened, endangered, or otherwise federally or state protected (protected) species;

- protecting and conserving the diversity of terrestrial wildlife, including protected species;

- improving water-based recreation;

- improving private and commercial fishing and shell-fishing harvests;

- decreasing the cost of drinking water treatment;

- decreasing the cost of aquatic vegetation control;

- improving soil quality; and,

- providing economic benefits to the agricultural producer.

The goals of the CREP appear similar to those of the Neuse River Basin Study. The Service encourages the Corps to consider this USDA program in planning the Civil Works project. There may be ways to complement and/or enhance the USDA effort. There should be an effort to avoid duplication or redundancy of efforts.

The Service appreciates the opportunity to provide these planning recommendations for the forthcoming DEIS. If you have questions regarding these comments or wish to discuss the development of the coordinated federal position, please contact Howard Hall at 919-856-4520, ext. 27 or by e-mail at < howard_hall@fws.gov >. Please provide this office with a copy of the coordinated federal position, if one is developed.

Sincerely,

Pete Benjamin
Ecological Services Supervisor

cc:

Vijai N. Rai, U. S. Department of the Interior, OEPC, Washington, DC (RE: ER 06/517)
Jeff Weller, USFWS. Atlanta, GA (RE: ER 06/517)
Gerald Miller, US EPA, Atlanta, GA
Ron Sechler, National Marine Fisheries Service, Beaufort, NC
David Cox, NC Wildlife Resources Commission, Creedmore, NC
Mr. John Dorney, NC Division of Water Quality, Raleigh, NC
Charles Jones, NC Division of Coastal Management, Morehead City, NC
Preston Pate, NC Division of Marine Fisheries, Morehead City, NC

TETRA TECH

March 6, 2008

Christine Miller
North Carolina Coastal Federation
3609 Highway 24 (Ocean)
Newport, NC 28570

Dear Ms. Miller:

On behalf of the US Army Corps of Engineers (USACE), Wilmington District and Tetra Tech, I would like to express our sincere appreciation for your presence and input at the December 4, 2007 partner meeting for the USACE Neuse River Basin subestuary restoration opportunities. I want to provide you with an update regarding our ongoing basinwide evaluation. You may remember that during our December meeting we discussed three promising subestuary restoration opportunities:

- Mouth of Gum Thicket Creek and adjacent shoreline
- Shoreline at the confluence of Gale Creek and the Intracoastal Waterway
- South River Subestuary

Tetra Tech reviewed the available information regarding these restoration opportunities, and through discussions with the USACE, we decided that sufficient information was available and that a field visit was not necessary at this time. Since we discussed the potential for future site visits at the December meeting, we want to provide you with this update. We appreciate your offer to visit the sites with us. All opportunities discussed at the December partner meeting will be included in an upcoming USACE report so that they can be considered in the future by either the USACE or other organizations. We are currently evaluating about 20 restoration opportunities throughout the Neuse River Basin, including the subestuary restoration opportunities that we discussed. Through this evaluation, we will select three to five opportunities for more detailed evaluation.

Please let me know if you have any comments or questions about this project update. We appreciate your continued interest in this project.

Sincerely,

Heather Fisher, AICP
Environmental Planner
Tetra Tech, Inc.

cc: Mitch Hall, US Army Corps of Engineers, Wilmington District
Tara Anderson, US Army Corps of Engineers, Wilmington District
Chuck Wilson, US Army Corps of Engineers, Wilmington District

Tetra Tech, Inc.
3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

TETRA TECH

March 6, 2008

Todd Miller
North Carolina Coastal Federation
3609 Highway 24 (Ocean)
Newport, NC 28570

Dear Mr. Miller:

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Tetra Tech, Inc.

cc: Mitch Hall, US Army Corps of Engineers, Wilmington District
Tara Anderson, US Army Corps of Engineers, Wilmington District
Chuck Wilson, US Army Corps of Engineers, Wilmington District

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3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

TETRA TECH

March 6, 2008

Craig Hardy
North Carolina Division of Marine Fisheries
3441 Arendell St.
Morehead City, NC 28557

Dear Mr. Hardy:

On behalf of the US Army Corps of Engineers (USACE), Wilmington District and Tetra Tech, I would like to express our sincere appreciation for your presence and input at the December 4, 2007 partner meeting for the USACE Neuse River Basin subestuary restoration opportunities. I want to provide you with an update regarding our ongoing basinwide evaluation. You may remember that during our December meeting we discussed three promising subestuary restoration opportunities:

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Tetra Tech, Inc.

cc: Mitch Hall, US Army Corps of Engineers, Wilmington District
Tara Anderson, US Army Corps of Engineers, Wilmington District
Chuck Wilson, US Army Corps of Engineers, Wilmington District

Tetra Tech, Inc.
3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

TETRA TECH

March 6, 2008

Clay Caroon
North Carolina Division of Marine Fisheries
3441 Arendell St.
Morehead City, NC 28557

Dear Mr. Caroon:

On behalf of the US Army Corps of Engineers (USACE), Wilmington District and Tetra Tech, I would like to express our sincere appreciation for your presence and input at the December 4, 2007 partner meeting for the USACE Neuse River Basin subestuary restoration opportunities. I want to provide you with an update regarding our ongoing basinwide evaluation. You may remember that during our December meeting we discussed three promising subestuary restoration opportunities:

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Environmental Planner
Tetra Tech, Inc.

cc: Mitch Hall, US Army Corps of Engineers, Wilmington District
Tara Anderson, US Army Corps of Engineers, Wilmington District
Chuck Wilson, US Army Corps of Engineers, Wilmington District

Tetra Tech, Inc.
3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

TETRA TECH

March 6, 2008

Brian Conrad
North Carolina Division of Marine Fisheries
3441 Arendell St.
Morehead City, NC 28557

Dear Mr. Conrad:

On behalf of the US Army Corps of Engineers (USACE), Wilmington District and Tetra Tech, I would like to express our sincere appreciation for your presence and input at the December 4, 2007 partner meeting for the USACE Neuse River Basin subestuary restoration opportunities. I want to provide you with an update regarding our ongoing basinwide evaluation. You may remember that during our December meeting we discussed three promising subestuary restoration opportunities:

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Environmental Planner
Tetra Tech, Inc.

cc: Mitch Hall, US Army Corps of Engineers, Wilmington District
Tara Anderson, US Army Corps of Engineers, Wilmington District
Chuck Wilson, US Army Corps of Engineers, Wilmington District

Tetra Tech, Inc.
3200 Chapel Hill-Nelson Hwy, Suite 105
PO Box 14409
Research Triangle Park, NC 27709
Tel 919-485-8278 Fax 919-485-8280

L 159

Environmental Address List

04/24/2006

Beaufort	Carteret	Craven	Duplin	Edgecomb	Franklin	Greene	Harnett
Johnston	Jones	Lenoir	Nash				

North Carolina Wesleyan College
3400 N. Wesleyan Blvd
Rocky Mount NC 27804

Town of Atlantic Beach
PO Box 10
Atlantic Beach NC 28512-0010

Glenoit Mills, Inc.
PO Box 1157
Tarboro NC 27886

Land Management Group, Inc
PO Box 2522
Wilmington NC 28402-2522

Luther Smith & Son Fish House
1023 S Seashore Drive
Atlantic NC 28511-9603

Martin Marietta Aggregates
PO Box 2326
New Bern NC 28560

4

Morehead City Shipping Company
State Port Maritime Bldg.
Morehead City NC 28557

Washington Service Center, USDA
155 Airport Rd
Washington NC 27889-9684

NC Council of Government
Region Q
PO Box 1787
Washington NC 27889

Evans Seafood Company
PO Box 534
Washington NC 27889-0534

New Bern Area Chamber of Commerce
PO Drawer C
New Bern NC 28563-8305

Edgecombe County Community College
2009 W. Wilson St.
Tarboro NC 27886

Princeville Tourism & Historic Society
PO Box 1292
Tarboro NC 27886

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

9

Roanoke Beacon
PO Box 726
Plymouth NC 27962-0726

Rocky Mount Area Chamber of Commerce
PO Box 392
Rocky Mount NC 27804

Sailcraft, Inc
PO Box 99
Oriental NC 28571-0099

Sprint
PO Box 1560
Rocky Mount NC 27804

Stroud Engineering PA
107-B Commerce Street
Greenville NC 27858-5027

Tarboro-Edgecombe Chamber of Commerce
PO Box F
Tarboro NC 27886

The Daily Southerner
PO Box 1199
Tarboro NC 27886

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

6

The Rocky Mount Telegram
PO Box 1080
Rocky Mount NC 27802

NC Department of Emergency Management
116 West Jones St
Raleigh NC 27601

Beaufort Fisheries, Inc
PO Box 240
Beaufort NC 28516-0240

Bud and Trish Moss
5228 Old Milburnie Rd
Wendell NC 27591

Deacon Jones, Jr.
PO Box 2280
Smithfield NC 27577

Frank and Gloria Chipman
1704 Cambridge Dr
Kinston NC 28504

Harvey and Beth Fisher
7308 Thompson Mill Rd
Wake Forest NC 27587

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

3

John and Betty Bikle
2304 Quail Rd
Wilson NC 27896

Marty and Leslie Measamer
205 Camden Way
Greenville NC 27858

Robert Youngblood
PO Box 398
Atlantic Beach NC 28512

Assistant to County Manager
Carteret County
Courthouse Square
Beaufort NC 28516

Federal Emergency Management Agency
3003 Chamblee-Tucker Rd
Atlanta GA 30341

Bateman Oil Company
PO Box 369
Belhaven NC 27810-0369

Morehead City Terminal Supervisor
Texasgulf, Inc
PO Box 745
Morehead City NC 28557-0745

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett

Johnston Jones Lenoir Nash

3

Beaufort Hyde News
PO Box 99
Belhaven NC 27810-0017

Bureau of Minerals Management
Mapping & Boundary Branch
P O Box 25165 MS-4011 ? **EIS/EA/FONSI 1 ROD 0**
Lakewood CO 80225-0165

Carteret County News-Times
PO Box 1679
Morehead City NC 28557-1679

County Shore Protection Manager
Carteret County
Courthouse Square
Beaufort NC 28516

CSX Transportation, Inc.
4901 Belfort Rd
Jacksonville FL 32256

Dare County League of Women Voters
PO Box 1945
Kitty Hawk NC 27949

Duplin Soil & Water Conservation Dist
PO Box 277
Kenansville NC 28349-0277

Beaufort	Carteret	Craven	Duplin	Edgecomb	Franklin	Greene	Harnett
Johnston	Jones	Lenoir	Nash				

4

Eastern Carolina Yacht Club
PO Box 1123
New Bern NC 28563-1123

Edgecombe County
PO Box 10, 201 Saint Andrew St
Tarboro NC 27886

Barnhill Contracting Co
PO Box 1529
Tarboro NC 27886

Town of Pine Knoll Shores
100 Municipal Circle
Pine Knoll Shores NC 28512-6801

Town of Swansboro
208 Main Street
Swansboro NC 28584-9998

Town of Newport
460 Howard Blvd
Newport NC 28570-9998

Washington Daily News

Washington NC 27889-9999

6

Town of Beaufort
701 Front Street
Beaufort NC 28516-9998

e-mail only :mike.hinton@nc.usda.gov

USDA, State Conservationist
Nat. Resources Conservation Service
4405 Bland Rd, Suite 205
Raleigh NC 27609

Trent Marine Service
510 Madame Moore Lane
New Bern NC 28562-6440

Honorable C. W. "Pete" Bland

NC Senate
3975 NC Hwy 118
Vanceboro NC 28586

Honorable Charles W. Albertson
NC Senator
Room 525, Legislative Bldg
Raleigh NC 27603-5925

Honorable Lucy T. Allen

NC Representative
312 N. Main St.
Louisburg, NC 27549

Mr W D Aman, Sr

124 Cedar Point Blvd
Swansboro NC 28584-9038

6

Area Conservationist
Natural Resources Conservation Services
USDA, Cashwell Office Park, Suite C
208 Mallory St
Goldsboro NC 27534

Honorable Marc Basnight
N.C. Senator
2007 Legislative Building
Raleigh NC 27601-2808

Ms Sybil Basnight
Friends of Roanoke Is
PO Box 1750
Manteo NC 27954

Honorable Doug Berger

NC Senate
PO Box 1101
Youngsville NC 27596

Mr R H Bishop

Belhaven NC 27810-9999

Honorable Harris Blake

NC Senate
PO Box 4266
Pinehurst NC 28374

Bob and Jan Andrews

1700 Westbrook
Wilson NC 27896

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

4

Mr Frank Bonner

PO Box 8
Aurora NC 27806-0008

Wallace C. Brittain
National Park Service.
Atlanta Fed. Ctr, 1924 Bldg
100 Alabama St. SW
Atlanta GA 30303

Honorable Harry Brown
NC Senator
2223 N. Marine Blvd
Jacksonville, NC 28546

Onslow Co.

Mr Eddie J. Bunn, PE, Resident Eng
NC Department of Transportation
Resident Engineer's Off - Nashville
3013 US 64-A
Nashville NC 27856

Honorable G. K. Butterfield
US House of Representatives
413 Cannon House Office Bldg.
Washington DC 20515

CAMA Officer
County of Craven
406 Craven Street
New Bern NC 28560-4971

CAMA Officer
Town of Cape Carteret
204 W B McLean Drive
Swansboro NC 28584

Onslow County

not in Neuse Basin?

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

CAMA Officer
Town of Emerald Isle
7500 Emerald Drive
Emerald Isle NC 28594-2999

CAMA Officer
County of Beaufort Planning Office
PO Box 1027
Washington NC 27889-1027

Lorenzo Carmen, County Manager
Edgecombe County
Box 10
Tarboro NC 27886

Chairman
Board of Lenoir County Commissioners
PO Box 3289
Kinston NC 28502-3289

Chairman
Carteret County Commissioners
Courthouse Square
Beaufort NC 28516

Chairman
Board of Jones County Commissioners
PO Box 266
Trenton NC 28585-0266

Chairman
Board of Nash County Commissioners
Courthouse, Room 104
226 West Washington Street
Nashville NC 27856-1255

7

Chairman
Board of Harnett County Commissioners
PO Box 759
Lillington NC 27546-0759

Chairman
Board of Greene County Commissioners
Suite A
229 Kingold Blvd
Snow Hill NC 28580-1331

Chairman
Board of Franklin County Commissioners
215 E Nash Street
Louisburg NC 27549-2561

Chairman
Board of Edgecombe County Commissioners
PO Box 10
Tarboro NC 27886-0010

Chairman
Board of Duplin County Commissioners
PO Box 585
Kenansville NC 28349-0585

Chairman
Board of Craven County Commissioners
Administration Building
406 Craven Street
New Bern NC 28560-4971

Chairman
Board of Beaufort County Commissioners

Washington NC 27889-9999

7

Chairman
Board of Johnston County Commissioners
PO Box 1049
Smithfield NC 27577-1049

Mr R W Chambers
Town of Newport
Inspection Department
PO Box 98
Newport NC 28570-0098

Ms Annette Chandler
The Sun Journal
PO Box 1149
New Bern NC 28563-1149

Chief Bldg Inspector
City of Morehead City
706 Arendell Street
Morehead City NC 28557-4234

Mr Robert M Chiles
PO Box 3496
New Bern NC 28564-3496

Commander
USCG Group Fort Macon
ATTN: Operations
2301 East Fort Macon Rd
Atlantic Beach NC 28512

Commanding Officer
Hobucken Station
US Coast Guard
Hobucken NC 28537-9999

Beaufort Carteret Craven Duplin Edgecomb Franklin Greene Harnett
Johnston Jones Lenoir Nash

5

Dr John Costlow, Director
Duke University Marine Lab
135 Duke Marine Lab Road
Beaufort NC 28516-9999

County Engineer
Beaufort County
PO Box 1027
Washington NC 27889-1027

County Manager
Nash County
Courthouse, Room 104
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ATTACHMENT A

PUBLIC AND AGENCY COMMENTS

WITH USACE RESPONSES

RECEIVED DURING THE EA COMMENT PERIOD

ATTACHMENT A

Comments Received on
Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

By letter dated November 30, 2011, the USACE notified and requested the public, local, State and Federal agencies for their review and comment on the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, North Carolina, dated October 2011.

All comments letters and memorandum are found in Attachment B and are listed in Section 5.0 of the FONSI. All comments requiring a response are listed below by commenting agency. The USACE has responded to each comment. When the USACE uses the word "Concur", we agree with the respective comment without caveat.

A.1 National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service. Email Dated 27 January 2012.

Comment 1: The National Marine Fisheries Service (NMFS) has reviewed the Neuse River Basin Draft Integrated Feasibility Report (IFR) and Environmental Assessment (EA), North Carolina (NC), dated October 11, 2011. This study was prepared in response to the Congressional Resolution which requested recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin. The plan was developed in partnership with the NC Division of Water Resources and encompassed a total of 6,234 square miles the third largest river basin in NC.

USACE Response: Noted.

Comment 2: Based on our review, we support the findings of this Study and the Tentative Selected Plan (National Ecosystem Restoration Plan) which was determined to have the greatest net benefits to the Neuse River Basin in North Carolina. Several components of the select plan would benefit NMFS trust resources including essential fish habitat (EFH) for federally managed species for which we share trust responsibilities.

USACE Response: Concur.

Comment 3: We are especially pleased with the inclusion of Modification of the Low-Head Dam on Little River, Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creek and Neuse River Estuary Oyster Reef Restoration in the overall project plans and look forward to working with the Corps of Engineers, Wilmington District in developing the details of these projects.

USACE Response: Noted.

A.1.B National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service. Letter dated May 14, 2012.

Comment 1: This responds to your e-mail dated March 5, 2012, requesting National Marine Fisheries Service (NMFS) concurrence with your project-effect determinations submitted pursuant to Section 7 of the Endangered Species Act (ESA) for the referenced Anny Corps of Engineers (COE) Wilmington District's construction permit application to restore a portion of the Neuse River Basin adjacent to Pamlico Sound, North Carolina. You determined that the proposed action may affect but is not likely to adversely affect Atlantic sturgeon and swimming sea turtles, and would have no effect on shortnose sturgeon. The COE contacted NMFS prior to submitting the above consultation request to inquire about a previously submitted consultation request dated November 11,2011, that was apparently never received by us. We requested additional information on the current letter via e-mail on March 12, 2012 and received a final response on March 14, 2012. Our findings on the effects of the proposed action are based on the project description in this informal consultation. If the proposed action changes, or if any new species are listed or critical habitat designated before all work is completed, these findings may be negated and re-initiation of consultation may be required.

USACE Response: Concur. If there is any change to the TSP or any new species listed (including critical habitat designated), the USACE will reinitiate Section 7 of the Endangered Species Act of 1973, as amended in consultation with NMFS.

Comment 2: The project has four main elements, each at different locations; the two elements discussed in this letter are located at latitude 35.0724°N and longitude 76.5995°W (North American Datum of 1983) for the Gum Thicket and Cedar Creek marsh restoration portion; and located at latitude 35.0009°N and longitude 76.5356°W (North American Datum of 1983) for the Neuse River oyster reef restoration portion of the project. The four main elements proposed under the Tentatively Selected Plan (TSP) for the Neuse River Basin Restoration are: (1) Modification of the Low-head Dam on the Little River in order to restore habitat connectivity for 46 miles of important spawning habitat for anadromous fish species between the Neuse River estuary and upstream freshwater tributaries; (2) restoration of 14.5 acres of damaged or eliminated riparian buffer adjacent to the Neuse River; (3) restoration of the estuarine wetlands at Gum Thicket and Cedar Creek in order to reduce erosion on approximately 59 acres of existing estuarine wetland, creating approximately 42 acres of additional estuarine wetland; and (4) restoration of approximately 10 acres of new oyster reef that supports approximately 80 acres of estuarine habitat to be managed by the state of North Carolina as oyster reef sanctuary. Only the Gum Thicket/Cedar Creek and Neuse River Oyster Reef restoration projects will be considered further in this consultation; the other two projects as planned will have no effect on ESA-listed marine species and occur in freshwater habitat where they are under the purview of the U.S. Fish and Wildlife Service.

USACE Response: Noted.

Comment 3: Five ESA-listed species of sea turtles (the endangered leatherback, Kemp's ridley, and hawksbill; the threatened/endangered! green; and the threatened loggerhead[2]) and the endangered[3] Atlantic sturgeon, can be found in or near the action area and may be affected by the projects. There is no critical habitat under NMFS' purview designated in or near the project areas for the species considered in this consultation.

We believe that the projects (e.g., Gum Thicket and Cedar Creek and the Neuse River oyster reef projects) are not likely to adversely affect sea turtles in the water. We have analyzed the proposed actions and believe the only routes of potential effects to sea turtles are from in-water placement (via barge) of oyster modules and in-water placement of the rock sills. Effects to sea turtles include the risk of injury from construction, which will be discountable due to the species' mobility (i.e., their ability to swim away from construction equipment/noise) and the implementation of NMFS' *Sea Turtle and Smalltooth Sawfish Construction Conditions*. Sea turtles may be affected by being temporarily unable to use the sites for forage habitat due to potential avoidance of construction activities, related noise, and physical exclusion from areas contained by turbidity curtains, but these effects will be insignificant, given the projects' small footprints and relatively short overall construction duration (i.e., 3 months). In addition, there are existing foraging and refuge resources available within the estuarine habitat just outside of and adjacent to the project areas. Disturbance from construction activities (e.g., placement of rock sill and oyster modules) and related noise will be intermittent and only occur for part of the construction period. Additionally, turbidity devices used will be based on site-specific needs and may involve a combination of silt barriers, silt curtains, floating silt curtains, or other devices deemed appropriate to contain sedimentation within the project area. These turbidity devices will only enclose the project site areas, will be removed upon project completion, and will not appreciably interfere with use of the area by sea turtles.

USACE Response: Concur.

Comment 4: We believe that both the Gum Thicket/Cedar Creek and Neuse River restoration projects are not likely to adversely affect Atlantic sturgeon and will have no effect on shortnose sturgeon. A two-year intensive gill net study was conducted to determine whether or not shortnose sturgeon could be found in what was once part of their historic range in the Neuse River. No shortnose sturgeon were found even during summer months when they would most likely occur in the lower Neuse River. The study areas showed extremely hypoxic conditions during summer months (2001-2002) which is likely the predominant factor leading to the extirpation of shortnose sturgeon in the area. However, juvenile Atlantic sturgeon were captured during this study in both the Gum Thicket and oyster restoration areas and other research shows that Atlantic sturgeon do utilize the Neuse River as well. Atlantic sturgeon may be affected by temporary loss of foraging habitat due to exclusion from benthic foraging areas in the Neuse River during oyster reef construction; however, exclusion from areas contained by turbidity curtains will be short-term and limited to small areas at any given time and these effects will be insignificant. The construction of the sill in Gum Thicket and Cedar Creek will have no effect on foraging for Atlantic sturgeon since the work will essentially take place in 2 feet of water just offshore from the shoreline, habitat where sturgeon are not likely to be foraging due to the shallow depths and proximity to shore. Turbidity curtains will help contain short-term turbidity from placement of rocks and sand for the sill and marsh planting and effects to nearby foraging habitat will be insignificant. The Neuse River is also a known spawning area for Atlantic sturgeon; however, no impeded migratory access is anticipated for either project due to their parallel and close to shore locations and effects to spawning are discountable. In fact, long-term restoration benefits for both Atlantic sturgeon spawning and foraging are expected as a result of both the marsh enhancement (Gum Thicket/Cedar Creek) and oyster restoration projects by stabilizing shoreline and improving water quality and benthic prey habitat. The transit of barges transporting oyster modules into the Neuse River poses a potential adverse effect to sturgeon by risk of vessel strike. However, the barge used for oyster restoration will be a shallow-draft barge moving at speeds less than 5 knots and the risk of a vessel strike to Atlantic sturgeon is discountable. Overall, these two restoration projects are expected to benefit Atlantic sturgeon in particular since they will result in increased wetland and estuarine habitat created by the Gum Thicket/Cedar Creek restoration.

USACE Response: We agree.

Comment 5: This concludes your consultation responsibilities under the ESA for species under NMFS' purview. Consultation must be reinitiated if a take occurs or new information reveals effects of the action not previously considered, or the identified action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat in a manner or to an extent not previously considered, or if a new species is listed or critical habitat designated that may be affected by the identified action.

USACE Response: Concur. If there is any change to the TSP or any new species listed (including critical habitat designated), the USACE will reinitiate Section 7 of the Endangered Species Act of 1973, as amended in consultation with NMFS.

A.2 U.S. Department of the Interior, Fish and Wildlife Service, Raleigh Ecological Services Field Office. Final Coordination Act Report, dated January 19, 2012.

Comment 1: FWS appreciates the opportunity to review this draft; we believe that it represents a significant step forward in determining important environmental restoration work that needs to be accomplished in the Neuse Basin and that it will make a substantial improvement to the ecology of the Neuse Basin when the work is implemented. A few specific comments and recommendations follow.

I. **Modification of the Low-head Dam on the Little River**
   - Significant discussion and work has been performed at this site by American Rivers (this information will be made available for your use).
   - Goldsboro is willing to have rock fish passage constructed at the dam but is currently unwilling to remove it due to loss of water storage if the dam is removed.
   - If the dam is not removed the next best option is Measure B- Build Rock Ramp. If that option is employed, it is very important to incorporate a low flow feature that allows adequate water depth and appropriate velocities at low flow to allow fish passage. FWS suggests including FWS, NMFS, NCWRC, NCDMF, and Dr. Joe Hightower and Joshua Raabe (Ph.D. candidate) in design discussions.

II. FWS suggests that the COE look at the sheet pile dam on the Neuse River Cutoff to see if raising the functional dam height would improve water availability at low flow at Goldsboro's primary intake and if placing rocks downstream of the structure would allow fish to pass the structure at low flow. It may be possible to raise the functional height of the sheet pile weir with rocks without having to raise any sheet pile. If so that would be preferred as the addition of rocks would improve the local habitat as well as possibly improving the water intake's effectiveness. This project is very timely, will benefit both migratory fish and the overall ecology of the Little River which is host to a number of rare and threatened species. For those reasons plus the fact that a good bit of progress has already been made the FWS puts this project at the top of the list for implementation.

USACE Response: We appreciate the interest and efforts of the agencies and technical experts regarding this project. We have and will continue to consider this input during the design process. Responses to the comments provided by the City of Goldsboro are included in Section A 10, below.

The USACE has been in discussion with the City of Goldsboro regarding their primary water intake located at the Neuse River Cutoff. That activity will continue separate from the TSP described in the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, North Carolina, dated October 2011.

Comment 2: Kinston East Wetland Complex

• Under measure B. Plant Vegetation FWS suggests that planting include bald cypress, black gum, mast producing oaks and if site hydrology and soils are conducive some Atlantic white cedar. FWS suggest 10 x 10 foot plant spacing except for the Atlantic white cedar which is better planted at a 6 x 8 or 7 x 7 spacing. The 10 x 10 foot spacing will allow room for volunteer plants which will create a more varied forest and natural setting. If a local forester suggests other plant spacing we will defer to more site specific plant recommendations if they are based on soils and hydrology. Both bald cypress and Atlantic white cedar are plants of high interest to the FWS because like longleaf pine they once covered large acreages in NC with associated wildlife benefits and those forests are mostly removed from the landscape. Mast producing oaks and black gum provide important forage for wildlife and bird species and are an important aspect to healthy riparian wetlands in the Neuse River Basin.

USACE Response: Once the 14.5 acre Neuse River floodplain area has been regraded, appropriate species of hardwood seedlings (i.e., bare root seedlings) will be planted on 10-foot centers. During the development of plans and specifications, the USACE will develop a species list in coordination with Federal and state agencies, which will include a mix of appropriate hardwood species. The USACE believes that adjacent areas will also supply supplemental seeds for natural tree regeneration of the Kinston area. The site will be monitored and if appropriate tree cover is not achieved, larger container trees could be planted in accordance with the adaptive management plan. Adaptive management is required the USACE will re-engage the sponsor and discuss opportunities for adaptive management.

Comment 3: Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creeks FWS recommends the sill be designed so that it has a natural appearance as well as protecting the shoreline. In order to do so it could be: built with curves instead of straight lines, built with varying heights and distance offshore, and be built with a variety of stone sizes and materials (marl and granite) which would provide a variety of habitats for aquatic fauna.

USACE Response: The USACE will ensure that the proposed sill along the shoreline of Gum Thicket and Cedar Creek will not be obtrusive. See Section 3.0 in the FONSI, which described the proposed refinements to the proposed shoreline stabilization at Gum Ticket and Cedar Creek. The proposed sill will be constructed at the -2 foot depth contour along the highly eroded shoreline of the project area. The height of the proposed sill would only average 1 foot higher than the Normal High Contour. The rock sill will be designed to be porous to water movement and provide regularly spaced overlap openings for the movement of juvenile fish and other aquatic species. See also response to NCWRC, (Letter A.8, comment #3), below.

Comment 4: Constructing New Oyster Reef Habitat. Oysters are a keystone species in North Carolina estuaries. FWS suggests carefully looking at alternative designs or technique that maintain site heterogeneity, avoidance of SAV impacts and provide good oyster production in a cost effective manner.

USACE Response: The USACE understands the importance of oysters in North Carolina and has coordinated the prospective new oyster sites with the NCDMF. The NCDMF proposes the construction of a new sanctuary in Neuse Estuary near Little Creek in 2012 in an effort to evaluate the feasibility and cost effectiveness of alternative reef materials including dome and pyramid shaped structures. We will consider their finding in our final reef designs. Any estuarine bottom within or adjacent to reef construction areas have or will be surveyed using side scan sonar to confirm the absence of existing oyster reef and/or SAV. If either existing oyster reef and/or SAVs are found in the prospective new oyster reef sites, the USACE will move the proposed reef sites in order to avoid any impacts to these habitats.

Comment 5: FWS concurs with the COE determinations on pages 196 thru 200 of the plan in regards to potential effects on Federally listed threatened or endangered species. These were no effect for Michaux's sumac, rough-leaved loosestrife, seabeach amaranth, and sensitive jointvetch. FWS also concurs with your determination that actions performed as described in the Tentatively Selected Plan (TSP) that dwarfwedge mussel, tar spinymussel, sea turtles, West Indian manatee may be affected but are not likely to be adversely affected. Please keep us informed as the TSP moves toward implementation. If your project description changes you should reinitiate consultation and we reserve the right to re-evaluate your determinations. You will need to consult with NMFS on shortnose sturgeon. FWS appreciates the COE's selection of projects that will benefit migratory fish, rare and threatened species in the Little River, neotropical migratory birds at the Kinston Wetland Complex, protection of important natural areas at Gun Thicket and Cedar Creeks, and restoration of keystone estuarine community at newly constructed oyster reef habitat.

USACE Response: If there is any change to the TSP, the USACE will reinitiate Section 7 of the Endangered Species Act of 1973, as amended in consultation with USFWS. The USACE has already initiated Section 7 consultation with the NMFS with species under their jurisdiction in the project area.

Comment 6: In summary FWS strongly supports the actions described in the TSP and appreciates your inclusion of our earlier suggestions. Please let us know how we can support the implementation of the described projects or help in any way.

USACE Response: Noted.

A.3 NC Department of Administration, State Clearinghouse, letter dated January 27, 2012.

Comment 7: The above referenced environmental impact information has been submitted to the State Clearinghouse under the provisions of the National Environmental Policy Act. According to G.S. 113A-10, when a state agency is required to prepare an environmental document under the provisions of federal law, the environmental document meets the provisions of the State Environmental Policy Act. Attached to this letter for your consideration are the comments made by agencies in the course of this review.

USACE Response: Concur. The USACE will consider and respond to all comments provided by the North Carolina State Clearinghouse.

A.4 NC Department of Environment and Natural Resources, letter dated January 25, 2012.

Comment 1: The Department has reviewed the proposed project. The applicant is asked to consider the attached comments prior to finalizing project plans. If additional information is needed, please notify our commenting agencies.

USACE Response: The USACE will consider and respond to all State agency comments prior to finalizing the TSP.

A.5 NC Department of Environment and Natural Resources, Division of Water Quality, letter dated January 11, 2012.

Comment 1: Kinston East Complex Site:

The proposed project is to restore hydrologic connectivity of a former 14.5 acres bottomland hardwood forest by removal of fill material followed by planting of grasses to stabilize the site. The proposed project is to utilize natural regeneration of seedling from the adjacent bottomland hardwood forest to reestablish native species.

Upon review of the subject project, this Office has the following comments:

• This Office recommends the planting of appropriate native bottomland hardwood seedlings at a standard planting density as recommended in Measure B. It is the opinion of this Office that natural regeneration of bottomland hardwood species from the adjacent areas will not be sufficiently restore the wetland area.

• Diesel fuel, fuel oil, and/or gasoline should not be used as a release agent on any mechanical equipment.

• All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials.

• Sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024); see NCDOT publication, Best Management Practices for the Protection of Surface Waters (March 1997):

• The outside buffer, wetland or water boundary and along the construction corridor within these boundaries shall be clearly marked with orange warning fencing (or similar high visibility material) for the areas that have been approved to infringe within the buffer, wetland or water prior to any land disturbing.

USACE Response: Once the 14.5 acre Neuse River floodplain has been regraded, the appropriate species of hardwood seedlings (i.e., bare root seedlings) will be planted on 10 foot centers. During the development of plans and specifications, the USACE will develop a species list in coordination with Federal and state agencies, which will include a mix of appropriate hardwood species. The USACE believes that adjacent areas will also supply supplemental seeds for natural tree regeneration of the Kinston area. The site will be monitored and if appropriate tree cover is not achieved, larger container trees could be planted in accordance with the adaptive management plan. Adaptive management is required the USACE will re-engage the sponsor and discuss opportunities for adaptive management.

The remainder of the comment deals with restrictions on the contractor as he is working at the site. Prior to any initiation of work, the required Sedimentation and Erosion Control (SEC) permit will be obtained from the NC Division of Land Resources. All conditions and restrictions of the SEC permit will be complied with by the contractor. Moreover, within the proposed plans and specifications for this project, the USACE will require the contractor to comply with the following conditions:

1. The Contractor is responsible for completing a Spill Control Plan. The Spill Control plan preparing and implementing procedures will include instructions, and reports to be used in the event of an unforeseen spill of a substance regulated by 40 CFR 68, 40 CFR 302, 40 CFR 355, and/or regulated under State or Local laws and regulations.

2. The contract specifications will require: Storage, fueling, and lubrication of equipment and motor vehicles be conducted in a manner that affords maximum protection against spills and leakage. Hazardous materials, fuel, lubricants, and other chemicals will be stored at least 100-feet away from all waterbodies. All construction equipment shall be fueled at least 100 feet away from all waterbodies (if possible) and protected with secondary containment. The contractor shall require the use of drip pans or drop cloths to catch drips and spills.

Comment 2: Low-head dam on the Little River:

The proposed project to restore aquatic habitat connectivity by removing a 20 ft section of the existing 100 ft-wide, 4 ft high concrete dam and installation of water control structure in order to provide sufficient water depth for the operation of the water treatment plant intake structure during the low flow periods in the summer . Upon review of the subject project, this Office has the following comments:

• All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials.

• Sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024) ; see NCDOT publication, Best Management Practices for the Protection of Surface Waters (March 1997).

USACE Response: Concur. See response to Comment 1, above. All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials. Prior to any modification of the low-head dam on the Little River, the required sediment and erosion control permit will be obtained from the NC Division of Land Resources.

Comment 3: Gum Thicket and Cedar Creek Restoration Opportunity Area:
The proposed project is to construct parallel rock sills approximately 3,500 foot-long at Gum Thicket Creek and 5,200 foot-long at Cedar Creek at a distance of 60 feet offshore. In addition, the proposed project is to construct a high marsh buffer by filling 30 feet waterward of the existing scrap and planting with Spartina species. Upon review of the subject project, this Office has the following comments:
• The proposed project should account for presence of submerged aquatic vegetation (SAV) and shellfish resource.

• The proposed project should also account for sediment transport within the project area that may possible create non-wetland conditions landward of the existing sill alignment due to sedimentation.
• The proposed project should also consider modification of the proposed design to minimize impacts to waters.
• Diesel fuel, fuel oil, and/or gasoline should not be used as a release agent on any mechanical equipment.
• All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids or other toxic materials.
• If any landward activities are conducted the appropriate sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024]: see NCDOT publication. Best Management Practices for the Protection of Surface Waters (March 1997)
• This Office recommends the proposed project design consider orienting the alignment of the sills along waterward contour of the shorelines and utilize offset every 200 feet along the rock sill in lieu of steep downs to promote increased aquatic passage.

USACE Response: Project areas have been surveyed for critical habitats and described below. No impacts to oyster reefs or SAVs are expected. GeoEye-1 satellite imagery (C 2011 GeoEye) dated May 9, 2011 at two scales (1:2400 and 1:3600) was inspected to identify any areas potentially having SAV or near shore submerged oyster reefs. The only area where SAV was apparent (from the May 9, 2011 aerial photography) was within Gum Thicket Creek in a location that would be protected by the proposed project, but, outside of the area impacted by any construction. Field surveys were conducted on February 7 and 8, 2012. The survey team included two biologist (a wetland, and a restoration specialist) a civil engineer, and two surveyors. The seas were calm and the bottom was visible from the surface at a depth of about 4 to 5 feet. Continual observations over the entire proposed project length were made by two biologist observers along two shore parallel transects that ranged from 75 to 150 feet offshore. No SAV or oyster reef was observed. Inspections in Gum Thicket found patches of R*uppia* in areas previously identified by mapping. Five long (approximately 2,500 feet long) perpendicular transects were also observed (areas of 6' deep or less) and probed (entire transect) using a 20 foot aluminum pole to estimate bottom type. Hard Sand (no penetration), Firm Sand (1" penetration) and Mud were encountered. No rock or shell was detected. Twenty-five shorter transects (about 200 foot long) were also surveyed. Additionally, transects were also surveyed at several natural and nearby constructed living shoreline sites in the area to serve as a reference for the proposed marsh restoration planting plan. All field personnel were on the lookout for SAVs none was observed with the exception of Gum Thicket Creek as noted above.

The USACE proposes to first construct the offshore rock sill along the shoreline of Gum Thicket and Cedar Creek. After the sill is in place, coarse sand with little or no silt (fine material) will then be placed landward of the existing sill along the eroded shoreline. Equipment used to place this sediment will also be used to shape and compact it in place. The appropriate marsh species will be then be immediately planted in the filled area. The proposed rock sill would stop offshore wind and wave erosion during the time required for the planted marsh to stabilize the sediment. When the USACE constructed the offshore rock sill at Festival Park in Manteo, NC, the contractor was required to use a floating silt curtain to contain any turbidity generated from the project. The floating silt curtain also helped in reducing any sediment transport, landward of the sill. If required, the contractor will deploy a floating silt curtain along the shoreline of Gum Thicket and Cedar Creek. With the order of work and these conditions in place, the USACE believes any movement of the compacted, shaped, and coarse sand fill area, landward of the sill would be minimized.

Prior to any construction, the required Sedimentation and Erosion Control (SEC) permit will be obtained from the NC Division of Land Resources. See response to Comment 1, above.

The USACE will further coordinate with the State and Federal agencies regarding the size and frequency of openings in the sill (see Section 3.0 Refinements to the TSP).

Comment 4: Oyster Growing restoration at Mid-River and North Shores Site: The proposed project is to construct two 40-acre new deepwater reefs by utilizing granite material located in middle of Neuse River and Neuse North Shores Site. Upon review of the subject project, this Office has the following comments:
• If reuse and/or recycled concrete are used for construction, the material must be free from loose dirt, fine particulate material and any petroleum pollutants. The concrete shall not have any exposed wire or rebar. Concrete shall not have been used as bridge decking, roadway surface, or holdings tanks for chemical pollutants.

USACE Response: Recycled materials are not proposed for reef construction at this time. However if detailed plans include reused concrete the suggested restrictions would be observed.

A.5 NC Department of Environment and Natural Resources, Public Water Supply Section. Memorandum dated January 10, 2012.

Comment 1: The Draft Integrated Feasibility Report and EA for the Neuse River Basin focus on water quality improvements and flood control. There is very little discussion on public water supply in the report. However water quality improvements could be beneficial to surface water treatments plants that withdraw drinking water supply from the Neuse River.

USACE Response: The USACE does not formulate ecosystem restoration projects for water quality enhancement, as it is not a Corps mission, although water quality improvements may be a secondary benefit of the project.

A.6 NC Department of Environment and Natural Resources, Division of Coastal Management, letter dated January 12, 2012.

Comment 1: The major theme behind the Neuse River Basin Integrated Feasibility Report is ecosystem restoration and flood risk management. To promote ecosystem enhancement the EA has identified numerous opportunities for restoring a variety of resources such as mussel populations, fish and oyster populations, and wetlands. The specifics of the 'Tentatively Selected Plan" is described in Chapter 7 of the EA.

USACE Response: Concur.

Comment 2: The EA also refers to the implementation of various management measures, such as retrofitting stormwater outfalls and upland storm water detention basins as undertakings for improving water quality. These measures have been identified as being the under the initiative and control of various municipalities. The treatment of stormwater runoff to enhance water quality of the Neuse River will be an important aspect to the success of the projects identified in Chapter 7 of the EA.

USACE Response: Concur. The USACE has identified these stormwater issues as potential Management Measures (see Table 3-2, in USACE, 2011). However, a number of Federal and state agencies have already addressed this issue. In December 1997, the North Carolina Environmental Management Commission (EMC) approved the Neuse Nutrient Sensitive Waters Management strategy. US EPA's *Nutrient Sensitive Waters Management Strategy* and NPDES stormwater regulations have caused actions to be taken to control sediment discharge from inland sources into rivers and streams and decrease the volumes of stormwater runoff that might result in adverse in-channel sediment movement. The Natural Resources Conservation Service (NRCS) also has two programs that are working to improve water quality throughout the Neuse River Basin by offering funding to farmers and ranchers to address soil, water, and natural resources issues. The NRCS Environmental Quality Improvement Program provides technical, educational, and financial assistance to eligible farmers to improve management practices on local farms. Effective August 1, 2000, North Carolina adopted the Neuse River Riparian Buffer Protection Rule for maintaining and protecting existing riparian buffers in the Basin (15A NCAC 2B .0233). That strategy consists of a series of rules to protect and preserve existing riparian buffers to maintain their nutrient-removal functions in the Basin.

Since these above mentioned agencies are already working on reducing stormwater impacts in the Neuse River Basin, the USACE has decided not to duplicate these efforts.

Comment 3: From the perspective of furthering a complete integrated management approach for improving the environmental health of the Neuse River Basin; treating water before it enters the Neuse River would seem to be a major objective. As indicated in the EA. the effort to improve water quality before it enters the Neuse River principally belongs to the local municipalities. Nevertheless, we would encourage the Corps to coordinate with the local municipalities to identify and prioritize treatment opportunities that can be incorporated into the project list contained in Chapter 7 of the EA.

USACE Response: The Corps of Engineers does not formulate ecosystem restoration projects for water quality enhancement, as it is not a Corps mission, although water quality improvements may be a secondary benefit of the project. Water quality improvements are being addressed under the State's NPDES and point and non-point source discharge programs.

Comment 4: Proposed Project Description: Gum Thicket/Cedar Creek rock sill proposal could have navigational impacts and the details or the proposal should he reviewed for consistency with CAMA and the Dredge and Fill Act.

USACE Response: During a recent visit to Gum Thicket and Cedar Creek on 7 and 8 February 2012, the USACE surveyed the offshore bathymetry of this area. The entire shoreline is very shallow with depths ranging from about 2 to 3 feet several hundred feet offshore. The proposed sill would be located in water depths of about 2 feet deep (at an average distance of 42 feet waterward of the Normal High Water (NHW) contour). The proposed sill and planted marsh would not cause any adverse navigational impacts since the surrounding water depths are very shallow and there are no existing navigation channels near this shoreline. In the Neuse river, the existing offshore navigation channels are thousands of feet from the Gum Thicket and Cedar Creek shoreline towards the center of the river.

The USACE has reviewed the TSP for both consistency with CAMA, which also includes the Dredge and Fill Act (see Attachment C).

It is the understanding of the Wilmington District that North Carolina's Dredge and Fill Law, NCGS 113-229, applies to those entities seeking permits from NCDCM, and not to federal agencies making determinations of consistency with the enforceable policies of the CAMA. Specifically, federal agencies are not identified in section (m) of the law as entities which are subject to these provisions; the law specifically identifies "State government or local governments," but not the federal government, as entities which must comply. It is our understanding that the intent of the dredge and fill law is expressed adequately in the enforceable policy found at 15A NCAC 07M.1102, which does apply to federal agencies.

Comment 5: Proposed Project Description: Gum Thicket/Cedar Creek sill will impact shallow bottom and possibly critical habitat areas (i.e. SAVs and shellfish). Any critical habitat areas should be identified and quantified.

USACE Response: Project areas have been surveyed for critical habitats and described below. No impacts to oyster reefs or SAVs are expected. GeoEye-1 satellite imagery (C 2011 GeoEye) dated May 9, 2011 at two scales (1:2400 and 1:3600) was inspected to identify any areas potentially having SAV or near shore submerged oyster reefs. The only area where SAV was apparent (from the May 9, 2011 aerial photography) was within Gum Thicket Creek in a location that would be protected by the proposed project, but outside of the area impacted by any construction. Field surveys were conducted on February 7 and 8, 2012. The survey team included two biologist (a wetland, and a restoration specialist), a civil engineer, and two surveyors. The seas were calm and the bottom was visible from the surface at a depth of about 4 to 5 feet. Continual observations over the entire proposed project length were made by two biological observers along two shore parallel transects that ranged from 75 to 150 feet offshore. No SAV or oyster reef was observed. However, inspections in Gum Thicket found patches of R*uppia* in areas previously identified by mapping. Five long (approximately 2,500 feet long) perpendicular transects were also observed (areas of 6' deep or less) and probed (entire transect) using a 20 foot aluminum pole to estimate bottom type. Hard Sand (no penetration), Firm Sand (1" penetration) and Mud were encountered. No rock or shell was detected. Twenty-five shorter transects (about 200 foot long) were also surveyed. Additionally, transects were also surveyed at several natural and nearby constructed living shoreline sites in the area to serve as a reference for the proposed marsh restoration planting plan. All field personnel were on the lookout for SAVs none was observed with the exception of Gum Thicket Creek as noted above.

Rangia clams could be present in the vicinity of the project along the shoreline of Gum Thicket and Cedar Creek; however, these species are not of commercial importance in the Neuse Estuary. The salinities in the project area average about 12 ppt on the basis of water quality modeling and would not be expected to support significant populations of hard clam that require average salinities greater than 20 ppt for larval and juvenile development (Mulholland, 1984). However, along the shoreline there are scattered beds of small (less than 1- inch in size) mussels in wave up rush areas that could be impacted by the proposed planting of marsh. However, once all work has been completed, they should repopulate the area to pre-project levels.

Comment 6: Proposed Project Description: The lower Neuse River Oyster Growing Area proposal should be consistent with the CAMA and the Dredge and Fill Act.

USACE Response: Concur. The USACE has reviewed the TSP for consistency with CAMA, which includes the Dredge and Fill Act (see Attachment C).

Comment 7: Feasibility: Please discuss the USACE's success rates and results with similar restoration efforts in the past.

USACE Response: While the Gum Thicket and Cedar Creek project is larger in scope it would support similar features to the living shoreline project constructed by the Corps and NCDWR at Roanoke Island Festival Park Project located on Ice Plant Island adjacent to Manteo, in Dare County, North Carolina. This project restored and protected about 1,500 feet of shoreline marsh. Both Festival Park and Gum thicket/Cedar Creek share a project design that expands on a "living shoreline" concept where restored natural marsh vegetation is the keystone, providing both estuarine habitat and shoreline stabilization. While a typical "living shoreline" design provides a low rock sill aligned along the toe of the restored marsh to improve shoreline sustainability. In both of these projects the sill is moved seaward, to provide quiet shallow water habitat between the marsh and the sill, improving conditions for the development of young fish, shrimp, and crabs. Three years of monitoring at Festival Park (completed in the fall of 2005) showed that despite several major storm events (including hurricanes Isabelle and Irene), the shoreline is now stable and restored estuarine habitats are thriving. The project received a NC Coastal Federation "Pelican Award" as the best restoration project along the northern NC coast in 2004. Two Coastal Federation living shoreline projects and a Sea Grant timber breakwater demonstration project are located within a mile of the proposed Gum Thicket/Cedar Creek project. Several topographical transects were surveyed by the Corps within each reference project, and at two additional nearby natural marsh sites. This elevation data will be considered in development of final project designs. The USACE has been involved in restoration of native oysters in the Chesapeake Bay. Successful native oyster restoration in the Great Wicomico River, a sub-estuary of the lower Chesapeake Bay was reported by Shulte et.al, (2009), where 9 reefs, totaling 35 hectares were restored as sanctuaries in 2004 by the U.S. Army Corps of Engineers. Pre-restoration surveys demonstrated that there were, on average, less than two oysters per square meter throughout the nine reef complexes. In 2007, the metapopulation on the nine reefs consisted of an estimated 184.5 million oysters representing a 57-fold augmentation of the resident Great Wicomico River population. Neuse River oyster reefs will reference NCDMF establishment of an existing sanctuary oyster reef there.

Comment 8: Accountability: Please discuss the USACE's response and actions if these projects fail.

USACE Response: The project will be monitored and adaptively managed as discussed in Appendix Q (found in the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011 (USACE 2011)). Adaptive management increases the likelihood of achieving desired project outcomes given uncertainties frequently associated with ecosystem restoration projects.

Comment 9: Invasive Species. Does the Neuse River Basin have an invasive species concern? According to the "Neuse Water Resources" (July 2010): "The worst noxious aquatic weed that infests the Neuse River Basin is Hydrilla verticillata, commonly referred to as hydrilla". The EA does not examine whether invasive species would constitute a significant concern. If so, would there be opportunities to include (in Chapter 7 of the EA) projects that would reduce the presence of invasive species. We suggest that the EA incorporate a discussion concerning invasive species.

USACE Response: None of the projects included in the TSP create permanent waterbodies and therefore would not be threatened by *Hydrilla* infestation. However, the portion of coastal marsh projects that are above normal high water (NHW) could be infested by *Phragmites* since this species has been identified and mapped within the project boundaries and in reference areas. It is expected that frequent inundation by salt water would control *Phragmites* growth in low marsh areas. Inclusion of project design elements such as steepening the slope in constructed high marsh to reduce the potential area of impact will be considered as appropriate during detailed design. Measures to reduce the potential for *Phragmites* infestation including pre and post construction herbicide treatment, construction of tidal channels between existing and newly disturbed ground would also be considered.

Comment 10: Section 8.7.7 briefly reviews the "Coastal Zone Management Act" and its relationship to North Carolina's coastal area management program. This section needs to be expanded to enhance the reader's understanding of the consistency review process, First, not all the counties within the Neuse River Basin are within North Carolina's coastal area. Second, that any Federal activity that could affect any coastal use or coastal resource within North Carolina's coastal area would be subject to consistency review even if located outside of North Carolina's coastal area.

USACE Response: Concur. The USACE understands that of the four components of the TSP, only stabilizing the shoreline at Gum Thicket and Cedar Creek and the construction of oyster reef would be located within the 20 CAMA coastal counties. The dam modification on the Little River in Goldsboro (Wayne County) and the Kinston East Wetland Complex in Lenoir County are not with the 20 CAMA coastal counties but the USACE will still need to determine consistency with the North Carolina's Coastal Management Plan. Once the TSP has been finalized and the FONSI signed, the USACE will apply for consistency determination from the NC Division of Coastal Management. No work will be undertaken without first obtaining the required North Carolina coastal zone consistency determination.

Comment 11: Section 1.8 lists the "Study Process and Participants". The North Carolina Wildlife Resources Commission (NCWRC) is not listed. Based on other sections of the EA, coordination with the NCWRC has been undertaken.

USACE Response: The USACE will add this state agency will be added to the list of study participants.

Comment 12: The abbreviation "TSP" for Tentatively Selected Plan and the abbreviation "CZMA" for "Coastal Zone Management Act" are missing from the list of "Acronyms and Abbreviations".

USACE Response: The USACE will add these abbreviations to the list of "Acronyms and Abbreviations".

A.7 NC Department of Public Safety, Emergency Management. Letter dated January 11, 2012.

Comment 1: As requested by the North Carolina State Clearinghouse, the North Carolina Department of Crime Control and Public Safety Division of Emergency Management Office of Geospatial and Technology Management (GTM) reviewed the draft report listed above and offer the following comments:

1) This study determined there were no significant opportunities for flood risk management projects in the Neuse River Watershed. However, projects recommended for ecosystem restoration may have the unintended result of impacting the flood risk as identified in the community's Flood Insurance Study. The proposed projects are located in a county or community that participates in the National Flood Insurance Program. A floodplain development permit should be obtained by the local floodplain administrator to ensure compliance with their flood damage prevention ordinance and the National Flood Insurance Program.

USACE Response: Concur. Once the TSP has been finalized, all required floodplain development permits will be obtained prior to construction.

Comment 2: The proposed modification of the low head dam on the Little River should include a hydraulic study to determine if the base flood elevations and/or floodway widths in the effective hydraulic model supporting the Wayne County Flood Insurance Study are impacted. Coordination with the City of Goldsboro's Floodplain Administrator should be made to determine if a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR) is required.

USACE Response: Modifications to the Little River low-head dam near Goldsboro to improve fish passage have been investigated by the engineering consultants Princeton Hydro, LLC. This work was contracted by American Rivers with funding from the Fish America Foundation and NOAA in coordination with City of Goldsboro, and NC state agencies. The analysis included evaluating upstream and downstream impacts caused by modification to the existing dam configuration utilizing the effective FEMA hydraulic floodplain model. Impacts to the upstream Goldsboro water supply intake were also evaluated with the model. The most current FEMA model was updated with surveyed cross-sections at the dam and flow data updated with additional USGS stream gauge records. The final product was an engineering report prepared by Princeton Hydro dated October, 2011 summarizing the dam's history, current impacts to the Little River, proposed improvements to the fish passage with computer model results of impacts to the floodplain and floodway. The main conclusions from the report were the low-head dam has no impact on flood levels above the 10-year event and no evaluated improvement options increase flood levels. Neither complete dam removal nor installing a rock ramp on the dam face increased up or downstream flood levels above existing levels.

The next step in pursuing dam modification to improve fish passage will be to submit documentation and supporting technical data from the model to FEMA for a No-rise Certificate or Letter of Map Revision. This step will require a decision from project partners on the final configuration of dam modifications to include in the hydraulic model. The revised model developed for American Rivers will be utilized. The adopted modification will also ensure no negative impacts to the upstream water supply intake.

Comment 3: The site for the removal of 14.5 acres of fill material at the Kinston East Wetland Complex is located in the floodway of the Neuse River. A hydraulic study to determine if this project will impact the effective Lenoir County Flood Insurance Study should be submitted to the City of Kinston's Floodplain Administrator. A floodway modification or reduction in flood levels may necessitate a Letter of Map Revision.

USACE Response: The proposed Kinston East Wetland restoration will reconnect 14.5 acres of filled floodplain to the hydrologic patterns of the Neuse River. The restoration will require the removal of approximately 4-ft depth of fill material over the 14.5 acres. The southern two-thirds of the proposed restoration area are within the Zone AE 100-year floodway of the Neuse River. To determine if there are any impacts to the effective Flood Insurance Study, a hydraulic analysis will be conducted. This analysis will utilize the effective FEMA hydraulic floodplain model to determine if there is any increase or decrease in flood levels or changes of the floodway boundaries. The analysis will be conducted by modifying the floodplain cross sections in the effective model to represent removal of the fill material in the wetland restoration area. The analysis will be coordinated with City of Kinston and North Carolina Division of Emergency Management to determine if a Letter of Map Revision is required.

Comment 4: Federal Executive Order 11988 directs federal agencies to evaluate the potential effects of any action taken in the floodplain and indicate whether the action conforms to applicable state or local floodplain protections standards (Section 2 (a)(3)).

USACE Response: Concur. During the development of plans and specifications, USACE will evaluate the potential effects of the TSP on floodplains and indicate whether the action conforms to applicable state and local floodplain protection standards.

A.8 NC Wildlife Resources Commission, letter dated January 26, 2012

Comment 1: Section 2.3.2.1 Aquatic Resources. In the discussion about the aquatic resources within the Neuse River, there was no mention of the inland primary nursery areas or anadromous fish spawning areas. Information about descriptive boundaries for inland primary nursery areas can be found under 15A NCAC IOC .0503 as boundaries for anadromous fish spawning areas can be found under 15A NCAC 03R .0115. Please feel free to contact the NCWRC for more information about sampling and other programs we have along the Neuse River in regards to aquatic resources.

USACE Response: In Section 2.3.2.1 Aquatic Resources (page 59 of the EA), the USACE indicates the following: *In 2000 North Carolina Wildlife Resources Commission (NCWRC) designated the Neuse River from Pitchkettle Creek (near Grifton, North Carolina) upstream to Milburnie Dam, including Craven, Pitt, Lenoir, Wayne, Johnston, and Wake counties, as Inland Primary Nursery Areas (15A NCAC 10C .0503). NCDMF defines a Primary Nursery Area (PNA) as that portion of the estuarine system where initial post-larval development takes place. PNAs include both water and marsh areas.*

The NCWRC has also designated anadromous fish spawning areas (according to 15A NCAC 03R .0115) in the main stem of the Neuse River (from State Road 2555 in Wake County to New Bern in Craven County) and in portions of its tributaries (Middle Creek, Little River, Mill Creek, Contentnea Creek, Bear Creek, Falling Creek, Kitten Creek, Pitchkettle Creek, Swift and Little Swift Creek, Trent River, etc.). The only project that is located within a designated anadromous fish spawning area of the Neuse River and its tributaries is the modification of the Little River Dam in Goldsboro. If this dam is modified, anadromous fish spawning habitat should be improved. Also in order to avoid anadromous fish spawning in the Little River, the USACE will ensure that all "in water" work is not from 15 February to September 30 of any year.

Comment 2: Section 2.3.2.2 Fauna. The document provides a thorough discussion about the listed species that occur within the Neuse Basin, but does not include a discussion of the non-listed species in the area, game or non-game species. The NCWRC recommends that the USACE provide more discussion about the public game lands that are within the area and other areas that have been protected for fauna in the Neuse River Basin. Locations of our game lands can be found on our website: www.ncwildlife.org. Additionally, please feel free to contact the NCWRC if you need more information about game and non-game species that occur in the area and projects that are occurring to monitor them.

USACE Response: Section 2.3.2.2 Fauna does provide a brief discussion on non-listed species in the area, game or non-game species in the Neuse River Basin. However, the USACE does mention that a more detailed description of these species can be found in the Cliffs of the Neuse and the Eno River State Parks published fauna studies.

As indicated in referenced NCWRC website, there are no public game lands within 30 miles of the low-head dam in Goldsboro. The 3,100 acre Dover Bay public game land is located off US Highway 70, near Cove City. The Dover Bay public game land is about 15 miles downstream of the Kinston East Wetland complex. The 1,094 acre Light Grand Pocosin public game land is located off NC Highway 306 near Bayboro. This NCWRC game land is about 12 miles from the Gum Thicket/Cedar Creek shoreline stabilization project. The Carteret County public game land near South River is about 6 miles away from the proposed oyster reef restoration area.

None of the components of the tentatively selected plan would adversely impact non-listed species in the area, game or non-game species, as well as any designated NCWRC public games lands. The USACE believes that these ecosystem restoration projects would benefit all these species in the Neuse River Basin.

Comment 3: Gum Thicket and Cedar Creek Alternative
This project includes the construction of a marsh sill to protect a significant area of marsh that has exhibited signs of erosion. The proposal includes a 3,500' sill in the Gum Thicket area and a 5,200' sill in the Cedar Creek area. These sills are proposed to be approximately 60' offshore with a base width of 30' and a top width of 3.5' that extends 2' above Mean High Water (MHW). Openings are proposed every 100' to allow water to flow behind the sill. Spartina is proposed to be planted landward the sill to enhance coastal marsh. Approximately 18 acres of habitat will be impacted with this design proposal. We have reviewed the project description and agree that a marsh sill will help stabilize the coastal marsh and shoreline landward the structure. However, we are concerned with the proposed size of the sill and the area of impact. In general, the NCWRC believes marsh sills should be constructed to protect and enhance a shoreline without armoring it completely. Sills should be located outside of important habitat areas, such as submerged aquatic vegetation (SAV), be relatively close to shore, and have a base width that creates a 2: I slope for a structure that is I' above NWL or NHW, whichever is the appropriate measurement for that body of water. Therefore, we recommend a reduction in the size of the structure to minimize impacts to shallow water habitats and public trust use. The sill should be placed closer to shore, have a more narrow bottom width, a more narrow top width, and not emerge as high above NHW. We recommend that the USACE look at several opening types for the 100' intervals, including overlaps and dropdowns. In addition to the requested structure design change, information should be provided regarding the planting of Spartina. This should include whether fill will be used landward the sill structure to achieve an appropriate substrate level, the types of plantings to be used, time of planting, and monitoring.

USACE Response: The proposed plan incorporates natural habitats into a shoreline stabilization design, maintains the connectivity between aquatic, intertidal and terrestrial habitats, and minimizes potential adverse impacts of shoreline stabilization on the estuarine ecosystem.

While these features (i.e., rock sills) have potential to generate significant environmental benefits, there are several regulatory concerns about the use of rock sills as shoreline protection measures. These concerns include: the replacement of shallow-water habitat with rock and consequently an alteration in ecosystem services of the site; filling of intertidal lands with potential for loss of public trust resources; loss of connectivity between aquatic and intertidal and terrestrial habitats; introduction of a foreign substrate to the area; scouring at the base of the sill, and; possible hazards to navigation. Therefore, there are limits on the amount of marsh fill, as well as the height and water-ward placement of the sill that are considered acceptable. For compliance with the NC general permit (GP) the marsh and structures are limited to within 30 feet of normal high water (NHW) line with a marsh elevation not to exceed mean high water and sill height limited to 6 inches above NHW. There are also requirements for providing sill openings (drop-downs) to promote access by nekton.

The current design is not constrained by the general permit conditions since this project will undergo NEPA review and will seek environmental clearances based on the specific merits of the project. However, the GP conditions are considered an indicator of generally accepted project scope and were considered in the Gum Thicket /Cedar Creek design that not only provides wetland shoreline stabilization but will also provide expanded ecosystem benefits from inclusion of a high marsh buffer (that requires elevation above NHW) and protected marsh edge shallow water habitat (requires that the sill is moved offshore of the marsh).

The current design balances the ecosystem services provided by several important habitat components. High marsh, tidal low marsh, marsh edge shallow-water bottom and rock structure are all included, recognizing the synergy and connectivity provided by locating these components adjacent to each other and in relatively close proximity.

The project would provide a narrow but productive band of tidal marsh. This is a keystone component in this wetland complex, supporting important nursery habitat for many species of estuarine-dependent fish. A high marsh wetland would be established up slope contributing to marsh diversity and providing a transitional connection to existing wetlands. Down slope from the tidal marsh, adjacent marsh edge shallow-water bottoms would support benthic microalgae communities and high densities of nekton and birds. An offshore sill would provide a unique attachment substrate for shellfish and epiphytes. This structure also provides wind and wave protection, calming the landward shallow water habitat, improving refuge value for juvenile fish and crabs.

The extent of high and low marsh that can be established is limited by the tide range and slope of the marsh substrate. There is basically no lunar tide at the Gum Thicket Cedar Creek site; however, a wind tide of about 1 foot is present. Emergent marsh establishment would be expected at elevations between the normal water level and about +2 feet, consistent with findings at previous marsh restoration project with similar wind tide driven tidal ranges. A sloped substrate is necessary to establish both high and low marsh communities and allow for those communities to develop naturally based on a fluctuating water level. Although constructing a more gradual slope could allow for more marsh area to be established, a slope of 10:1 is desirable from a regulatory standpoint (minimizing the distance that the marsh substrate is placed off shore while allowing establishment of a marsh fringe with a stable slope and adequate drainage of the root zone during low tide events).

Elevations below normal water level would be inundated much of the time and not expected to support marsh but would colonize with a shallow water benthic community and provide marsh edge shallow aquatic habitat discussed below.

Marsh edge shallow water habitat, located at the interface between marsh and open water, has been found to support higher concentrations of fish, shrimp and crabs than adjacent open waters. Various studies have identified this effect to be highest next to the marsh, diminishing with distance from shore and extending about 7 to 10 meters Baltz et al. (1993) observed an increased abundance of marsh associated fish out to about 7 meters. Minello and Rozas (2002) found that blue crab and shrimp densities were also highest next to the marsh edge and rapidly declined to 10 meters. Irlandi and Crawford (1997) identified the marsh edge as being within 10 meters and supporting increased numbers of pinfish relative to adjacent mud flats.

Based on these considerations, the preliminary design would create about a 20 ft width of high and low marsh. To allow for a 20 ft of shallow open water marsh-edge habitat, the inner tow of the sill would be placed approximately 40 ft offshore. No impacts to existing oyster reef and SAVs will occur for this proposed action. The exact alignment of the sill would be determined during the development of plans and specifications of this study.

The sill foot print will be minimized to the degree practical while providing adequate wave protection and durability. The current bottom width is expected to be about 26 feet.

Comment 4: Little River Dam Removal
The USACE is proposing to improve anadromous fish and mussel populations improving fish passage at the low head dam at the City of Goldsboro's secondary water intake. Three measures are outlined in the document: to build a dam gate, construct a rock ramp or to remove the dam. The NCWRC supports projects that improve fish passage along the Neuse River and request that the USACE consult with our anadromous fish biologist, Bennett Wynne when these measures are further discussed. When evaluating the preferred measure, the USACE should consider the moratorium NCWRC has on in-water work that runs from 15 February until 30 September.

USACE Response: Concur. The USACE will continue to coordinate this project with the property owner, the City of Goldsboro as well as the State and Federal agencies (including American Rivers) as final plans are developed. The USACE will agree that no in-stream work will occur from 15 February to September 30.

Comment 5: Neuse River Oyster Growing Area Alternative
This portion of the plan includes constructing deep water reefs to help restore oyster habitat and address projected habitat loss. Several potential sites were examined for their sanctuary potential and methods of construction and management were gleaned from existing state programs and successes.

The NCWRC supports oyster habitat restoration and encourages the USACE to consult with the NC Division of Marine Fisheries and the National Marine Fisheries Service to determine appropriate locations and construction designs for success. We have minimal concerns regarding resource impacts as long as important habitat areas are avoided and the structures to not impose a threat to navigation or significantly impact public trust use.

USACE Response: The proposed oyster reef restoration locations have been reviewed by the NCDMF and NMFS. Coordination with these and other interested agencies will continue as final plans are developed. Any estuarine bottom within or adjacent to reef construction areas have or will be surveyed using side scan sonar to confirm the absence of existing oyster reef and/or SAV.

A.9 NC Department of Cultural Resources, State Historic Preservation Office. Letter dated September 15, 2011.

Comment 1: Thank you for your transmittal of August 15, 2011. We have reviewed the Cultural Resources Study Plan for above project and offer the following comments.

Portions of the project are in Wayne and Lenoir counties. The Wayne County project is for the Low Head Dam, Little River near Goldsboro. The plan is to remove a portion of an existing dam to provide a better pathway for fish migration. This project is located at the existing Goldsboro WTP and will use a two-acre staging area. The dam itself is not a significant feature, and the staging area is previously disturbed. The Lenoir County project calls for restoration of the Kinston West Wetland Complex within highly disturbed portions of the floodplain east of Kinston. No archaeological sites are recorded within the project area. The Wyse Fork Battlefield is about one mile away, across the river. It is unlikely that significant sites will be affected by the restoration activities. We have no comment on the Wayne and Lenoir County projects.

USACE Response: Noted.

Comment 2: Other portions of the overall project are located in Pamlico County and consist of the Gum Thicket and Cedar Creek Restoration and oyster reef restoration within the Neuse River Estuary. On Page 6 of the document, four archaeological sites are mentioned within the Gum Thicket and Cedar Creek project area. These sites include 31PM28, 31PM32, 31PM133, and 31PM34. It is noted that the sites had been visited by OSA staff in the late 1980's and found to be heavily eroded. Since that time these sites are believed to have been lost to erosion. Two additional sites, 31PM98 and 31PM35 are also noted on OSA maps to be very near or within the project area. 31PM98 is located at the southern end of the project area and 31PM35 is located at the northern end. The document states that a shoreline examination by the Wilmington COE will take place prior to construction. We recommend that sites 31PM98 and 31PM35 be included in this inspection.

USACE Response: Concur. Sites 31PM35 and 31PM98 will be included in the shoreline inspection at Gum Thicket and Cedar Creek restoration.

Comment 3: We have no comment on the oyster reef restoration areas in terms of terrestrial archaeological resources. Staff at the Office of State Archaeology - Underwater Branch reviewed the Cultural Resources Study Plan for the above project and offers the following additional comments to those of the terrestrial archaeologists. The underwater research files have references to extensive maritime activities and shipwreck losses in the general project vicinity of the Gum Thicket/Cedar Creek Restoration and the Oyster Reef Restoration. There is a high probability that unknown potentially significant submerged cultural resources may exist within the proposed project area.

USACE Response: Noted.

Comment 4: We concur with the recommended plan that a detailed shoreline examination by the USACE be coordinated with OSA and UAB staff prior to construction in the Gum Thicket/Cedar Creek portion of the APE. Additionally, construction personnel and equipment operators should be made aware that the possibility exists that work may unearth buried remains not apparent during initial archaeological reconnaissance. In the event that such occurs, work should move to another area and the Underwater Archaeology Branch be contacted immediately (910-458-9042) so a staff member can be sent to assess the remains and determine the proper course of action.

USACE Response: Concur. Construction personnel and equipment operators will be made aware of the possibility of unearthing buried cultural material. Should unknown cultural material be encountered, work in that area will cease until a professional assessment in consultation with UAB has been made.

Comment 5: The Oyster Reef Restoration portion of the overall plan creates a bottom disturbance that may damage unknown archaeological resources. We therefore recommend a comprehensive survey be conducted by an experienced archaeologist to identify the presence and significance of submerged archaeological remains lying with the project boundaries. Potential effects on these resources should be assessed prior to the initiation of construction activities. Detailed requirements of this survey should be coordinated with UAB archaeologists.

USACE Response: Concur. The USACE will assess potential effects on underwater resources and the level of investigation needed in consultation with UAB archaeologists following identification of specific oyster reef restoration sites.

Comment 6: We have determined that the project as proposed will not have an effect on any historic structures. The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

USACE Response: Noted.

A.10 North Carolina Department of Cultural Resources, State Historic Preservation Office. Letter dated December 15, 2011.

Comment 1: We have conducted a review of the project and are aware of no historic resources which would be affected by the project. Therefore, we have no comment on the project as proposed.

USACE Response: Noted.

Comment 2: The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

USACE Response: Noted.

A.10 City of Goldsboro. Letter dated January 17, 2012.

Comment 1: Thank you so much for allowing the City of Goldsboro to comment on the Neuse River Basin DRAFT Integrated Feasibility Report and Environmental Assessment- October 2011. We respectfully submit the following *comments* pertaining to the "Modification of the Low-head Dam on the Little River" portion of the Tentatively Selected Plan:

1. Since February 2010, the City of Goldsboro has worked with American Rivers to identify alternatives to improve fish passage for the dam on the Little River owned by the City of Goldsboro since 1914. A final report entitled, "Dam Removal Alternative Analysis for Goldsboro Dam, Little River Summary Report- City of Goldsboro, Wayne County, NC- October 2011" identified five (5) alternatives to improve fish passage. The alternatives were:

a. Alternative 1 a- Full dam removal (decrease elevation by 4.19')
b. Alternative 1 b- Full dam removal (decrease elevation by 3.64')
c. Alternative 2a- Lower dam and install rock ramp (decrease elevation by 2.12')
d. Alternative 2b- Lower abutments and install rock ramp (no elevation change)
e. Alternative 3- Modified dam (i.e., bottom hinge gate)

USACE Response: Noted.

Comment 2: The City of Goldsboro's main interest with any proposed modifications to its Little River dam is to preserve its ability to always maintain a viable emergency back-up water supply for the City, though it is supportive of improving fish passage if possible.

USACE Response: Noted.

Comment 3: On November 17, 2011, these five alternatives from the study were discussed at a meeting with representatives from the City of Goldsboro, American Rivers, North Carolina Wildlife Resources Commission, US Fish and Wildlife Services, NOAA National Marine Fisheries Service, and the NC State University. For the past couple of years, NC State University researchers conducted a fish passage study through the Little River dam using a microchip fish counting method. They gave a presentation at the meeting and showed that the current fish passage through the dam was 74% to 77% for American Shad, 82% for Gizzard Shad, and 72% to 75% for Flathead Catfish.

USACE Response: Noted.

Comment 4: Alternative 2b- Lower abutments and install rock ramp was the selected alternative chosen by the City of Goldsboro because it would not compromise the city's ability to provide an emergency backup water supply and it should improve fish passage.

USACE Response: The USACE understands from earlier discussions with the City of Goldsboro that any modification of the existing low head dam on the Little River must not jeopardize the upstream secondary water intake. The USACE agrees that a rock ramp would not adversely impact the City's upstream secondary water intake and improve fish passage over this obstruction.

Comment 5: The fish experts, US Fish and Wildlife Services, NC Wildlife Resources Commission, and NOAA National Marine Fisheries Services, and the NC State University, at the November 17, 2012 meeting could not predict the percent improvement of fish passage at the dam with Alternative 2b, but felt that there would be some improvement with the addition of the rock ramp. It is expected that this fish rock ramp project will move forward for construction.

USACE Response: Noted. The USACE will continue to coordinate this action with the City of Goldsboro and the fisheries experts discussed above.

A.11 American Rivers. Letter dated January 20, 2012.

Comment 1: Please accept these comments from American Rivers in regard to the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (herein referred to as "Corps Report") dated October 2011. For the last year, American Rivers has been directly engaged on a project involving one of the four components of the Tentatively Selected Plan (TSP) outlined in this document, "Modification of the Low-Head Dam on the Little River."

USACE Response: Noted.

ATTACHMENT B

LETTERS, EMAILS, AND MEMORANDA RECEIVED DURING THE EA COMMENT PERIOD

On November 30, 2011, the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011 was mailed to federal and state agencies and the interested public for a 30-day review and comment period. Letters, emails, and memoranda on the EA (Attachment B) were received from the following:

Federal Agencies

• US Department of Interior, Fish and Wildlife Service

• US Department of Commerce, NOAA, National Marine Fisheries Service

State Agencies

• NC Department of Administration, State Clearinghouse (Note: This agency is responsible for coordinating North Carolina's review of Federal environmental documents and responding to appropriate Federal officials on behalf of North Carolina)

• NC Department of Environment and Natural Resources, Division of Water Quality

• NC Department of Environment and Natural Resources, Public Water Supply Section

• NC Department of Environment and Natural Resources, Division of Coastal Management

• NC Department of Public Safety, Emergency Management

• NC Wildlife Resources Commission

• NC Department of Cultural Resources, State Historic Preservation Office

Local Communities

• City of Goldsboro

Elected Officials

• No Comments Received

Conservation Groups

• American Rivers

Interested Businesses, Groups, and Individuals

• No Comments Received

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

January 19, 2012

Mr. Hugh Heine
U.S. Army Corps of Engineers, Wilmington District
69 Darlington Avenue
Wilmington, North Carolina 28403

Reference: U.S. Fish and Wildlife Service Final Fish and Wildlife Coordination Act Report for the *Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment*, dated October 2011.

Dear Mr. Heine:

The U.S. Fish and Wildlife Service (FWS) has reviewed the *Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment*, dated October 2011. This letter constitutes the FWS Final Fish and Wildlife Coordination Act Report for the *Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment*, dated October 2011. The comments in this letter provide information in accordance with provisions of the National Environmental Policy Act of 1969 (42 U.S.C 4321-4347, January 1, as amended 1975 and 1994), Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543), Fish and Wildlife Coordination Act (16 U.S.C. 661-667e., March 10, 1934, as amended 1946, 1958, 1978, and 1995).

FWS appreciates the opportunity to review this draft; we believe that it represents a significant step forward in determining important environmental restoration work that needs to be accomplished in the Neuse Basin and that it will make a substantial improvement to the ecology of the Neuse Basin when the work is implemented. A few specific comments and recommendations follow.

I. **Modification of the Low-head Dam on the Little River**

- Significant discussion and work has been performed at this site by American Rivers (this information will be made available for your use).
- Goldsboro is willing to have rock fish passage constructed at the dam but is currently unwilling to remove it due to loss of water storage if the dam is removed.
- If the dam is not removed the next best option is Measure B- Build Rock Ramp. If that option is employed, it is very important to incorporate a low flow feature that allows

adequate water depth and appropriate velocities at low flow to allow fish passage. FWS suggests including FWS, NMFS, NCWRC, NCDMF, and Dr. Joe Hightower and Joshua Raabe (Ph.D. candidate) in design discussions.

- FWS suggests that the COE look at the sheet pile dam on the Neuse River Cutoff to see if raising the functional dam height would improve water availability at low flow at Goldsboro's primary intake and if placing rocks downstream of the structure would allow fish to pass the structure at low flow. It may be possible to raise the functional height of the sheet pile weir with rocks without having to raise any sheet pile. If so that would be preferred as the addition of rocks would improve the local habitat as well as possibly improving the water intake's effectiveness.

- This project is very timely, will benefit both migratory fish and the overall ecology of the Little River which is host to a number of rare and threatened species. For those reasons plus the fact that a good bit of progress has already been made the FWS puts this project at the top of the list for implementation.

2. **Kinston East Wetland Complex**

- Under measure B. Plant Vegetation FWS suggests that planting include bald cypress, black gum, mast producing oaks and if site hydrology and soils are conducive some Atlantic white cedar. FWS suggest 10 x 10 foot plant spacing except for the Atlantic white cedar which is better planted at a 6 x 8 or 7 x 7 spacing. The 10 x 10 spacing will allow room for volunteer plants which will create a more varied forest and natural setting. If a local forester suggests other plant spacing we will defer to more site specific plant recommendations if they are based on soils and hydrology. Both bald cypress and Atlantic white cedar are plants of high interest to the FWS because like longleaf pine they once covered large acreages in NC with associated wildlife benefits and those forests are mostly removed from the landscape. Mast producing oaks and black gum provide important forage for wildlife and bird species and are an important aspect to healthy riparian wetlands in the Neuse River Basin.

3. **Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creeks** FWS recommends the sill be designed so that it has a natural appearance as well as protecting the shoreline. In order to do so it could be:

- built with curves instead of straight lines,
- built with varying heights and distance offshore, and be
- built with a variety of stone sizes and materials (marl and granite) which would provide a variety of habitats for aquatic fauna.

4. **Constructing New Oyster Reef Habitat**

- Oysters are a keystone species in North Carolina estuaries. FWS suggests carefully looking at alternative designs or technique that maintain site heterogeneity, avoidance of SAV impacts and provide good oyster production in a cost effective manner.

FWS concurs with the COE determinations on pages 196 thru 200 of the plan in regards to potential effects on Federally listed threatened or endangered species. These were no effect for Michaux's sumac, rough-leaved loosestrife, seabeach amaranth, and sensitive jointvetch. FWS also concurs with your determination that actions performed as described in the Tentatively Selected Plan (TSP) that dwarfwedge mussel, tar spinymussel, sea turtles, West Indian manatee may be affected but are not likely to be adversely affected. Please keep us informed as the TSP moves toward implementation. If your project description changes you should reinitiate consultation and we reserve the right to re-evaluate your determinations. You will need to consult with NMFS on shortnose sturgeon. FWS appreciates the COE's selection of projects that will benefit migratory fish, rare and threatened species in the Little River, neotropical migratory birds at the Kinston Wetland Complex, protection of important natural areas at Gun Thicket and Cedar Creeks, and restoration of keystone estuarine community at newly constructed oyster reef habitat.

In summary FWS strongly supports the actions described in the TSP and appreciates your inclusion of our earlier suggestions. Please let us know how we can support the implementation of the described projects or help in any way. Should you have any specific questions regarding this letter please contact Mike Wicker (919-856-4520 ext. 22 or mike_wicker@fws.gov). Also feel free to contact me with questions of a more general nature at (919-856-4520 ext.11 or pete_benjamin@fws.gov).

Sincerely,

Pete Benjamin
Ecological Services Field Supervisor

Heine, Hugh SAW

From: Ron Sechler [ron.sechler@noaa.gov]
Sent: Friday, January 27, 2012 3:09 PM
To: Heine, Hugh SAW
Cc: smtp-Sechler, Ron; Pace Wilber; Robin Wiebler
Subject: Re: FW: Neuse River Feasibility Study (UNCLASSIFIED)

Hugh,
The National Marine Fisheries Service (NMFS) has reviewed the Neuse River Basin Draft Integrated Feasibility Report (IFR) and Environmental Assessment (EA), North Carolina (NC), dated October 11, 2011. This study was prepared in response to the Congressional Resolution which requested recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin. The plan was developed in partnership with the NC Division of Water Resources and encompassed a total of 6,234 square miles the third largest river basin in NC.

Based on our review, we support the findings of this Study and the tentative Selected Plan (National Ecosystem Restoration Plan) which was determined to have the greatest net benefits to the Neuse River Basin in North Carolina. Several components of the select plan would benefit NMFS trust resources including essential fish habitat(EFH) for federally managed species for which we share trust responsibilities.

We are especially pleased with the inclusion of Modification of the Low-Head Dam on Little River, Restoration of the Estuarine Wetlands at Gum Thicket and Cedar Creek and Neuse River Estuary Oyster Reef Restoration in the overall project plans and look forward to working with the Corps of Engineers, Wilmington District in developing the details of these projects.

Thank you for the opportunity to provide comments. The NMFS looks forward to working with the Wilmington District, Corps of Engineers in developing the details of the Neuse River Basin Plan.
Regards,

Ron Sechler

NOAA, National Marine Fisheries Service

Habitat Conservation Division

101 Pivers Island Road

Beaufort, North Carolina 28516

Phone: 252-728-5090

Fax: 252-728-8728

Email: ron.sechler@noaa.gov

On Fri, Jan 27, 2012 at 2:06 PM, Heine, Hugh SAW <Hugh.Heine@usace.army.mil> wrote:

Classification: UNCLASSIFIED
Caveats: NONE

-----Original Message-----
From: Heine, Hugh SAW
Sent: Friday, January 27, 2012 8:10 AM
To: 'ron.sechler@noaa.gov'
Subject: FW: Neuse River Feasibility Study (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Ron,

Enclosed is the transmittal letter. You can review the document at the USACE web site:

http://www.saw.usace.army.mil/Neuse-River/DRAFT%20Neuse_Main_Report.pdf

Thanks.

-----Original Message-----
From: Heine, Hugh SAW
Sent: Friday, January 20, 2012 7:46 AM
To: 'ron.sechler@noaa.gov'
Subject: Neuse River Feasibility Study (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Ron,

See enclosed letter. Please provide comments regarding EFH and T&E species. Thanks.

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

Classification: UNCLASSIFIED
Caveats: NONE

North Carolina
Department of Administration

Beverly Eaves Perdue, Governor | Moses Carey, Jr., Secretary

January 27, 2012

Mr. Hugh Heine
Dept. of the Army/Corps of Engineers
Environmental Resources Section
P.O. Box 1890
Wilmington, NC 28402-1890

Re: SCH File # 12-E-0000-0146; EA; The Neuse River Basin Draft Integrated Feasibility Report and EA recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin.

Dear Mr. Heine:

The above referenced environmental impact information has been submitted to the State Clearinghouse under the provisions of the National Environmental Policy Act. According to G.S. 113A-10, when a state agency is required to prepare an environmental document under the provisions of federal law, the environmental document meets the provisions of the State Environmental Policy Act. Attached to this letter for your consideration are the comments made by agencies in the course of this review.

If any further environmental review documents are prepared for this project, they should be forwarded to this office for intergovernmental review.

Should you have any questions, please do not hesitate to call.

Sincerely,

William E. H. Creech

Attachments

cc: Region J
Region P

Mailing Address:
1301 Mail Service Center
Raleigh, NC 27699-1301

Telephone: (919)807-2425
Fax (919)733-9571
State Courier #51-01-00
e-mail state.clearinghouse@doa.nc.gov

Location Address:
116 West Jones Street
Raleigh, North Carolina

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NCDENR

North Carolina Department of Environment and Natural Resources

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

MEMORANDUM

TO: Zeke Creech
State Clearinghouse

FROM: Melba McGee
Environmental Review Coordinator

RE: 12-0146 Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, Wake, Durham, Johnston, Carteret and Lenoir County

DATE: January 25, 2012

The department has reviewed the proposed project. The applicant is asked to consider the attached comments prior to finalizing project plans. If additional information is needed, please notify our commenting agencies directly.

Thank you for the opportunity to respond.

Attachments

1601 Mail Service Center, Raleigh, North Carolina 27699-1601
Phone: 919-707-8600 \ Internet: http://portal.ncdenr.org

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7

NCDENR

North Carolina Department of Environment and Natural Resources

Division of Coastal Management

Beverly Eaves Perdue Governor	Braxton C. Davis Director	Dee Freeman Secretary

January 12, 2012

Melba McGee
Environmental Coordinator
Office of Legislative & Intergovernmental Affairs
Department of Environment and Natural Resources
1601 Mail Service Center
Raleigh, NC 27699-1601

SUBJECT: Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment for the Neuse River Basin, North Carolina (SCH#12-0146, and DCM#20110183)

Dear Ms. McGee:

Thank you for the opportunity to review the "*Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment*" (EA, October 2011) that was prepared by the US Army Corps of Engineers (Corps). This document has been prepared by the Corps to offer recommendations concerning flood control, environmental protection, and restoration of the Neuse River Basin. The purpose of this review by the North Carolina Division of Coastal Management (DCM) is to review the adequacy of the environmental analysis contained in the draft EA.

- The major theme behind the Neuse River Basin Draft Integrated Feasibility Report is ecosystem restoration and flood risk management. To promote ecosystem enhancement the EA has identified numerous opportunities for restoring a variety of resources such as mussel populations, fish populations, oyster populations, and wetlands. The specifics of the "*Tentatively Selected Plan*" are described in Chapter 7 of the EA.

  The EA also refer to the implementation of various management measures, such as retrofitting stormwater outfalls and upland storm water detention basins as a undertakings for improving water quality. These measures have been identified as being the under the initiative and control of various municipalities. The treatment of stormwater runoff to enhance water quality of the Neuse River will be an important aspect to the success of the projects identified in Chapter 7 of the EA.

  From the perspective of furthering a complete integrated management approach for improving the environmental health of the Neuse River Basin; treating water before it enters the Neuse River would seem to be a major objective. As indicated in the EA, the effort to improve water quality before it enters the Neuse River principally belongs to the local municipalities. Nevertheless, we would encourage the Corps to coordinate with the local municipalities to identify and prioritize treatment opportunities that can be incorporated into the project list contained in Chapter 7 of the EA.

400 Commerce Ave., Morehead City, NC 28557-3421
Phone: 252-808-2808 \ FAX: 252-247-3330 Internet: www.nccoastalmanagement.net
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One NorthCarolina *Naturally*

- Proposed Project Description: Gum Thicket/Cedar Creek rock sill[1] proposal could have navigational impacts and the details of the proposal should be reviewed for consistency with CAMA and the Dredge and Fill Act

- Proposed Project Description: Gum Thicket/Cedar Creek sill will impact shallow bottom and possibly critical habitat areas (i.e. SAVs and shellfish). Any critical habitat areas should be identified and quantified.

- Proposed Project Description: The lower Neuse River Oyster Growing Area[2] proposal should be consistent with the CAMA and the Dredge and Fill Act.

- Feasibility: Please discuss the USACE's success rates and results with similar restoration efforts in the past.

- Accountability: Please discuss the USACE's response and actions if these projects fail.

- Invasive Species: Does the Neuse River Basin have an invasive species concern? According to the "*Neuse Water Resources Plan*" (July 2010): "*The worst noxious aquatic weed that infests the Neuse River Basin is Hydrilla verticillata, commonly referred to as hydrilla*". The EA does not examine whether invasive species would constitute a significant concern. If so, would there be opportunities to include (in Chapter 7 of the EA) projects that would reduce the presence of invasive species.[3] We suggest that the EA incorporate a discussion concerning invasive species.

- Section 8.7.7 briefly reviews the Federal "*Coastal Zone Management Act*" and its relationship to North Carolina's coastal area management program. This section needs to be expanded to enhance the reader's understanding of the consistency review process. First, not all the counties within the Neuse River Basin are within North Carolina's coastal area. Second, that any Federal activity that could affect any coastal use or coastal resource within North Carolina's coastal area would be subject to consistency review even if located outside of North Carolina's coastal area.

- Section 1.8 lists the "*Study Process and Participants*". The North Carolina Wildlife Resources Commission (NCWRC) is not listed. Based on other sections of the EA, coordination with the NCWRC has been undertaken.

- The abbreviation "*TSP*" for "*Tentatively Select Plan*" and the abbreviation "*CZMA*" for "*Coastal Zone Management Act*" are missing from the list of "*Acronyms and Abbreviations*".

Thank you for your consideration of the North Carolina Coastal Management Program.

Sincerely,

Stephen Rynas, AICP
Federal Consistency Coordinator

cc: Doug Huggett, Division of Coastal Management
Roy Brownlow, Division of Coastal Management
Brad Connell, Division of Coastal Management

---

1 Note: A similar Gum Thicket/Cedar Creek rip rap revetment proposal has been discussed with the DCM by the current property owners.
2 Note: The NCDMF has a CAMA Major Permit to construct the lower Neuse River Oyster Reef Sanctuary. This project is currently underway.
3 Table 4-3 notes the presence of invasive vegetation at Yates Mill Run Borrow Pit and that it is not being carried forward.

Department of Environment and Natural Resources

Reviewing Office: Rd. Reg. Envir.

INTERGOVERNMENTAL REVIEW - PROJECT COMMENTS

Project Number: 12-0146 Due Date: ______

After review of this project it has been determined that the ENR permit(s) and/or approvals indicated may need to be obtained in order for this project to comply with North Carolina Law. Questions regarding these permits should be addressed to the Regional Office indicated on the reverse of the form. All applications, information and guidelines relative to these plans and permits are available from the same Regional Office.

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
	Permit to construct & operate wastewater treatment facilities, sewer system extensions & sewer systems not discharging into state surface waters	Application 90 days before begin construction or award of construction contracts. On-site inspection. Post-application technical conference usual	30 days (90 days)
	NPDES - permit to discharge into surface water and/or permit to operate and construct wastewater facilities discharging into state surface waters	Application 180 days before begin activity. On-site inspection. Pre-application conference usual. Additionally, obtain permit to construct wastewater treatment facility-granted after NPDES. Reply time, 30 days after receipt of plans or issue of NPDES permit-whichever is later.	90-120 days (N/A)
	Water Use Permit	Pre-application technical conference usually necessary	30 days (N/A)
	Well Construction Permit	Complete application must be received and permit issued prior to the installation of a well	7 days (15 days)
✓	Dredge and Fill Permit	Application copy must be served on each adjacent riparian property owner. On-site inspection. Pre-application conference usual. Filling may require Easement to Fill from N.C. Department of Administration and Federal Dredge and Fill Permit	55 days (90 days)
	Permit to construct & operate Air Pollution Abatement facilities and/or Emission Sources as per 15 A NCAC (2Q.0100 thru 2Q.0300)	Application must be submitted and permit received prior to construction and operation of the source. If a permit is required in an area without local zoning, then there are additional requirements and timelines (2Q.0113).	90 days
	Permit to construct & operate Transportation Facility as per 15 A NCAC (2D.0800, 2Q.0601)	Application must be submitted at least 90 days prior to construction or modification of the source.	90 days
	Any open burning associated with subject proposal must be in compliance with 15 A NCAC 2D.1900	N/A	60 days (90 days)
	Demolition or renovations of structures containing asbestos material must be in compliance with 15 A NCAC 20.1110 (a) (1) which requires notification and removal prior to demolition. Contact Asbestos Control Group 919-707-5950		
	Complex Source Permit required under 15 A NCAC 2D.0800		
X	The Sedimentation Pollution Control Act of 1973 must be properly addressed for any land disturbing activity. An erosion & sedimentation control plan will be required if one or more acres to be disturbed. Plan filed with proper Regional Office (Land Quality Section) At least 30 days before beginning activity. A fee of $65 for the first acre of any part of an acre. An express review option is available with additional fees. APPLIES TO ALL RESTORATION & DAM REMOVAL EFFORTS.		20 days (30 days)
	Sedimentation and erosion control must be addressed in accordance with NCDOT's approved program. Particular attention should be given to design and installation of appropriate perimeter sediment trapping devices as well as stable stormwater conveyances and outlets		(30 days)
	Mining Permit	On-site inspection usual. Surety bond filed with ENR Bond amount varies with type mine and number of acres of affected land. Any are mined greater than one acre must be permitted. The appropriate bond must be received before the permit can be issued	30 days (60 days)
	North Carolina Burning permit	On-site inspection by N.C. Division Forest Resources if permit exceeds 4 days	1 day (N/A)
	Special Ground Clearance Burning Permit - 22 counties in coastal N.C. with organic soils	On-site inspection by N.C. Division Forest Resources required "if more than five acres of ground clearing activities are involved. Inspections should be requested at least ten days before actual burn is planned."	1 day (N/A)
	Oil Refining Facilities	N/A	90-120 days (N/A)
	Dam Safety Permit	If permit required, application 60 days before begin construction. Applicant must hire N.C. qualified engineer to: prepare plans, inspect construction, certify construction is according to ENR approved plans. May also require permit under mosquito control program. And a 404 permit from Corps of Engineers. An inspection of site is necessary to verify Hazard Classification. A minimum fee of $200.00 must accompany the application. An additional processing fee based on a percentage of the total project cost will be required upon completion.	30 days (60 days)

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
[ ]	Permit to drill exploratory oil or gas well	File surety bond of $5,000 with ENR running to State of NC conditional that any well opened by drill operator shall, upon abandonment, be plugged according to ENR rules and regulations.	10 days N/A
[ ]	Geophysical Exploration Permit	Application filed with ENR at least 10 days prior to issue of permit. Application by letter. No standard application form.	10 days N/A
[ ]	State Lakes Construction Permit	Application fees based on structure size is charged. Must include descriptions & drawings of structure & proof of ownership of riparian property.	15-20 days N/A
[✓]	401 Water Quality Certification	N/A	60 days (130 days)
[ ]	CAMA Permit for MAJOR development	$250.00 fee must accompany application	55 days (150 days)
[ ]	CAMA Permit for MINOR development	$50.00 fee must accompany application	22 days (25 days)
[ ]	Several geodetic monuments are located in or near the project area. If any monument needs to be moved or destroyed, please notify: N C. Geodetic Survey, Box 27687 Raleigh, NC 27611		
[ ]	Abandonment of any wells, if required must be in accordance with Title 15A. Subchapter 2C 0100.		
[ ]	Notification of the proper regional office is requested if "orphan" underground storage tanks (USTS) are discovered during any excavation operation.		
[ ]	Compliance with 15A NCAC 2H 1000 (Coastal Stormwater Rules) is required.		45 days (N/A)
[✓]	Tar Pamlico or Neuse Riparian Buffer Rules required.		

* Other comments (attach additional pages as necessary, being certain to cite comment authority)

Multi. County Project

REGIONAL OFFICES

Questions regarding these permits should be addressed to the Regional Office marked below.

☐ **Asheville Regional Office**
2090 US Highway 70
Swannanoa, NC 28778
(828) 296-4500

☐ **Fayetteville Regional Office**
225 North Green Street, Suite 714
Fayetteville, NC 28301-5043
(910) 433-3300

☐ **Mooresville Regional Office**
610 East Center Avenue, Suite 301
Mooresville, NC 28115
(704) 663-1699

☒ **Raleigh Regional Office**
3800 Barrett Drive, Suite 101
Raleigh, NC 27609
(919) 791-4200

☒ **Washington Regional Office**
943 Washington Square Mall
Washington, NC 27889
(252) 946-6481

☒ **Wilmington Regional Office**
127 Cardinal Drive Extension
Wilmington, NC 28405
(910) 796-7215

☐ **Winston-Salem Regional Office**
585 Waughtown Street
Winston-Salem, NC 27107
(336) 771-5000

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NCDENR
North Carolina Department of Environment and Natural Resources
Division of Water Quality

Beverly Eaves Perdue Governor	Charles Wakild, P. E. Director	Dee Freeman Secretary

MEMO

To: Melba McGee, Environmental Coordinator, Office of Legislative and Intergovernmental Affairs

Through: Al Hodge, Supervisor, Surface Water Protection

From: Anthony Scarbraugh, Environmental Specialist

Subject: **Comments on Review of Environmental Assessment (EA) – The Neuse River Basin Draft Integrated Feasibility Report and EA recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin.**

Date: January 11, 2012

The following comments by the Division of Water Quality are in response to the review of the Neuse River Basin Draft Integrated Feasibility Report and EA recommendations for projects known as Kinston East Complex Site, Low-head dam on the Little River, Gum Thicket and Cedar Creeks Restoration Opportunity Area and Oyster Growing restoration at Mid-River and North Shores site. This Office has reviewed the proposed projects as summarized below and submits the following comments.

Kinston East Complex Site:
The proposed project is to restore hydrologic connectivity of a former 14.5 acres bottomland hardwood forest by removal of fill material followed by planting of grasses to stabilize the site. The proposed project is to utilize natural regeneration of seedling from the adjacent bottomland hardwood forest to reestablish native species.

Upon review of the subject project, this Office has the following comments:

- This Office recommends the planting of appropriate native bottomland hardwood seedlings at a standard planting density as recommended in Measure B. It is the opinion of this Office that natural regeneration of bottomland hardwood species from the adjacent areas will not be sufficiently restore the wetland area.
- Diesel fuel, fuel oil, and/or gasoline should not be used as a release agent on any mechanical equipment.
- All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials.
- Sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024]; see NCDOT publication, Best Management Practices for the Protection of Surface Waters (March 1997).
- The outside buffer, wetland or water boundary and along the construction corridor within these boundaries shall be clearly marked with orange warning fencing (or similar high visibility material) for the areas that have been approved to infringe within the buffer, wetland or water prior to any land disturbing.

North Carolina Division of Water Quality
943 Washington Square Mall
Washington, NC 27889
Internet: www.ncwaterquality.org
Phone: 252-946-6481
FAX 252-946-9215

Low-head dam on the Little River:
The proposed project to restore aquatic habitat connectivity by removing a 20 ft section of the existing 100 ft-wide, 4 ft-high concrete dam and installation of water control structure in order to provide sufficient water depth for the operation of the water treatment plant intake structure during the low flow periods in the summer .

Upon review of the subject project, this Office has the following comments:

- All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials.
- Sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024]; see NCDOT publication, Best Management Practices for the Protection of Surface Waters (March 1997).

Gum Thicket and Cedar Creek Restoration Opportunity Area:
The proposed project is to construct parallel rock sills approximately 3,500 foot-long at Gum Thicket Creek and 5,200 long at Cedar Creek at a distance of 60 feet offshore. In addition, the proposed project is to construct a high marsh buffer by filling 30 feet waterward of the existing scrap and planting with Spartina species.

Upon review of the subject project, this Office has the following comments:

- The proposed project should account for presence of submerged aquatic vegetation (SAV) and shellfish resource.
- The proposed project should also account for sediment transport within the project area that may possible create non-wetland conditions landward of the existing sill alignment due to sedimentation.
- The proposed project should also consider modification of the proposed design to minimize impacts to waters.
- Diesel fuel, fuel oil, and/or gasoline should not be used as a release agent on any mechanical equipment.
- All mechanized equipment operated near surface waters should be regularly inspected and maintained to prevent contamination of waters from fuels, lubricants, hydraulic fluids, or other toxic materials.
- If any landward activities are conducted the appropriate sediment and erosion control measures shall adhere to the design standards for sensitive watersheds [15A NCAC 4B .0024]; see NCDOT publication, Best Management Practices for the Protection of Surface Waters (March 1997)
- This Office recommends the proposed project design consider orienting the alignment of the sills along waterward contour of the shorelines and utilize offset every 200 feet along the rock sill in lieu of steep downs to promote increased aquatic passage.

Oyster Growing restoration at Mid-River and North Shores Site:
The proposed project is to construct two 40-acre new deepwater reefs by utilizing granite material located in middle of Neuse River and Neuse North Shores Site.

Upon review of the subject project, this Office has the following comments:

- If reuse and/or recycled concrete are used for construction, the material must be free from loose dirt, fine particulate material and any petroleum pollutants. The concrete shall not have any exposed wire or rebar. Concrete shall not have been used as bridge decking, roadway surface, or holdings tanks for chemical pollutants.

If you should have any questions or require additional information you may e-mail me at anthony.scarbraugh@ncdenr.gov or contact me by phone at 252-948-3924.

NCDENR

North Carolina Department of Environment and Natural Resources

Division of Water Quality

Beverly Eaves Perdue Governor	Charles Wakild, P. E. Director	Dee Freeman Secretary

TO: **Melba McGee, Environmental Coordinator**

FROM: **Joanne Steenhuis, Senior Environmental Specialist** JHS

THROUGH: **James H. Gregson, Surface Water Protection Regional Supervisor** JHG

DATE: **January 10, 2012**

SUBJECT: **Environmental Assessment – The Neuse River Basin Draft Integrated Feasibility Report and EA recommendations regarding flood control (flood risk management), environmental protection and restoration, and related purposes for the Neuse River Basin.**

Project No. **12-0146**

COUNTY: **Carteret County**

The Wilmington Regional Office has reviewed the environmental assessment for the Neuse River Basin draft integrated feasibility report. The Division of Water Quality (DWQ) has the following comments:

1) Any proposed impacts to wetlands or waters will require a 401 certification, including the restoration efforts proposed;
2) The DWQ supports any efforts in improving the water quality in the Neuse River Basin.

Thank you for the opportunity to comment.

WiRO

1617 Mail Service Center, Raleigh, North Carolina 27699-1617
Location: 512 N. Salisbury St. Raleigh, North Carolina 27604
Phone: 919-807-6300 \ FAX: 919-807-6492
Internet: www.ncwaterquality.org

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DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
PUBLIC WATER SUPPLY SECTION

Project Number **12-0145**
County **Lenoir, Carteret, Wake, Durham, Johnston**

Inter-Agency Project Review Response

Project Name **Neuse River Basin**

Type of Project **EA - Neuse River Basin Draft Integrated Feasibility Report & EA recommendations regarding flood control (flood risk mgmt), environmental protection & restoration, related purposes for Neuse River Basin**

☐ The applicant should be advised that plans and specifications for all water system improvements must be approved by the Division of Water Resources/Public Water Supply Section prior to the award of a contract or the initiation of construction (as required by 15A NCAC 18C .0300et. seq.). For information, contact the Public Water Supply Section, (919) 733-2321.

☐ This project will be classified as a non-community public water supply and must comply with state and federal drinking water monitoring requirements. For more information the applicant should contact the Public Water Supply Section, (919) 733-2321.

☐ If existing water lines will be relocated during the construction, plans for the water line relocation must be submitted to the Division of Water Resources, Public Water Supply Section, Technical Services Branch, 1634 Mail Service Center, Raleigh, North Carolina 27699-1634, (919) 733-2321.

☒ For Regional and Central Office comments, see the reverse side of this form.

Jim McRight	PWSS	12/21/2011
Review Coordinator	Section/Branch	Date

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DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WATER RESOURCES
PUBLIC WATER SUPPLY SECTION
Inter-Agency Project Review Response

Project Number **12-0146**

County **Lenoir, Carteret, Wake, Durham, Johnston**

Project Name Neuse River Basin

Type of Project EA - Neuse River Basin Draft Integrated Feasibility Report & EA recommendations regarding flood control (flood risk mgmt), environmental protection & restoration, related purposes for Neuse River Basin

Comments provided by:

☐ Regional Program Person

☒ Regional Supervisor for Public Water Supply Section

☐ Central Office program person

Name Michael Douglas-Raleigh RO Date: 12/12/2011

Telephone number: 919-791-4200

Program within Division of Water Resources:

☒ Public Water Supply

☐ Other, Name of Program

Response (check all applicable):

☐ No objection to project as proposed

☐ No comment

☐ Insufficient information to complete review

☐ Comments attached

☒ See comments below

The Draft Integrated Feasibility Report & EA for the Neuse River Basin focus on water quality improvements and flood control. There is very little discussion on public water supply in the report. However, water quality improvements could be beneficial to surface water treatment plants that withdraw drinking water supply from the Neuse River.

Return to:
Public Water Supply Section
Environmental Review Coordinator for the
Division of Water Resources

16

Project Number
12-0146
County:
Lenoir, Carteret, Wake, Durham, Johnston

DEPARTMENT OF ENVIRONMENT AND
NATURAL RESOURCES
DIVISION OF WATER RESOURCES
PUBLIC WATER SUPPLY SECTION

Inter-Agency Project Review Response

Project Name: Neuse River Basin Type of Project: EA -- Neuse River Basin Draft Intergrated Feasibility Report & EA recommendations regarding flood control (flood risk mgnt), environmental protection & restoration, related purposes for the Neuse

Comments provided by:

- [ ] Regional Program Person
- [x] Regional Supervisor for Public Water Supply Section
- [ ] Central Office program person

Name: Joey White Telephone #: (252) 948-3894 Date Rec'd: 12/23/11
Date Rev'd: 01/10/12

Program within Division of Environmental Health:

- [x] Public Water Supply
- [ ] Other, Name of Program ____________________

Response (check all applicable):

- [x] No objection to project as proposed
- [ ] No comment
- [ ] Insufficient information to complete review
- [ ] Comments attached
- [x] See comments below

- Water quality improvements could be beneficial to surface water treatment plants that withdraw drinking water supply from the Neuse River.

Return to
Public Water Supply Section
Environmental Review Coordinator
for the Division of Environmental Health

17

North Carolina Wildlife Resources Commission

Gordon S. Myers, Executive Director

MEMORANDUM

TO: Melba McGee, Environmental Coordinator
Office of Legislative and Intergovernmental Affairs
North Carolina Department of Environment and Natural Resources

FROM: Maria Dunn, Northeast Coastal Region Coordinator
Habitat Conservation Program

DATE: January 26, 2012

SUBJECT: Comments on the Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment, Wake, Durham, Johnston, Lenoir, and Carteret Counties, North Carolina.
OLIA No. 12-0146

Biologists with the North Carolina Wildlife Resources Commission (NCWRC) reviewed the EA with regard to impacts of the project on fish and wildlife resources. Our comments are provided in accordance with the North Carolina Environmental Policy Act (G.S. 113A-1 et seq., as amended; 1 NCAC-25), provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), the Coastal Area Management Act (G.S. 113A-100 through 113A-128), and Sections 401 and 404 of the Clean Water Act (as amended).

The United States Army Corps of Engineers (USACE) has submitted an EA regarding the Neuse River Basin and proposed recommendations regarding environmental protection and restoration. Several projects were reviewed taking into consideration environmental benefits, success, costs, and need. As a result the USACE has selected Alternative G – Modified as their preferred National Ecosystem Restoration Plan (NERP). This plan includes the following projects within the Neuse Basin: Gum Thicket and Cedar Creek Alternative, Kinston East Wetland Restoration Alternative, Low-head Dam on the Little River Alternative, and Oyster Reef Restoration Alternative. The NCWRC has reviewed the descriptions of the projects within this plan and has the following comments.

__Section 2.3.2.1 Aquatic Resources__

In the discussion about the aquatic resources within the Neuse River, there was no mention of the inland primary nursery areas or anadromous fish spawning areas. Information about descriptive boundaries for inland primary nursery areas can be found under 15A NCAC 10C .0503 as boundaries for anadromous

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

fish spawning areas can be found under 15A NCAC 03R .0115. Please feel free to contact the NCWRC for more information about sampling and other programs we have along the Neuse River in regards to aquatic resources.

Section 2.3.2.2 Fauna

The document provides a thorough discussion about the listed species that occur within the Neuse Basin, but does not include a discussion of the non-listed species in the area, game or non-game species. The NCWRC recommends that the USACE provide more discussion about the public game lands that are within the area and other areas that have been protected for fauna in the Neuse River Basin. Locations of our game lands can be found on our website: www.ncwildlife.org. Additionally, please feel free to contact the NCWRC if you need more information about game and non-game species that occur in the area and projects that are occurring to monitor them.

Gum Thicket and Cedar Creek Alternative

This project includes the construction of a marsh sill to protect a significant area of marsh that has exhibited signs of erosion. The proposal includes a 3,500' sill in the Gum Thicket area and a 5,200' sill in the Cedar Creek area. These sills are proposed to be approximately 60' offshore with a base width of 30' and a top width of 3.5' that extends 2' above Mean High Water (MHW). Openings are proposed every 100' to allow water to flow behind the sill. *Spartina* is proposed to be planted landward the sill to enhance coastal marsh. Approximately 18 acres of habitat will be impacted with this design proposal.

We have reviewed the project description and agree that a marsh sill will help stabilize the coastal marsh and shoreline landward the structure. However, we are concerned with the proposed size of the sill and the area of impact. In general, the NCWRC believes marsh sills should be constructed to protect and enhance a shoreline without armoring it completely. Sills should be located outside of important habitat areas, such as submerged aquatic vegetation (SAV), be relatively close to shore, and have a base width that creates a 2:1 slope for a structure that is 1' above NWL or NHW, whichever is the appropriate measurement for that body of water. Therefore, we recommend a reduction in the size of the structure to minimize impacts to shallow water habitats and public trust use. The sill should be placed closer to shore, have a more narrow bottom width, a more narrow top width, and not emerge as high above NHW. We recommend that the USACE look at several opening types for the 100' intervals, including overlaps and dropdowns. In addition to the requested structure design change, information should be provided regarding the planting of *Spartina*. This should include whether fill will be used landward the sill structure to achieve an appropriate substrate level, the types of plantings to be used, time of planting, and monitoring.

Little River Dam Removal

The USACE is proposing to improve anadromous fish and mussel populations improving fish passage at the low head dam at the City of Goldsboro's secondary water intake. Three measures are outlined in the document: to build a dam gate, construct a rock ramp or to remove the dam. The NCWRC supports projects that improve fish passage along the Neuse River and request that the USACE consult with our anadromous fish biologist, Bennett Wynne when these measures are further discussed. When evaluating the preferred measure, the USACE should consider the moratorium NCWRC has on in-water work that runs from 15 February until 30 September.

Neuse River Oyster Growing Area Alternative
This portion of the plan includes constructing deep water reefs to help restore oyster habitat and address projected habitat loss. Several potential sites were examined for their sanctuary potential and methods of construction and management were gleaned from existing state programs and successes.

The NCWRC supports oyster habitat restoration and encourages the USACE to consult with the NC Division of Marine Fisheries and the National Marine Fisheries Service to determine appropriate locations and construction designs for success. We have minimal concerns regarding resource impacts as long as important habitat areas are avoided and the structures to not impose a threat to navigation or significantly impact public trust use.

We appreciate the opportunity to provide comments on this feasibility report and EA. If you need further assistance or additional information, please contact me at (252) 948-3916.

Neuse River SA, HQW, NSW.
SA, HQW, NSW.
SA, HQW, NSW waters Gum Thicket

North Carolina Department of Public Safety

Emergency Management

Beverly Eaves Perdue, Governor
Reuben F. Young, Secretary

H. Douglas Hoell, Jr., Director

January 11, 2012

JAN 2012
RECEIVED
Secretary's Office
DOA

State Clearinghouse
N.C. Department of Administration
1301 Mail Service Center
Raleigh, North Carolina 27699-1301

Subject: Intergovernmental Review State Number: 12-E-0000-0146
Neuse River Basin Draft Integrated Feasibility Report and EA

As requested by the North Carolina State Clearinghouse, the North Carolina Department of Crime Control and Public Safety Division of Emergency Management Office of Geospatial and Technology Management (GTM) reviewed the draft report listed above and offer the following comments:

1) This study determined there were no significant opportunities for flood risk management projects in the Neuse River Watershed. However, projects recommended for ecosystem restoration may have the unintended result of impacting the flood risk as identified in the community's Flood Insurance Study. The proposed projects are located in a county or community that participates in the National Flood Insurance Program. A floodplain development permit should be obtained by the local floodplain administrator to ensure compliance with their flood damage prevention ordinance and the National Flood Insurance Program.

2) The proposed modification of the low head dam on the Little River should include a hydraulic study to determine if the base flood elevations and/or floodway widths in the effective hydraulic model supporting the Wayne County Flood Insurance Study are impacted. Coordination with the City of Goldsboro's Floodplain Administrator should be made to determine if a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR) is required.

3) The site for the removal of 14.5 acres of fill material at the Kinston East Wetland Complex is located in the floodway of the Neuse River. A hydraulic study to determine if this project will impact the effective Lenoir County Flood Insurance Study should be submitted to the City of Kinston's Floodplain Administrator. A floodway modification or reduction in flood levels may necessitate a Letter of Map Revision.

MAILING ADDRESS:
4719 Mail Service Center
Raleigh NC 27699-4719
www.ncem.org

EMAP Accredited

OFFICE LOCATION:
1812 Tillery Place
Raleigh, NC 27604
Telephone: (919) 715-5711
Fax: (919) 715-0408

4) Federal Executive Order 11988 directs federal agencies to evaluate the potential effects of any action taken in the floodplain and indicate whether the action conforms to applicable state or local floodplain protections standards (Section 2 (a)(3)).

Thank you for your cooperation and consideration. If you have any questions concerning the above comments, please contact John Gerber, P.E., CFM, the NFIP State Coordinator at (919) 715-5711 x106, by email at jgerber@ncem.org or at the address shown on the footer of this letter.

Sincerely,

Kenneth W. Ashe, P.E., CFM
Assistant Director

c: John Gerber, NFIP State Coordinator

NORTH CAROLINA STATE CLEARINGHOUSE
DEPARTMENT OF ADMINISTRATION
INTERGOVERNMENTAL REVIEW

COUNTY: WAKE
CARTERET
DURHAM
JOHNSTON
LENOIR

H07: CONSERVATION OF COASTAL FISH & WILDLIFE HABITATS

DEC 19 2011

STATE NUMBER: 12-E-0000-0145
DATE RECEIVED: 12/14/2011
AGENCY RESPONSE: 01/09/2012
REVIEW CLOSED: 01/13/2012

MS RENEE GLEDHILL-EARLEY
CLEARINGHOUSE COORDINATOR
DEPT OF CULTURAL RESOURCES
STATE HISTORIC PRESERVATION OFFICE
MSC 4617 - ARCHIVES BUILDING
RALEIGH NC

ER 11-1590
See Attached copy of 9/15/11 letter

REVIEW DISTRIBUTION

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DENR LEGISLATIVE AFFAIRS
DEPT OF CULTURAL RESOURCES
DEPT OF TRANSPORTATION
EASTERN CAROLINA COUNCIL
TRIANGLE J COG

PROJECT INFORMATION

APPLICANT: Dept. of the Army/Corps of Engineers
TYPE: National Environmental Policy Act
Environmental Assessment

DESC: The Neuse River Basin Draft Integrated Feasibility Report and EA recommendations regarding flood control (flood risk management), environmental protection and restortation, and related purposes for the Neuse River Basin.

CROSS-REFERENCE NUMBER: 06-E-0000-0316

The attached project has been submitted to the N. C. State Clearinghouse for intergovernmental review. Please review and submit your response by the above indicated date to 1301 Mail Service Center, Raleigh NC 27699-1301.

If additional review time is needed, please contact this office at (919)807-2425.

AS A RESULT OF THIS REVIEW THE FOLLOWING IS SUBMITTED: ☐ NO COMMENT ☒ COMMENTS ATTACHED

SIGNED BY: Renee Gledhill-Earley DATE: 12-23-11

RECEIVED DEC 2011 Secretary's Office DOA

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North Carolina Department of Cultural Resources

State Historic Preservation Office

Ramona M. Bartos, Administrator

Beverly Eaves Perdue, Governor
Linda A. Carlisle, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

September 15, 2011

John Mayer
US Army Corps of Engineers, Wilmington District
69 Darlington Ave.
Wilmington, NC 28403

Re: Neuse River Basin Feasibility Study, Cultural Resources Study Plan, Wayne, Lenoir, and Pamlico Counties, ER 11-1590

Dear Mr. Mayer:

Thank you for your transmittal of August 15, 2011. We have reviewed the Cultural Resources Study Plan for above project and offer the following comments.

Portions of the project are in Wayne and Lenoir counties. The Wayne County project is for the Low Head Dam, Little River near Goldsboro. The plan is to remove a portion of an existing dam to provide a better pathway for fish migration. This project is located at the existing Goldsboro WWTP and will use a two-acre staging area. The dam itself is not a significant feature, and the staging area is previously disturbed. The Lenoir County project calls for restoration of the Kinston West Wetland Complex within highly disturbed portions of the floodplain east of Kinston. No archaeological sites are recorded within the project area. The Wyse Fork Battlefield is about one mile away, across the river. It is unlikely that significant sites will be affected by the restoration activities. We have no comment on the Wayne and Lenoir County projects.

Other portions of the overall project are located in Pamlico County and consist of the Gum Thicket and Cedar Creek Restoration and oyster reef restoration within the Neuse River Estuary. On Page 6 of the document, four archaeological sites are mentioned within the Gum Thicket and Cedar Creek project area. These sites include 31PM28, 31PM32, 31PM33, and 31PM34. It is noted that the sites had been visited by OSA staff in the late 1980's and found to be heavily eroded. Since that time these sites are believed to have been lost to erosion. Two additional sites, 31PM98 and 31PM35 are also noted on OSA maps to be very near or within the project area. 31PM98 is located at the southern end of the project area and 31PM35 is located at the northern end. The document states that a shoreline examination by the Wilmington COE will take place prior to construction. We recommend that sites 31PM98 and 31PM35 be included in this inspection.

We have no comment on the oyster reef restoration areas in terms of terrestrial archaeological resources.

Staff at the Office of State Archaeology - Underwater Branch reviewed the Cultural Resources Study Plan for the above project and offers the following additional comments to those of the terrestrial archaeologists.

The underwater research files have references to extensive maritime activities and shipwreck losses in the general project vicinity of the Gum Thicket/Cedar Creek Restoration and the Oyster Reef Restoration. There is a high probability that unknown potentially significant submerged cultural resources may exist within the proposed project area.

We concur with the recommended plan that a detailed shoreline examination by the USACE be coordinated with OSA and UAB staff prior to construction in the Gum Thicket/Cedar Creek portion of the APE. Additionally, construction personnel and equipment operators should be made aware that the possibility exists that work may unearth buried remains not apparent during initial archaeological reconnaissance. In the event that such occurs, work should move to another area and the Underwater Archaeology Branch be contacted immediately (910-458-9042) so a staff member can be sent to assess the remains and determine the proper course of action.

The Oyster Reef Restoration portion of the overall plan creates a bottom disturbance that may damage unknown archaeological resources. We therefore recommend a comprehensive survey be conducted by an experienced archaeologist to identify the presence and significance of submerged archaeological remains lying with the project boundaries. Potential effects on these resources should be assessed prior to the initiation of construction activities. Detailed requirements of this survey should be coordinated with UAB archaeologists.

We have determined that the project as proposed will not have an effect on any historic structures.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, please contact Renee Gledhill-Earley, environmental review coordinator, at 919-807-6579. In all future communication concerning this project, please cite the above-referenced tracking number.

Sincerely,

Renee Gledhill-Earley

for Ramona M. Bartos

North Carolina Department of Cultural Resources
State Historic Preservation Office
Ramona M. Bartos, Administrator

Beverly Eaves Perdue, Governor
Linda A. Carlisle, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

December 15, 2011

Hugh Heine
Corps of Engineers, Wilmington District
69 Darlington Avenue
Wilmington, NC 28403
hugh.heine@usace.army.mil

Re: Neuse River Basin Integrated Feasibility Report and Environmental Assessment, North Carolina, Multi County, ER 11-1590

Dear Mr. Heine:

We have received notification from the US Army Corps of Engineers concerning the above project.

We have conducted a review of the project and are aware of no historic resources which would be affected by the project. Therefore, we have no comment on the project as proposed.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, please contact Renee Gledhill-Earley, environmental review coordinator, at 919-807-6579. In all future communication concerning this project, please cite the above-referenced tracking number.

Sincerely,

Renee Gledhill-Earley

for Ramona M. Bartos

City of Goldsboro
P.O. Drawer A
North Carolina
27533-9701

January 17, 2012

Mr. Hugh Heine
U.S. Army Corps of Engineers
Wilmington District
69 Darlington Avenue
Wilmington, NC 28403

RE: Comments on the Neuse River Basin DRAFT Integrated Feasibility Report and Environmental Assessment- October 2011

Mr. Heine-

Thank you so much for allowing the City of Goldsboro to comment on *the Neuse River Basin DRAFT Integrated Feasibility Report and Environmental Assessment- October 2011*. We respectfully submit the following comments pertaining to the "Modification of the Low-head Dam on the Little River" portion of the Tentatively Selected Plan:

1. Since February 2010, the City of Goldsboro has worked with American Rivers to identify alternatives to improve fish passage for the dam on the Little River owned by the City of Goldsboro since 1914. A final report entitled, "*Dam Removal Alternative Analysis for Goldsboro Dam, Little River Summary Report- City of Goldsboro, Wayne County, NC- October 2011*" identified five (5) alternatives to improve fish passage. The alternatives were:

    a. Alternative 1a- Full dam removal (decrease elevation by 4.19')
    b. Alternative 1b- Full dam removal (decrease elevation by 3.64')
    c. Alternative 2a- Lower dam and install rock ramp (decrease elevation by 2.12')
    d. Alternative 2b- Lower abutments and install rock ramp (no elevation change)
    e. Alternative 3- Modified dam (i.e. bottom hinge gate)

2. The City of Goldsboro's main interest with any proposed modifications to its Little River dam is to preserve its ability to always maintain a viable

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emergency back-up water supply for the City, though it is supportive of improving fish passage if possible.

3. On November 17, 2011, these five alternatives from the study were discussed at a meeting with representatives from the City of Goldsboro, American Rivers, North Carolina Wildlife Resources Commission, US Fish and Wildlife Services, NOAA National Marine Fisheries Service, and the NC State University. For the past couple of years, NC State University researchers conducted a fish passage study through the Little River dam using a microchip fish counting method. They gave a presentation at the meeting and showed that the current fish passage through the dam was 74% to 77% for American Shad, 82% for Gizzard Shad, and 72% to 75% for Flathead Catfish.

4. Alternative 2b- Lower abutments and install rock ramp was the selected alternative chosen by the City of Goldsboro because it would not compromise the city's ability to provide an emergency backup water supply and it should improve fish passage.

5. The fish experts, US Fish and Wildlife Services, NC Wildlife Resources Commission, and NOAA National Marine Fisheries Services, and the NC State University, at the November 17, 2012 meeting could not predict the percent improvement of fish passage at the dam with Alternative 2b, but felt that there would be some improvement with the addition of the rock ramp. It is expected that this fish rock ramp project will move forward for construction.

Please let me know if you have any questions regarding these comments. Thank you.

Sincerely,

Karen Brashear

Karen Brashear
Public Utilities Director
(919) 735-3329

cc: Scott Stevens, City Manager

American Rivers
Thriving By Nature

January 20, 2012

Mr. Hugh Heine
U.S. Army Corps of Engineers
Wilmington District
69 Darlington Avenue
Wilmington, NC 28402

Dear Mr. Heine,

Please accept these comments from American Rivers in regard to the *Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment* (herein referred to as "Corps Report") dated October 2011. For the last year, American Rivers has been directly engaged on a project involving one of the four elements of the Tentatively Selected Plan (TSP) outlined in this document, "Modification of the Low-Head Dam on the Little River."

American Rivers received funding in May, 2010 from the Fish America Foundation and NOAA to conduct an alternatives analysis/feasibility study and preliminary design plans for restoration at the low-head dam on the Little River in Goldsboro. The purpose of this study was to identify alternatives which would preserve the City's back-up water supply behind the dam, while restoring fish passage, habitat, flow, and sediment transport in this section of the river. American Rivers has coordinated with multiple partners on this effort, including the City of Goldsboro Public Utilities Department and members of NC Aquatic Connectivity Team (NC ACT), including NCDENR, US Fish and Wildlife Service, NC Wildlife Resources Commission, NC State University, and the Corps of Engineers. We contracted stream restoration engineers and water intake experts from Princeton Hydro and GPM Associates to conduct this study.

The alternatives analysis was completed in October 2011 and forwarded to project partners including the Corps of Engineers. The report without appendices is included as an attachment to this letter; the report with appendices will be mailed hard copy. The analysis outlines 3 alternatives for restoration at the site, and several sub-options within each alternative as follows:

1. Full Dam Removal
   - Alternative 1A: Full Dam Removal and Natural Adjustment
   - Alternative 1B: Full Dam Removal and Rock Riffle

2. Dam Modification and Rock Ramp Installation
   - Alternative 2A: Lower Dam and Install Rock Ramp
   - Alternative 2B: Lower Abutments and Install Rock Ramp

3. Dam Modification (Alternative 3)
   - Obermeyer Gate
   - Bottom-hinged Gate with cable hoists
   - Inflatable Dam
   - Stop Log Dam
   - Hinged Flashboards

All alternatives were found to be feasible from engineering and cost perspectives and could provide fish passage while maintaining the City's water supply demand. Full dam removal (Alternative 1A or 1B) would provide the most efficient fish passage at the site and would likely restore more riverine functions and values than the other alternatives. Alternative 1B was the preferred option for American Rivers and the fisheries agency partners given the environmental benefit, calculated ability to meet the City's water supply needs, and reasonable cost for construction. The City of Goldsboro noted concern over emergency water supply storage, so it was determined at this time to further investigate the rock ramp option as a short-term solution until the storage concern could be addressed. American Rivers is developing preliminary (30%) design plans of the rock ramp, which will complete this phase of the project and current funding from FAF-NOAA.

It should be noted that preliminary cost estimates were developed for each of these alternatives, which were generally found to be lower than the estimates outlined in the Corps Report in Table 5-5 (pp 138). For example, our Alternatives Analysis estimated the cost of a full rock ramp (Alt 2B) to be $80,000-$100,000, compared to the $240,650 estimate shown in Table 5-5. Additionally, our analysis estimated the cost of dam removal and alterations of the water intake (Alt 1B), to be $175,000-$300,000, compared to the $1,163,605 shown in Table 5-5. A more detailed cost estimate for the rock ramp is now being developed as part of the preliminary design.

It is noted in Table 3-4 in the Corps Report (pp 92), and again on pp 103, that the Low-Head Dam in Goldsboro is "not being pursued by others," which per the information above is an incorrect statement. However, any support and resources the Corps of Engineers could bring to advance the project would be beneficial.

We appreciate the opportunity to comment on this report, and applaud the Corps of Engineers' interest in ecological restoration in the Neuse River basin.

Sincerely,

Lynnette Batt
Associate Director, River Restoration Program, SE Region
American Rivers

Enc (2) – Goldsboro Alternatives Analysis Report without Appendices attached; Report with Appendices mailed hard copy

North Carolina Office
331 West Main Street
Suite 504
Durham, NC 27701

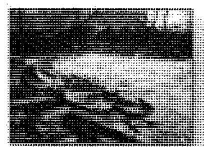
919.682.3197
lbatt@americanrivers.org
www.americanrivers.org

Dam Removal Alternatives Analysis for Goldsboro Dam, Little River Summary Report

City of Goldsboro, Wayne County, NC

Prepared for:

American Rivers, Inc.
Attn: Lynnette Batt
331 West Main Street, Suite 504
Durham, NC 27701
919-682-3197
lbatt@americanrivers.org



Prepared by:

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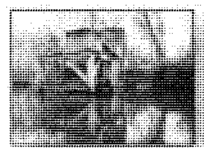

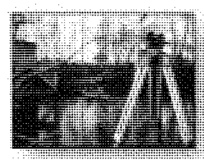

October 2011

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Princeton Hydro

Contents

Executive Summary

Princeton Hydro was contracted by American Rivers to support the restoration of the Little River by developing and analyzing alternatives for removal or reconfiguration of the Goldsboro Dam that maintain existing water supply capability while restoring fish habitat and reestablishing access for migratory fish. The primary project constraint is determined by the existing water supply intake configuration, pumping infrastructure and water withdrawal demand. The current water supply system is composed of an intake structure situated in a permanent scour hole in the channel, a 30-inch gravity-fed intake pipe that extends to a wet well and pumphouse with three pumps. From the pumphouse, the Water Treatment Plant withdraws at a maximum rate of 9 MGD. This back-up water supply is utilized typically during high flows but must also be reliable during low flows. The project team included water supply experts to determine requirements for the water intake and pumping system and utilized hydrologic and hydraulic modeling to assess the viability of various conceptual dam removal and reconfiguration alternatives.

The flowing alternatives were investigated for the Goldsboro Dam to provide improved fish passage while maintaining the full use of City of Goldsboro's backup water supply intake on the Little River:

1. Full Dam Removal
   Alternative 1A: Full Dam Removal and Natural Adjustment
   Alternative 1B: Full Dam Removal and Rock Riffle

2. Dam Modification and Rock Ramp Installation
   Alternative 2A: Lower Dam and Install Rock Ramp
   Alternative 2B: Lower Abutments and Install Rock Ramp

3. Dam Modification
   - Obermeyer Gate
   - Bottom-hinged Gate with cable hoists
   - Inflatable Dam
   - Stop Log Dam
   - Hinged Flashboards

All alternatives were found to be feasible from an engineering and cost perspective and could provide fish passage while maintaining the City's water supply demand. Full dam removal would provide the most efficient fish passage at the site and has the potential to restore more riverine functions and values. However further discussion with the City and the project partners, based primarily on the City's concerns over additional pump station maintenance, has eliminated Alternative 1A as an option due to the need for an additional air scouring device to ensure the reliability of this option. Alternative 1B only requires the relocation of the suction pumps within the pumphouse, and does not require an air scouring system or any modification to the in-channel intake, it is therefore, still considered the strongest alternative to achieve all project goals. If the City does not wish to consider any dam removal option, then Alternative 2A, lowering the dam and installing a small rock ramp fishway, would be considered the next strongest alternative and would likely be one of the least expensive options. Alternative 3, the modification of the dam to incorporate an adjustable gate structure, would then be third on the list of recommended alternatives, but may require the full removal and reconstruction of the dam.

Background

The Goldsboro Dam is located in the City of Goldsboro, on the Little River, a tributary to the Neuse River. Following three dam removals on the Little River in the past 15 years, American Rivers is actively advancing dam removal to restore fish habitat and open access to migratory fish. The Little River supports a diverse assemblage of resident and migratory fish as well as rare mussels. The impacts of these dams, and their removals, on fish spawning habitat and migration have been the subject of ongoing research. American Rivers contracted Princeton Hydro to develop and analyze alternatives for dam removal or modification that restore natural river functions and maintain water supply for the City of Goldsboro.

Princeton Hydro staff conducted a site investigation on February 10 and 11, 2011 with project team members: Lynnette Batt (American Rivers, Associate Director, River Restoration Program, Southeast Region), and David Monie (Water Resources Engineer, GPM Associates). Members of the project team met with staff from the City of Goldsboro Public Utilities, and investigated the dam, impoundment and intake structures for the Water Treatment Plant. The following report describes the various factors that affect the feasibility of dam removal or modification and analyses the various conceptual design alternatives that balance the need for water supply with fish passage and ecological restoration.

Site Investigation

Dam

The Goldsboro Dam is primarily concrete with steel sheet piling visible in some locations along the upstream face. Abutments extend approximately 15 feet from the left bank and 52.5 feet from the right bank at approximate elevation 67.15 feet (NAVD88). The central notch in the dam, which acts as the spillway, is approximately 37.5 feet wide at approximate elevation 64.2 feet (NAVD88); the spillway elevation varies from 64.02 to 64.25, with its lowest point being at the northern end of the spillway/notch. Wooden logs (i.e. timbers) were visually observed on the downstream face of the spillway below the water surface at the time of the survey. The timbers appeared to span the base of the spillway, lying perpendicular to flow. The Goldsboro Department of Public Utilities lacked any official records or historical documentation about the construction, or any deconstruction, lowering, or failure of the dam. In the absence of reliable information, it has been suggested the dam may have partially blown out in a flood event. However, several signs strongly suggest that the dam was intentionally lowered and systematically dismantled. First, concrete rubble is evenly distributed on the downstream side of the abutments and the spillway in an organized and stable orientation only possible by intentional placement. Secondly, the concrete edges of the spillway/notch are right-angled even faces that were likely created by concrete cutting or mechanical impact equipment. If the dam had breached during a flood event, it is likely that the concrete would have ruptured along fractures leaving rough edges and concrete rubble haphazardly strewn about downstream of the breach. Thirdly, anecdotal evidence attests to a deconstruction project: one local senior citizen who arrived on-site during the survey claimed to have witnessed when the dam was notched. The remaining portion of the dam that was visible during our site inspection appears to be in fair condition.

Water Intake

The City of Goldsboro's existing backup water supply intake is located approximately 200 feet upstream of the dam. Design plans by William Olsen, dated March 1927, are included in the Appendix. The pumping station is located on river left; the elevated access way (81.72' NAVD88) extends approximately

50 feet into the channel to a concrete tower that houses an actuator connected to the sluice gate at the intake pipe. The concrete housing is stabilized by an exterior steel retrofit structure with four corner pilings on separate foundations in the channel bottom. The 30" intake pipe inlet is situated approximately 7 feet above the channel bottom in a permanent scour hole (top of pipe is at elevation 59.22' NAVD88). When river flows are at the elevation of the lowest point in the spillway (64.02' NAVD88), the intake pipe is submerged by 4.8 feet.

Impoundment

Princeton Hydro investigated the impoundment, noting channel and bank conditions, riparian land use, adjacent wetlands, and any potential project constraints. The investigation continued approximately 1 mile upstream of the dam and approximately 1,000 feet downstream of the dam. A portion of the effective FEMA hydraulic model for the Little River was reviewed, updated and rerun for this project. Interpretation of the FEMA FIS profile indicates the impoundment may extend up 9,400 LF during low flow; however, due to the low head and notch, the dam's impoundment is non-existent when the dam is completely submerged during flood events (10, 50, 100, 500-yr). Therefore the length of the impoundment created by the remaining portion of the Goldsboro Dam varies significantly depending on flow. The impoundment is riverine in character (i.e. "confined to a narrower channel width") and shallow, which promotes sediment transport during higher flows and prohibits significant sediment deposition. Indeed, during the field investigation, in the upstream portions of the impoundment, flow was observable and the backwater influence of the dam was difficult to discern. The gradient of the Little River in this reach is low which is not unusual in the inner Coastal Plain physiographic region. As expected with the low gradient and broad floodplain, the channel is highly sinuous (sinuosity = 1.5) with remnant ox-bows. Channel substrate and bank materials are predominantly fine, including sand, silt and clay with little gravel. Lower banks are generally vegetated and stable, though most higher banks (greater than 5 feet above normal water surface elevation) are vertical and actively eroding in places. Bank conditions do not change noticeably from downstream to upstream of the dam. Banks have been stabilized in the vicinity of the dam (approximately 300 feet downstream and upstream) with large stone and concrete fragments. Channel width also does not change noticeably from upstream to downstream of the dam owing to the low dam height and riverine character of the impoundment. However, gravels are more common downstream of the dam, where free-flowing conditions dominate. Immediately adjacent to the channel, the riparian area is predominantly coastal plain woodlands. The encompassing floodplain land use is primarily agricultural (row crop and nursery) with associated water supply ponds, managed turf (golf course), and Interstate 795 (to the east). Water withdrawal equipment was observed on the right bank approximately 2000 feet upstream of the dam and may have been connected to an adjacent agricultural pond. No other structures or utilities (e.g. power, sewer, or gas lines), other than the City's water supply intake discussed previously, were observed in or near the channel that could be directly affected by the removal of the dam and anticipated channel adjustment.

Topographic Survey

Cross-Sectional Survey

An initial cross-sectional survey in the vicinity of the dam was completed by Princeton Hydro to develop a base hydraulic model for preliminary assessment of initial conceptual design alternatives. Cross-sections were surveyed at five locations ((1) downstream of the dam, (2) at the dam, (3) immediately upstream of dam, (4) at the intake structure, and (5) upstream of the intake structure) using a rod and level and were permanently marked with metal pins at the endpoints. A professional surveyor was contracted to provide surveyed control elevations (NAVD88) for a temporary bench mark on the dam, on the catwalk over the intake and the front steps of the pump house. This survey control was used to adjust rod and level survey elevations and water supply intake infrastructure to the standard vertical datum (NAVD88). (Note: these control elevations were corrected by the subsequent professional survey described below.) Surveyed cross-sections were then incorporated into an existing FEMA hydraulic model, and utilized to determine preliminary feasibility of conceptual design alternatives.

Professional Survey

After various conceptual design alternatives were deemed feasible, the professional surveyor was again contracted to complete a detailed survey of the dam, upstream and downstream channel, likely access and staging areas, and several upstream cross-sections. Data from this complete survey superseded and replaced the previous control elevations established during the work described above; accordingly, elevations of the conceptual design alternatives have been adjusted based on the latest survey data and therefore differ from previous project documentation. Based on this follow-up survey, a more detailed hydraulic model was developed to further assess the conceptual design alternatives. An Existing Conditions Plan is included in the Appendices.

Primary Factors Determining Feasibility

Several variables were identified as primary factors that had been issues of concern and determined the feasibility of the conceptual design alternatives: impounded sediment, fisheries and fish passage, estimated construction costs, long-term maintenance, and water supply capabilities. General findings related to some of these factors are described below. Additional factors that differ among the proposed conceptual design alternatives are compared in the following Alternative Analysis section.

Impounded Sediment

Sediment management has been considered by the US Fish & Wildlife Service (USFWS). In a December 2008 report, Tier 1 Preliminary Evaluation of Pollutant Sources to the Impounded Reaches of Five Dams in the Neuse River Basin, North Carolina, the USFWS reviewed existing information on pollutant sources and sinks. The objective of the study was to identify conditions that would either necessitate sediment sampling and chemical analysis or justify no further action in regards to sediment contamination. The report states that no known significant organic or inorganic pollutant sources occur within a one-mile assessment area surrounding the Goldsboro Dam on the Little River. More importantly, the report concludes that no further sediment characterization work is recommended unless confirmatory sampling is desired. Furthermore, the report states that not enough of an impoundment remains behind the breached dam for downstream sediment mobilization to be a concern for partial or full dam removal.

Princeton Hydro's field investigation of the impoundment and review of aerial photos also revealed no potential sources of sediment contamination, aside from adjacent agricultural fields, in the lower impoundment, thus corroborating the USFWS report in the immediate upstream vicinity. Inspection of random sediment samples during the investigation also did not reveal any visual sign of contamination. To measure sediment depths and estimate sediment volumes, Princeton Hydro manually probed sediments (using a galvanized, segmented sediment probe capable of penetrating 12 feet) in the vicinity of the dam, the water supply intake structures and immediately upstream. As anticipated, maximum sediment depths upstream of the dam do not exceed the height of the dam (approximately 3 feet) and, owing to the riverine nature of the impoundment, are distributed like fluvial bed features according to predictable variations in velocity and shear stress. As such, sediment depths were greatest on the inside of the first upstream meander bend (i.e. point bar, 3 feet sand/silt/clay) and on the channel margins. Sediments depths were lowest in the thalweg (0 – 2 feet). The volume of potentially impounded sediments in the vicinity of the dam (within 500 LF) based on these probing depths is estimated to be around 3,400 CY. Sediment grain-size varied in a similar spatial pattern, with lateral fining. Coarse (i.e. sand) sediment predominated in the thalweg; silt and clay was more common on the point bar and channel margins. Below the layer of less-compacted sediments (0 – 2.5 feet thick), a densely compacted layer was encountered that was likely the original channel bottom. In the channel center, sands appeared to be underlain by coarse sand or gravel; in the channel margins, sediments were underlain by very dense clay. Due to the dam's low head and the riverine impoundment, sediments are no longer actively accumulating upstream of the dam, nor are they in permanent storage. Instead, the impoundment may be characterized as a reach that is still transporting sediment, mainly at higher flows, albeit at a reduced transport rate averaged over time. These sediments currently cover coarser sediments of the original stream bottom, which will be re-exposed and serve as potential spawning habitat upon dam removal. In conclusion, due to the dam's low head and the shallow, riverine character of the impoundment, sediment accumulation is minimal; thus, downstream transport is not a concern for this dam removal project.

Fisheries and Fish Passage

Princeton Hydro reviewed existing literature on the fisheries of the Neuse River and surrounding watersheds. Beasley and Hightower[1] have documented that the Quaker Neck Dam, a low head dam near Goldsboro, NC, had significantly reduced the migration of striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) and limited access to preferential spawning grounds that were more abundant in upstream reaches. Burdick and Hightower[2] documented increased utilization of upstream spawning habitats by American shad, hickory shad (*Alosa mediocris*) and striped bass, following the removal of the Quaker Neck Dam. Raabe and Hightower[3] studied fish migration specifically on the Little River following the removal of three low head dams on that river since 1998. The authors found that the Goldsboro Dam, in its current notched condition, was primarily an impediment to migration during low flows, while individual fish often waited for prolonged periods for higher flows to pass the Goldsboro Dam. Reported data from 4/27/2009 to 5/25/2009 shows that the number of Gizzard shad and American shad passing the Goldsboro Dam was highest when flows ranged from 70 to 212 CFS at the USGS gage near Princeton, NC (gage 02088500). For 2009, passage rates for tagged individuals were 74% for American shad, 83% for gizzard shad, and 72% for flathead catfish. This research suggests that the removal of the notched dam would likely enable more frequent movement and efficient upstream migration for the range of migratory fish species in the Little River basin. In addition, the removal of the dam, return of free-flowing conditions and increased sediment transport through the existing impoundment may result in the exposure and creation of preferential spawning habitat. The conceptual design alternatives presented in a subsequent section of this report, are compared based on their abilities to provide improved fish passage and restore habitat while balancing water withdrawal capabilities.

[1] Beasley, C.A. and Hightower, J.E. 2000. Effects of a low-head dam on the distribution and characteristics of spawning habitat used by striped bass and American shad. Transactions of the American Fisheries Society. 129:1316-1330.
[2] Burdick, S.M. and Hightower, J.E. 2006. Distribution of spawning activity by anadromous fishes in an Atlantic slope drainage after removal of a low-head dam. Transactions of the American Fisheries Society. 135:1290-1300.
[3] Raabe, J.K. and Hightower, J.E. 2010. Assessing benefits to migratory fishes of habitat restored by dam removal. Draft 2006-2008 Report. USGS / NC Cooperative Fish and Wildlife Research Unit / NCSU Department of Zoology.

Water Supply

As the sole purpose of the dam, continued water supply is recognized as the paramount limiting factor in the decision-making process and as such, project proponents have made a concerted effort to engage the City of Goldsboro, Department of Public Utilities, Water Treatment Plant Division, (who operate and maintain the dam) at the outset of this project and to ensure no loss in water withdrawal capability or water supply capacity under any future scenario that seeks to improve fish passage and restore riverine functions.

Intake Operations

The project team (Princeton Hydro and GPM Associates), led by Water Treatment Plant operators, inspected the pump house, pumps, wet well, catwalk, and intake structure; reviewed engineering drawings of those structures; and, learned the key technical aspects of the water intake and treatment operation from plant operators. The Goldsboro Dam impounds water for the City's back-up water supply intake on the Little River. The primary water supply intake is located on the nearby Neuse River. The City of Goldsboro activates the back-up water supply on the Little River when water quality degradation in the Neuse River compromises the water treatment process (e.g. bacteria laden runoff from upstream pig farming operations during heavy storms and floods), when the primary water intake is non-operable, or for brief periods during annual maintenance checks on the Little River Intake System. Indeed, according to Water Treatment Plant records, four periods of activation of the Little River Intake system during the late 1990s coincided with flood events on the Neuse River (Table 1). The Little River intake is not normally activated during periods of low flow. The complete cessation of flow (i.e. zero discharge, 0 CFS) has occurred, according to the USGS gage at Princeton (see Hydrology section below), in the Little River and is likely due to over allocation of water withdrawal rights in the upper watershed. However the City staff note that they have never observed a zero flow occurrence on the Little River. Plans for the Water Supply Intake Design (1927) are included in the Appendices.

Table 1. Usage of Little River Water Supply Intake (January 1995 - December 1999).

Date(s)	Max Withdrawal (MGD)	Coincident with Flood Event	Flow in Little River (cfs)
April 22, 1995	6.708		75
May 1, 1995	5.833		50
May 22, 1995	5.396		20
Sept 7, 1996 – Oct 31, 1996	8.670	Yes	Max: 7,131; Mean: 1,376
Nov 11, 1996	4.335	Yes	422
Sept 18, 1999 – Oct 31, 1999	7.331	Yes	Max: 22,095; Mean: 2,529
Nov 14, 1999 – Nov 29, 1999	6.500	Yes	Max: 414; Mean: 240

Water Intake Assessment

The water intake pump facility and intake structure was evaluated to ascertain required water depths at the intake pipe and in the wet well. Consideration was given to the capacity and arrangement of the pumps and the potential for excessive headloss, vortex formation, pumping disruption and mechanical damage during low flows. The current maximum rate of water withdrawal is 9 MGD, according to water treatment plant operators. Water withdrawal is accomplished with the use of three (3) pumps with the following capacities: 6 MGD, 4 MGD, and 3.6 MGD. Attaining the maximum withdrawal rate requires the use of the largest pump simultaneously with one of the smaller pumps. Water depths in the Little River at the intake would have to be maintained at 61.9' (NAVD88) to compensate for the creation of headloss due to suction during the simultaneous operation of two pumps. The distance between each pump is sufficient such that the vortex at the larger 6 MGD pump would not pose a risk of damage to the other two pumps during the maximum pumping rate. In the unlikely event that the Little River intake would be required to pump 9.0 MGD during relatively low to moderate flow conditions, the use of the largest pump and the mid-size pump would be utilized with the largest pump pumping 5.2 MGD and the midsized pump pumping 3.8 MGD. This is the basis of the determination of the minimum depth in the stream required to avoid a vortex forming in the pump suction gallery. With these pumping rates, the largest pump would control the water level requirement in the pump suction gallery since the pumps are spaced far enough apart to avoid significant interference. Calculations show that there would need to be 4.46 feet of water above the centerline of the 14" pump suction line. The headloss in the 30-inch suction pipe is minimal, but would equal approximately 0.04 feet. There would be insignificant headloss for water flowing in the intake gallery. Since the centerline of the pumps suction pipes are located at approximately 57.40 feet MSL, the minimum water level at the intake would need to be 61.90 feet (57.40' MSL + 4.46 feet + 0.04') (NAVD88). The related hydraulic calculations are included in Appendices.

Hydrologic and Hydraulic Analysis

Hydrology

Peak discharge estimates were obtained, and extrapolated as necessary based on drainage area, from the effective FEMA Flood Insurance Study (FIS). Regional Hydrologic Loading Analysis (RHLA) was used to generate low flow estimates. Analysis of flow data from the two USGS gages (80 years of record) on the Little River and neighboring watersheds confirmed that the Little River experiences extreme low water conditions June-October. Specifically, for this analysis, daily mean discharge (DMD) data from the USGS stream gage 02088500 Little River at Princeton, NC, was utilized, and data was transposed to the Goldsboro Dam site using a ratio of the drainage areas (factor of approximately 1.32). Over the 80 year period of record, the minimum median (50%) flow is 6.6 CFS, minimum mean flow 25.0 CFS, minimum flow is 0 CFS. This 0 CFS discharge has been recorded at the upstream gage nearly 20 times over the period of record, specifically during August 2002, September 2005, and September 2007. The water withdrawal at Goldsboro Dam is not typically activated during such low flow conditions because the Little River tends to run dry before the primary water withdrawal source on the Neuse River, and the City does not wish to dewater the Little River below the dam. Since the existing dam does not provide water storage, flow in the channel must exceed the withdrawal rate (9 MGD maximum or 13.9 CFS) to avoid dewatering the Little River. Nevertheless, these low flow conditions were utilized as worst-case scenario to model the impacts of head-loss under the different alternatives.

Additionally, for modeling of various alternatives, specific flow rates were determined to meet required hydraulic conditions (i.e. minimum WSEL at water supply intake). These flow rates were compared to DMD statistics for context.

Flow data compiled from the above analyses are reported in the below table, including both the identification abbreviation used in the hydraulic model discussed below, and a description of the flow statistic. Additional relevant hydrologic data and calculations are included in the Appendices.

Table 2. Hydrologic Summary

Statistic	Discharge (CFS)	Description
Minimum DMD Period of Record	0.0001	Minimum recorded Daily Mean Discharge (DMD) for Period of Record (0.0 cfs actual value)
Mean of Minimum DMD	25	Mean of minimum recorded Daily Mean Discharge (DMD) over Period of Record
Mean of 5% DMD	46.5	Mean of 5th% recorded Daily Mean Discharge (DMD) over Period of Record
Mean of 10% DMD	62.1	Mean of 10th% recorded Daily Mean Discharge (DMD) over Period of Record
Mean of 25% DMD	100.2	Mean of 25th% recorded Daily Mean Discharge (DMD) over Period of Record
Mean of 50% (Median) DMD	181.6	Mean of median (50th%) recorded Daily Mean Discharge (DMD) over Period of Record
March Mean of Median DMD	423.6	Mean of Median (50th%) recorded Daily Mean Discharge (DMD) for month of March over Period of Record
April Mean of Median DMD	265.9	Mean of Median (50th%) recorded Daily Mean Discharge (DMD) for month of April over Period of Record
May Mean of Median DMD	121.5	Mean of Median (50th%) recorded Daily Mean Discharge (DMD) for month of May over Period of Record
June Mean of Median DMD	79.9	Mean of Median (50th%) recorded Daily Mean Discharge (DMD) for month of June over Period of Record
July Mean of Median DMD	70.1	Mean of Median (50th%) recorded Daily Mean Discharge (DMD) for month of July over Period of Record
FEMA 10-yr	6800	10% annual exceedance probability (AEP) discharge
FEMA 50-yr	12300	2% annual exceedance probability (AEP) discharge
FEMA 100-yr	15750	1% annual exceedance probability (AEP) discharge
FEMA 500-yr	26000	0.2% annual exceedance probability (AEP) discharge
WSEL = 61.9' (1A)	164.64	Discharge at which WSEL of 61.9' is predicted at water supply intake, under Alternative 1A (flow exceeded 31% of period of record)
WSEL = 61.9' (1B)	76.32	Discharge at which WSEL of 61.9' is predicted at water supply intake, under Alternative 1B (flow exceeded 53% of period of record)
Minimum Pumping Rate (9 MGD)	13.93	Minimum pumping rate as identified by City of Goldsboro

These hydrologic data were subsequently utilized as noted in the hydraulic analyses, described below.

Hydraulics

For preliminary modeling efforts, cross-sectional survey data collected by Princeton Hydro was utilized to supplement channel geometry for the subject stream reach and incorporated into the broader existing FEMA FIS hydraulic model of the Little River. The original hydraulic model existed in HEC-2 format and was therefore imported into the USACE HEC-RAS program. Through this preliminary modeling, it was determined that the existing dam has no effect on WSEL (downstream = upstream) during the storm flows modeled (10-, 50, 100-, and 500-yr events), which is consistent with the FEMA FIS profile, and as such these regulatory events were omitted from the final feasibility modeling.

For the final feasibility analysis, professional topographic survey was obtained (Benton & Associates, October 2001) and utilized for geometry input data, and supplemented where necessary with LiDAR data obtained from the NC State GIS Department. These data were combined and pre-processed using the USACE HEC-GeoRAS. This interface allows the preparation of geometric data within the ArcGIS platform for import into HEC-RAS. As with the preliminary analysis, USACE HEC-RAS program was utilized for the hydraulic calculations. Cross-sections from Station 1409 (approximately 900 ft upstream of the dam) to Station 258 (approximately 300 ft downstream of dam) were utilized to represent the project reach. The existing Goldsboro Dam is located at Station 515, with the water supply intake located at Station 721 in the final feasibility modeling.

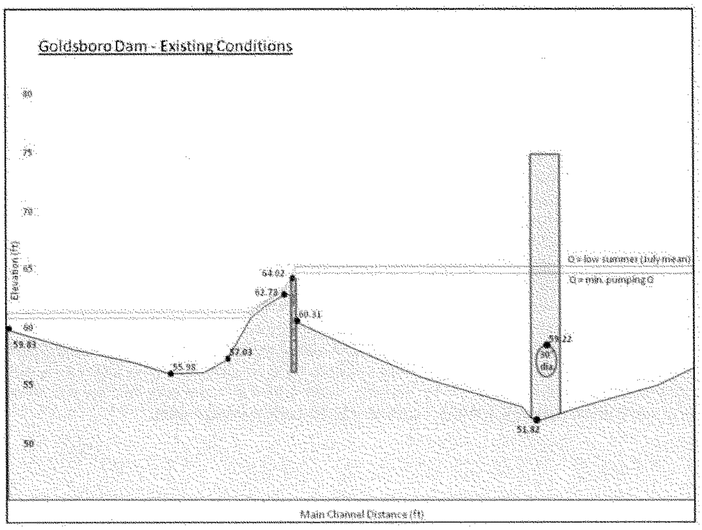
The Manning's roughness coefficients, 'n', for the stream channel and overbanks were assigned to each cross section. These 'n' values were evaluated and assessed from Princeton Hydro's site visits, with horizontal variation as necessary due to bank vegetation, concrete (both dam and breach) and gravel/cobble bars, and channel substrate.

The existing dam was defined using multiple closely spaced cross-sections to account for both longitudinal and horizontal variation of the dam and the downstream riprap slopes. Under each alternative scenario conditions, geometry at the dam section was adjusted to detail both the dam modification as well as anticipated conditions in the surrounding cross-sections.

The HEC-RAS model developed was a one-dimensional, steady peak flow, mixed flow analysis, using flows generated from the hydrologic analyses. Upstream boundary conditions were set to normal depth using the slope identified in the FIS, while the downstream boundary conditions were set to critical depth, as the downstream riffle serves as a hydraulic control at which the range of flows modeled will pass through critical depth. Resulting WSEL and velocities are consistent with site survey and field observations, lending confidence to the overall modeling effort.

The analysis shows that under no flow conditions (which is the worst case scenario) the water surface elevation at the intake pump is dictated by the elevation of the downstream grade control (i.e. the existing dam). Survey data shows that the top of the 30-inch intake pipe is at elevation 59.22' (NAVD88), approximately 4.8 feet above the lowest point in the channel cross-section. Currently, the lowest elevation on the dam's spillway is at 64.02' (NAVD88) and the riffle downstream of the dam is at 59.83' (NAVD88). Under various removal scenarios, hydraulic conditions are controlled by this downstream riffle.

Relevant input data and results of the hydraulic modeling are included in the Appendices, and are discussed within each alternative scenario described below.



Conceptual Design Alternatives

Five conceptual design alternatives have been developed by the project team and are described below in detail. General findings are summarized in the table below. Conceptual design alternatives are compared in the table at the end of this section.

1. Full Dam Removal

Complete removal of the dam is part of Conceptual Design Alternatives 1A and 1B. The two dam removal alternatives differ in the elevation to which the dam is removed and the type and extent of modification to the water supply intake infrastructure that would be necessary to retain water withdrawal capabilities at low flows.

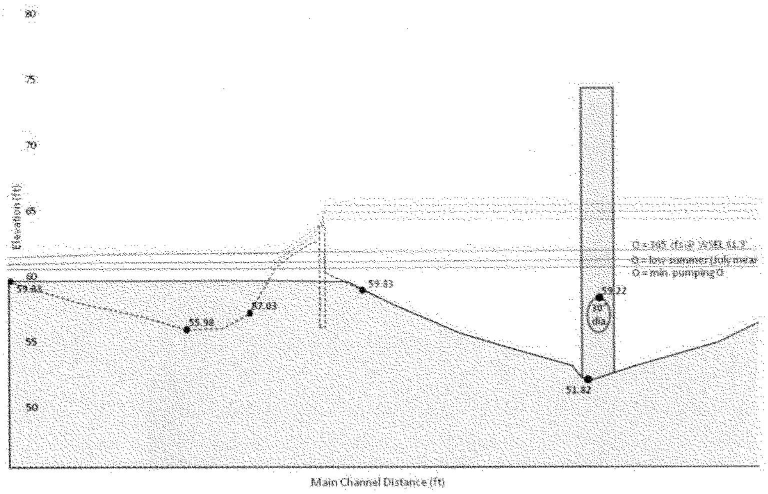
Alternative 1A: Full Dam Removal and Natural Adjustment

Alternative 1A involves removing the dam entirely and allowing the river bed to adjust naturally. The anticipated elevation of the river bed following passive recovery is 59.83' (NAVD88) based on the anticipated equilibrium slope in this reach. This elevation was chosen as it is anticipated to be controlled by the downstream riffle (at the same elevation), which ultimately controls the range of modeled flows through the entire reach, and geometry both at the dam and immediately downstream were adjusted to be consistent cross-sectional area to unconfined sections both upstream and downstream.

This alternative would eliminate any man-made barrier to fish passage and fish movement / migration would be restored to the natural conditions of this river. This full removal also has the greatest potential for restoring natural sediment transport processes through the impoundment and exposing or creating preferred spawning habitat.

This alternative would, however, require modification to the intake screens, intake pipes and replacement of the existing pumps to retain water withdrawal capabilities at flows below 164.64 CFS. This flow was identified specific to Alternative 1A as the discharge below which the modeled WSEL at the water supply intake drops below elevation 61.9', the minimum functioning elevation for the existing system. Specifically for this alternative, a new intake would need to be installed utilizing specialized intake screens with protective ends designed for river conditions. This arrangement would include 12-inch screens located near the bottom of the stream in the scour hole near the intake. These screens would be connected through the existing wet well into the suction lines for the pumps with a 20 inch pipe, such that the pumps would be directly connected to the intake screens. The specialized intake screens would be outfitted with an air scouring system that is activated periodically to flush accumulated debris. These components are proven technologies that function reliably in river applications. The existing pumps would need to be replaced with new pumps with more powerful pumping capabilities since there would not be a net positive suction head on these pumps under very low flow conditions (water level below 60.4' MSL). A preliminary estimated cost range for this intake and pump modification work would be between $250,000 and $400,000, with an additional $50,000 to $75,000 to remove the dam – a more accurate estimate could be generated after preliminary design is completed. A conceptual design of the required water intake and pumping changes are shown on Sheets 1 and 2 of the Conceptual Water Intake Modifications in the Appendices.

Goldsboro Dam – Alt #1a Full Dam Removal



No maintenance would be required at the dam and, with the proposed modifications, some additional maintenance and operation would be required at the intake structure and pump facility. Intake screens modified with an air scouring system will ensure that the intake does not get blocked with sediment. While removal of the dam would be relatively simple and inexpensive, modification to the intake and pumps would be costly, but not outside the range of infrastructure improvements sometimes needed for dam removals. See the table at the end of this section.

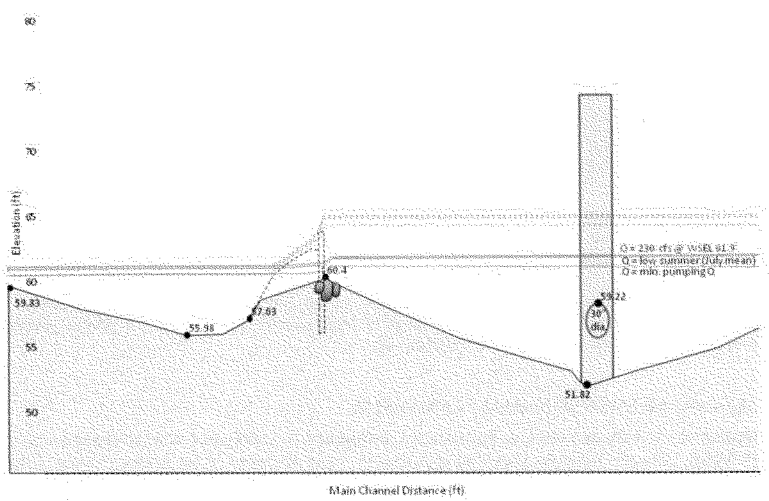
Alternative 1B: Full Dam Removal and Rock Riffle

Alternative 1B involves removing the dam but establishing a stable rock riffle at elevation 60.4' (NAVD88). This elevation was chosen as consistent with the elevations of the stream channel at the upstream face of the dam, anticipated to be controlled through the use of natural materials, and geometry both at the dam and immediately downstream were adjusted to be consistent cross-sectional area to unconfined sections both upstream and downstream.

This option would restore unimpeded fish passage at all but the lowest flows, when shallow water depth over the riffle may hinder fish passage. However, during these lowest flows, fish passage is likely obstructed at other natural riffles as well. This alternative would increase the potential for sediment transport, although to a lesser extent than Alternative 1A, and assist in exposing or creating preferred spawning habitat.

In addition, this alternative would require some modification to the pump suction pipes within the pumphouse, but no modification of the in-channel intake pipe or pumps to retain water withdrawal capabilities at flows below 76.32 CFS. Similar to Alternative 1A, this flow was identified specific to Alternative 1B as the discharge below which the modeled WSEL at the water supply intake drops below elevation 61.9', identified as the minimum functioning elevation for the existing system. Specifically for Alternative 1B, the existing pump suction pipes in the wet well would need to be repositioned. The new pipes would need to be cored through the wall separating the pump room and the wet well closer to the floor such that it would take water from a lower level and greatly reduce any vortex that may be formed. The existing pumps would work in this alternative and not require replacement as in Alternative 1A. A preliminary estimated cost range for this suction pipe relocation work would be between $100,000 and $200,000, with an additional $75,000 to $100,000 to remove the dam and construct a stable rock riffle – a more accurate estimate could be generated after preliminary design is completed.

Goldsboro Dam – Alt #1b Full Dam Removal to 60.4



No maintenance would be required at the dam and no increased maintenance would be required at the intake structure with the proposed modifications. While removal of the dam and the construction of a small rock riffle would be relatively simple and inexpensive, relocation of the suction pipes increases costs; however, again, not outside the range of infrastructure improvements sometimes needed for dam removals. See the table at the end of this section. The conceptual drawing of the change to the pump suction pipes is shown on Sheet 1 of the Conceptual Water Intake Modifications in the Appendices.

Note that for both alternatives 1A and 1B, additional water intake configurations were considered such as an off-line bypass channel/pond or well, but were dismissed early on in the alternatives assessment when it became clear that the existing water intake and pumping facility could be more easily modified than the construction of a new facility, and met all the projects needs to maintain the current water demand. This was primarily due to the unexpected depth at which the current water intake is set in comparison to the dam elevation and riverbed both downstream and upstream of the dam. The large scour hole where the current water intake is located is self scouring and maintains free of impounded sediment even with the dam in place. Removal or lowering of the dam, as well as the other alternatives considered, will only promote higher velocities in this reach and will maintain the pools self scouring nature.

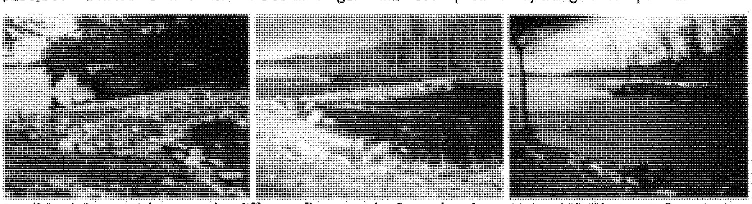
2. Dam Modification and Rock Ramp Installation

Lowering or modifying the dam and installing a rock ramp fishway are parts of Conceptual Design Alternatives 2A and 2B. Importantly, neither alternative requires modification of the intake structures nor pumping machinery; therefore, these alternatives are the least costly.

Alternative 2A: Lower Dam and Install Rock Ramp

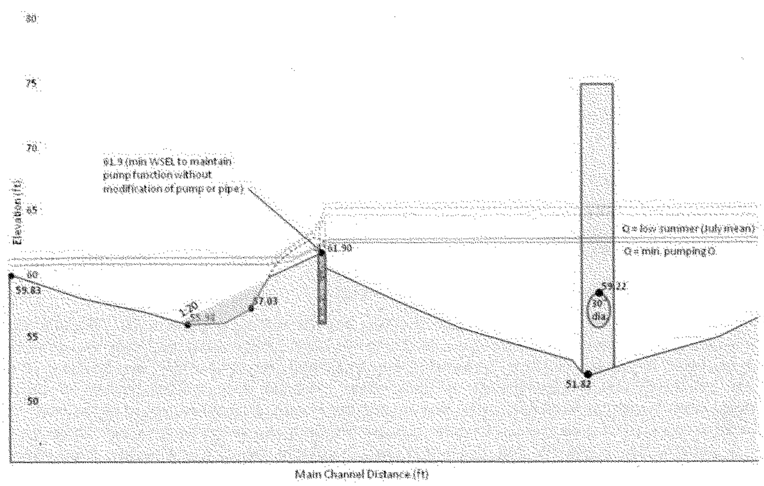
Alternative 2A involves lowering the dam (both abutments and spillway) to 61.9' (NAVD88) and installing a rock ramp fishway at a slope passable to fish (20:1). The existing rock/concrete debris fill downstream of the dam would be reshaped and extended with imported cobbles and boulders. It is anticipated that suitable existing materials (rock, stream substrate, etc.) would be re-used for a rock ramp, with the goal of balancing cut/fill and limiting the amount of required import of material. In addition to a gradual slope, this design would incorporate energy dissipation features and concentrated flow paths to create velocities and depths that enable upstream migration of American shad, striped bass and other fish species of interest. Fish passage during low flows would be accommodated as much as possible with the concave surface of the ramp creating a low flow pathway. Lowering the dam approximately 2 FT increases the potential for sediment transport, although to a lesser extent than Alternatives 1A and 1B, and helps to expose or create some preferred spawning habitat further upstream.

This alternative does not require any modification to the intake structures or pumps to retain existing withdrawal capabilities, as in Alternatives 1A and 1B. Maintaining the water surface elevation at 61.9' (NAVD88) at the water intake even during the lowest of flow accommodates the required head for the safe and proper functioning of the existing intake pipes and pumps during normal times of use (i.e. moderate to high flows). The calculations that determine the minimum water level behind the dam for utilizing the existing pumping equipment are provided in the Appendices. A preliminary estimated cost range for this dam modification and rock ramp fishway installation work would be between $80,000 and $100,000 – a more accurate estimate could be generated after preliminary design is completed.



Small Rock Ramp Fishway under different flows on the Sennebec Dam, Union ME (Photos: J. Reardon)

Goldsboro Dam – Alt #2a Lower Dam and Install Rock Ramp



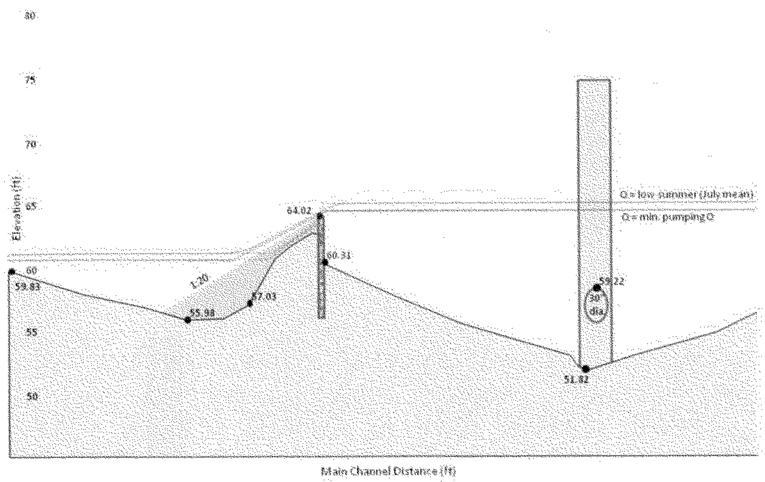
Some infrequent maintenance may be required for the lowered dam and the rock ramp fishway, as these will be permanent structures within the waterway. Lowering of the dam and installation of the smaller rock ramp fishway would amount to moderate estimated costs relative to the dam work proposed for Alternatives 1A and 1B. With no work required at the intake or pumps, this alternative is estimated to be the least costly. See the table at the end of this section.

Alternative 2B: Lower Abutments and Install Rock Ramp

Alternative 2B involves lowering the dam abutments to the existing elevation of the spillway (64.02' NAVD88) and installing a rock ramp fishway at slope passable to fish (20:1). The existing rock / concrete debris fill downstream of the dam would be reshaped and extended with imported cobbles and boulders. It is anticipated that suitable existing materials (rock, stream substrate, etc.) would be re-used for a rock ramp, with the goal of balancing cut/fill and limiting the amount of required import of material. However, due to the higher elevation of the dam, the rock riffle would be longer and require more imported material than in Alternative 2A. This rock ramp fishway design also would incorporate energy dissipation features and concentrated flow paths to create velocities and depths that enable upstream migration of American shad, striped bass and other fish species of interest. As with Alternative 2A, fish passage during low flows would be accommodated as much as possible with the concave surface of the ramp creating a low flow pathway. The alternative would exert little or no change to sediment transport and not result in exposure or creation of preferred spawning habitat in the impoundment.

This alternative does not require any modification to the intake structures or pumps to retain existing withdrawal capabilities, as in Alternatives 1A and 1B. Maintaining the water surface elevation at 64.4' (NAVD88) results in little or no change in water surface elevations from existing conditions. A preliminary estimated cost range for this dam modification and rock ramp fishway installation work would be between $80,000 and $100,000 (similar to Alt 2A, since more material would need to be imported and less dam modification is needed) – a more accurate estimate could be generated after preliminary design is completed.

Goldsboro Dam – Alt #2b Lower Abutments and Install Rock Ramp



Occasional routine maintenance would be required for the modified dam and rock ramp fishway. Modification of the dam and installation of the rock ramp fishway would amount to estimated construction costs slightly greater than Alternative 2A due to the additional material and construction required for the larger rock ramp. With no work required at the intake or pumps, this alternative is less expensive than Alternatives 1A and 1B. See the table at the end of this section.

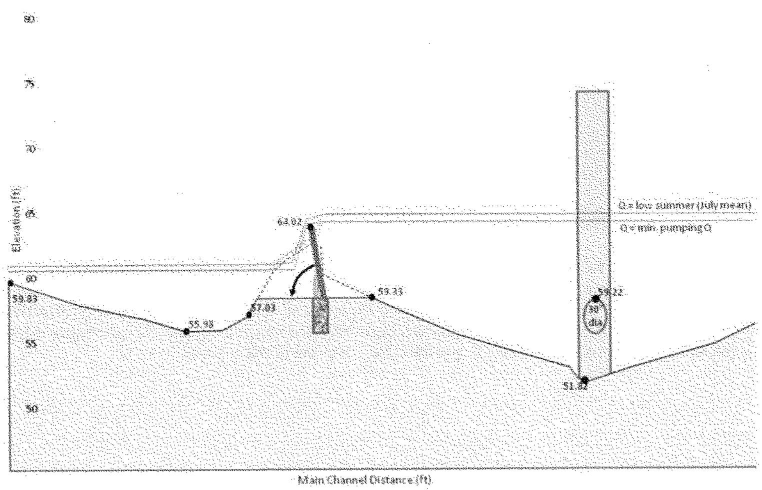
3. Dam Modification

The final alternative developed for this analysis involves reconstructing the dam or a portion of the dam to accommodate a gate structure that can adjust the height of impounded water depending on water withdrawal needs. It is likely that the majority if not all of the existing dam would need to be removed such that a suitable foundation could be constructed for the installation of a gate structure.
Options for the gate structure include:

- Obermeyer Gate
- Bottom-hinged Gate with cable hoists
- Inflatable Dam
- Stop Log Dam
- Hinged Flashboards

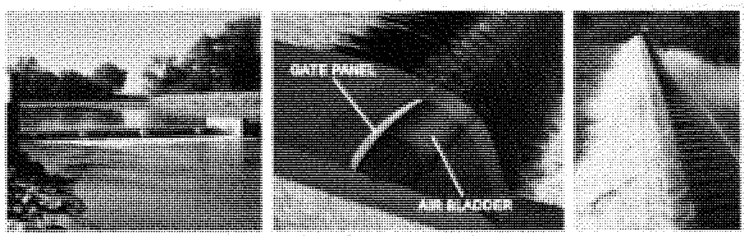
These options can be used over a narrow section of the dam length (i.e. 30ft) or along the entire dam length (105 ft). The wider configuration will allow for better debris and sediment transport; however the narrower gate configuration maybe needed in order to maintain suitable water depths for fish passage under lower flows. When the gate is down, flush with the riverbed, the crest of the gate will need to be at a single elevation, and not concave like a natural riverbed, therefore unless the crest is fully backwatered under low flow scenarios, the wider width opening could promote shallow uniform flows unsuitable for fish passage. Costs for this alternative will vary depending on the type of adjustable gate structure utilized and the width proposed, but will likely fall between $200,000 and $500,000.

Goldsboro Dam – Alt #3 Modified Dam (i.e. Bottom Hinged Gate)



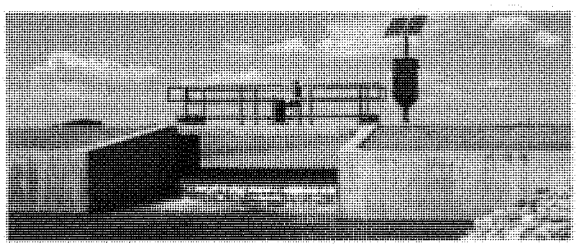
The various gate options are described in more detail below (all photographs for this section were taken off the internet from various manufactures' sites or from example projects completed by others):

Obermeyer Gate – An Obermeyer gate is a bottom hinged steel gate operated with a pneumatic support system. In simple terms it consists of a row of steel gate panels supported on their downstream side by inflatable air bladders. This spillway gate system is attached to a foundation structure by stainless steel anchor bolts. No intermediate piers are required. The gaps between adjacent panels are spanned by reinforced EPDM rubber webs clamped to adjacent gate panel edges. The Obermeyer gate is modular for ease of installation and shipping. Unlike rubber inflatable dams, the steel gate panels overhang the air bladder in all positions, protecting the bladder from floating logs, debris, ice, etc. The typical life span of the air bladders are 30 to 35 years but this life span can be extended to 40-45 years if the gate remains down and the bladders remain submerged under water the majority of the time. The in-water portions of the Obermeyer gate would cost approximately $60,000 for a 30 foot wide, 5 foot high gate (or approximately $500/sf). In addition the air supply equipment and control system would add an additional $10,000. Installation runs approximately 40% of the total gate cost and replacement of the air bladders runs an additional 40% of the total gate cost. Additional costs will include the construction of a concrete base/foundation along the riverbed such that the gate can be anchored in place. The cost of the concreted base will vary depending on final configuration of the dam and gate opening.



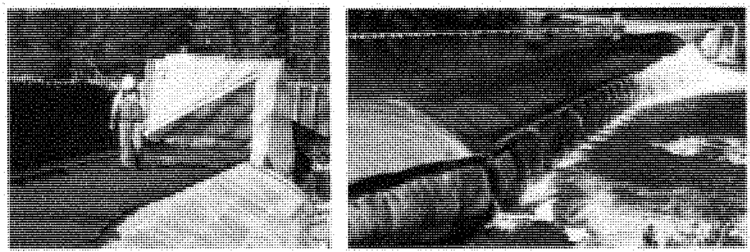
Obermeyer Gates (**www.obermeyerhydro.co**)

Bottom-hinged Gate with cable hoists – A bottom-hinged gate, such as an overshot gate manufactured by Armtec, is a bottom hinge gate with a channel-floor recess that enables the fully opened gate to lie flat on the channel floor. The gate creates a moveable weir spillway. Overshot gates are operated by single or tandem cable hoists from a catwalk spanning the gate opening. However alternative hoisting mechanisms may be available that do not require a draw bridge.



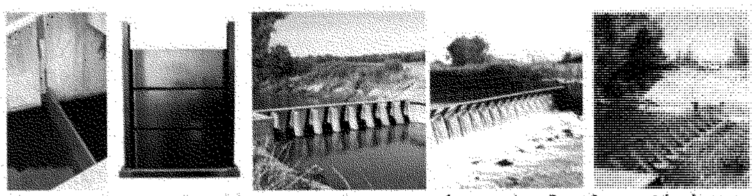
Bottom-hinged Overshot Gate with Cable Hoist (**www.armtec.com**)

Inflatable Dam - Inflatable dams are made of cylindrical rubber fabric bladders. The fabric is multi-layer fabric typically consisting of synthetic fiber, rubberized on one or both sides. A layer of stainless steel mesh or ceramic chips is sometimes embedded in the surface layer to reduce or prevent vandal damage. The rubber bladder is anchored to a foundation structure and can be inflated with a small compressor. The typical life span of the rubber bladder is 30 years but this life span can be extended if the entire bladder remains submerged under water the majority of the time.



Inflatable Dam (left: bladder deflated with temporary water control upstream; right: inflated bladder)
(Photo source: Atlantic Fluid Technology Inc.)

Stop Log Dam – A Stop-log Dam generally features several 5-foot-wide openings, called bays, with provisions to add and remove wooden or aluminum stop logs. The stop logs are set into the bays under low flow conditions within grooves typically cast into concrete piers, or built into fabricated metal bays. The water surface elevation upstream of the dam is controlled by the number of stop-logs placed in each bay. The stop logs are typically placed and removed by hand, but can be fitted with a lifting mechanism typically mounted on a catwalk spanning the bays.



Stop Logs and Stop Log Dams (Photo sources: 1. **www.annarbor.com** Argo Dam; 2. **www.trisuria.com**; 3-5. by M. Whitman of McPherrin and McGowan Dams)

<u>Hinged Flashboards</u> – Hinged flashboards can be constructed out of wood, aluminum or steel and are anchored to a concrete foundation structure using hinges. The flashboards can then be manually raised or lowered as needed during low flows and buttressed into an upright position.

Buttressed Flashboards (Photo: by L. Wildman of Cumberland Dam)

All of the adjustable gate options would only be need to be in their upright positions, and capable of backwatering water surface elevations to the current levels provided by the existing dam, during periods of low flow. During higher flows water surface elevations are maintained at acceptable levels for a fully functioning water supply intake even without a dam.

Fish passage and sediment transport for this alternative would vary considerably depending on the status of the gate level. With the gate flush with the riverbed, fish passage and sediment transport would likely be fully restored, as conditions would revert to a channel profile comparable to full dam removal. Although sediment and debris transport will also depend on the width of the gate used. As the dam/gate is elevated, fish passage and sediment transport would decline. At maximum height, fish passage would be obstructed, sediment transport would be arrested and water surface elevations would be unchanged from existing conditions. However since the dam would only need to be at maximum height during a water supply diversion in low flows, it is expected that this condition would be very infrequent and would therefore not significantly impact annual fish runs.

This alternative would require the on-going maintenance, to ensure the structural integrity and to clear collected debris if a stop log structure or narrow gate is utilized. The central columns needed to hold stop-logs in place have a high propensity to collect debris in riverine environments, especially when the stoplogs are removed.

As previously stated cost of dam modification for this alternative would be high, relative to Alternatives 2A and 2B. While no modification of the intake structure or pumps is required, installation of an adjustable gate or dam could cost approximately $200,000 and $500,000 for the initial construction, and then, depending on the gate or dam type selected, would require ongoing maintenance and potential replacement of key features, such as the air bladders if an inflatable dam or Obermeyer gate is used. It is likely that the Bottom-hinged gate with a cable hoist will the most reliable lowest tech solution that still meets the project goals while minimizing future maintenance, however this can be determined in preliminary design if Alternative 3 is selected by the City and project partners.

Conceptual Design Alternatives			General Description	Fisheries	Water Supply Intake	Maintenance	Cost of Dam Work	Cost of Water Intake Modifications
1. Full Dam Removal	A	Anticipated control elevation at 59.83'	Remove dam. Riverbed anticipated to adjust to elevation 59.83'.	Restores fish passage at all flows. Restoration of sediment transport has greatest potential to enhance spawning habitat in impounded reach.	Requires substantial modifications to intake pipes and pumps.	No maintenance at dam site and no increased maintenance at water intake if the modifications are made. The modified intake screens will also help to ensure that the intake never gets blocked with sediment.	Low. Removal of dam 50-75K	High. Modification to intake pipes and pumps. 250-400K if water is diverted during flows <164cfs
	B	Establish control elevation at 60.4'	Remove dam. Establish riverbed elevation at 60.4' with rock riffle.	Restores fish passage at most flows. Restoration of sediment transport has high potential to enhance spawning habitat in impounded reach.	Requires modification to internal suction pipes but not to in-stream intake or pumps.	No maintenance at dam site and no increased maintenance at water intake if the modifications are made.	Low. Removal of dam & limited subsurface grade control 75-100K	Moderately High. Modification of pump suction pipes. 100-200K if water is diverted during flows <75cfs
2. Modify Dam and Create Ramp	A	Lower Dam to 61.9' Flatten slope of existing riffle to 20:1	Remove dam sidewalls and most of vertical extent to elevation 61.9'. Re-shape existing riffle with imported cobbles/boulders to create fish passable slope (20:1).	Restores fish passage at most flows. Partial restoration of sediment transport has some potential to enhance spawning habitat in impounded reach.	No modification to intake pipes or pumps required. Water level is sufficient during all flows.	Some maintenance of lowered dam and riffle maybe needed overtime.	Moderate. Most of dam to be removed; modification of rock riffle 80-100K	No cost.
	B	Spillway to Remain at 64.02' Build new rock ramp at 20:1 slope	Lower dam sidewalls to elevation 64.02'. Construct rock ramp at fish passable slope (20:1) with imported cobbles/boulders.	Restores fish passage at most flows. Little change in sediment transport and spawning habitat.	No modification to intake pipes or pumps required. Little/No change in existing water levels.	Maintenance of the lowered dam and rock ramp will be needed.	Moderately High. Sides of dam to be lowered to spillway elevation; import of cobbles/boulder and construction of rock ramp 80-100K	No cost.
3. Modify Dam		Dam Elevation Variable with Modifiable Structure 59.83' - 64.02'	Reconstruct portion of dam to create modifiable dam that can temporarily raise water surface elevation when needed.	Fish passage and potential for sediment transport varies with dam height adjustment and flow.	No modification to intake pipes or pumps required. At maximum height, existing water levels are maintained.	Debris will need to be cleaned out from modified dam if it builds up. The new structure will need to be maintained and adjusted based on water withdrawal demand.	High. Demolition of existing dam and construction of new structure. 200-500K	No cost.

Recommendations and Conclusions

The conceptual design alternatives described above form an assemblage of feasible solutions, considering both engineering design and construction cost, to meet water supply and fish passage objectives. The following recommendations are offered to facilitate project partners in the decision-making process and in bringing this project to a successful conclusion.

Full dam removal would provide the most efficient fish passage at the site and restore more riverine functions and values. However, discussion with the City and other project partners, based primarily on the City's concerns with additional maintenance with the intake and pump station, has eliminated full removal (Alternative 1A) as a viable option due to the need for an additional air scouring device at the intake. Further development of Alternative 1B – full removal and installation of a rock riffle at elevation 60.4' – now appears to be the strongest alternative. Alternative 1B does not require modification of the intake pipes as preliminarily estimated, or installation of an air scouring system. Instead, only the suction pipes, which lead from the wet well to the pumps, require modification (i.e. re-positioning them to a lower elevation within the wet well). This modification would be less costly than Alternative 1A and would require no additional maintenance beyond existing conditions.

If however, the City does not wish to consider full dam removal, then Alternative 2A – lowering the dam to 61.9' and installing a rock ramp fishway – becomes the second strongest alternative. With no modification of water supply infrastructure, Alternative 2A has the lowest probable cost and is attractive due to its simple construction.

In lieu of Alternatives 1B and 2A, the next strongest alternative would be Alternative 3 – modification of the dam to incorporate an adjustable gate structure. This alternative may require the full removal and reconstruction of the dam and therefore would incur the highest cost, but it would provide the City an adjustable functioning dam and the ability to fully control the water surface elevation at the intake.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
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St. Petersburg, FL 33701-5505
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http://sero.nmfs.noaa.gov

MAY 14 2012 F/SER31:JC

Mr. Hugh Heine
Wilmington District Corps of Engineers
69 Darlington Avenue
Wilmington, North Carolina 28403

Re: Neuse River Basin Restoration

Dear Mr. Heine:

This responds to your e-mail dated March 5, 2012, requesting National Marine Fisheries Service (NMFS) concurrence with your project-effect determinations submitted pursuant to Section 7 of the Endangered Species Act (ESA) for the referenced Army Corps of Engineers (COE) Wilmington District's construction permit application to restore a portion of the Neuse River Basin adjacent to Pamlico Sound, North Carolina. You determined the proposed action may affect but is not likely to adversely affect Atlantic sturgeon and swimming sea turtles, and would have no effect on shortnose sturgeon. The COE contacted NMFS prior to submitting the above consultation request to inquire about a previously submitted consultation request dated November 11, 2011, that was apparently never received by us. We requested additional information on the current letter via e-mail on March 12, 2012, and received a final response on March 14, 2012. Our findings on the effects of the proposed action are based on the project description in this informal consultation. If the proposed action changes, or if any new species are listed or critical habitat designated before all work is completed, these findings may be negated and reinitiation of consultation may be required.

The project has four main elements, each at different locations; the two elements discussed in this letter are located at latitude 35.0724°N and longitude 76.5995°W (North American Datum of 1983) for the Gum Thicket and Cedar Creek marsh restoration portion; and located at latitude 35.0009°N and longitude 76.5356°W (North American Datum of 1983) for the Neuse River oyster reef restoration portion of the project. The four main elements proposed under the Tentatively Selected Plan (TSP) for the Neuse River Basin Restoration are: (1) Modification of the Low-head Dam on the Little River in order to restore habitat connectivity for 46 miles of important spawning habitat for anadromous fish species between the Neuse River estuary and upstream freshwater tributaries; (2) restoration of 14.5 acres of damaged or eliminated riparian buffer adjacent to the Neuse River; (3) restoration of the estuarine wetlands at Gum Thicket and Cedar Creek in order to reduce erosion on approximately 59 acres of existing estuarine wetland, creating approximately 42 acres of additional estuarine wetland; and (4) restoration of approximately 10 acres of new oyster reef that supports approximately 80 acres of estuarine habitat to be managed by the state of North Carolina as oyster reef sanctuary. Only the Gum Thicket/Cedar Creek and Neuse River Oyster Reef restoration projects will be considered further in this consultation; the other two projects as planned will have no effect on ESA-listed marine species and occur in freshwater habitat where they are under the purview of the U.S. Fish and Wildlife Service.

Restoration of Estuarine Wetlands at Gum Thicket and Cedar Creek

Objective

Restore ecological functions within an approximately 60-acre, highly degraded estuarine wetland within the Gum Thicket and Cedar Creek sub-estuaries in order to improve estuarine wetland function over a 50-year period of post-construction monitoring.

Proposed Action

A shallow-water (< 2 feet normal high water (NHW) rock sill (granite and limestone) will be constructed along approximately 3,500 linear feet of estuarine habitat following the contour of the shoreline about 60 ft offshore. The dimensions of the sill would be 30 feet wide (at the base) by 3,500 feet long by about 3 feet tall for the Gum Thicket portion and the same dimensions for the Cedar Creek portion but extending approximately 5,200 linear feet. Gum Thicket and Cedar Creek sills together will protect approximately 8,700 linear feet of shoreline. The sill will be constructed primarily of rock with some sand trucked into an onshore staging area (3-acre site already created on the uplands) and then dispersed onsite by a shallow-draft barge. The top of the sill will be located approximately 1 foot above NHW. Four-foot-wide openings will be placed every 100 feet along the length of the sills to facilitate movement of water, nekton, and plankton in and around the project area. The substrate along the intended sill footprint has no submerged aquatic vegetation or oyster beds present according to COE surveys completed on February 7-8, 2012. Between the sill and the shoreline some additional sand fill may be needed in order to plant marsh grasses (approximately 6 acres of *Spartina* spp.) that will add additional stability and habitat on the landward side of the sill. The primary benefit expected from this portion of the project is to provide approximately 6 acres of planted marsh that would help protect hundreds of acres of adjacent marsh/wetlands in Gum Thicket and Cedar Creek project areas. No dredging is associated with this project. The estimated total construction time for the sills at both locations will be approximately 3 to 6 months.

Neuse River Estuary Oyster Reef Restoration

Objective

Build a matrix of two oyster reefs over approximately 20 acres of sandy estuarine habitat within two 40-acre oyster sanctuaries (10-acre reefs for each of the two sanctuaries) to be managed by the State of North Carolina.

Proposed Action

The newly created oyster sanctuaries will be demarcated by corner buoys within the Neuse River basin at two locations including a mid-river site in the lower estuary and a site on the Neuse northern shore. Oyster reef restoration would contribute to ongoing state efforts to offset historic reef loss in the Neuse River and Albemarle Pamlico Estuary. Sanctuary areas will be off limits to oyster dredging/harvesting and shrimp trawling. Oyster matrices will be constructed of individual 4-foot-high modules with flat-top plateaus of seeded substrate (culch) constructed of a mix of limestone marl and concrete. Designated placement areas for the oyster modules will be verified for absence of submerged aquatic vegetation and existing oyster shell bottoms using side-scan sonar prior to final site designation. A one and a half acre upland staging area has been designated for oyster module preparation and a shallow-draft barge will be used to place modules onsite. Proposed oyster reefs will be located within depths of between 11 and 20-feet-deep at NHW; therefore, clearance between the tops of the oyster reef modules and the surface will be from between 7 to 16 feet. Turbidity resulting from construction is expected to be minimal and turbidity control devices waterward of the project footprint will be used during oyster reef construction and remain in place for the duration of the project. In-water construction is expected to take approximately 3 months to complete.

Five ESA-listed species of sea turtles (the endangered leatherback, Kemp's ridley, and hawksbill; the threatened/endangered[1] green; and the threatened loggerhead[2]) and the endangered[3] Atlantic sturgeon, can be found in or near the action area and may be affected by the projects. There is no critical habitat under NMFS' purview designated in or near the project areas for the species considered in this consultation.

We believe that the projects (e.g., Gum Thicket and Cedar Creek and the Neuse River oyster reef projects) are not likely to adversely affect sea turtles in the water. We have analyzed the proposed actions and believe the only routes of potential effects to sea turtles are from in-water placement (via barge) of oyster modules and in-water placement of the rock sills. Effects to sea turtles include the risk of injury from construction, which will be discountable due to the species' mobility (i.e., their ability to swim away from construction equipment/noise) and the implementation of NMFS' *Sea Turtle and Smalltooth Sawfish Construction Conditions*. Sea turtles may be affected by being temporarily unable to use the sites for forage habitat due to potential avoidance of construction activities, related noise, and physical exclusion from areas contained by turbidity curtains, but these effects will be insignificant, given the projects' small footprints and relatively short overall construction duration (i.e., 3 months). In addition, there are existing foraging and refuge resources available within the estuarine habitat just outside of and adjacent to the project areas. Disturbance from construction activities (e.g., placement of rock sill and oyster modules) and related noise will be intermittent and only occur for part of the construction period. Additionally, turbidity devices used will be based on site-specific needs and may involve a combination of silt barriers, silt curtains, floating silt curtains, or other devices deemed appropriate to contain sedimentation within the project area. These turbidity devices will only enclose the project site areas, will be removed upon project completion, and will not appreciably interfere with use of the area by sea turtles.

We believe that both the Gum Thicket/Cedar Creek and Neuse River restoration projects are not likely to adversely affect Atlantic sturgeon and will have no effect on shortnose sturgeon. A two-year intensive gill net study was conducted to determine whether or not shortnose sturgeon could be found in what was once part of their historic range in the Neuse River. No shortnose sturgeon were found even during summer months when they would most likely occur in the lower Neuse River.[4] The study areas showed extremely hypoxic conditions during summer months (2001-2002) which is likely the predominant factor leading to the extirpation of shortnose sturgeon in the area.[5] However, juvenile Atlantic sturgeon were captured during this study in both the Gum Thicket and oyster restoration areas and other research shows that Atlantic sturgeon do utilize the Neuse River as well. Atlantic sturgeon may be affected by temporary loss of foraging habitat due to exclusion from benthic foraging areas in the Neuse River during oyster reef construction; however, exclusion from areas contained by turbidity curtains will be short-term and limited to small areas at any given time and these effects will be insignificant. The construction of the sill in Gum Thicket and Cedar Creek will have no effect on foraging for Atlantic sturgeon since the work will essentially take place in 2 feet of water just offshore from the shoreline, habitat where sturgeon are not likely to be foraging due to the shallow depths and proximity to shore. Turbidity curtains will help contain short-term turbidity from placement of rocks and sand for the sill and marsh planting and effects to nearby foraging habitat will be insignificant. The Neuse River is also a known spawning area for Atlantic sturgeon; however, no impeded migratory access is anticipated for either project due to their parallel and close to shore locations and effects to spawning are discountable. In fact, long-term

[1]Green turtles are listed as threatened, except for breeding populations in Florida and the Pacific coast of Mexico, which are listed as endangered.
[2]Northwest Atlantic Ocean Distinct Population Segment (DPS).
[3]There are two DPSs of Atlantic sturgeon in the southeastern Atlantic region, the Carolina and South Atlantic DPSs, both of which are listed as endangered.
[4]Oakley, N.C. 2003. Status of shortnose sturgeon, *Acipenser brevirostrum*, in the Neuse River, North Carolina. M.S. thesis. North Carolina State University, Fisheries and Wildlife Science.
[5]Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48:319-334.

restoration benefits for both Atlantic sturgeon spawning and foraging are expected as a result of both the marsh enhancement (Gum Thicket/Cedar Creek) and oyster restoration projects by stabilizing shoreline and improving water quality and benthic prey habitat. The transit of barges transporting oyster modules into the Neuse River poses a potential adverse effect to sturgeon by risk of vessel strike. However, the barge used for oyster restoration will be a shallow-draft barge moving at speeds less than 5 knots and the risk of a vessel strike to Atlantic sturgeon is discountable. Overall, these two restoration projects are expected to benefit Atlantic sturgeon in particular since they will result in increased wetland and estuarine habitat created by the Gum Thicket/Cedar Creek restoration.

This concludes your consultation responsibilities under the ESA for species under NMFS' purview. Consultation must be reinitiated if a take occurs or new information reveals effects of the action not previously considered, or the identified action is subsequently modified in a manner that causes an effect to the ESA-listed species or critical habitat in a manner or to an extent not previously considered, or if a new species is listed or critical habitat designated that may be affected by the identified action.

We have enclosed other relevant information for your review. If you have any questions, please contact Joseph Cavanaugh, consultation biologist, at (727) 551-5097 or by e-mail at Joseph.Cavanaugh@noaa.gov.

Sincerely,

Miles M Croom

for Roy E. Crabtree, Ph.D.
Regional Administrator

Enclosures (2)

File: 1514-22.F.4
Ref: I/SER/2011/00654

PCTS Access and Additional Considerations for ESA Section 7 Consultations (Revised 7-15-2009)

Public Consultation Tracking System (PCTS) Guidance: PCTS is an online query system at **https://pcts.nmfs.noaa.gov/** that allows federal agencies and U.S. Army Corps of Engineers' (COE) permit applicants and their consultants to ascertain the status of NMFS' Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations, conducted pursuant to ESA section 7, and Magnuson-Stevens Fishery Conservation and Management Act's (MSA) sections 305(b)2 and 305(b)(4), respectively. Federal agencies are required to enter an agency-specific username and password to query the Federal Agency Site. The COE "Permit Site" (no password needed) allows COE permit applicants and consultants to check on the current status of Clean Water Act section 404 permit actions for which NMFS has conducted, or is in the process of conducting, an ESA or EFH consultation with the COE.

For COE-permitted projects, click on "Enter Corps Permit Site." From the "Choose Agency Subdivision (Required)" list, pick the appropriate COE district. At "Enter Agency Permit Number" type in the COE district identifier, hyphen, year, hyphen, number. The COE is in the processing of converting its permit application database to PCTS-compatible "ORM." An example permit number is: SAJ-2005-000001234-IPS-1. For the Jacksonville District, which has already converted to ORM, permit application numbers should be entered as SAJ (hyphen), followed by 4-digit year (hyphen), followed by permit application numeric identifier with no preceding zeros. For example: SAJ-2005-123; SAJ-2005-1234; SAJ-2005-12345.

For inquiries regarding applications processed by COE districts that have not yet made the conversion to ORM (e.g., Mobile District), enter the 9-digit numeric identifier, or convert the existing COE-assigned application number to 9 numeric digits by deleting all letters, hyphens, and commas; converting the year to 4-digit format (e.g., -04 to 2004); and adding additional zeros in front of the numeric identifier to make a total of 9 numeric digits. For example: AL05-982-F converts to 200500982; MS05-04401-A converts to 200504401. PCTS questions should be directed to Eric Hawk at Eric.Hawk@noaa.gov. Requests for username and password should be directed to PCTS.Usersupport@noaa.gov.

EFH Recommendations: In addition to its protected species/critical habitat consultation requirements with NMFS' Protected Resources Division pursuant to section 7 of the ESA, prior to proceeding with the proposed action the action agency must also consult with NMFS' Habitat Conservation Division (HCD) pursuant to the MSA requirements for EFH consultation (16 U.S.C. 1855 (b)(2) and 50 CFR 600.905-.930, subpart K). The action agency should also ensure that the applicant understands the ESA and EFH processes; that ESA and EFH consultations are separate, distinct, and guided by different statutes, goals, and time lines for responding to the action agency; and that the action agency will (and the applicant may) receive separate consultation correspondence on NMFS letterhead from HCD regarding their concerns and/or finalizing EFH consultation.

Marine Mammal Protection Act (MMPA) Recommendations: The ESA section 7 process does not authorize incidental takes of listed or non-listed marine mammals. If such takes may occur an incidental take authorization under MMPA section 101 (a)(5) is necessary. Please contact NMFS' Permits, Conservation, and Education Division at (301) 713-2322 for more information regarding MMPA permitting procedures.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, FL 33701

SEA TURTLE AND SMALLTOOTH SAWFISH CONSTRUCTION CONDITIONS

The permittee shall comply with the following protected species construction conditions:

a. The permittee shall instruct all personnel associated with the project of the potential presence of these species and the need to avoid collisions with sea turtles and smalltooth sawfish. All construction personnel are responsible for observing water-related activities for the presence of these species.

b. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing sea turtles or smalltooth sawfish, which are protected under the Endangered Species Act of 1973.

c. Siltation barriers shall be made of material in which a sea turtle or smalltooth sawfish cannot become entangled, be properly secured, and be regularly monitored to avoid protected species entrapment. Barriers may not block sea turtle or smalltooth sawfish entry to or exit from designated critical habitat without prior agreement from the National Marine Fisheries Service's Protected Resources Division, St. Petersburg, Florida.

d. All vessels associated with the construction project shall operate at "no wake/idle" speeds at all times while in the construction area and while in water depths where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will preferentially follow deep-water routes (e.g., marked channels) whenever possible.

e. If a sea turtle or smalltooth sawfish is seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle or smalltooth sawfish. Operation of any mechanical construction equipment shall cease immediately if a sea turtle or smalltooth sawfish is seen within a 50-ft radius of the equipment. Activities may not resume until the protected species has departed the project area of its own volition.

f. Any collision with and/or injury to a sea turtle or smalltooth sawfish shall be reported immediately to the National Marine Fisheries Service's Protected Resources Division (727-824-5312) and the local authorized sea turtle stranding/rescue organization.

g. Any special construction conditions, required of your specific project, outside these general conditions, if applicable, will be addressed in the primary consultation.

Revised: March 23, 2006

Appendix E: Water Quality

Appendix E includes original documentation of water quality conditions in the Neuse River Basin. This material may be used to supplement more recent information presented in the main body of the Feasibility Report. Several completed total maximum daily loads (TMDLs) in the basin are presented in this appendix providing readers information on the causes of water quality impairment in the basin. Every two years that state finalizes (with USEPA) a list of waterbodies not meeting their designated use. This list is referred to as the 303(d) list, from Section 303(d) of the Clean Water Act. The most recent finalized version (2008) is presented in this appendix as of September 2010. The *Nutrient Sensitive Waters Management Strategy Protection and Maintenance of Existing Riparian Buffers* is also presented for readers to better understand actions taken by the state.

Every five years the state presents current water quality conditions in the basin in the *Neuse River Basinwide Water Quality Study*. The current study (finalized in 2009) is available for download from the NC Division of Water Quality's internet web page. This document is referenced and summarized in the Feasibility Report but is not included in this appendix.

The following was taken verbatim from NCDNR, Albemarle-Pamlico National Estuary Program (2000):

> *Compared to the other river basins in the Albemarle-Pamlico region, the impairment of water uses in the Neuse basin affects less area, but the basin is affected by more severe localized problems. Water use impairment affects 30% of the freshwater stream miles and 9% of the estuarine area. In the freshwater portion, the most widespread causes of impairment are high levels of sediment and low dissolved oxygen. In the estuarine area, the most widespread causes of impairment are high levels of chlorophyll a, reflecting algal growth, and high levels of nutrient runoff from both urban areas and agriculture.*
>
> *Due to eutrophication in the estuarine area, the lower Neuse River Basin has been classified as nutrient sensitive waters (NSW) since 1988. The upper Neuse River basin above Falls Lake has been classified NSW since 1983. In eutrophic water bodies, such as the lower Neuse River, frequent algal blooms reduce available dissolved oxygen and result in fish kills and general environmental stress for aquatic organisms.*
>
> *The waters between Minnesott Beach and New Bern are highly use-impaired as a result of frequent algal blooms. Such symptoms of eutrophication in the Neuse River Estuary have resulted in special concern for nutrient loadings in the basin. Closures of shellfish harvesting areas are another consequence of impairment in the estuarine portion of the basin. Closures result when concentrations of fecal coliform indicate a possible health hazard for human consumption. This has resulted in the closure of shellfish waters in the lower Neuse River Estuary. Since 1980, substantial increases in the acreage of shellfish closures occurred in the South River and Oriental areas.*
>
> *Local concentrations of toxic substances, particularly metals and dioxin, have been identified at several sites in the Neuse basin. Samples of water, sediments, and fish tissues have indicated areas of concern for impacts on aquatic life and human health. Compared to the other major river basins of the APES region, toxic concentrations of metals in the water column were highest in the Neuse, particularly in the upper portion of the basin in Durham and Wake counties.*
>
> *Concentrations of metals in sediments are of particular concern in the estuarine portion of the Neuse basin in the New Bern-Bridgeton, Slocum Creek, Lawson Creek-Trent River, and Oriental Harbor areas. Fish tissues sampled at 13 sites had concentrations of metals and other substances at levels of concern for human health. The area of greatest concern is Slocum Creek. Concentrations of metals in fish tissues were of*

> *particular concern for wildlife along Contentnea Creek at Wilson and along the Neuse River at New Bern and Kinston.*
>
> *Dioxin concentrations that may be of concern for human health and for wildlife were found in the Neuse near the Weyerhauser facility at New Bern. The Weyerhauser plant has since changed its bleaching process in an effort to minimize this source of dioxin. Contamination levels for dioxin in the Neuse were generally lower than in the Chowan, Roanoke, and Albemarle basins.*

According to the Neuse River Basinwide Water Quality Study (NCENR 2008b):

> *Biological, chemical and physical monitoring data presented in this basinwide water quality plan is based on data collected in calendar years 2002 through 2006. This is the same data window used for the 2008 Integrated Report (303(d) and 305(b) listings). The routine biological monitoring in the Neuse River basin took place in 2005.*
>
> *In the entire Neuse River basin, 459 freshwater stream miles (14 percent of the total miles), 13,538 freshwater acres (76 percent), 35 saltwater stream miles (25 percent), and 57,648 saltwater acres (16 percent) were impaired for one or more surface water quality standards.*
>
> *The majority of the freshwater stream miles in the Neuse River basin are impaired due to impaired biological integrity (BI), low dissolved oxygen levels and elevated turbidity. The majority of the fresh and saltwater acres are impaired as a result of elevated chlorophyll a and high pH (due to elevated nutrients), turbidity and bacteria (fecal coliform and enterococci) levels.*

Eutrophication became a water quality concern in the lower Neuse River Basin in the late 1970s and early 1980s. Nuisance algal blooms prevalent in the upper estuary prompted investigations by NCDWQ. The investigations, as well as other studies, indicated that algal growth was being stimulated by excess nutrients entering the estuarine waters of the Neuse River. In 1988 the lower Neuse River Basin received the supplemental classification of nutrient-sensitive waters (NSW). As part of this early nutrient strategy, new and expanding NPDES discharges, as well as existing facilities with design flows greater than 0.05 MGD, were assigned a quarterly average phosphorus limit of 2 mg/L. Phosphorus loading was greatly reduced, and algal blooms in the river and freshwater portions of the estuary were reduced as a result of this action.

The 1993 *Neuse River Basin-wide Water Quality Plan* recognized that eutrophication continued to be a water quality problem in the estuary below New Bern. Extensive fish kills in 1995 prompted further study of the problem. Low dissolved oxygen levels associated with algal blooms were determined to be a probable cause of many of the fish kills. Researchers also suggested that the toxic dinoflagellate, *Pfiesteria piscida*, might have been responsible for a number of the fish kills.

The severe fish kills, algal blooms, and correspondingly high levels of chlorophyll *a* prompted NCDWQ to place the Neuse River Estuary on the 1994 303(d) list of impaired waters. In 1996 the North Carolina Senate Select Committee on River Water Quality and Fish Kills sponsored a workshop with numerous scientists familiar with the Neuse River's water quality problems. The group reached consensus that a 30 percent reduction in total nitrogen entering the estuary was a good starting goal to reduce the extent and duration of algal blooms. In 1996 the 30 percent reduction was put into law (Session Laws 1995, Section 572). The state funded the Neuse Modeling and Monitoring Project (ModMon) to quantitatively assess the interactions and pathways between nutrients, phytoplankton, and dissolved oxygen in the estuary. A TMDL was developed in two stages and approved by USEPA in 2002 to address the nitrogen overloading to the estuary. The TMDL developed for the Neuse River Estuary showed that a 30 percent reduction in nitrogen loading is needed.

The NCEMC adopted a comprehensive set of permanent rules that became effective August 1, 1998, to implement the Neuse River Nutrient Strategy. While individual implementation dates varied, all the rules were fully implemented by 2003.

The rules are as follows:

> *Toxic substances enter the basin through both point and nonpoint sources. The point sources in the A/P [Albemarle-Pamlico] Sounds region have been evaluated for their potential to cause toxicity. There are at least 21 dischargers in the Neuse basin that contribute loadings of four metals: zinc, copper, lead, and chromium. Eleven dischargers in the Neuse basin may contribute to instream water quality concentrations of toxics that exceed acceptable levels during low flow conditions. Seven dischargers in the basin have been identified that may potentially exceed such levels under average flow conditions. These dischargers are in Orange, Durham, Wake, and Johnston counties. Another cause of concern for the water quality of the basin is the occurrence of fish and shellfish diseases and kills.*
>
> *Between late 1986 and late 1989, 41 fish kills were reported in the Neuse basin. About two-thirds of these kills occurred in the upper half of the river basin. Low dissolved oxygen, disease, and suspended sediments were suspected of causing the kills. Another possible cause of fish kills in the Neuse basin is a toxic dinoflagellate recently discovered in the Albemarle-Pamlico region. This organism is thought to have been responsible for at least 25% of the fish kills in the Neuse basin over the last two years. The relationship of this organism's behavior to phosphate levels is now under investigation.*
>
> *The largest source of nonpoint source pollution in the basin is agriculture. Several urban areas in the basin provide another source of runoff. These*

areas include Durham, Raleigh, Smithfield, Wilson, Goldsboro, Kinston, New Bern, and Havelock. In urban areas, there is a high potential for stormwater to move rapidly into streams and rivers without adequate filtration. Waste disposal sites are another source of polluted runoff. The Neuse basin has over 70 solid and hazardous waste sites, most of which are concentrated in the upper basin counties. There are almost 400 permits for point source discharges in the Neuse basin.

Total Maximum Daily Load for Total Nitrogen to the Neuse River Estuary, North Carolina

June 1999

Neuse River Basin

Prepared by:
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I. Background And Purpose

I-A. Section 303(d) Requirements

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or waters which have impaired uses. Waters may be excluded from the list if existing control strategies for point and nonpoint source pollution will achieve standards and uses. Listed waterbodies must be prioritized, and a management strategy or total maximum daily load (TMDL) must subsequently be developed for all listed waters. The 303(d) process is presented in Figure 1.

I-B. Neuse Basin Description

The Neuse River originates northwest of Durham and flows southeasterly for over 150 miles past Raleigh, Smithfield, Goldsboro and Kinston before it reaches its estuary around New Bern (Figure 2). The Neuse River's watershed encompasses nearly 6200 square miles over 19 counties. A few miles above New Bern, the river takes on estuarine characteristics as it widens but remains shallow (< 5 m), frequently resulting in minimal discharge and long hydraulic residence times. The Neuse River estuary stretches to the southeast for 25 miles until it reaches Cherry Point (Minnesott Beach on the north side), where it turns to the northeast and continues for another 20 miles before meeting Pamlico Sound. Estuarine salinity varies vertically and horizontally with saltwater inflow from the sound, meteorological conditions (wind and precipitation), and river discharge (Pinckney et al., 1997). Up-estuary advancement of saline water along the bottom occurs in the growing season during low to moderate discharge and prevailing southwest winds. Saltwater advance typically persists until heavy winter rains result in high river discharge that drives the salt wedge back into the sound.

I-C. History of Nutrient Issues in the Neuse Basin

Eutrophication became a water quality concern in the lower Neuse River Basin in the late 1970s and early 1980s through the proliferation of nuisance algal blooms (Paerl 1983, 1987; Stanley 1983; Christian et al. 1986). A prevalence of algal blooms in the freshwater portion of the basin prompted a special Division of Water Quality (DWQ) investigation of the Neuse River beginning in 1979 (Tedder et al., 1980). This study found that phytoplankton growth in the Neuse was not limited by the major nutrients of nitrogen or phosphorus. Similar conclusions derived from other studies led to a ban on phosphate detergent and classification of the lower basin as nutrient sensitive water (NSW); both actions were instituted in January, 1988. One requirement of the NSW strategy was that all new and expanding NPDES dischargers, as well as existing ones with design flows greater than 0.05 MGD, must meet a quarterly average phosphorus limit of 2 mg/l.

In 1993, DWQ completed the Neuse River Basinwide Water Quality Management Plan, which recognized the reductions in total phosphorus loading that had been achieved through the phosphate detergent ban and the NSW strategy. Furthermore, the reduction

Figure 1. The 303(D) Process

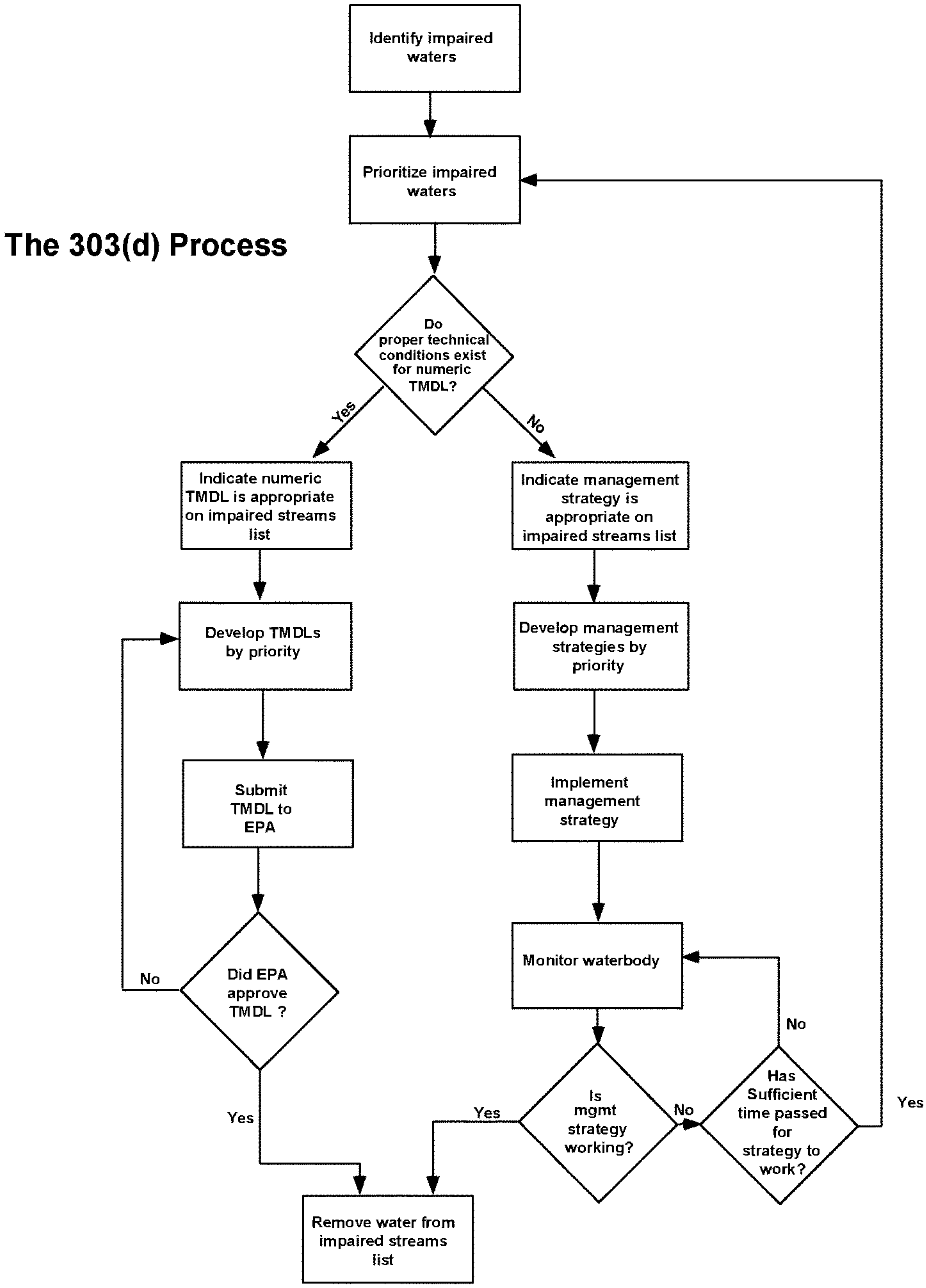
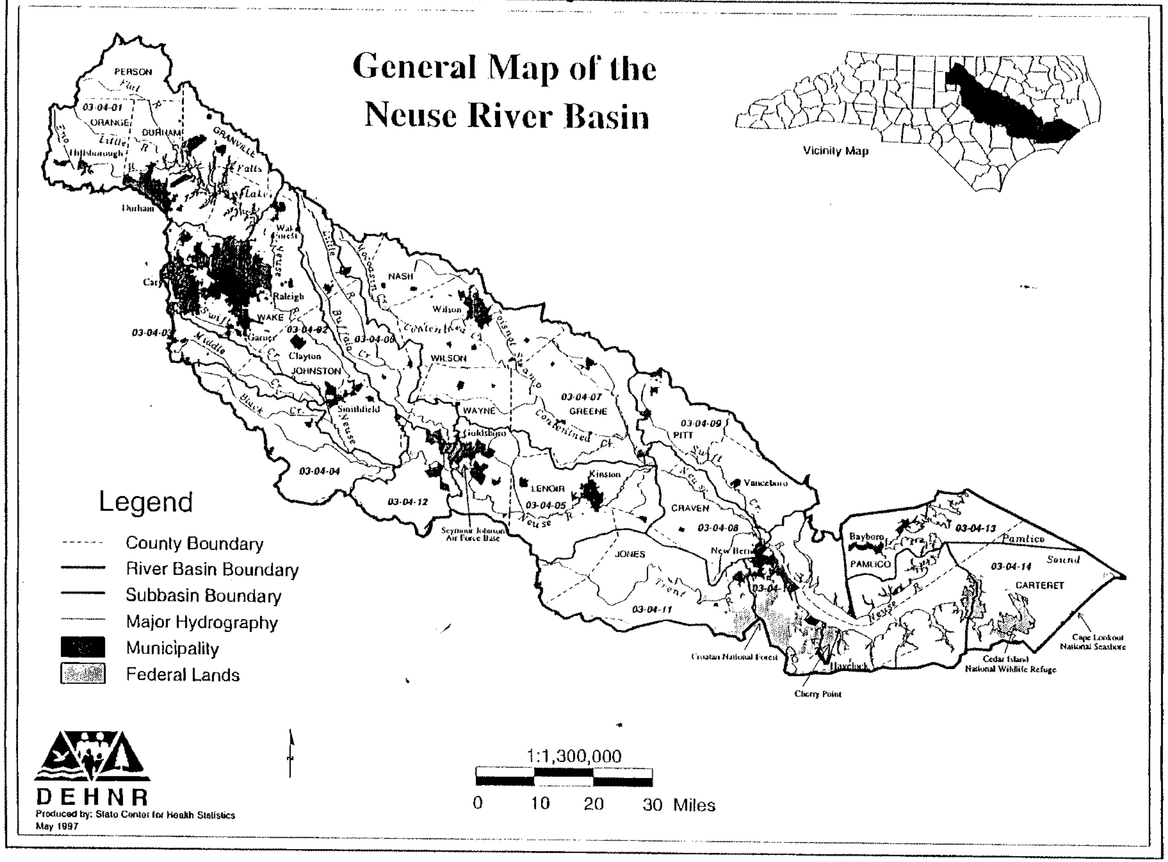


Figure 2.


General Map of the
Neuse River Basin
Vicinity Map
Legend
County Boundary
River Basin Boundary
Subbasin Boundary
Major Hydrography
Municipality
Federal Lands
DEHNR
Produced by: State Center for Health Statistics
May 1997
1:1,300,000
0 10 20 30 Miles
PERSON
ORANGE
DURHAM
GRANVILLE
WAKE
JOHNSTON
NASH
WILSON
WAYNE
GREENE
LENOIR
PITT
CRAVEN
JONES
PAMLICO
CARTERET
Durham
Raleigh
Clayton
Smithfield
Wilson
Kinston
Vanceboro
New Bern
Bayboro
Havelock
Cherry Point
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03-04-14
Pamlico Sound

in phosphorus loading greatly reduced algal blooms in the river and freshwater, uppermost portion of the estuary. However, the plan recognized that eutrophication was still a problem in much of the estuary. The plan indicated that a water quality model of the estuary would be developed, and that addressing eutrophication in the estuary was a priority (NCDEM, 1993).

During July, September, and October 1995, extensive fish kills occurred in the Neuse estuary, primarily from New Bern to Minnesott Beach. Millions of menhaden, as well as flounder, croaker and rock fish were killed. DWQ conducted extensive water quality sampling in the areas of the fish kills. The sampling showed the water was often hypoxic only 1 to 2 meters below the surface. The results also showed a prevalence of algal blooms. Though not directly linked to these fish kills through published data, a toxic dinoflagellate, *Pfiesteria piscida*, has been found in the water where many of the fish kills occurred (Burkholder and Glasgow, 1997). Researchers have suggested that *Pfiesteria* may have been responsible for 30 to 50 percent of the fish kills in the estuary. Furthermore, its presence is thought to be stimulated by eutrophic conditions (Burkholder et al. 1995). In sum, the 1995 fish kills and threat of *Pfiesteria* led to a review of water quality and management actions to expedite nutrient loading reductions in the system.

I-D. Pollutant Addressed by TMDL

The Neuse River was listed as one of the 20 most threatened rivers in the United States because of the frequency, magnitude and areal extent of phytoplankton blooms (American Rivers, Washington, D.C. 1996). As a result of these phytoplankton blooms and chlorophyll *a* levels, North Carolina placed the Neuse River estuary on its 1994, 1996 and 1998 303(d) impaired waters lists. Controlling nutrients is the most direct way to reduce chlorophyll *a* concentrations, and the science indicates nitrogen is the main nutrient of concern in the estuary. Early nutrient addition bioassays (Paerl 1987, Rudek et al. 1991, Paerl et al. 1995) and nutrient uptake kinetics studies (Boyer et al. 1994) showed that phytoplankton growth was nitrogen limited throughout the estuary. Other bioassay studies found that nitrogen enrichment yielded similar phytoplankton growth as with nitrogen and phosphorus enrichment (Paerl et al. 1995, Pinckney et al. 1997). Some parties suggest that quasi-quantitative management of phosphorus is needed as well. This does not appear to be necessary as colimitation by nitrogen and phosphorus only appears to occur during high spring loading events when it is not likely that any management strategy would reduce productivity due to the presence of abundant nitrogen and phosphorus (Paerl et al. 1990, Rudek et al. 1991, Paerl et al. 1995). In a letter to Dr. Tim Spruill of USGS on December 22, 1998, Dr. Hans Paerl noted that much of the present watershed phosphorus loading is naturally occurring, and originally derived from soil weathering, mineralization, and solubilization processes. Such sources would be extremely difficult to manage, and the Clean Water Act does not require that natural sources be reduced. Furthermore, nitrogen and anthropogenically derived phosphorus have similar sources, and many of the nonpoint source management strategies aimed at nitrogen will obtain parallel phosphorus reductions.

Tetra Tech (Butcher 1999 - see TMDL Reduction Target Section) considered the nitrogen to phosphorus (N:P) ratio to determine which was the limiting nutrient, and found that gross N:P ratios, based on annual load estimates at Fort Barnwell, show an increase coincident with the phosphate detergent ban, though the ratio is generally less than 10. The individual observations show that temporary high N:P ratios, often above 15, have occurred since 1989. Tetra Tech states that a ratio between 10 and 15 is generally regarded as a dividing line between nitrogen and phosphorus limitation, which would indicate occasional limitation by phosphorus. This analysis was conducted at Fort Barnwell, well upstream from the impaired segments, in strictly freshwater. Somewhere between Streets Ferry Bridge and Cherry Point would be the preferred site(s) for this analysis. Furthermore, as Dr. Martin Lebo of Weyerhaeuser notes (letter to Dr. Tim Spruill, USGS on December 18, 1998), typically half of the total nitrogen pool is comprised of organic nitrogen, which is "largely resistant to microbial degradation over typical residence times for water in the estuary and, thus, only partially available to stimulate algal growth. The impact of organic nitrogen fractions on the appropriate N:P ratio for calculations...is that a realistic number is 15-20." This would certainly decrease the frequency of apparent phosphorus limitation. Additionally, it appears by the individual observation plots (Butcher, 1999) that the high N:P ratios occur in the late-winter and spring, and as previously stated, nutrient limitation is particularly challenging under those conditions. Finally, trend analyses indicate that phosphorus loads have been decreasing over much of the basin, which suggests that reducing phophorus loads will not impact the estuary as much as reducing nitrogen loads. These analyses are highlighted in the Riverine Loading subsection.

The remainder of this document describes the TMDL that has been developed for total nitrogen across the entire Neuse basin.

II. TMDL DEVELOPMENT

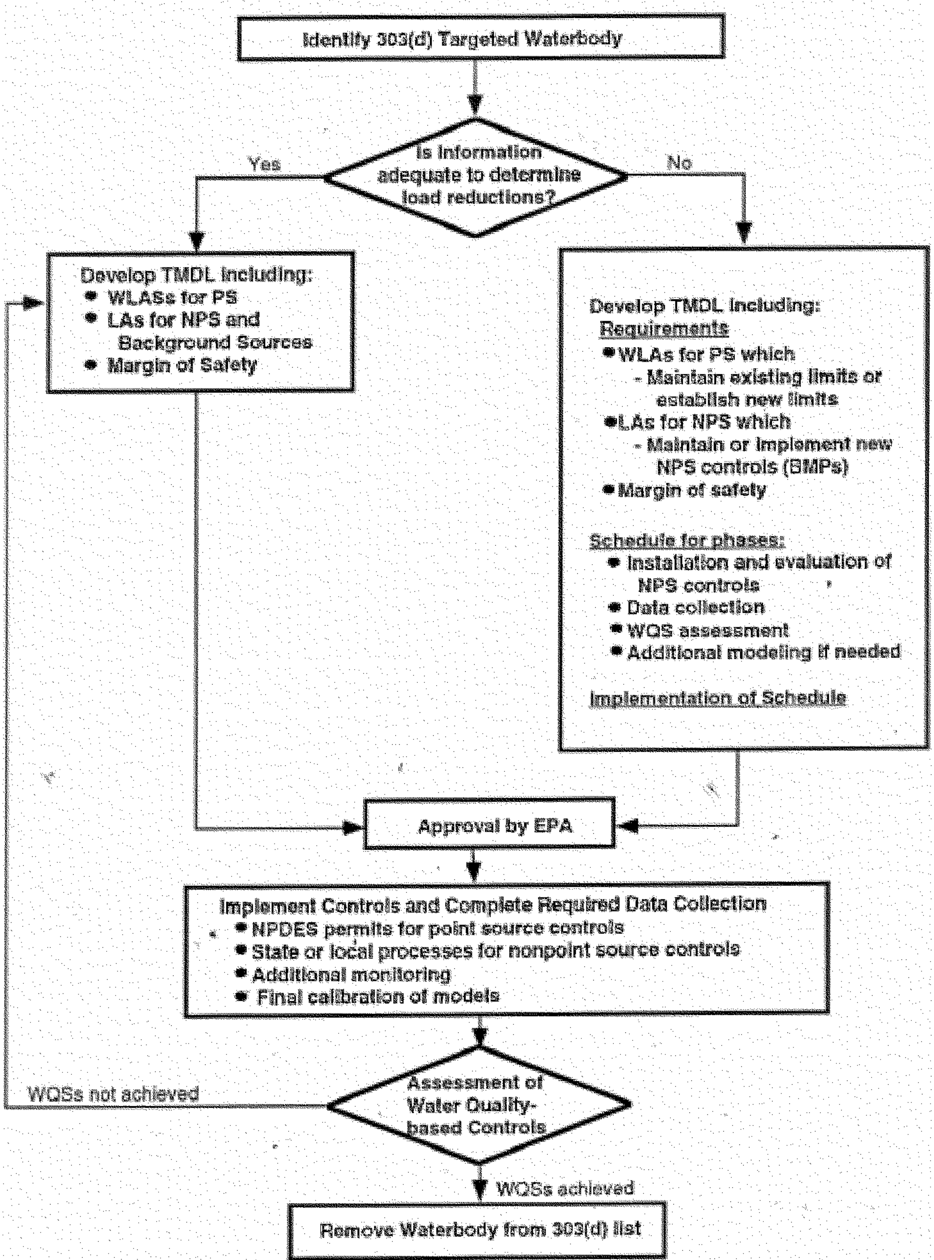
II-A. TMDL Approach

In 1991, the Environmental Protection Agency (EPA) published guidance for states to follow when developing TMDLs (USEPA, 1991). This guidance document outlined two potential approaches, one to follow when available data are adequate to develop the TMDL and the allocations between point and nonpoint sources, and one to follow when there is greater uncertainty in the data. These approaches are illustrated in Figure 3.

EPA has used the term "phased TMDL" for TMDLs developed where there is a higher degree of uncertainty in the TMDL calculations and allocations. The narrative portion of the guidance states that the "phased approach is required when the TMDL involves both point and nonpoint sources and the point source WLA is based on a LA for which nonpoint source controls need to be implemented" (USEPA, 1991).

North Carolina has opted to develop a phased TMDL for nitrogen in the Neuse River Basin for several reasons: there is no estuarine water quality model at this time, the fate

Figure 3 Development of TMDLs for Targeted Waterbodies



Source: EPA, Guidance for Water Quality - based Decisions: The TMDL Process, April 1991.

and transport of nitrogen is not clearly understood, there is uncertainty in the magnitude of the various nonpoint sources, and nutrient studies are ongoing in the basin.

Due to the lack of a fully calibrated estuarine response model, there is no good tool to determine the allowable nutrient loads to the Neuse River estuary. Therefore, the first phase of this TMDL is based on the best professional judgment of scientists who have done much research in the Neuse River and other analyses. There is much ongoing work in the Neuse River estuary including the development of an estuarine response model that will provide DWQ with more information. The TMDL process is iterative, and DWQ will continue to evaluate available data, assess use support, and the TMDL (subsection on Future Phases of TMDL, Figure 14 for phased schedule). If data indicate that there are more effective methods to address the eutrophication issues in the estuary, DWQ will modify the management strategies that have been developed to implement the first phase of the TMDL. If an acceptable estuarine response model and other pertinent research indicate that the TMDL itself must be modified, this will occur as well. Further information on this on-going monitoring, future work, and schedules is provided in the Subsection entitled "Ongoing and Future Studies in the Neuse River", beginning on p. 29.

The remainder of this section of the report will describe the science that is available to further examine the nitrogen loading reduction target, the TMDL calculation, and the allocation among the sources. The Clean Water Act also requires that all TMDLs account for seasonality and a margin of safety. Due to the lack of an estuarine response model, these issues are difficult to quantify, but they are addressed qualitatively in this section as well.

II-B. TMDL Reduction Target

There is broad consensus among the water quality experts, both within and outside DWQ, that a thirty percent reduction in total nitrogen is a good initial step to restore water quality in the Neuse River estuary. At a January 1996 workshop sponsored by the NC Senate Select Committee on River Water Quality and Fish Kills, a consensus was reached by the numerous scientists familiar with the Neuse River that a 30 percent reduction in total nitrogen was a good goal. A summary of this meeting is included in Appendix I. This goal was codified by the NC General Assembly during its 1996 session in Session Laws 1995, Section 572 (Appendix II). While comments have been received that indicate a 50% reduction in total nitrogen is needed in the Neuse River, insufficient evidence was submitted to support this conclusion.

Presently, phytoplankton growth dynamics, nutrient pathways and sediment diagenesis in the Neuse River estuary are only partially understood. The scientific community has an idea of how basic processes operate but cannot quantify, or reduce uncertainty about many of the processes that lead to nuisance algal blooms, anoxia, and fish kills. However, this state of gross uncertainty is likely to improve in the near future as there are numerous State-funded Neuse River MODeling and MONitoring (MODMON) projects underway. One of their main purposes is to quantitatively assess interaction and the pathways between nutrients, phytoplankton, and dissolved oxygen. Once this research is completed, the Neuse stakeholders will have a greatly enhanced ability to assess an appropriate load reduction target.

Currently, there is no estuarine water quality model available that can be used to predict the effects of this proposed nitrogen reduction on water quality standards in the estuary, although significant progress has been made on a model that will ultimately be used to refine the TMDL presented in this report. There are other tools that were examined to determine if there is sufficient evidence at this time to refine the scientists' recommendation. The following sections briefly outline available tools, their limitations, and how they were used to examine the reduction target.

Estuarine Response Model

The 1996 General Assembly allocated money to monitor and model the Neuse River estuary. DWQ contracted with a team of university researchers to collect monitoring data throughout the estuary and develop a two dimensional estuarine water quality model to determine allowable nutrient loads. This effort is part of MODMON.

At this time, the model has been calibrated using data collected between May and September 1991. An uncertainty analysis has also been developed for this calibration period. Data collected from June through December 1997 have been used for model verification.

Dr. James Bowen, the principal investigator developing the estuary model, has stated that the model should ultimately be able to be used to determine nutrient TMDLs for the Neuse River estuary, however, Dr. Bowen has stated, also, that the model is not yet ready to be used in that manner (personal communication on January 12, 1999, letter from Dr. Bowen to EPA on February 19, 1999). The following reasons have been cited: (1) difficulty establishing initial conditions without a full calendar year of data; (2) inadequate data to develop downstream boundary condition; (3) need for sediment model that will do multi-year simulations; and (4) 1991 and 1997 were fairly average hydrologic years to simulate with a model. Further information on each of these reasons is provided below.

Data were available from May through September 1991 and June through December 1997 for model development. In each of these years, the high winter and spring discharge and loads that occur prior to the summer conditions have not been monitored. Therefore, it is difficult to quantify the initial conditions that occur prior to the growing season, when hypoxia is prevalent. Work is currently underway to use data collected from January through December, 1998 to refine the model. These data do capture the winter and spring discharge/load needed to quantify initial conditions.

The model is very sensitive to the downstream boundary conditions as this is used to calibrate its hydrodynamic component. For the runs completed to date there were no good data available at the downstream boundary. Current velocity data collected near Cherry Point were used to set the downstream boundary, but there is quite a bit of uncertainty associated with this indirect method. A water level monitor is necessary further downstream, and that was installed in January, 1998.

The current model contains a single constituent sediment model. The model predicts sediment organic carbon and then calculates sediment oxygen demand and nutrient fluxes for ammonium and phosphate. Data are available that indicate the sediments are a major source of nutrients and oxygen demand, and it will be critical to develop a sediment model that is capable of doing multi-year simulations (DWQ 1998, Bowen and Hieronymus 1999, Christian & Thomas 1999). Without the capability of doing multiyear simulations, the model is only designed to predict what the change in water quality would be in the year that nitrogen reductions occur. This will not provide accurate predictions of long term water quality improvement, while there is consensus among research scientists that improvement will likely take a number of years following achievement of reduced loading. The 1998 General Assembly allocated additional money to extend the MODMON project. A proposal has been submitted by Dr. Bowen to obtain funds to include a multi-year simulation sediment model within the estuary water quality model.

Finally, 1991 and 1997 were similar and average hydrologic years. There were no high discharge, winter/spring loading events, or periods of hot and dry weather in the summer. The model in its current state could only predict water quality conditions for years with similar flow regimes. 1998 was different hydrologically and will enable us to predict water quality under a wider array of conditions. High flows were experienced in early 1998, and there was one period of anoxia and fish kills.

DWQ intends to use the 1998-calibrated version of the estuary water quality model to refine its estimates of the TMDL. The estuary model should be delivered to DWQ in April, 2000 and DWQ will work with stakeholders to use the model to refine the total nitrogen loading target. The enhanced sediment component of the model will be included in the version DWQ uses for developing management scenarios. Further information is provided in section VI titled "Future TMDL Initiatives", beginning on p. 41.

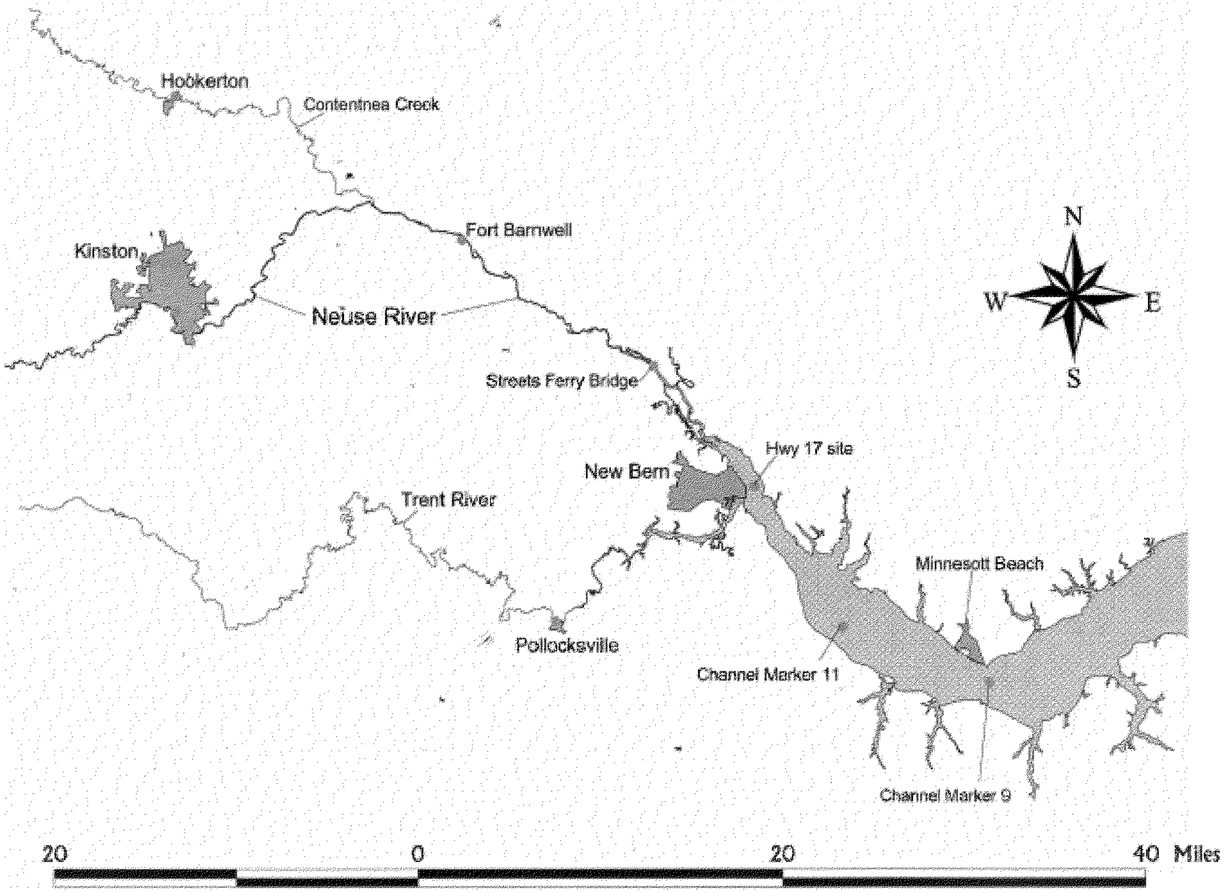
Statistical Approaches

This subsection considers several analyses to assess the present validity of the scientists' best professional judgement that a 30% nitrogen reduction represents a reasonable initial target. These analyses include: (1) DWQ's trend analysis of riverine loading and a hindcast estimate of loading in 1975, (2) Stow and Borsuk's "An Examination of Long Term Nutrient Data in the Neuse River Watershed", (3) Tetra Tech's analysis of the TMDL. Refer to Figure 4 for a map of the estuary and relevant sites to the following analyses.

Riverine Loading

This portion of the TMDL addresses the issue of historical riverine nutrient loading through monotonic trend analysis. Because we lack the tools to make a linkage between

Figure 4. Map of Neuse River Estuary and Sites Relevant to the TMDL



riverine nutrient loading and algal response in the estuary, some efforts to determine a reduction target have been shifted to examine changes in riverine loading over time. If loading has increased as estuary water quality has declined, nutrient load targets similar to those that occurred when estuary water quality was acceptable could be determined. Acceptable water quality is defined by DWQ as when a water body supports its designated uses. North Carolina's 305(b) report, as well as research in 1975 reported that the Neuse estuary was meeting its uses (Hobbie and Smith, 1975), so 1975 has been used as the beginning year for this nutrient loading trend analysis. As will be shown in Section III, DWQ uses 1991-1995 to determine baseline loads so 1995 was chosen as the end of the trend analysis period.

Kinston is the farthest downstream site on the main stem of the Neuse that records both flow and nutrient concentration. However, Kinston does not include loading from Contentnea Creek, the Neuse River's largest tributary. To address Contentnea Creek, DWQ assessed nutrient loading trends at Hookerton, NC, the most downstream monitoring site in the Contentnea Creek watershed to provide both discharge and nutrient concentration data. DWQ chose this approach because flow was not measured at Ft. Barnwell (on Neuse, includes Contentnea Creek discharge) until recently; it must be estimated during the period of interest with a regression equation that uses flow at Kinston, and this introduces error. Additionally, one of the MODMON projects that is near publication, Stow and Borsuk's "An Examination of Long Term Nutrient Data in the Neuse River Watershed", addresses loading at Kinston and is presented as another approach to trend analysis.

Scientists studying the Neuse River estuary have identified nitrogen as the limiting nutrient in phytoplankton growth on a year-round basis (Boyer et al 1994, Paerl 1987, Paerl et al 1998, Pinckney et al. 1998, Rudek et al 1991,). Probably because of the phosphorus ban in 1988, DWQ found an overall decreasing trend in total phosphorus load at Kinston and Hookerton between 1975 and 1995. For these reasons, the trend analyses focus on nitrogen but will also provide less detailed phosphorus information.

Seasonal Kendall Tests

To determine if a trend in loading was present at Kinston and Hookerton between 1975 and 1995, DWQ employed the seasonal Kendall (SK) test on log normalized, flow-corrected, nitrogen and phosphorus loads. The SK is a nonparametric method that is considered the standard for water quality trend analyses (Reckhow 1999, Aroner 1995). The limitations of the SK are that it only considers monotonic (unidirectional) trends, and that it provides limited insight on the cause of trends compared to other methods. DWQ is primarily interested in detecting a monotonic change since 1975, so that limitation is acceptable. Also, the SK does not provide an efficient hindcast estimate of earlier data. A hindcast estimate in trend analysis is a linear slope which allows estimation of loads at a desired period in the record given a known load at some other date. In this instance, total nitrogen load between 1991 and 1995 has been quantified (Section on TMDL Calculation), so with a robust slope, estimates of loading in the mid 1970s may be obtained. The Sen slope estimator, typically used with the SK, is not considered an efficient estimator of slope as it considers median values in the trend. A more robust hindcast estimate of the slope of nitrogen loads at Kinston was therefore developed using ordinary least squares regression (accounting for correlation) and autoregression, which are techniques professed by a recognized time series statistician, Dr. David Dickey, at N.C. State University (personal communication January 22, 1999). These techniques are also useful in explaining the cause of the trend. To estimate if real delivery has changed, DWQ also examined the results of the SK test on unadjusted load.

The goal of the trend analysis is to make some statement about changes in watershed activity over the period of record. There are numerous factors that explain the variability in load, but after correcting for the deterministic factors of flow and seasonality, one of the primary remaining factors must be watershed activity, or more explicitly, anthropogenic loading. Anthropogenic loading is what we can manage to meet a load reduction target so it is logical that we focus our trend analysis on this. DWQ chose to look at flow adjusted load as the basis for trend detection. DWQ is interested in load because it captures some signal of the important nonpoint source events. Concentration would lose the nonpoint source signals because higher flows often mean dilution of the carried constituents. Also, load is preferred to concentration because it is the standard by which progress in implementation will be measured. It seems reasonable to adjust for flow since it tends to represent recent weather patterns that have no reflection on changes in watershed activity; however, there may be hydrologic alterations in the watershed which do reflect changes in land use and will affect flow. Flow adjusted load is not an ideal measurement of anthropogenic loading but it seems to be as close as one can get in this context.

The calculation of nutrient loads that were subjected to trend analysis began with concentration data that were gathered between 1975 and 1995. Samples were not collected on a monthly basis until 1985, so there is more uncertainty associated with pre-1985 concentrations. USGS provided an estimate of average daily flow, in cubic feet per second (cfs), for each day. DWQ only used the flow values for those days when concentration samples were collected. To determine load in pounds per day, the following formula was used (variables in italics, conversion factors in plain text):

(*flow in cfs*)*(.646 MGD/cfs)*(*conc. in mg/l*)*(8.34 (lbs/day)/(MGD*mg/l))

The next step was to adjust for the deterministic, or exogenous, factors of flow and seasonality. The goal of removing these exogenous factors is to consider the factors which explain variability in load that cannot be accounted for; principally, this includes anthropogenic loading, or the changes in load that may be attributed to human management actions. The load data were then log normalized to ease the flow adjustment process. Flow adjustment is accomplished using a LOWESS technique on a load versus flow plot. The LOWESS technique is a smoothing approach that uses moving averages to estimate the variability in load that may be explained by flow. The LOWESS line is subtracted from the load (by individual observation) leaving a flow adjusted set of residual values.

The second deterministic effect that DWQ addressed is seasonality. The SK test adjusts for seasonality by removing the variability in load that may be explained by the time of year when the data were collected. For instance, we might expect the highest load to occur in January, when winter rains deliver nonpoint source nutrients that have been stored on land during drier periods. Some of this effect may be removed when the data are flow adjusted, but that which remains may be accounted for by subtracting the monthly load means for the period of record from the residuals.

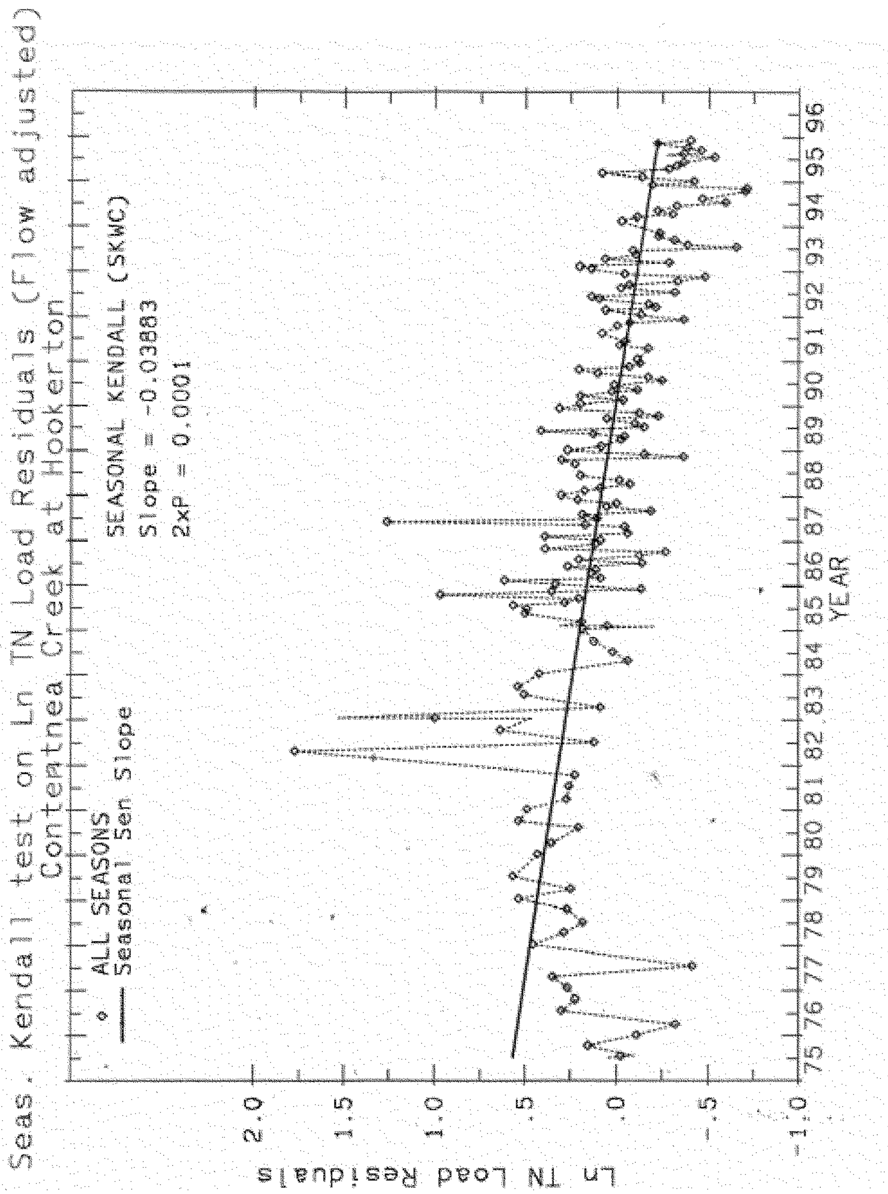
There are two versions of the SK test in WQHYDRO, the statistical package for water quality trend analysis that DWQ used for this study. The first does not have a correction for serial correlation (assumes that has been eliminated) and the second includes a correction for serial correlation. The software manual recommends that the latter be selected when dealing with data sets that span 10 years or longer, and where serial correlation exists after adjusting for exogenous factors (Aroner, 1995). In all cases serial correlation was evident, and since our period of record exceeds 10 years, the SK with correction was employed. The test with correction comprises power, which is the ability to detect a trend when one is present. A priori, the α significance level for accepting the presence of a trend was 0.10 for all SK time series analysis. For borderline cases, DWQ looks at alternate means of analyzing the trend.

Trend analyses of flow adjusted nitrogen and phosphorus loads from Contentnea Creek at Hookerton using the SK test reveal significant decreasing trends in both nitrogen load and phosphorus load. Table 1 shows the results of each SK test. For nitrogen, the Z statistic was -4.04; this signifies that a decreasing trend exists (Figure 5). Also, a 2P value of .00005 indicates that, with the available data, there is a 5 in one hundred thousand chance of concluding that there is a trend when one does not exist. The test on flow adjusted phosphorus load yielded a Z statistic of -3.44 and that a decreasing trend exists (Figure 6). Considering the phosphate detergent ban in 1988, one might expect a decreasing trend in total phosphorus load, but a decreasing trend in nitrogen load may come to many as a surprise. However, it is clear by visual inspection that a decreasing trend exists in both nitrogen and phosphorus loads since 1985.

Kinston trend analyses for flow adjusted nitrogen and phosphorus loads reveal a significant increasing and decreasing trend, respectively (Figures 7 and 8). For nitrogen, the Z statistic was 1.71, and a 2P value of 0.087. Because of the low significance value, the nitrogen load trend analysis at Kinston is open to question. Further analysis by an academic statistician confirmed the trend, and that analysis is provided in the following subsection. For phosphorus, the Z statistic was -3.6333.

To determine if real delivery at Kinston and Hookerton has changed, DWQ performed supplemental analyses using the SK test on unadjusted load (load not corrected for flow). Interestingly, two of the trends seen in flow adjusted load no longer appear in this version; nitrogen load at Kinston and Hookerton do not show a significant trend (Figures 9 and 10). Decreasing phosphorus load trends remain at Kinston and Hookerton, however, with reduced 2P values of 0.013 and 0.086, respectively (Figures 11 and 12).

Figure 5.



Seas. Kendall test on Ln TN Load Residuals (Flow adjusted)
Contentnea Creek at Hookerton
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = -0.03883
2xP = 0.0001
Ln TN Load Residuals
2.0
1.5
1.0
.5
0.0
-.5
-1.0
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
YEAR

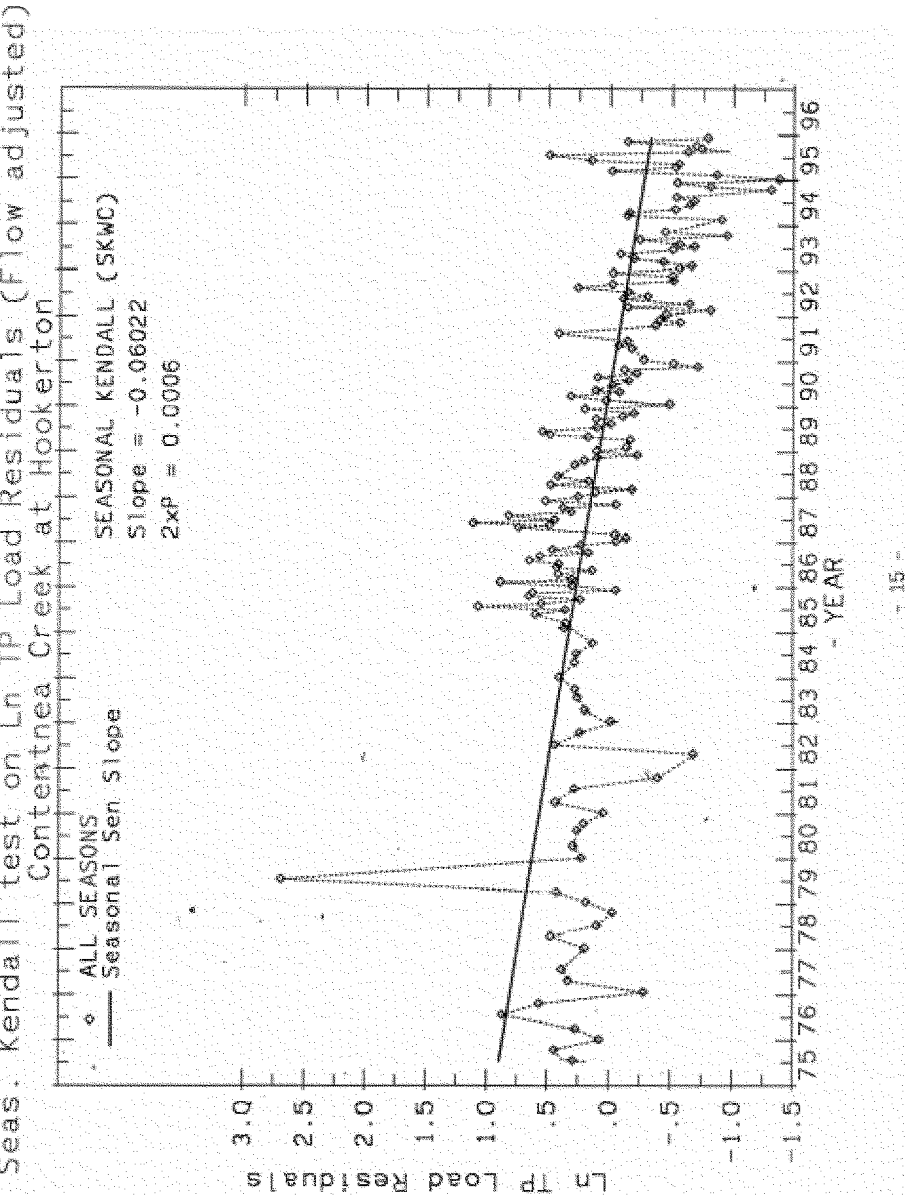

Seas. Kendall test on Ln TP Load Residuals (Flow adjusted)
Contentnea Creek at Hookerton
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWD)
Slope = -0.06022
2xP = 0.0006
Ln TP Load Residuals
3.0
2.5
2.0
1.5
1.0
.5
.0
-.5
-1.0
-1.5
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
YEAR

Figure 6.

Figure 7.

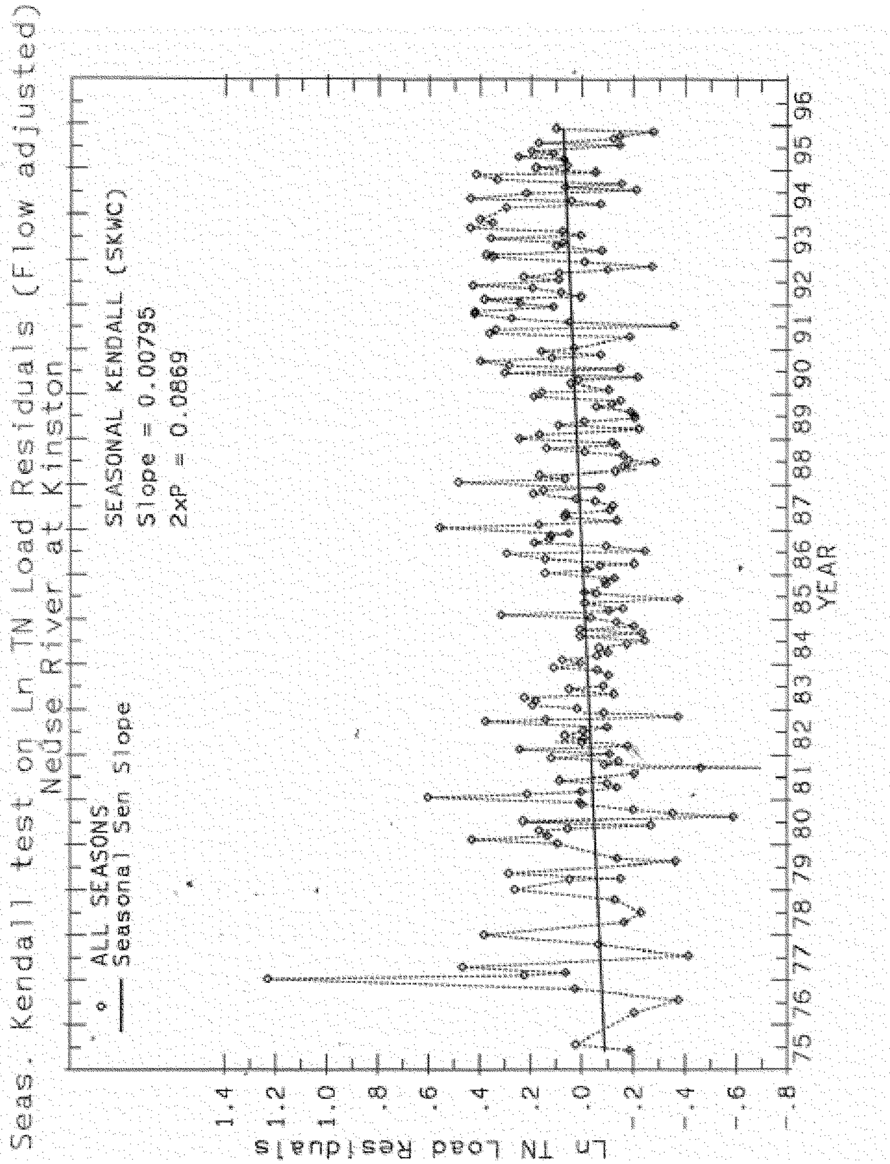

Seas. Kendall test on Ln TN Load Residuals (Flow adjusted)
Neuse River at Kinston
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = 0.00795
2xP = 0.0869
Ln TN Load Residuals
YEAR

Figure 8.

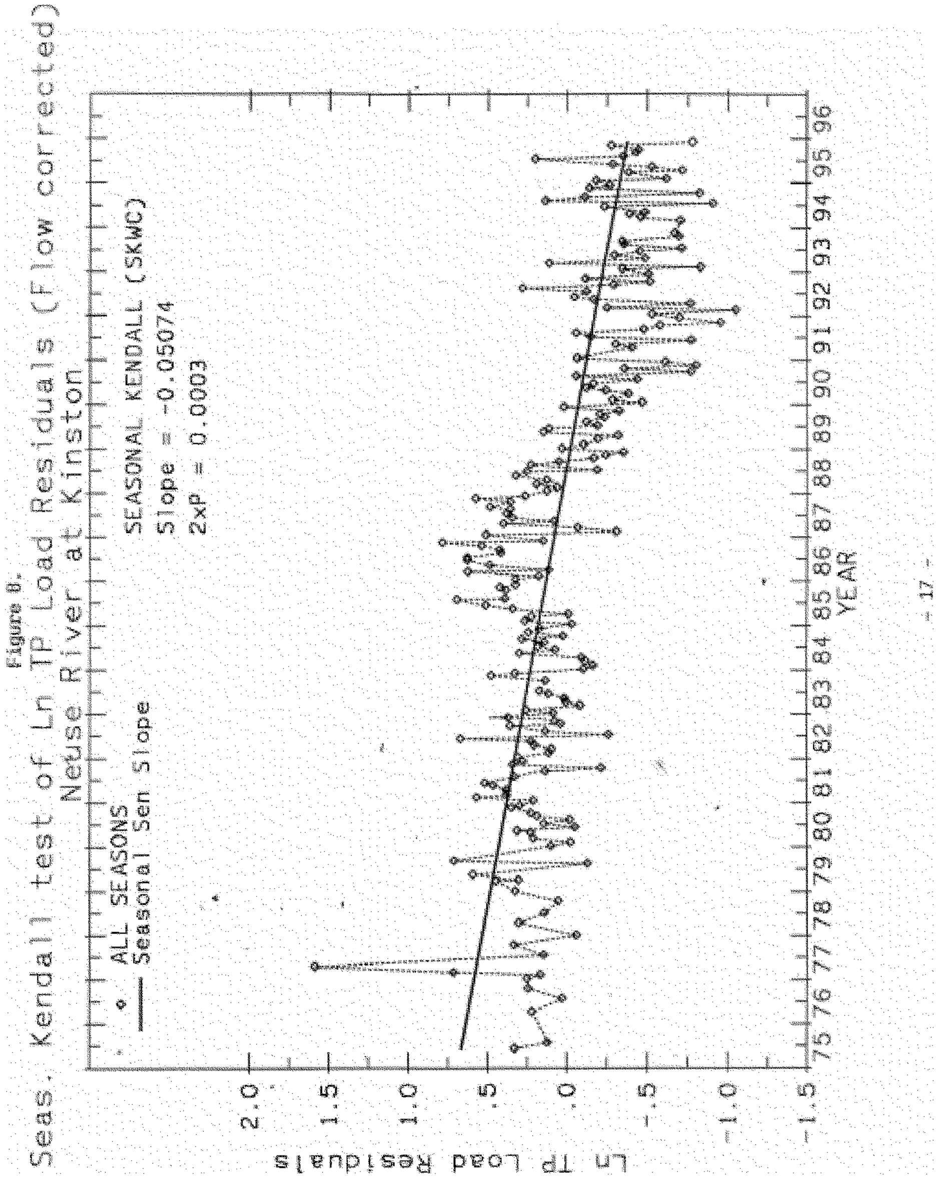

Seas. Kendall test of Ln TP Load Residuals (Flow corrected)
Neuse River at Kinston
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = -0.05074
2xP = 0.0003
Ln TP Load Residuals
2.0
1.5
1.0
.5
0.
-.5
-1.0
-1.5
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
YEAR

Figure 9.

Seasonal Kendall test on Ln TN Load
Neuse River at Kinston

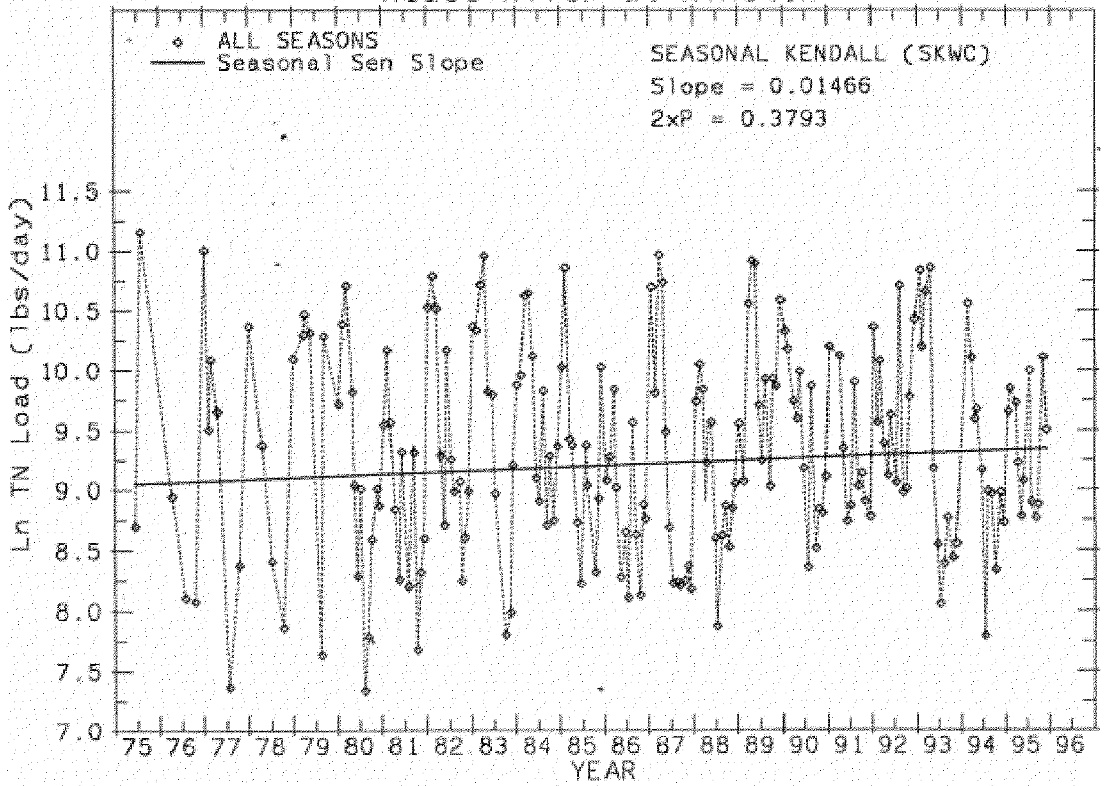
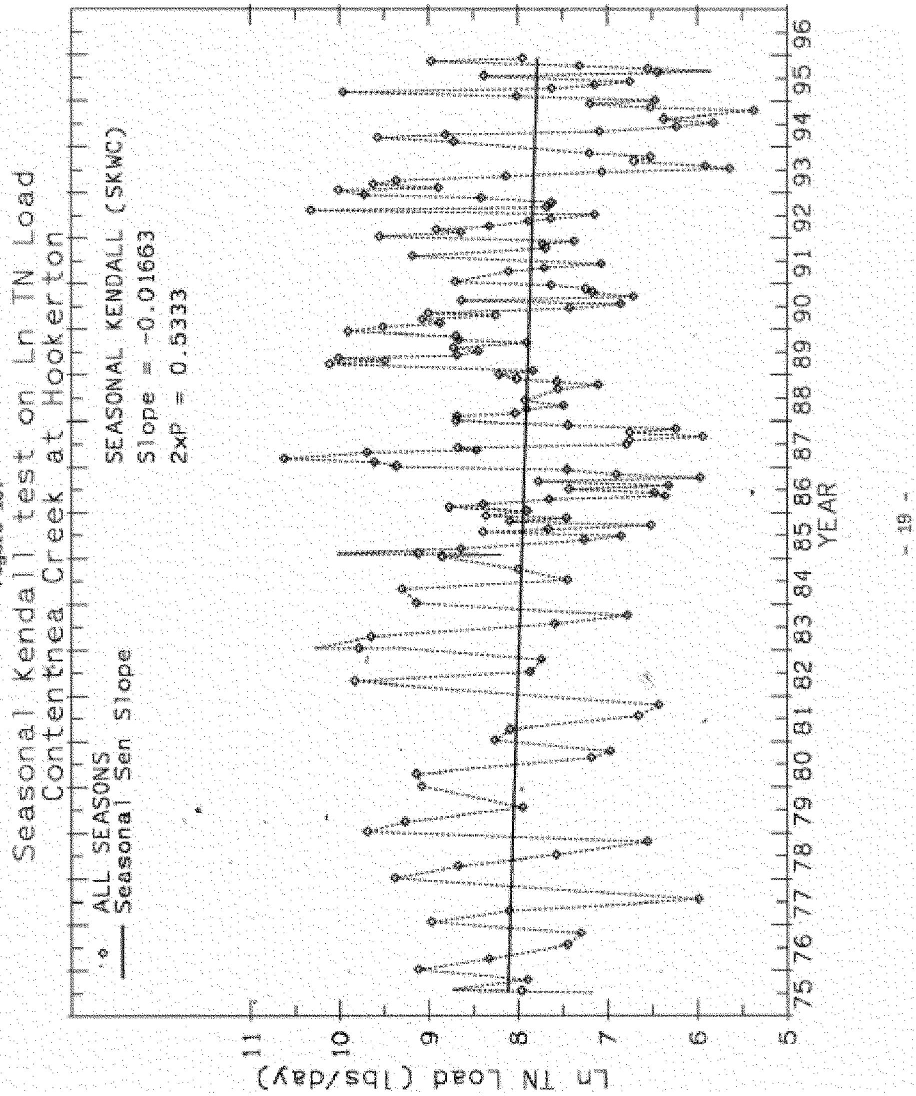
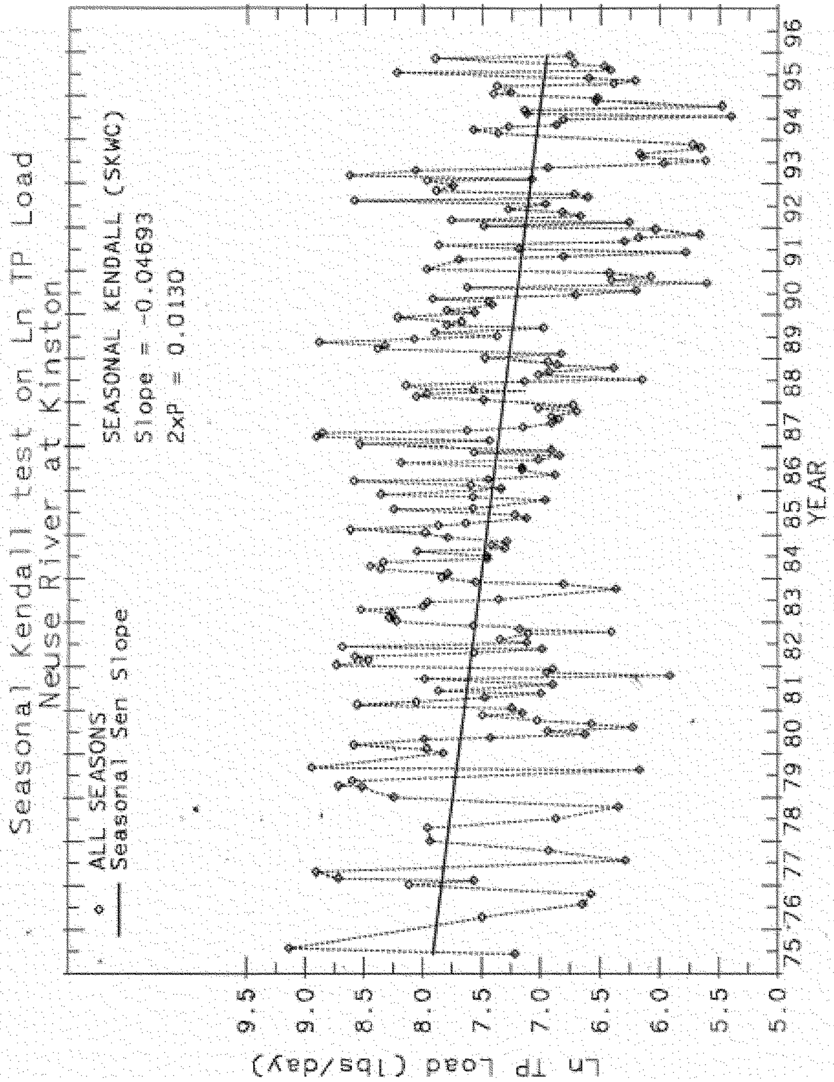


Figure 10.



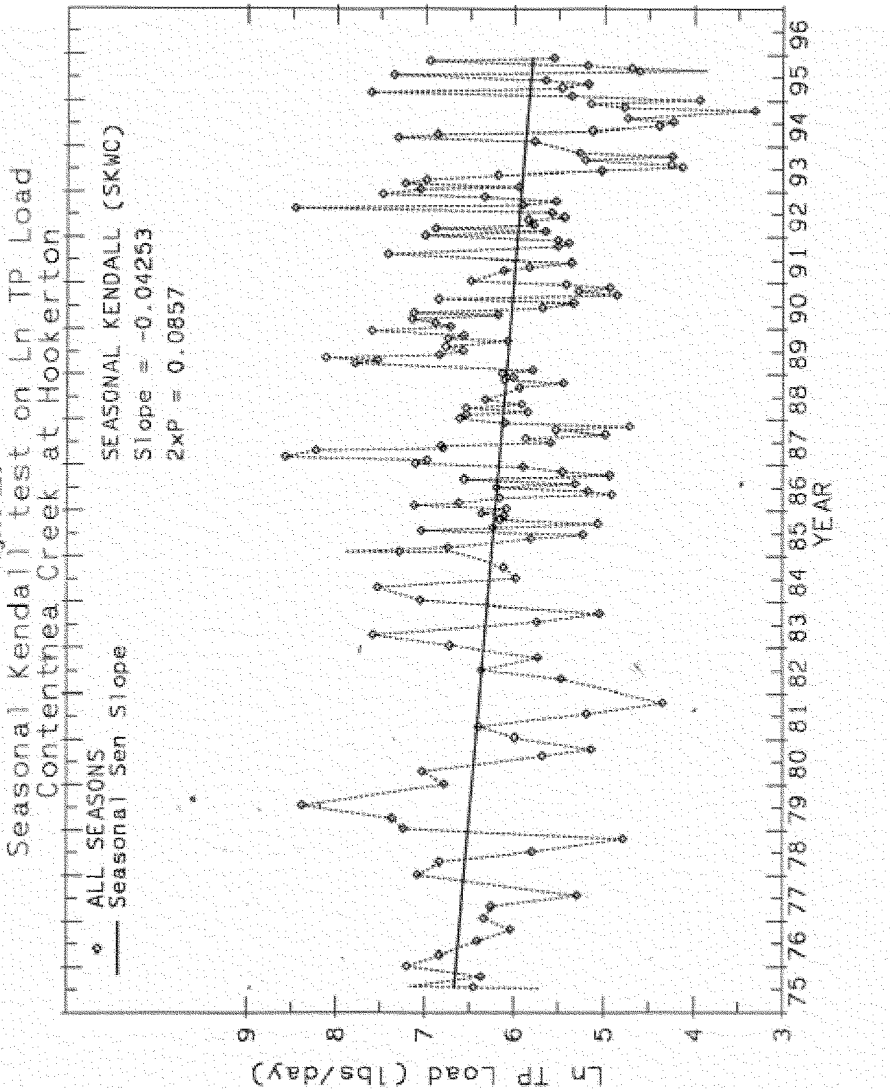
Seasonal Kendall test on Ln TN Load
Contentnea Creek at Hookerton
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = -0.01663
2xP = 0.5333
Ln TN Load (lbs/day)
11
10
9
8
7
6
5
YEAR
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96

Figure 11.



Seasonal Kendall test on Ln TP Load
Neuse River at Kinston
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = -0.04693
2xP = 0.0130
Ln TP Load (lbs/day)
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
YEAR

Figure 12.


Seasonal Kendall test on Ln TP Load
Contentnea Creek at Hookerton
ALL SEASONS
Seasonal Sen Slope
SEASONAL KENDALL (SKWC)
Slope = -0.04253
2xP = 0.0857
Ln TP Load (lbs/day)
YEAR
3
4
5
6
7
8
9
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96

Considering the differing trend analyses of flow adjusted load and load it appears that process changes such as land use management and wastewater treatment in the Kinston watershed have been somewhat offset by meteorological differences over the period of record. This amounts to seemingly no significant change in real delivery to the estuary.

Table 1. Seasonal Kendall test results.

SK test subject	Location	Significance	2P-value
Ln TN Load (flow adj.)	Hookerton	sig. decreasing	0.00005
Ln TP Load (flow adj.)	Hookerton	sig. decreasing	0.00058
Ln TN Load (flow adj.)	Kinston	sig. increasing	0.0869
Ln TP Load (flow adj.)	Kinston	sig. decreasing	0.00028
Ln TN Load (unadj.)	Hookerton	not significant	0.5333
Ln TP Load (unadj.)	Hookerton	sig. decreasing	0.0857
Ln TN Load (unadj.)	Kinston	not significant	0.3830
Ln TP Load (unadj.)	Kinston	sig. decreasing	0.0130

Autoregression on Kinston Nitrogen Load

In order to make hindcast estimates of what loads were like in the mid 1970s at Kinston, DWQ consulted Dr. David Dickey, a Professor of Statistics at N.C. State University. The Sen slope estimate is rather inefficient for this purpose since it focuses on median values and does not consider outliers. Dr. Dickey used autoregression and ordinary least squares regression (accounting for correlation) to determine if the DATE variable (trend) was a statistically significant variable after accounting for variability due to flow and seasonality. Moreover, if that variable was significant, its coefficient provides an efficient hindcast estimate of the slope of the loading trend. This analysis was only performed on nitrogen loads at Kinston. Variability in log of load, the dependent variable, was explained by several variables: the log of flow, sine and cosine waves used to explain seasonal variation, and date. The sine and cosine waves capture periodic highs and lows at certain frequencies that may be attributed to seasonal variation. The results show that variability due to date was significant at 99%, and that the estimated increase in load was less than 1 percent (0.84%) per year (Table 2). The annual increase in load amounts to less than 17 percent from 1975-1995. So, from a riverine loading perspective, this result indicates that a 30% reduction in total nitrogen would bring loading in the watershed at Kinston to levels that are below those that occurred when water quality was acceptable.

Table 2. Autoregression results:

Variable	B Value (Coeff.)	Std. Error	t Ratio	Approx. Prob.	Slope in %
Intercept	3.232510	0.1603	20.164	0.0001	
LOG OF FLOW	0.796791	0.0187	42.704	0.0001	
SIN	0.094248	0.0263	3.577	0.0004	
COS	0.120952	0.0245	4.938	0.0001	
DATE	0.000023	8.723E-6	2.615	0.0096	0.84

Duke University Trend Analyses

Another study that has high relevance to this TMDL is that of Duke University reseachers Stow and Borsuk. They examined trends in nutrient data from 1979 to 1997 in the Neuse River watershed at Falls Lake outlet, Clayton and Kinston (1999, in draft). The portion of this study that is relevant to the TMDL focuses on loads and adjusted concentrations for total nitrogen and total phosphorus. The authors determined the presence of a trend by visual inspection as they question the validity of assuming linearity in a trend. Also, they make the point that it is possible to show a trend in either direction in the same data set by selecting optimal beginning and end points. The problem of selection of beginning and ending dates may be avoided by using visual inspection for determination of a trend. Stow and Borsuk report that no distinct nitrogen trends are discernable at Kinston. The report adds that the lack of trend at Kinston is reflected in the lack of obvious nitrogen concentration trends in the estuary. The authors suggest that this absence of downstream nutrient increases indicate "that the current water quality impairment in the lower river and estuary may result from chronic nutrient overloading rather than recent changes in the watershed."

By considering all of the evidence in this TMDL on trends in nutrient loading at Kinston and Hookerton, DWQ's (with NCSU) analysis on flow adjusted nitrogen loading at Kinston is the only case of an increasing trend, and based on Stow and Borsuk's work, this is open to question. The differences between the two approaches include: the beginning and ending dates for the period of record, the base parameter by which a trend is evaluated (flow adjusted load versus flow adjusted concentration), the use of flow data without concentration on the same day (Stow and Borsuk used regression type methods to fill in concentration for missing days), and the means to detect trend (test versus visual inspection). It is not clear how to resolve these differences except to say that a 30% reduction appears conservative with respect to riverine loading.

Tetra Tech analysis of River Nutrient Loads and Nutrient Reduction Targets

Through a contractual arrangement with EPA to support the review of the Neuse TN TMDL, Dr. Jonathan Butcher of Tetra Tech (Butcher, 1999) conducted analyses of river nutrient loads and nutrient reduction targets. Tetra Tech used somewhat different methods than either DWQ, or Stow and Borsuk, to analyze trends at Kinston and Ft. Barnwell, and concluded that no increasing trends in nitrogen loading exist between the mid-1970s and the present. As with DWQ's analysis, phosphorus loading showed decreasing trends due to the phosphate detergent ban in 1988. Tetra Tech also examined the relationship between chlorophyll *a* in the estuary and nutrient loading, and found no simple and clear relationship. It seems that an estuary nutrient response model will be necessary to form a quantitative TMDL, as existing point measurements of chlorophyll *a* do not "appear to provide a sufficiently sensitive indicator." Citing Hobbie and Smith (1975), Tetra Tech notes that 1970-1973 may "arguably represent pre-impairment conditions" in the estuary. By comparing nitrogen concentrations at New Bern during that time period and the 1991-1995 DWQ baseline loading period, Tetra Tech suggests that a 30% reduction in nitrogen loading is an appropriate target.

To examine river nutrient loading trends, Tetra Tech used annual average estimates of total nitrogen and total phosphorus loads. In contrast to DWQ, which analyzed trends based on point estimates of load on days when concentration data were collected, Tetra Tech employed a ratio method of flow weighted concentration to estimate loads on a daily basis (USGS provides daily flow data) before calculating an annual average. Tetra Tech's method is analogous to using regression of concentration against flow to estimate load at all flow levels. There seems to be benefits and drawbacks to both methods. By estimating daily load based on a few concentration data points per year, Tetra Tech is introducing error that is not present in DWQ's trend analysis. On the other hand, DWQ does not consider the full flow regime for a given year, and relies on the sampling frequency to capture representative flows. DWQ adjusted its load estimates for flow so that the omission of the complete flow record is less critical. Another difference between methods is that DWQ ran its trend tests through 1995 (end of baseline), while Tetra Tech included data through 1997. Tetra Tech began its trend analysis in 1975 at Fort Barnwell and in 1974 at Kinston. DWQ did not receive data prior to 1975 from a STORET download request.

Tetra Tech and DWQ came to the same conclusion about a decreasing trend in phosphorus loading at Kinston since the mid-1970s, but differed in that DWQ found a slightly increasing nitrogen trend there, while Tetra Tech found none. Tetra Tech used a flow regression equation developed by Weyerhaeuser to estimate flows at Fort Barnwell and perform trend analyses there. Because it found inhomogeneity in a test of seasonal trend, Tetra Tech examined nitrogen loading trends by quarter at Fort Barnwell and found only one significant trend (decreasing) in the first quarter, the rest were not significant. In addition to examining nutrient loading trends at Kinston and Fort Barnwell, Tetra Tech addressed concentration data at New Bern from 1974-1997. In this case, there was little evidence of a trend, although a gradual decline is possible.

If it can be shown that there is a trend in chlorophyll *a* concentration, or correlation between chlorophyll *a* and nitrogen load, then the case for the proposed TMDL would be strengthened. These issues were addressed by considering four groups of sampling stations in the estuary. Summer average chlorophyll *a* concentrations do appear to be higher in 1979-1997 than 1970-1974, though the data were analyzed using different methods, and the earlier period represents only monthly sampling. Tetra Tech notes that there have been frequent exceedances of the chlorophyll *a* standard of 40 μg/l. "It may well be that the standard is not realistically attainable in the Neuse estuary." Also, Tetra Tech found a weak relationship between summer chlorophyll *a* and annual total nitrogen load. "The results suggest that high nitrogen loads have potentially bad implications but do not identify a target load. To a large extent, the weak relationship likely highlights the inadequacy of point chlorophyll *a* measurements as an index of primary productivity. A better comparison to nitrogen loading could likely be obtained if estimates of annual primary productivity integrated over both space and time were available. High feedback rates from nitrogen from the sediment may, however, further obscure this effect, as blooms may be supported in part by nitrogen accumulated from previous years' loading." This is a succinct reiteration of what DWQ has said about the need for an estuary response model and one of the difficulties (internal load from sediment organic matter) its developer is currently experiencing.

Next, Tetra Tech closely evaluated the Sea Grant study by Hobbie and Smith (1975) which contained estuary chlorophyll *a* and nutrient data between 1970-1973. That period appears to be the closest match to pre-impairment conditions in the estuary, and thus a good case for an empirical target. Comparison of chlorophyll *a* results above the water quality standard show an increase in such events at the estuary sites of Broad Creek and Minnesott Beach, between 1989-1997 relative to 1970-1973. Though there have been relatively small increases in the median values, the 90th percentile at Broad Creek has doubled and the 95th percentile at Minnesott Beach has tripled. Again, bias due to analytical methods is certainly possible. River nutrient loads between these two periods cannot be compared as there was sparse monitoring in the river for the 1970-1973 period. Average total nitrogen concentrations at New Bern are available, and show an increase from 0.67 mg/l for the "pre-impairment baseline" to 0.97 mg/l for the 1991-1995 DWQ baseline. Tetra Tech attempted to verify the accuracy of Hobbie and Smith's total nitrogen data by comparing Hobbie and Smith's ratio of nitrate-plus-nitrite to total nitrogen to that of later periods and reported that they are nearly constant, and thus, sufficient to use. Based on this comparison of nitrogen data, Tetra Tech suggests that a 31% reduction in total nitrogen concentration, and a 25% reduction in nitrate-plus-nitrite concentration, are needed to return to conditions of the early 1970s.

Finally, Tetra Tech, based on its analyses, supports DWQ's 30% reduction in nitrogen with a few warnings. One, their analysis supports a reduction in concentration at New Bern instead of loads at Fort Barnwell. The relationship between the two may not be linear, depending on the rate of uptake between the two locations, and the rate of downstream mixing in the estuary. Secondly, another analysis for the mid estuary may be needed as increased algal blooms there may be attributable to direct deposition of atmospheric nitrogen (Paerl et al., 1995) beyond increases in watershed load. Third, the conclusions in the analysis depend on the interpretation of 1970-1973 conditions as representing pre-impairment. Finally, the analysis of temporal reference conditions suggests that a reduction slightly greater than 30% may be required. Presumably, Tetra Tech is referring to the 31% that was cited earlier. If so, this assumes that the difference between DWQ's 30% and Tetra Tech's 31% is significant.

The second point regarding the possible need for another mid estuary analysis may be addressed by pointing to the recent mid estuary dilution assay results of Piehler and Paerl (See following subsection, Algal Assays). Also, it seems somewhat difficult to reconcile Tetra Tech's observation that nitrogen concentrations at New Bern between 1974 and 1997 showed "little evidence of a trend, although a gradual decline is possible" yet median 1991-1995 total nitrogen concentration showed a 31% increase over that of 1970-1973.

Algal Assays

A nutrient dilution bioassay is being conducted by Piehler and Paerl of UNC's Institute of Marine Science at a riverine and an estuarine site in the Neuse River estuary (Piehler and Paerl 1999, preliminary results). This study gives us a look at what effect a 30% nitrogen reduction would have on estuary productivity.

Some of the early dilution bioassay work on the river portion of the Neuse system was considered by the Senate Select Committee to arrive at the original 30% nitrogen reduction target (Paerl and Bowles 1987, Paerl 1987). The current project is designed to move the focus from the river to the estuary. There is one site at the head of the estuary, Streets Ferry Bridge, and a second between New Bern and Cherry Point at Marker 15. To accomplish the simulation, 3 liters are removed from a 10 liter container of estuarine water, and replaced with 3 liters of major ion solution that lacks nitrogen. The bioassays were performed 7 times between August 1997 and August 1998. The standard used to evaluate differences is assimilation number, or productivity/Chl a per hour. By dividing by Chl a, the biomass that is removed in the dilution process is corrected for. Mean assimilation numbers in the dilutions were lower than the control in 11 out of 14 observations. In the experiments thus far, there is a significant reduction in the productivity (assimilation number) at the Marker 15 site with a 30% reduction in nitrogen concentration ($p<0.05$, ANOVA). There is not a significant difference between the dilutions and the controls at Streets Ferry Bridge.

One limitation of this experiment with respect to the TMDL is that the bioassays examine changes in nutrient concentration and not nutrient loads. The next year of the project will further explore the necessary reduction in nutrients during highest loading conditions, typically spring, to test for an observed decline in assimilation number. Also, the project will attempt to reduce uncertainty by examining the potential effects of the quantity and type of light received by the phytoplankton.

This research lends credence to the TMDL because it shows that a 30% reduction in nitrogen has a noticeable effect on productivity in the estuary. While productivity may be implicitly related to Chl a, they may not correlate well in space and time because of downstream gradients in algal growth rates (Pinckney et al, 1997). In other words, as growth rate decreases downstream, chl a per unit productivity may increase. It is problematic that a statistically significant difference was not detected at Streets Ferry Bridge. This lack of a difference appears to be attributable to the fact that 3 of the 7 dilutions at this site were roughly equal to or greater than the control. This seems unlikely to occur in a "real world" scenario since only nitrogen inputs are being managed; however, the researchers will investigate potential causes of this unexpected result in the coming year. The factors that could cause a diluted sample to be higher than its control include: the toxic constituents are diluted; color is diluted and hence light availability is increased to detrimental levels; and finally, some unknown constituent(s) is (are) diluted.

In the second phase of the TMDL, this research will serve as one of several tools to guide the decision making process on the appropriate reduction target.

From the studies by Piehler and Paerl, DWQ understands that the 30% nitrogen load reduction should have a noticeable effect on Neuse River estuary water quality, but that given the complexity of the system, a direct correlation between loading and Chl a response is impossible at present.

Reduction Target Conclusion

The available data and research are not yet adequate and linked sufficiently to be used for a final TMDL, however, they do support the best professional judgement of scientists that 30 percent represents a reasonable initial target. Statistical analyses indicate that a 17 to 31 percent reduction in nitrogen is needed. Dilution assays indicate that a 30 percent reduction will result in decreased productivity in the estuary.

The work that has been presented in the past year is very encouraging and gives DWQ a clearer picture of where we stand in the phased TMDL schedule. There is every indication that once the MODMON research is completed in a couple years, it would provide the stakeholders and DWQ with the tools necessary to better evaluate a TMDL. Building consensus does not seem so daunting when there are numerous projects that have a common goal, yet provide different and mutually beneficial perspectives on the task. Interest has been expressed by many of the major scientists working in the Neuse arena to participate in the stakeholder process by presenting their findings for all to consider. Furthermore, DWQ completed a rule-making process for the TMDL's implementation strategy in August, 1998. Not only is the momentum not in favor of an adjusted target, neither are the data nor research consensus.

II-C. Margin of Safety

The Clean Water Act requires that TMDLs include a margin of safety. Since the first phase of the TMDL is based on a review of available information and the best professional judgment of scientific experts, a margin of safety cannot be quantified at this time. An inherent margin of safety in the phased approach to developing a TMDL is that the TMDL will be revisited. DWQ will review all available data and tools and commits to public notice a revised TMDL by March, 31 2001 in accordance with the schedule below. Also, please refer to Figure 14 on p. 44 for a more detailed schedule.

April 1, 2000	A CE-QUAL-W2 model (estuary response model) of the Neuse estuary will be completed to the extent that it will be ready to use as a tool for the completion of the second phase of the TMDL.
July 1, 2000	The nitrogen reduction goal (i.e. the total percent reduction necessary to support the estuary's uses) will be completed using the CE-QUALW2 model and other data and tools

	available. The state will provide EPA with the appropriate information to review by this date. If the model and other tools are not ready or capable of predicting the nitrogen reduction goal, the State will be prepared to revise the TMDL to include an explicit margin of safety (i.e. an additional reduction will be added to the proposed 30% reduction). The State will provide EPA Region IV with the documentation that includes: (1) the explicit margin of safety that the State intends to use: and (2) the rationale for the value of this margin of safety.
August 1, 2000	EPA Region IV will approve/disapprove the State's nitrogen reduction goal submitted on July 1, 2000.
March 31, 2001	The State will public notice for comment the 2nd phase of the TMDL.
July 31, 2001	The State will submit the 2nd phase of the TMDL to EPA for approval/disapproval.
August 30, 2001	EPA Region IV will make an approval/disapproval decision on the 2nd phase of the TMDL.

II-D. Seasonality

Studies have shown that high spring total nitrogen loading followed by low flow, warm weather conditions in the summer and early fall determine, in part, the magnitude and frequency of algal blooms and fish kills during the warmer months (Paerl, 1987). In addition, studies have shown that algal activity in the estuary increases following storm events in the basin (Mallin et al. 1993). Thus, in order to control the eutrophication problem in the estuary, it will likely be necessary to control nutrient loading from storm events. In general, nitrogen loading during the late winter and early spring as well as during summer storm events will be important to control. Paerl et al. (1998) examined the Neuse estuary's response to nutrient loads under three scenarios: an average hydrologic year; a year with high summer loads; and a year in which two hurricanes hit the North Carolina coast. The researchers determined that an annual reduction in total nitrogen will likely improve water quality in average flow years, but in years with high summer loading and hurricanes, additional controls may be needed. However, it is likely that no nutrient control strategy would protect the Neuse River estuary from algal blooms and fish kills following hurricanes.

Network Analysis

Christian and Thomas (in draft, 1999) have been developing a network analysis of the Neuse River. This project uses a group of algorithms to evaluate networks of material flows within a structured system. The purpose of this ecological network analysis is to provide understanding of the relationship between nitrogen loading and recycling, the fates of loaded nitrogen, and exported interseasonal variation of both model inputs and outputs. The study used data collected between Spring 1985 and Winter 1989. There are two conclusions in this analysis that have relevance to the seasonality in this first phase TMDL: (1) seasonal phytoplankton response in the estuary is more coupled to seasonal loads in the winter than summer, and (2) there is a high degree of recycling of nutrients within the estuary.

By examining correlation between loading by season and phytoplankton uptake, the authors detected a trend where winter and spring primary productivities are more closely related to loading than summer and fall primary productivities. The correlation coefficients for winter, spring, summer and fall were 0.90, 0.95, -0.59, and 0.42, respectively. This result might be expected as winter flows are typically higher and can transport more nutrients farther into the estuary for uptake. The authors were interested in testing this hypothesis more rigorously, but due to a lack of standardization for primary productivity estimates and incomplete loading estimates from all sources of the estuary, it was considered not within the scope of this study. This points to the need for more research on seasonal phytoplankton response to nitrogen loading before the TMDL can be divided into smaller time increments.

Another seasonal observation from the Christian and Thomas research was the dependance of phytoplankton on nitrogen that once resided in the sediment. For winter that rate was 5-32 % and in summer it was 71-85%. Other studies have shown that the sediments can be a significant source of nitrogen to the water column under summer/fall conditions (Fisher et al, 1982, NCDWQ, 1998). Again, this result is not surprising since warm temperatures promote microbial breakdown of organic matter and enhance ammonium flux from the sediment to the water column. Similarly, it makes sense that primary productivity is more closely correlated to winter riverine loading because internal recycling is suppressed in winter.

The implications for the TMDL are that, in terms of phytoplankton response, winter is the more sensitive period to riverine loading. Phytoplankton growth in the summer is more linked to nitrogen which moves through the sediments. This point may be less applicable than it appears, however, if most of the nutrients, during either season, remain in the estuary for reuse during subsequent seasons. Christian and Thomas note that two of their work's weaknesses are nitrogen export to Pamlico Sound and denitrification. Without a good understanding of estuarine nitrogen export, it is difficult to tell what the net effect is of the seasonal link between loading and uptake.

The long hydraulic residence times, high productivity, and microbial recycling result in multiple uses of nitrogen during its stay within the estuary. The Finn Cycling Index, which measures percent of total nitrogen flux involved in cycling, was generally 90% or greater throughout the study. Christian and Thomas' work also showed that phytoplankton can take up a given atom of nitrogen up to 35 times before exiting the system. This indicates that nitrogen is cycling through the Neuse estuary, and each nitrogen atom can remain in the system for a while. While nutrient loads may be higher during the winter and spring, these winter and spring loads may be stored in the sediments and used as a source by algae during summer months. Therefore, an annual loading target is appropriate during the first phase of the TMDL given that nitrogen is reused after initial seasonal riverine loading.

Seasonality Conclusion

DWQ acknowledges that, based on work by Christian and Thomas and others, the late winter and early spring loads are important to control. Therefore, seasonality will be addressed in more detail in the second phase of the TMDL. The estuary model that is being developed and other information being collected should provide further insight into the importance of controlling nitrogen on a seasonal basis, and DWQ will incorporate this information in the next phase of the TMDL.

Although the TMDL loading targets are annual for the first phase of this TMDL, the implementation plans to achieve the loads will address the seasonality issue to an extent. The nonpoint source BMPs are designed to reduce nitrogen loading during storm events and, therefore, will reduce nitrogen loads during the winter and spring period, as well as summer storm events that the literature indicates are important to control. Point sources will be limited for nitrogen on an annual basis with a goal to achieve at least half the necessary reductions during the summer months. Biological activity in treatment plants is a function of temperature. As temperature increases, nutrient removal increases. Thus, wastewater treatment plants will achieve the greatest portion of their reductions during the warmer summer months when point sources contribute a greater portion of the nitrogen load to the estuary. A review of the effluent data for the facilities in the Neuse River Basin generally indicates that nitrogen load does not increase in the summer months. A review of data collected on facilities in the Tar-Pamlico River Basin that are achieving nitrogen removal also indicates that that nitrogen load does not increase in the summer. If the data and modeling tools developed in the next couple years indicate that the point sources need to be controlled on shorter time frames, these limits will be included in the NPDES permits when they are renewed in 2003.

III. Total Nitrogen TMDL Calculation

III-A. Baseline Loading for Total Nitrogen

The 1991-1995 period was used to calculate baseline nutrient loads at New Bern. Since load is a function of concentration and flow, it is important to understand that an increase or decrease in load may be a function of rainfall rather than activities occurring in the watershed. Thus, it is important to choose a range of years that covers different rainfall events. The period 1991-1995 represented high and low flow spring and summer periods. Average annual total nitrogen load at New Bern was estimated to be 9.4 million pounds per year based on this time frame. To obtain these loading estimates the following steps were performed:

- The daily flows measured at a USGS gaging station at Kinston were used to predict daily flows at Streets Ferry using a flow correlation developed by Weyerhaeuser Corporation (DiPeiro et al. 1994):

  Flow near New Bern = $1.242*(\text{Flow at Kinston})^{1.024}$

- The FLUX model developed by the U.S. Army Corps of Engineer's (Walker, 1985) was used to estimate total loading at Fort Barnwell based on estimated daily flows and the observed relationship between nitrogen concentration and flow. Total nitrogen load on the Trent River near Pollocksville was estimated using data collected during a special study from June 1995 to August 1996 and the FLUX model.

- Effluent monitoring data from Weyerhaeuser, Cherry Point, and other WWTPs below the sampling point were used to determine the additional point source load below Fort Barnwell.

- Direct atmospheric deposition to the impaired portion of the estuary was estimated using an atmospheric deposition coefficient of 8.75 lb/acre-year and 28,950 acres, the impaired area in the estuary. The result was 253,000 pounds of nitrogen directly deposited on the estuary. It should be noted that atmospheric deposition above the estuary was taken into account through the instream loading measurements which reflect all source contributions.

- The load at New Bern from the Neuse was assumed to be the load at Fort Barnwell plus the load from the Trent River at Pollocksville plus 100 percent of the load from dischargers downstream of Fort Barnwell plus 100 percent of the direct atmospheric deposition to the estuary.

The average TN load of 9.65 million pounds per year at New Bern is the baseline from which the TMDL, described later in this report, is calculated.

III-B. TN TMDL

The TMDL for total nitrogen is a 30% reduction from the baseline load. This equates to 70% of the baseline load of 9.65 million pounds per year for a TMDL of 6.76 million pounds per year at New Bern.

Allocation of Allowable Nitrogen Load

In order to meet the 30% reduction target at New Bern, it was decided to reduce the loads from point sources and nonpoint sources by 30%. Within a given source category, some individual sources (for example, an individual farm or NPDES facility) could reduce by loads greater or less than 30% provided that the overall reduction for that category of sources was 30%. Much of the following sections are devoted to assessing the baseline load, but conclude with the allowable loads, following reduction, for each source.

Point Sources

For point sources, the 1995 load was estimated by first calculating the end-of-pipe nitrogen load based on actual flow and concentration data submitted by the wastewater treatment plants. For the minor facilities where total nitrogen data were not available or the data provided were inconsistent (that is, ammonia concentrations in excess of total nitrogen concentrations), the concentration was assumed to be equal to 21 mg/l, the average concentration of other minor facilities in the basin. The annual nitrogen load at the end-of-pipe for each facility was calculated as the sum of the loads calculated from monthly average flows and concentrations. If monthly concentration data were not available, available data were averaged over quarterly periods.

The next step was to determine the percentage of total nitrogen from each facility that was transported to the estuary. This was done using a general nutrient transport model. A certain percentage of the nutrients deposited in the upper portion of the basin is lost to various processes such as conversion to nitrogen gas, an inert form of the nutrient, and subsequently released to the atmosphere. Fate and transport models are therefore used to estimate nutrient delivery to the estuary.

DWQ has developed a GIS-based nutrient fate and transport model for the Neuse River Basin to New Bern. Within the model, the delivered load is assumed to be a function of the location of a source within the basin, the stream velocities between the source and the estuary, and the rate at which the pollutant load decays along the route.

The nitrogen transport model is a refinement of the modeling framework previously provided by the Research Triangle Institute, and relies on the Reach File 3.0 (RF3) hydrography database developed by the US EPA. A first order decay equation is used to simulate the loss of nitrogen down the network as described by the following equation:

$$\text{Percent TN delivered} = e^{(-k*t)} * 100$$

where: k = "decay" coefficient that represents the loss of total nitrogen from the system in /day

t = time of travel from a stream reach to the estuary in days.

For this model application, it was assumed that the decay rate was equivalent to 0.2 /day and velocity was equivalent to 18 mi/day throughout the basin. At this time, the decay rate is based on literature values. It should be noted that the literature values vary greatly, and studies should be performed in the Neuse River Basin to further refine this value. The MODMON project described in the subsection entitled “Ongoing and Future Studies in the Neuse Basin” may address the decay rate. The velocity assumption is based on data collected at U.S. Geological Survey gaging stations.

Due to the uncertainty in the decay rate and velocity rates, it was decided to break the basin into four zones rather than assigning each NPDES facility an individual transport percentage. The model was linked into a GIS system, and the results are displayed in Figure 13. This method estimates that approximately 2.34 million pounds per year of total nitrogen that originates from point sources arrives at New Bern.

Allowable Point Source Load

Thus, the point source total nitrogen allocation at New Bern is 1.64 million pounds per year, a 30% reduction from the estimated 1995 delivered load to the estuary.

Nonpoint Sources

Baseline NPS Loading

Since point sources contribute approximately 2.34 million pounds of total nitrogen per year, nonpoint sources were calculated by difference to contribute the remainder of the baseline load or 7.31 million pounds per year (9.65 – 2.34 million pounds per year).

In order to partition the baseline nonpoint source load into the various categories such as agriculture, forestry, and urban areas, the export coefficient method was used to estimate the amount of nitrogen that enters surface waters from the various landuses/landcovers. Numerous studies have been conducted to determine the amount of nitrogen that leaves a watershed and enters surface waters on an annual basis. The export coefficient approach can be used to describe the amount of nutrients leaving a given land use type. The export coefficient itself is derived from an examination of actual field measurements taken over a period of time and is usually a single number expressed as mass/area/time.

The export coefficients developed by Research Triangle Institute (Dodd and McMahon, 1992) were used as a basis for determining export. The export coefficient for atmospheric deposition was updated using data available from the National Atmospheric Deposition Program (NCEMC, 1997a). Table 3 contains the nitrogen export coefficients.

Table 3: Export Coefficients Used in TN Loading Calculations in Neuse River Basin

Land Use	Export Coefficient (lb/acre-year)
Urban	8.06
Cultivated	13.56
Managed Herbaceous	4.37
Forest	1.72
Open Water (direct atmospheric depostion)	8.75

The 1993-95 infrared satellite imagery data was used to estimate acreages of various land use within the basin. Since the land cover did not have municipal area interpreted, DWQ

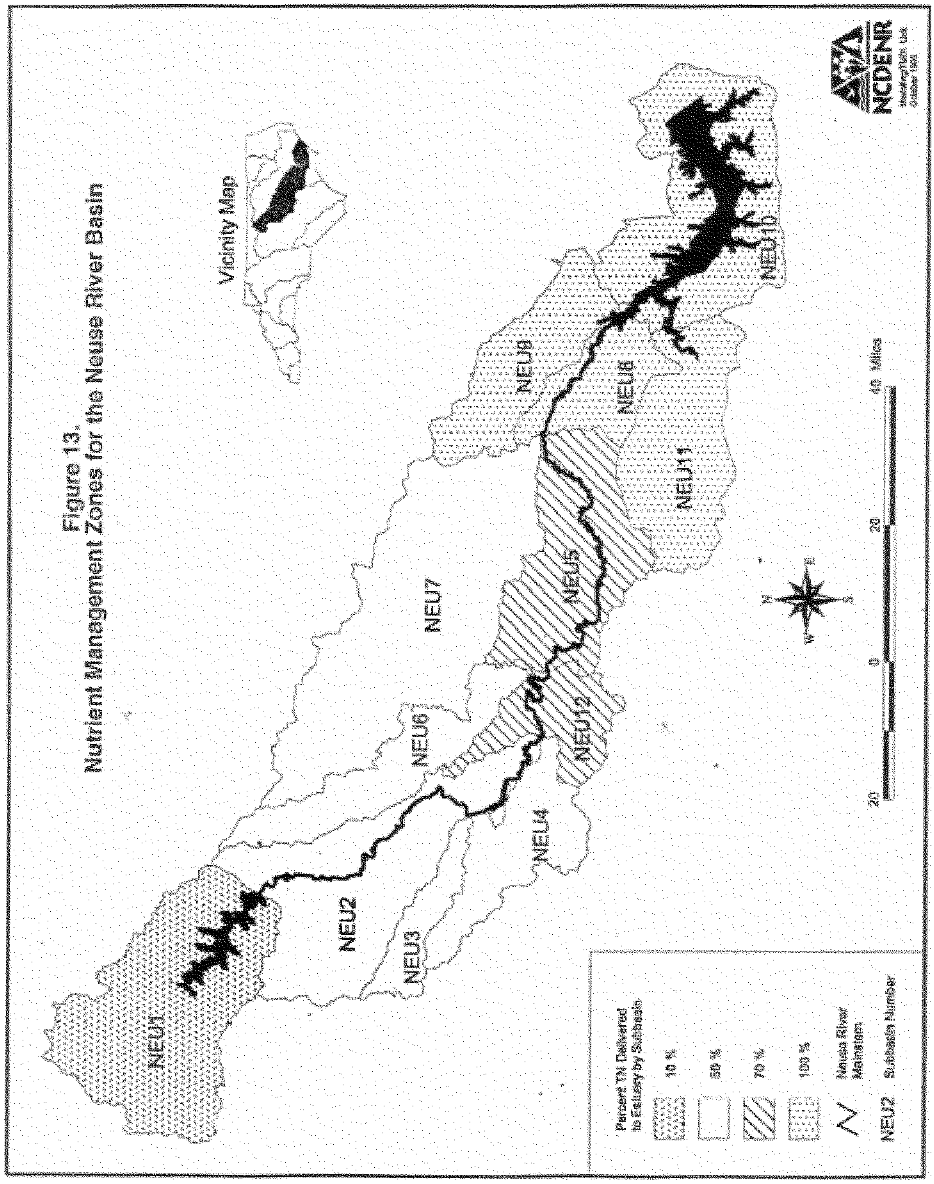


Figure 13.
Nutrient Management Zones for the Neuse River Basin
Vicinity Map
NEU1
NEU2
NEU3
NEU4
NEU5
NEU6
NEU7
NEU8
NEU9
NEU10
NEU11
NEU12
Percent TN Delivered to Estuary by Subbasin
10 %
50 %
70 %
100 %
Neuse River Mainstem
NEU2 Subbasin Number
20
0
20
40 Miles
N
S
E
W
NCDENR

surveyed municipalities in the basin with populations greater than 5000 to determine an estimate of average land use within municipal areas. Total nitrogen load was estimated using these export coefficients for cultivated land, managed herbaceous land, forests, urban land, and direct atmospheric deposition on open water. The following estimates of nitrogen load resulted:

Table 4: Estimated TN Load by Land Cover for Neuse River Basin

Land Use	Acres in Trent	TN in Trent (lb/yr)	Acres above New Bern	TN above New Bern (lb/yr)	TN in Basin (lb/yr)	Percent Load from Land Use
Urban	1,635	13,178	192,407	1,550,800	1,563,979	8%
Cultivated	75,437	1,022,926	850,279	11,529,783	12,552,709	67%
Mngd Herb	6,425	28,077	137,158	599,380	627,458	3%
Forest	200,073	344,126	1,932,297	3,323,551	3,667,676	20%
Open Water	1,076	9,415	36,810	322,088	331,503	2%

The direct deposition to the estuary was also estimated. There are 28,950 impaired acres in the estuary below New Bern. Using the same export coefficient of 8.75 lb/acre-year results in an estimated load of 0.25 million pounds directly deposited on the estuary below New Bern.

The managed herbaceous land use was then partitioned into agricultural and urban land uses based on Department of Agriculture Survey results. The survey indicated that approximately 25% of turf grass is in non-agricultural use such as golf courses, lawns and commercial lands and the remaining 75% was in agricultural land. Based on these numbers, the managed herbaceous land use was split into urban and forested land, and a general agricultural class was created.

The final step in calculating the baseline nonpoint source loads was to estimate the total nitrogen loading that is actually transported to the estuary for each land use type. Export coefficients are a measure of the nitrogen load leaving a given land use type. Some of this nitrogen is lost as it travels to a nearby stream and eventually to the estuary. DWQ assumed that the nitrogen load to the estuary for each land use was proportionate to the loads estimated at the edge of field. The atmospheric deposition directly to the estuary below New Bern was added to the load estimated to be directly deposited on open water above New Bern (i.e. 100% of this load was assumed to be transported to the estuary). Table 5 shows the final baseline total nitrogen loads by category for the Neuse River Basin:

Table 5: Baseline TN Loads by Land Use Category

Land Use	**Baseline TN Load (million lb/yr)**
Urban	0.65
Agriculture	4.90
Forest	1.38
Open Water (Atmospheric Deposition)	0.38
Total Baseline NPS Load	7.31

Allowable NPS Loads

DWQ initially set 30% reduction targets from the baseline calculation for each nonpoint source category. Commentors indicated that reductions could not be made from forested land. Therefore, the nitrogen from this land use was considered as background in the final allocation. The 30% reduction that would be needed from forested land was allocated among agriculture and urban land in proportion to their respective land areas within the basin. The allocation targets for each nonpoint source category are included in Table 6.

Table 6: Allocation Targets by Land Use Category

Land Use	**TN Allocation (lb/yr)**
Agriculture	3,090,000
Urban	390,000
Open Water (Atmospheric Deposition)	260,000
Forest (Background)	1,380,000
Total	5,120,000

(Note: The numbers in the above table differ from those that would be calculated from the table reported in the 1997 Report of Proceedings for three reasons. First, based on comments from EPA, the Trent River nonpoint source loads were included in the calculations. Second, based on comments from EPA, atmospheric deposition below New Bern was accounted for. Third, the point source numbers were checked by obtaining the lab sheets from each facility with permitted flows of 0.5 MGD or greater. The numbers for the smaller dischargers were also quality assured with hard copies of the discharge monitoring reports to ensure the numbers were entered correctly into the computer compliance system. Thus, the allocation to point sources has changed slightly since the 1997 Report of Proceedings was drafted, and this affected the nonpoint source allocations slightly).

It should also be noted that this TMDL accounts for only the nitrogen entering the estuary via freshwater. Because nitrogen is soluble, it is transported through groundwater. At this time, the amount of nitrogen entering the Neuse River from groundwater sources is unknown and cannot be quantified. Groundwater is accounted for in the nonpoint source allocation, since the baseline load at Fort Barnwell and Pollocksville (Trent watershed) includes all sources, even those that cannot be quantified for allocation purposes with current data. Some of the control measures to reduce nitrogen loading in the basin such as buffers, do reduce the nitrogen load from groundwater.

IV. Implementation of the Nitrogen TMDL

DWQ developed rules to require nitrogen reductions from both point and nonpoint sources within the Neuse River Basin. A copy of the adopted rules is included in Appendix III. A brief summary of the various rules along with other implementation plans to achieve the 30% reduction is provided below:

IV-A. Point Source Implementation

Rules were drafted that require all dischargers below the Falls Dam that have a design flow of 0.5 MGD or greater (major dischargers) to meet annual nitrogen loads based on their permitted flow and a concentration of approximately 3.7 mg/l TN. The current point source rule contains limits of 5.5 mg/l TN for major dischargers above Falls Dam. A mechanism was also established that allowed the point sources to meet the nitrogen reduction goal collectively. The intent of this rule was to achieve a 30% reduction in point source loading at the estuary. However, a mistake was made in the calculations that were done to evaluate different management scenarios, and the rules as currently drafted will not likely achieve the 30% reduction for point sources at the estuary. Therefore, DWQ is holding the NPDES permits in the Neuse River until guidance is received from the Environmental Management Commission on potential rule changes. We expect to receive this guidance in the next few months, and the point source community is prepared to meet a 30% reduction in nitrogen loading. In the meantime, EPA has requested that DWQ delay issuing NPDES permits until April 30, 1999 pending review of this TMDL.

IV-B. Nonpoint Source Implementation

Four main rules were drafted requiring mandatory nonpoint source controls for nitrogen in the Neuse River Basin. These were rules concerning: (1) stormwater, (2) agriculture, (3) nutrient management planning, and (4) buffer requirements. Each of these rules with the exception of the buffer rule was adopted as permanent rules by the 1998 General Assembly and became effective on August 1, 1998. A temporary buffer rule has been in effect since July 22, 1997. Further information on each of the rules and the status of the buffer requirements, as well as other initiatives is provided below:

Stormwater Rule

The stormwater rules apply to the 10 largest municipalities and 5 counties within the Neuse River Basin. The rules require DWQ and the local governments to develop a model stormwater management plan that addresses new development, public education, illegal discharges, and identifying existing sites by August 1, 1999 that could, potentially, be retrofitted with stormwater controls. Local governments then have an additional 18 months to develop a local plan that includes the same components as the model plan.

Agriculture Rule

The rule provides each farmer with two options to achieve the nitrogen reduction goals:

- Participate in a local nitrogen reduction strategy that would include specific plans that would enable farmers to collectively meet the nitrogen reduction goal, or
- Implement standard best management practices such as buffers, water control structures, and nutrient management plans.

Under the first option, two main committees have been formed: a Basin Oversight Committee and a Local Advisory Committee for each county in the Basin. The Basin Oversight Committee is charged with the following responsibilities:

- Develop method to track nitrogen loads and reductions from farms
- Refine calculations on agriculture nitrogen loads to the Neuse River
- Allocate nitrogen goals to each county/watershed in the basin based on strategies developed by the Local Advisory Committees.
- Review and approve county/watershed nitrogen reduction strategies

While the rules specify that the agricultural community achieve a 30% reduction in total nitrogen, the Basin Oversight Committee is urging the agricultural community to achieve a 35-40% reduction in total nitrogen loading in the basin which is in agreement with the TMDL allocation for agriculture.

The Local Advisory Committee is charged with the following resonsibilities:

- Sign up farmers for this option
- Develop local strategies to meet county/watershed nitrogen reduction goal
- Submit annual progress reports to Basin Oversight Committee

Farmers who choose to implement standard best management practices under the second option will have to comply with the BMPs outlined in Table 7.

Table 7: Standard BMPs Required for Farmers Selecting Option 2

BMP(s) Implemented	Required Riparian Area Zones and Vegetation
Nutrient Management *and* Controlled Drainage	No Riparian Area Requirement
Nutrient Management *or* Controlled Drainage	20' Forested Riparian Area *or* 30' Vegetated Filter Strip
Loss of Cropland Required for Receipt of Federal Tobacco Allotments (no Nutrient Management or Controlled Drainage)	20' Forested Riparian Area *and* 30' Vegetated Filter Strip
None of the above BMPs	30' Forested Riparian Area *and* 20' Vegetated Filter Strip

Nutrient Management Rule

Persons who apply fertilizer to or manage 50 or more acres per year of cropland, golf courses, recreational lands, rights-of-way, lawns and gardens in commercial and residential areas, and other turfgrass areas have two options to comply with the Neuse rules. They may complete training and continuing education in nutrient management or develop a written nutrient management plan for all property where nutrients are applied. If they choose to complete nutrient management training, they must do so within 5 years of the effective date of the rule. If they choose to develop nutrient management plans, the plans for cropland must meet the standards and specifications of the USDA National Resources Conservation Service or the standards and specification adopted by the NC Soil and Water Conservation Commission. The nutrient management plans for other lands must meet recommended guidelines from land-grant universities. It should be noted that the nutrient management planning requirements are above and beyond the reduction requirements for agriculture and urban lands. Therefore, a greater than 30% reduction should be achieved from these land uses which is in accordance with the TMDL allocations for these land uses.

Buffer Rule

The Neuse River Riparian Area Protection and Maintenance rule was first put into effect as a temporary rule on July 22, 1997 by the NC Environmental Management Commission. Since that date, this temporary rule has provided protection for riparian areas with existing forest vegetation along all perennial and intermittent streams, lakes, ponds and estuaries in the Neuse River Basin. The protected riparian area consists of two zones. Zone 1 is the first 30 feet directly adjacent to the waterbody, which is required to be essentially undisturbed forest vegetation. Zone 2 is an additional 20 feet adjacent to Zone 1, which is required to be dense vegetation which may be managed. The temporary rule includes allowances for activities such as road and utility crossings, water-dependent activities and limited tree harvest within the riparian area.

In 1998, the General Assembly considered adoption of the Neuse River Riparian Area rule as a permanent rule. Rather than approving the permanent rule, the General Assembly approved House Bill 1402. House Bill 1402 allows DWQ to continue implementing the temporary Riparian Area rule for one more year with some modifications in the definitions of streams, forest vegetation and vested rights. In addition to the changes to the temporary rule, House Bill 1402 calls for the formation of a Stakeholder Advisory Committee. The Committee, which has been meeting frequently, is responsible for making recommendations to the EMC by April, 1999 on some of the technical issues associated with the Riparian Area Rule. These issues include: defining a stream, creating a riparian area mitigation program, and delegating the riparian area program to local governments. Based on the Committee's recommendations, the EMC will recommend revised language for the temporary Riparian Area rule and will begin the permanent rule-making process for the revised rule.

Other Expected Agricultural Reductions

North Carolina was awarded $256 million in Comprehensive Reserve Enhancement Program (CREP) funds for use in establishing best management practices (BMPs) in its nutrient sensitive waters basins including the Neuse River. The agricultural agencies are expecting the farming community to use this funding to implement the Neuse River agricultural rules as well as to implement additional BMPs. Therefore, we expect the agricultural community to surpass its loading target for total nitrogen. When the TMDL is updated, the programs funded with CREP money will be reviewed in order to estimate the loading reductions that have been achieved to date. It is important to note that full compliance with the TMDL requirements has been established for 2003, and the TMDL will be reviewed in 2001.

IV-C. Atmospheric Nitrogen Implementation

Although there is no rule specific to the Neuse River Basin to control atmospheric sources of nitrogen, there are measures which are being enacted that should reduce atmospheric emission of nitrogen. First, last month, EPA finalized a landmark Clean Air Act rule requiring utilities and large industrial sources throughout 22 Eastern states to reduce by 85% their emissions of nitrogen oxides (NOx) by 2003 (U.S. E.P.A., 1998b). This translates to a best estimate of reduced nitrogen load of 4.1 million lbs/yr to the Albemarle/Pamlico Sound (U.S. E.P.A., 1998a), of which the Neuse estuary is a section. This estimate assumes that 10% of nitrogen deposited on land surfaces in a given watershed is exported to the estuary.

Secondly, the NC Environmental Management Commission passed a temporary rule in February, 1999 that requires all animal operations to implement BMPs to control odor being emitted from the facilities. The effective date of this rule was March 1, 1999. If odor complaints persist, further measures will be required. The rule-making process to develop a permanent rule will begin in Fall 1999. The scientific literature suggests that reducing odor may help reduce ammonia emissions (personal communication with Dr. Viney Aneja, February 19, 1999).

Finally, the local plans called for in the Neuse Rules may address some of the atmospheric load originating on urban and agricultural land in the basin. As part of their strategy to reduce nitrogen loading it may be deemed appropriate to target atmospheric sources.

IV-D. Conclusions on Implementation Issues

DWQ believes there is reasonable assurance that an overall 30% reduction in total nitrogen will be achieved. The rules assure that a 30% reduction in total nitrogen will be achieved from point sources, urban areas, and agricultural lands. In addition, the nutrient management rule requires reductions above and beyond the reductions required for agriculture and urban lands; therefore, greater than a 30% reduction will be achieved from these sources through the rules.

Further reductions are expected from agricultural lands based on two sources: (1) the Basin Oversight Committee established by the Neuse agricultural rules is urging counties to implement BMPS that will achieve a 35-40% reduction in total nitrogen and (2) the agricultural agencies are expecting farmers to implement BMPs above and beyond those required by the Neuse agricultural rule with the CREP money that has been awarded to North Carolina.

Finally, reductions in atmospheric nitrogen will be achieved through new federal and state rules. The EPA has estimated that nitrogen oxide deposition in the Albemarle Pamlico Estuary system will be reduced by 4.1 million pounds per year. EPA could not provide DWQ with specific information on the reductions that would be expected in the Neuse, but the Neuse is a major estuary within this system. The odor control rule adopted by the EMC will result in reduced ammonia emissions to the watershed. At this time, the reductions cannot be quantified, but DWQ will review any new information concerning the effectiveness of this rule when the TMDL is reviewed in 2001.

V. Public Participation

40 CFR 130.7 requires that TMDLs go through a public participation process. The public had multiple opportunities to comment on and participate in public discussion of the 30% reduction target, as well as the point and nonpoint source rules that DWQ has developed in order to implement the TMDL (described above). At the public meetings, the reduction target was justified based on the Senate Select Committee's recommendation. Specifically, the DWQ held six public workshops in New Bern and Smithfield in May 1996 in order to obtain input from the public early in the process. Four public hearings were then held in November 1996 in Raleigh, New Bern, Goldsboro, and Kinston to obtain public input on the proposed TMDL and the rules that were drafted to implement the TMDL. Based on the comments received at this hearing, substantial changes were made to the rule, and a second set of public hearings was held in October 1997 in New Bern and Raleigh. A copy of the announcements for the public hearings is included in Appendix IV. The comments from each hearing are summarized in the Report of Proceedings that was written following each hearing (NCEMC, 1997a; NCEMC, 1997b), and the workshop comments were summarized in a report prepared by the Division (NCDEM, 1996).

In general, most commentors supported the 30% reduction in total nitrogen. Although no one stated that they believed a 30% reduction would indeed restore water quality given the complexity of estuarine systems, people believed that it was a good goal until more information including modeling analyses were available to modify that goal. The Neuse River Foundation commented during each public meeting that a fifty percent reduction in total nitrogen was needed. DWQ did not believe there was sufficient evidence to change the TMDL, and the target has not been modified. More detail on this comment and other comments specific to the TMDL are provided in Appendix V.

VI. Future TMDL Initiatives

VI-A. Tracking Progress With the TMDL

The DWQ installed a continuous gage and began collecting daily nutrient concentration data at Fort Barnwell in 1996. As long as funding of this gage and daily monitoring continue, the DWQ will continue to collect the data. These data will be used to calculate nitrogen loading at Fort Barnwell. To be consistent with the method in which the TMDL was calculated, the flows may need to be scaled up to flows at Streets Ferry. Weekly ambient data collected at the gaged site on the Trent River at Pollocksville will be used to calculate Trent River loads. Point source loading will then be added in to estimate the loads at New Bern. Direct atmospheric deposition to the estuary based on an estimate from the export coefficient method will be added to the load. Better methods may be available to estimate this load, but the export coefficients will be used to be consistent with the manner in which the TMDL was calculated. Future updates of the TMDL will further address this issue. Since flow and concentration determine load, compliance with the TMDL will be done over a five year period using the FLUX model to offset annual flow variability. This is consistent with the manner in which the baseline load and TMDL were calculated. The updated loading analysis will be performed on the basin planning cycle, and the information will be provided in the basin plan that is scheduled for mid 2002.

DWQ will determine if loads appear to be decreasing. It is important to note that there is greater uncertainty in trends based on short time periods, but DWQ will attempt to statistically analyze the data during each basin cycle. It is also important to note that many of the point and nonpoint source controls are not required to be fully implemented until 2003. Thus, total nitrogen load reductions that do not achieve the loading target during the upcoming basin cycle may not be indicative of an ineffective management strategy, but rather the result of management practices still being installed throughout the basin. In the next phase of the TMDL, DWQ will review available information to determine if it appears that the implementation strategies need to be revised in order to meet the TMDL goal. Ultimately, the goal of DWQ and the Clean Water Act is to restore the uses of the estuary. DWQ has established a Rapid Response Team in the Neuse estuary to collect data during fish kills and algal blooms and assist in monitoring the estuary. DWQ will report on the frequency and extent of algal blooms and fish kills that have occurred within the estuary in future updates of the Neuse River Basinwide Water Quality Management Plan.

VI-B. Future Phases of the TMDL

DWQ will use all available studies to re-evaluate the TMDL and management strategies (See following section entitled "Ongoing and Future Studies in the Neuse River") following the schedule in Figure 14 and Table 8. DWQ will use the results of all MODMON data collection and modeling to revise the TMDL and management strategy. The extension of the MODMON project indicates that all work should be completed by January, 2001. DWQ will use this information and any other new data and models that result from the projects described below to revise the TMDL and implementation plan. Specifically, seasonality and phosphorus loading will be addressed using the estuary model and any other means possible. DWQ will involve stakeholders in the TMDL review process. North Carolina's Administrative Procedures Act (APA) requires a minimum of two years to complete a new rule. Therefore, if rule making proceeds without any hold-ups, new rules could be completed by the end of 2001 with an effective date of August 2002. This would just meet the schedule to include the revised TMDL and implementation strategies in the next update of the Neuse Basinwide Plan which is scheduled for completion in late 2002 or early 2003.

The potential exists that new information will indicate that the current TMDL is not adequate, but the new information may not be adequate to determine the exact nutrient reductions that are needed in order to achieve water quality standards. If the model and other tools are not ready or capable of predicting the nitrogen reduction goal, the State will be prepared to revise the TMDL to include an explicit margin of safety. A revised phased TMDL will be developed based on the new data, modeling tools and expert opinion of the scientists. Extensive public involvement would be built into the process as required by the federal regulations and North Carolina statutes.

Table 8: Milestone Dates to Review and Revise the Neuse TN TMDL

April 1, 2000	A CE-QUAL-W2 model (estuary response model) of the Neuse estuary will be completed to the extent that it will be ready to use as a tool for the completion of the second phase of the TMDL.
July 1, 2000	The nitrogen reduction goal (i.e. the total percent reduction necessary to support the estuary's uses) will be completed using the CE-QUALW2 model and other data and tools available. The state will provide EPA with the appropriate information to review by this date. If the model and other tools are not ready or capable of predicting the nitrogen reduction goal, the State will be prepared to revise the TMDL to include an explicit margin of safety (i.e. an additional reduction will be added to the proposed 30% reduction). The State will provide EPA Region IV with the documentation that includes: (1) the explicit margin of safety that the State intends to use: and (2) the rationale for the value of this margin of safety.
August 1, 2000	EPA Region IV will approve/disapprove the State's nitrogen reduction goal submitted on July 1, 2000.
March 31, 2001	The State will public notice for comment the 2nd phase of the TMDL.
July 31, 2001	The State will submit the 2nd phase of the TMDL to EPA for approval/disapproval.
August 30, 2001	EPA Region IV will make an approval/disapproval decision on the 2nd phase of the TMDL.

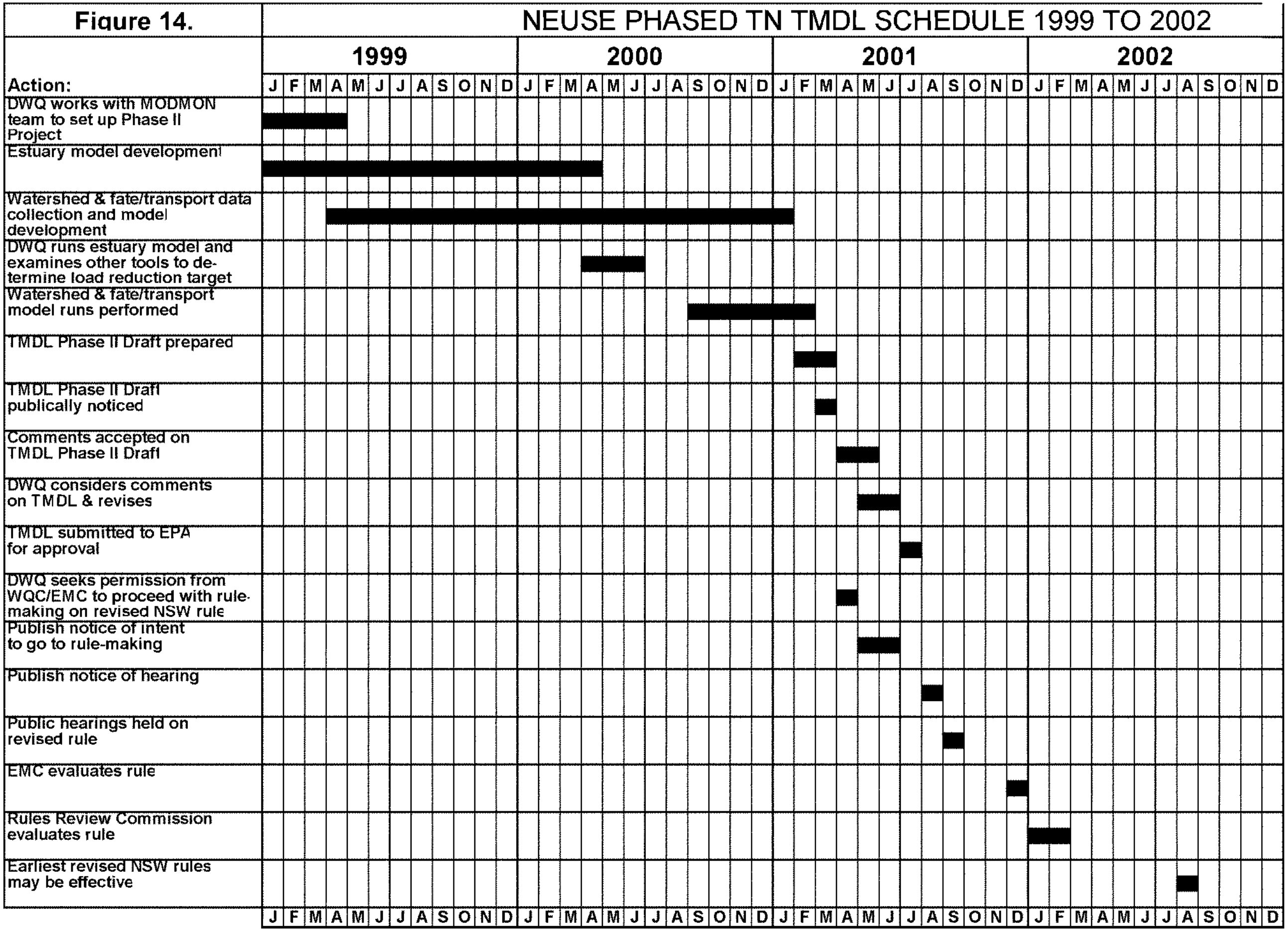


Figure 14.
NEUSE PHASED TN TMDL SCHEDULE 1999 TO 2002
1999
2000
2001
2002
J F M A M J J A S O N D
Action:
DWQ works with MODMON team to set up Phase II Project
Estuary model development
Watershed & fate/transport data collection and model development
DWQ runs estuary model and examines other tools to determine load reduction target
Watershed & fate/transport model runs performed
TMDL Phase II Draft prepared
TMDL Phase II Draft publically noticed
Comments accepted on TMDL Phase II Draft
DWQ considers comments on TMDL & revises
TMDL submitted to EPA for approval
DWQ seeks permission from WQC/EMC to proceed with rule-making on revised NSW rule
Publish notice of intent to go to rule-making
Publish notice of hearing
Public hearings held on revised rule
EMC evaluates rule
Rules Review Commission evaluates rule
Earliest revised NSW rules may be effective

VI-C. Ongoing And Future Studies In The Neuse River

There are many studies that are ongoing in the Neuse River Basin that are pertinent to the nitrogen TMDL discussion, and these efforts are described in this section. Further information on Neuse River studies can be found at the North Carolina Water Resources Research Institute website at www2.ncsu.edu/ncsu/CIL/WRRI.

MODMON

Using money allocated by the 1996 North Carolina General Assembly, DWQ contracted work with a team of university researchers to collect monitoring data in the estuary and develop a two dimensional estuarine response model (MODMON). The initial version of the model is being verified using seven months of data that was collected beginning in June 1997. This model is being updated with data collected from January-December, 1998 and will include a sediment model. DWQ should receive the model in June, 2000; this tool will be valuable in evaluating the nitrogen loading targets.

The General Assembly approved in October, 1998 a budget that includes an item to extend the MODMON work. The General Assembly's budget package includes developing a model of the Neuse watershed that includes examining instream fate and transport issues and linking it to the estuarine response model. The additional work is projected to be completed in January 2001.

Groundwater Studies

The General Assembly provided funds for researchers at North Carolina State University (NCSU) to determine the extent to which animal waste lagoons may impact groundwater in the state. Preliminary research has shown that groundwater may account for a significant portion of the nitrogen load in the Neuse River Basin, and data collected from this study will help determine the magnitude of the impact from agricultural lagoons on nitrogen loading in the basin. A final document will be completed in 1999.

The U.S. Geological Survey is doing a study on the effects of buffers on groundwater and the subsequent impact on surface water quality. As part of this study, they are also trying to quantify the amount of nitrogen that is discharged to surface water from shallow and deep aquifers.

There is also a 319 project that has been funded in which maps of the basin will be developed that show areas where controls should be targeted in terms of groundwater vulnerability and potential for subsurface pollutant transport to streams.

Nitrogen Isotope Study

Different sources of nitrogen have their own isotopes, and studying these isotopes will help identify the relative magnitude of different nitrogen sources within the Neuse River Basin. This study, funded by the General Assembly, will provide valuable information on the sources of nitrogen in the basin for inclusion in the modeling framework. This work will enable DENR to develop more effective nitrogen management plans. The study will be completed by 2000.

Atmospheric Deposition of Nitrogen

The General Assembly allocated funds to identify the amount of atmospheric nitrogen reaching the Neuse River estuary. Data collected under this study are being used in the atmospheric module of the estuary response model. In addition, data on atmospheric loading on the landscape will be needed to develop a linked watershed and estuary modeling framework. Furthermore, UNC Chapel Hill scientists are being funded to examine management practices that promote conversion of nitrogen compounds in animal waste to benign nitrogen gas.

Dr. Viney Aneja of NCSU and others are being contracted by the NC Division of Air Quality (DAQ) to study how much wet and dry deposition is occurring in various regions of North Carolina, as well as to gain a better understanding of the extent of atmospheric ammonium enhancement from animal operations.

The deposition study is just beginning and expected to last 3-4 years. It is primarily aimed at understanding dry deposition as our knowledge of that is presently very minimal compared to to that of wet deposition. It will progressively measure deposition on a grassy field, a crop field and an aquatic ecosystem. In the meantime, the group will model the transport and transformation of atmospheric nitrogen (primary NH_3/NH_4^+ with some NOx) to develop concentration fields that will predict deposition. DAQ will make ground measurements of deposition at a few ground locations including swine operations to calibrate this modeling exercise.

The emissions study will measure emissions from numerous sources within swine operation (house, lagoon, spray field) and combine those results with those from similar studies (USDA, USEPA) to make statistical estimates of emissions on a larger scale. In the future, this type of study will be expanded to include other animals such as turkeys and chickens.

Buffers

WRRI is funding NCSU scientists to refine design criteria for vegetative buffers along streams to control nitrogen loading.

RIMDESS

DENR obtained funds from the Environmental Protection Agency (EPA) to develop a shell to facilitate a modeling system that links the estuary model to a watershed model, groundwater model and atmospheric model. DENR contracted with the Research Triangle Institute (RTI) to develop this tool which is called the River Management Decision Support System (RIMDESS). RIMDESS is intended to provide DENR with the ability to review various nitrogen management options in the basin, and assess the cost-effectiveness of these options. The framework to do this has been established, but the RIMDESS frame needs to be filled with the different model components, such as the estuarine model, and updated information.

MIMS

The U.S. Environmental Protection Agency is developing a multi-media integrated modeling system (MIMS) that will be an object-oriented modeling approach to holistically review environmental problems. The MIMS project will be using the Neuse River as a prototype and will include nitrogen in the surface waters, atmosphere, groundwater and watershed. They are planning on being able to use the project for TMDL issues, but the modeling system will not be available until 2008. Efforts are underway to coordinate this project such that it builds on the MODMON work and hopefully reduces the time frame for completion.

Other EPA Initiatives

EPA's Research Triangle Park office has much ongoing research in the Neuse River. At a meeting of the MIMS team in September 1998, DWQ was informed of these efforts. There is one part of this effort directly related to the nitrogen TMDL. EPA is developing a land use database that will be used to develop nonpoint source nutrient models of the basin. EPA is planning to complete these models by the end of 2000, and they can be used to allocate the allowable nitrogen load among various sources.

DWQ will use this ongoing research as it reviews data for inclusion in future updates of the TMDL and Neuse Basinwide Water Quality Management Plan. These data will be used to assess water quality in the estuary, determine use support ratings, and review the effectiveness of the proposed TMDL and the strategies to implement it.

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Total Maximum Daily Loads for Fecal Coliform Bacteria and for Copper to Pigeon House Branch, North Carolina

Final Version Approved by EPA

June, 2003

Neuse River Basin

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Final version submitted to EPA

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Final version submitted to EPA

SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. **303(d) Listed Waterbody Information**
State: North Carolina
County: Wake

Major River Basin: Neuse River Basin
Watershed: Pigeon House Branch - in Upper Neuse Watershed HUC 03020201

Impaired Waterbody (2000 303(d) List):

Stream Index #	Segment Name	Designated Use	
		Partial Support [mi.]	Not Support [mi.]
27-33-18	Pigeon House Branch – source to Crabtree Creek	---	2.9

Constituent(s) of Concern: Fecal Coliform Bacteria, Copper

Designated Uses: Biological integrity, propagation of aquatic life, and recreation.

Applicable Water Quality Standards for Class C Waters:
Fecal coliforms shall not exceed a geometric mean of 200/100ml (membrane filter count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100 ml in more than 20 percent of the samples examined during such period.

Copper: 7 ug/l.

2. **TMDL Development**

Analysis/Modeling:
Load duration curves based on cumulative frequency distribution of flow conditions in the watershed. Allowable loads are average loads over the recurrence interval between the 95th and 10th percent flow exceeded (excludes extreme drought (>95th percentile) and floods (<10th percentile). Percent reductions expressed as the average value between existing loads (calculated using an equation to fit a curve through actual water quality violations) and the allowable load at each percent flow exceeded.

Critical Conditions:
Critical conditions are accounted for in the load curve analysis by determining the average difference between the existing load violation trend line and the allowable load line. This approach was chosen because existing load violations occur at all flow levels.

Seasonal Variation:
Seasonal variation in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous flow gage and the use of all readily available water quality data collected in the watershed.

3. **Allocation Watershed/Stream Reach:**

Pollutant	LA	WLA [1]	MOS [2]	TMDL	Percent Reduction[3]
Fecal Coliform	2.04×10^8 counts/day	7.63×10^9 counts/day	Explicit	7.83×10^9 counts/day	78%
Copper	3.35×10^5 ug/day	1.26×10^7 ug/day	Explicit	1.29×10^7 ug/day	66%

Notes:
WLA = wasteload allocation, LA = load allocation, MOS = margin of safety
1. WLA = TMDL – LA - MOS; where TMDL is the average allowable load between the 95th and 10th percent flow exceeded.
2. Margin of safety (MOS) equivalent to 10 percent of the target concentration for fecal coliform and 14 percent for copper.
3. Average reduction required over the range of flows between the 95th and 10th percent flow exceeded, as estimated in Pigeon House Branch using the continuous streamflow gage from nearby Rocky Branch.

4. **Public Notice Date:** April 15, 2003

5. **Submittal Date:**

6. **Establishment Date:**

7. **Endangered Species (yes or blank):**

8. **EPA Lead on TMDL (EPA or blank):**

9. **TMDL Considers Point Source, Nonpoint Source, or both:** both

For Fecal Coliform Bacteria and Copper

To Pigeon House Branch

1.0 Introduction

On the draft 2002 North Carolina Integrated Report, the North Carolina Division of Water Quality (DWQ) identified a 2.9-mile segment (27-33-18) of Pigeon House Branch in the Neuse Basin as impaired by fecal coliform bacteria and copper. The impaired segment extends from the stream's source to its confluence with Crabtree Creek. This section of the stream is located in subbasin 03-04-02. Pigeon House Branch is designated as a class C water. Class C waters are freshwaters that are protected for secondary recreation, fishing, and propagation and survival of aquatic life.

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. This list, contained within Categories 4 through 7 of the Integrated Report, is submitted biennially to the U.S. Environmental Protection Agency (EPA) for review. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Category 5 of the Integrated Report. A TMDL is the maximum amount of a pollutant (e.g., fecal coliform or copper) that a waterbody can receive and still meet water quality standards, and an allocation of that load among point and nonpoint sources. The objective of a TMDL is to estimate allowable pollutant loads and allocate to known sources so that actions may be taken to restore the water to its intended uses (USEPA, 1991). Generally, the primary components of a TMDL, as identified by EPA (1991, 2000a) and the Federal Advisory Committee are as follows:

Target identification or selection of pollutant(s) and endpoint(s) for consideration. An endpoint is an instream numeric target. The pollutant and endpoint are generally associated with measurable water quality related characteristics that indicate compliance with water quality standards. North Carolina indicates known problem pollutants on the 303(d) list.

Source assessment. Sources that contribute to the impairment should be identified and loads quantified, to the extent that that is possible.

Reduction target. Estimation of level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the waterbody, highlighting how current conditions deviate from the target endpoint. Generally, this component is identified through water quality modeling.

Margin of safety. The margin of safety addresses uncertainties associated with pollutant loads, modeling techniques, and data collection. Per EPA (2000a), the margin of safety may be expressed explicitly as unallocated assimilative capacity (portion of TMDL) or implicitly through conservative assumptions. The margin of safety should be included in the reduction target.

Allocation of pollutant loads. Allocating available pollutant load (TMDL), and hence pollutant control responsibility, to the sources of impairment. The wasteload allocation portion of the TMDL accounts for the loads associated with existing and future point sources. The load allocation portion of the TMDL accounts for the loads associated with existing and future nonpoint sources. Any future nonpoint source loading should remain within the TMDL that is calculated in this assessment; in other words, this TMDL does not leave allocation for future sources.

Seasonal variation. The TMDL should consider seasonal variation in the pollutant loads and endpoint. Variability can arise due to streamflows, temperatures, and exceptional events (e.g., droughts and hurricanes).

Critical conditions. Critical conditions occur when fecal coliform levels exceed the standard by the largest amount. If the modeled load reduction is able to meet the standard during critical conditions, then it should meet the standard at all, or nearly all, times.

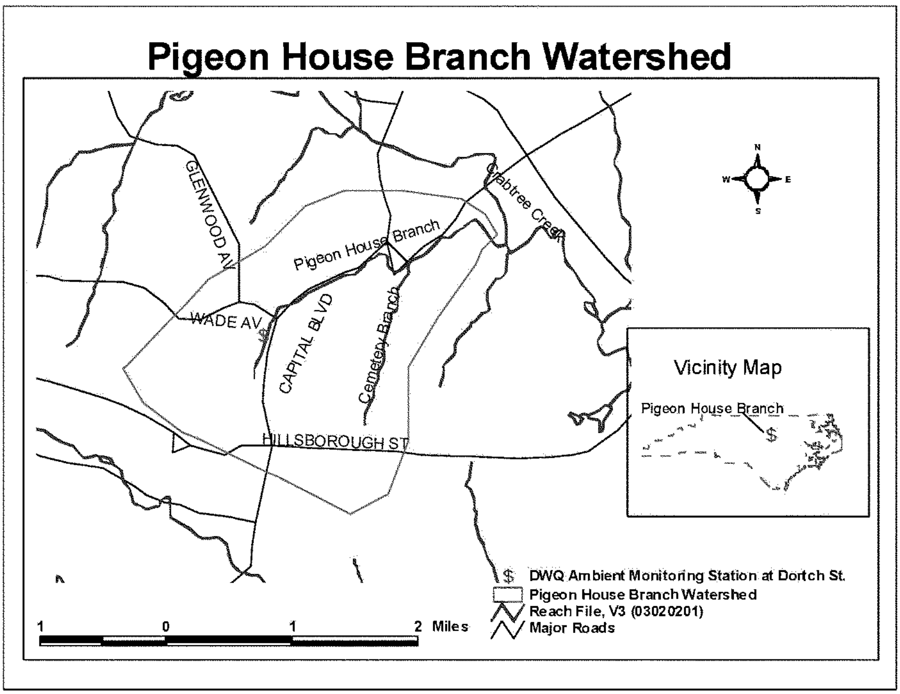
Section 303(d) of the CWA and the Water Quality Planning and Management regulation (USEPA, 2000a) require EPA to review all TMDLs for approval or disapproval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of the 2002 Integrated Report. Waterbodies remain on Category 4a until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may still result in the restoration of water quality.

The goal of the TMDL program is to restore designated uses to water bodies. Thus, the implementation of bacteria and copper controls will be necessary to restore designated uses in Pigeon House Branch. Although an implementation plan is not included as part of this TMDL, reduction strategies are needed. The involvement of local governments and agencies will be critical to developing an implementation plan and reduction strategy.

1.1 Watershed Description

Pigeon House Branch, located in the upper Neuse basin, drains into Crabtree Creek within the City of Raleigh (see Figure 1). The creek's watershed lies entirely within Wake County and is about 4 square miles in area. DWQ has an ambient water quality monitoring site (Storet number J3300000) at Dortch St., about 2.5 miles from the confluence with the Crabtree Cr. The watershed at this point is 1.15 square miles. <u>This will be the evaluation point for the TMDL since fecal coliform and copper data have been and will continue to be collected here</u>.

Figure 1.



Note: watershed delineation in Fig. 1 is inexact, and has been used for display purposes only.

The land use/land cover characteristics of the watershed were determined using 1996 land cover data that were developed from 1993-94 LANDSAT satellite imagery. The North Carolina Center for Geographic Information and Analysis, in cooperation with the NC Department of Transportation and the United States Environmental Protection Agency Region IV Wetlands Division, contracted Earth Satellite Corporation of Rockville, Maryland to generate comprehensive land cover data for the entire state of North Carolina. Tabulated land cover/land use data for the Pigeon House Branch Watershed are shown in Table 1. During the formation of this geographic dataset, developed land was identified using the proportion of synthetic cover present; low density developed was 50-80% synthetic cover, and high density developed was 80-100% synthetic cover. Assuming that synthetic cover is impervious, and that all non-developed land cover classes have 1% impervious cover, the Pigeon House Branch watershed is estimated to have 57-78% impervious surface.

That the impervious cover estimate is so high is not surprising considering the watershed is entirely within the City of Raleigh. For management purposes, DWQ will consider that there is only one land class in Pigeon House Branch watershed – urban land. This land, however, may be drained by a variety of means. These include storm pipes and sewers that are under the separate jurisdiction of the City of Raleigh, Department of Transportation, federal government (railroad tracks), and Wake County, as well as overland runoff and interflow from urban land into the stream network.

Table 1. Land use/land cover in Pigeon House Branch watershed

Land Use/Land Cover	**Pigeon House Branch Watershed Acres**
High Density Developed	1314 (49.1%)
Low Density Developed	946 (35.4%)
Cultivated	0 (0.0%)
Managed Herbaceous	127 (4.7%)
Forest	289 (10.8%)
Total	2674

The USGS 14-digit hydrologic unit code (HUC) for Pigeon House Branch is 03020201090020.

1.2 Water Quality Monitoring Program

There are two sources of fecal coliform and copper data for Pigeon House Branch: 1) data from the North Carolina Division of Water Quality's ambient monitoring program; 2) special study data collected by the City of Raleigh. More information is provided below, and both of these datasets are included in Appendix I.

Pigeon House Branch was listed as impaired based on data from the DWQ ambient monitoring station, which is located at Dortch St. or approximately 2.5 miles from the stream's confluence with Crabtree Creek. Water samples collected at this site on a monthly basis are analyzed for fecal coliform, copper and other water quality parameters.

DWQ used the ambient data as the basis for the TMDL calculation because those data have been collected on a consistent basis, and will be used to assess compliance in the future. Furthermore, DWQ conducts ambient monitoring using QAQC (quality assurance and quality control) protocols established for sample collection and analysis. Raleigh undertook monitoring, as described below, for their own source identification purposes; consequently, Raleigh did not follow formal QAQC protocols for sample collection and transport. As a result, Raleigh data will be used in this TMDL for source assessment and implementation strategy development purposes.

The City of Raleigh conducted synoptic sampling at 12 locations in the Pigeon House Branch watershed. Raleigh sampled these sites on 8 days (approximately weekly) in June and July 2001. The samples were analyzed for a number of water quality parameters, including fecal coliform and copper. These data show extremely high fecal coliform levels, with noticeably higher counts at the entrance to Equipment Service Depot off of West St., at the culvert between West St. and Peace St., and at Automotive Way past Crabtree Boulevard. More attention to these data may help to identify specific sources of fecal coliform, possibly including leaky sewer lines and illicit discharges.
The copper data from Raleigh do not show the same level of impairment as DWQ's copper data; however, there are some sites, particularly the entrance to the Equipment Service Depot off of West St. and the culvert between West St. and Peace St., which indicate copper impairment.

1.3 Water Quality Targets

The North Carolina fresh water quality standard for **fecal coliform** in Class C waters (T15A: 02B.0211) states:

> Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (membrane filter count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100 ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique will be used as the reference method.

The instream numeric target, or endpoint, is the restoration objective expected to be reached by implementing the specified load reductions in the TMDL. The target allows for the evaluation of progress towards the goal of reaching water quality standards for the impaired stream by comparing the instream data to the target. For this TMDL the water quality target is the instantaneous concentration of 400cfu/100ml. Cfu stands for colony-forming units; it may also be referred to as simply 'counts' in this assessment. The geometric mean will not be considered because the method used to develop the TMDL analysis method is incompatible with the available data; the method relies on observed data, and, as previously mentioned, those are limited to a monthly frequency. Typically in North Carolina, compliance with the instantaneous part of the fecal coliform criterion has also meant compliance with the geometric mean part of the criterion.

For **copper**, the North Carolina freshwater **action level for toxic substances** in Class C waters (T15A: 02B.0211) states:

If the Action Levels for any of the substances listed in this Subparagraph (which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics or associated waste characteristics) are determined by the waste load allocation to be exceeded by a receiving water by a discharge under the specified low flow criterion for toxic substances (Rule .0206 in this Section), the discharger shall monitor the chemical or biological effects of the discharge; efforts shall be made by all dischargers to reduce or eliminate these substances from their effluents. Those substances for which Action Levels are listed in this Subparagraph shall be limited as appropriate in the NPDES permit based on the Action Levels listed in this Subparagraph if sufficient information (to be determined for metals by measurements of that portion of the dissolved instream concentration of the Action Level parameter attributable to a specific NPDES permitted discharge) exists to indicate that any of those substances may be a causative factor resulting in toxicity of the effluent. NPDES permit limits may be based on translation of the toxic form to total recoverable metals. Studies used to determine the toxic form or translators must be designed according to "Water Quality Standards Handbook Second Edition" published by the Environmental Protection Agency (EPA 823-B-96-007) which are hereby incorporated by reference including any subsequent amendments. The Director shall consider conformance to EPA guidance as well as the presence of environmental conditions that limit the applicability of translators in approving the use of metal translators.

(a) Copper: 7 ug/l

For purposes other than consideration of NPDES permitting of point source dischargers as described in this Subparagraph, the Action Levels in this Rule, as measured by an appropriate analytical technique, per 15A NCAC 2B .0103(a), shall be considered as the numerical ambient water quality standard(s). (emphasis added for this TMDL document)

In essence, the North Carolina TMDL criterion for copper is 7 ug/l. The term 'action level' refers to a water quality standard for a parameter that is not highly bioaccumulative, and that has variable toxicity to aquatic life due to chemical and environmental variables such as chemical form, solubility, stream pH, and stream hardness. Instream toxicity testing and biological sampling may be used to determine compliance with an action level parameter such as copper.

2.0 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of fecal coliform bacteria and copper in the watershed. It is a qualitative assessment due to the requirements of the simpler analysis method of this TMDL. Further source characterization may be done before and/or during TMDL implementation.

2.1 Point Source Assessment

General sources of fecal coliform and copper are divided between point and nonpoint sources. Currently, there are no facilities in the watershed that discharge **wastewater** through the National Pollutant Discharge Elimination System (NPDES).

A recent EPA mandate (Wayland, 2002) requires NPDES permitted **stormwater** to be placed in the wasteload allocation (WLA), which had previously been reserved for continuous point source wastewater loads. The two entities that are permitted through Phase I of the NPDES stormwater program to discharge in the Pigeon House Branch watershed are the City of Raleigh (NC0029033) and the North Carolina Department of Transportation (NCS000250). As part of Phase II of the NPDES stormwater program, Wake County, which has jurisdiction over some land and storm pipes in the Pigeon House Branch watershed, will be added.

2.2 Nonpoint Source Assessment

Nonpoint sources of fecal coliform bacteria include those sources that can **not** be identified as entering the waterbody at a specific location (e.g., an NPDES permitted pipe). In theory, nonpoint source pollution includes urban, agricultural and background (e.g., forest, wildlife) sources. Fecal coliform bacteria may originate from human and non-human sources. Table 2 lists the potential human and animal nonpoint sources of fecal coliform bacteria (Center for Watershed Protection, 1999). The nonpoint sources of fecal coliform bacteria in Pigeon House Branch include runoff from urban development (non-NPDES regulated stormwater), sewer line systems (leaky sewer lines and sewer system overflows), wildlife, and probably illicit connections in unknown locations.

Nonpoint sources of **copper** in Pigeon House Branch watershed generally include urban stormwater, and potentially sewer line systems (leaky sewer lines and sewer system overflows).

A more specific discussion of the nonpoint sources of fecal coliform and copper in the Pigeon House Branch watershed is provided below.

2.2.1 Livestock

There is no known livestock in the Pigeon House Branch watershed.

Table 2. Potential sources of fecal coliform bacteria in urban watersheds (Center for Watershed Protection, 1999).

Source Type		**Source**
Human Sources	Sewered watershed	Combined sewer overflows
		Sanitary sewer overflows
		Illegal sanitary connections to storm drains
		Illegal disposal to storm drains
Non-human Sources	Domestic animals and urban wildlife	Dogs, cats
		Rats, raccoons, opossum, squirrels
		Pigeons, gulls, ducks, geese

2.2.2 Failed Septic Systems

There are no septic systems in the Pigeon House Branch watershed.

2.2.3 Urban Development

Fecal coliform bacteria can originate from various urban sources. These sources include pet and wildlife waste, illicit discharges/connections of sanitary waste, and leaky sewer systems. Additionally, in the Pigeon House Branch watershed there may be a homeless human population, which could account for additional fecal coliform loading.

Copper originates from various urban sources as well. The primary source of copper in urban stormwater is deposition of abraded automobile brake linings (brake emissions) on roads (Davis et al., 2001; Malmqvist, 1983; Hewitt and Rashed, 1990). Davis et al. (2001) estimated that copper from brake wear composed at least 50% of copper in stormwater; this was from an analysis of a low density residential area that assumed residents account for all vehicle traffic, or where all travel outside the area is matched by non-resident travel inside. The proportion of copper from vehicle brakes is likely to be significantly greater than 50% in the Pigeon House Branch watershed, where major traffic thoroughfares with non-resident traffic are likely to increase vehicle copper loadings. Secondary sources include building siding (possibly from wood preservative) and roofs (especially commercial buildings), and wet and dry atmospheric deposition (Davis et al., 2001). Additional sources may include leaky sewer systems and sanitary sewer overflows.

2.2.4 Sanitary Sewer Overflows

The city of Raleigh owns and operates a wastewater treatment plant and sewage collection system. From 1997 through 2002, Raleigh reported five sanitary sewer overflows (SSOs) of greater than 1,000 gallons, including one SSO of greater than 50,000 gallons in the Pigeon House watershed. There were also six SSOs of less than 1,000 gallons during that time. None of the SSOs appeared in the monitoring data, as samples where not taken within 10 days of a spill, or in one case the spill occurred outside of the monitoring station's watershed. DWQ did not explicitly account for SSOs in the modeling. They are merely mentioned as a source of fecal coliform, and potentially copper, that should receive further attention during development of an implementation strategy.

2.2.5 Wildlife

Wildlife is a source of fecal coliform bacteria throughout the watershed. Wildlife deposit feces containing fecal coliform bacteria on the land surface; later, the bacteria may be transported to the drainage network via runoff or shallow groundwater following a rain event. Direct deposition of fecal coliform bacteria from wildlife into the stream is another avenue for loading. Wildlife in Pigeon House Branch watershed is expected to include raccoons, opossum, squirrels, and birds (pigeons in particular).

2.3 Source Assessment Conclusion

The source assessment for this TMDL is offered as a qualitative assessment of the potential sources of fecal coliform and copper. For copper, it is highly likely that automobile brake deposits are the leading source, followed by buildings and atmospheric deposition. Fecal coliform sources are less certain. The primary sources are likely to be leaky sewer systems, and urban runoff containing fecal coliform from pet waste, wildlife waste and potentially human waste. Other sources may include sanitary sewer overflows, and illicit discharges/connections of sanitary waste. The specific entry points to Pigeon House Branch from all of these sources are not currently known, though the City of Raleigh has conducted some spatially intensive monitoring which may shed light on this (see page 9 and Appendix I).

Additionally, Raleigh and DWQ are collaborating on a bacterial source tracking project that will seek to identify general fecal coliform sources (i.e., human, pets, or wildlife).

3.0 Analytical Approach

Since the allocation of the Pigeon House Branch TMDLs is essentially limited to one source, urban stormwater (that regulated by NPDES, the City of Raleigh and the Department of Transportation as of January 2003; and that which is not regulated by NPDES, State Government Complex and Wake County land as of January 2003), a model to establish pollutant contribution by various sources is not required. Consequently, the primary analysis need is determining the TMDL, or amount of load reduction. Rather than use a complex, mechanistic model such as HSPF, DWQ will employ a load duration approach to determine these TMDLs. Using this approach provides a simplified and direct manner to establish the relationship between water quality and streamflow. Load duration curves are based entirely on observed data, and they employ a cumulative frequency distribution of streamflow. The methodology used will be described further below and is based on work by Stiles in Kansas (2002), Cleland (2002), and Sheely in Mississippi (2002).

3.1 Flow Duration Curves

In order to develop a load duration curve for TMDL development, the first step is to create a flow duration curve, which displays the cumulative frequency distribution of daily flow data over the period of record. The duration curve relates flow values measured at a monitoring station to the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which are exceeded nearly 100 percent of the time, to highest, which are exceeded less than 1 percent of the time.

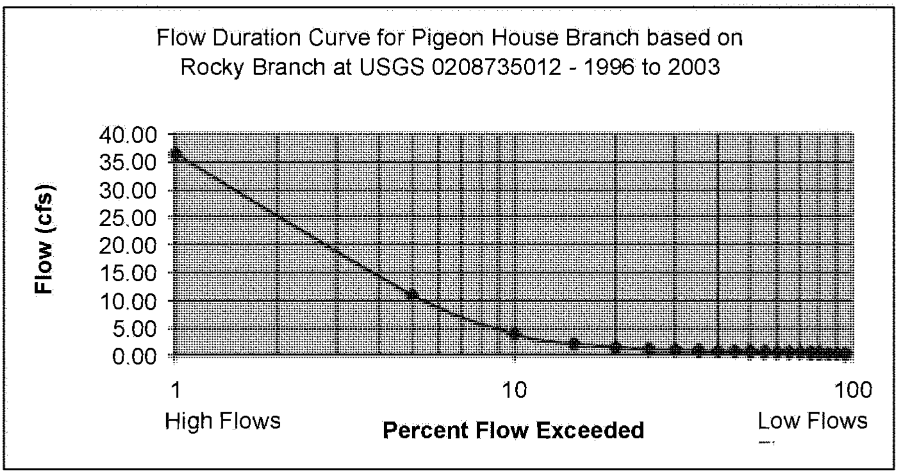
Flow duration curves are limited to the period of record available at a monitoring station. The confidence in the duration curve approach in predicting a realistic percent load reduction increases when longer periods of record are used to generate the graphs. One of the shortcomings of using this method to develop TMDLs is that many ambient monitoring locations, including that at Pigeon House Branch, do not have a USGS gage. However, a nearby gage in a watershed of similar size and land use as the ungaged watershed can be used to estimate flows. Flows at the ungaged location can be estimated using a drainage area ratio, as explained below.

DWQ developed a flow duration curve using daily streamflow data collected at a continuous gage on Rocky Branch (USGS 0208735012) between October 1996 and March 2003. There were other alternatives that were not quite as useful as the Rocky Branch gage. Pigeon House Branch has a gage (USGS 0208732534), but that drains only 0.27 square miles of the watershed and often reports zero flow; at the ambient monitoring station, the watershed drains 1.15 square miles. Another option was the USGS gage (0208732885) at Marsh Creek. The record for this extends as far back as 1984, but it drains 6.84 square miles. The flow per drainage area ratios for Marsh Creek and Rocky

Branch are similar, though Rocky Branch's ratio is slightly higher. After comparing the flow duration curves using the various gages, DWQ chose the Rocky Branch gage because it is nearby, and drains a nearly identical amount of land (1.17 square miles) as Pigeon House Branch at Dortch St. The Rocky Branch watershed is slightly less urban than that of Pigeon House Branch, though it still has a significant amount of impervious area.

To estimate Pigeon House Branch flows from Rocky Branch flows, DWQ completed the following steps: 1) list the observed Rocky Branch flows chronologically during the entire period of record; 2) calculate the daily flow per square mile by dividing the observed flows by the watershed area; 3) order the results from 2) and rank them according to percentile; and finally, 4) multiply the result from 3) by the area of the Pigeon House Branch watershed. The result may be seen in Figure 2 below.

Figure 2.



3.2 Load Duration Curves

Flow duration curves are transformed into load duration curves by multiplying the flow values along the flow duration curve by the pollutant concentrations and the appropriate conversion factors. On the load duration curve, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical criteria for fecal coliform and copper, less the margin of safety, and on flow values from the flow duration curve. The line drawn through the allowable load data points is called the target line.

The existing load is simply based on measured fecal coliform and copper concentrations and an estimate of flow in the stream during sampling days, plus conversion factors. An example of this calculation is provided:

1.28 cfs * 590 counts/100 ml * 1000 ml/l * 7.462 gallons/cfs * 3.785 l/gallon * 86400 sec./day

= 1.84 * 10^10 counts/day

In this TMDL, the estimate of flow comes from the USGS report of mean daily flow at Rocky Branch (USGS 0208735012, see previous section). There is an exception to this statement, however; between 1994 and 1996, DWQ used Marsh Cr. mean daily flow to calculate load on Pigeon House Branch, as flow data did not become available until 1996 on Rocky Branch. The positioning of the existing load on the plot is based on the recurrence interval (percent flow exceeded) of the estimated flow. Existing loads that plot above the target line indicate a violation of the water quality criterion, while loads plotting below the line represent compliance. The load duration plots for Pigeon House Branch are shown in Figures 3 and 4.

Figure 3.

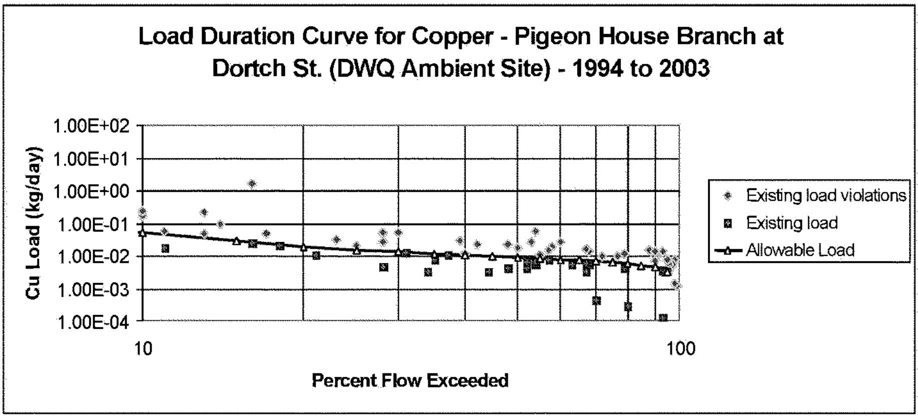
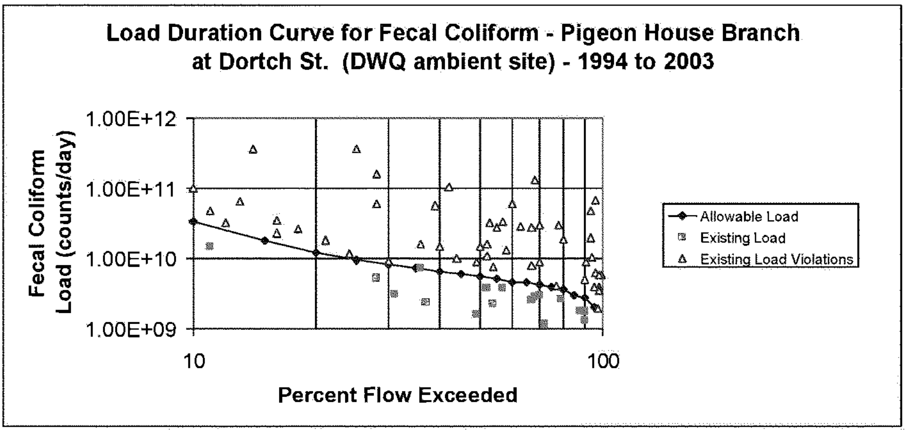


Figure 4.



Further explanation on how load duration curves are used to calculate the TMDLs is provided below.

4.0 Total Maximum Daily Load

A Total Maximum Daily Load is the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount among point and nonpoint sources. A TMDL comprises the sum of wasteload allocations (WLA) for point sources, load allocations (LA) for nonpoint sources, and a margin of safety. This definition is expressed by the equation:

$$TMDL = S\ WLA + S\ LA + MOS$$

The objectives of the TMDL are to estimate allowable pollutant loads, and to allocate to the general pollutant sources in the watershed. Providing recommendations for regulatory or other actions to be taken to achieve compliance with applicable water quality criteria based on the relationship between pollution sources and in-stream water quality conditions is more the focus of an implementation strategy, which will be done separately following this assessment.

40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measures. The fecal coliform TMDL will be expressed in terms of counts per day, and represents the maximum one-day load the stream can assimilate and maintain the water quality criterion. For copper, the TMDL is expressed as micrograms per day, and represents the maximum one-day load the stream can assimilate and maintain the water quality criterion.

The two main components of a TMDL, the reduction target, including a margin of safety, and the allocation strategy, will be presented in the following sections.

4.1 Reduction Target

To determine the amount of fecal coliform and copper load reduction necessary to comply with the water quality criteria, the period of critical conditions and the existing loading must be established.

4.1.1 Existing Conditions

The load duration curves for the impaired streams in the watershed are presented in Figure 5 and 6 on following pages. The criteria violations occur at both high and low flows, which indicate that impairment occurs during wet and dry weather. This also means that the sources of fecal coliform and copper are both near the stream channel, as evidenced by high concentrations during dry weather/low flow, and distant from the stream channel, as evidenced by high concentrations during high flows. The wet weather fecal coliform impairment appears to be more intractable as, at higher flows, the proportion of samples in violation of the allowable load to samples below the allowable load is greatest.

Superimposed on the graphs is a trend through the data points violating the water quality criterion. A power curve provided the best fit, as determined by the correlation coefficient, R^2 (see Figures 5 and 6 below). The trend equations appear above the curves in each of the figures. Due to the scatter in the fecal coliform violations, the best R^2, 0.58, remained somewhat low (see Figure 6).

To represent the TMDLs as a single value, the existing load was calculated from the trend as the average of the load violations occurring when the flow (or load) was exceeded at a frequency greater than 10 percent and less than 95 percent. Additionally, the average load is calculated by using percent flow exceeded in multiples of 5 percent. Consideration of violations of the one-day maximum fecal coliform criterion for Pigeon House Branch when the flow frequency is between 10 and 95 percent, yields loads ranging between 9.49 X 10^9 and 1.63 X 10^{11} counts/day. The average of these values, 3.61 X 10^{10} counts/day, represents the total existing load in the stream. For copper, the range of one-day violations of the criterion includes loads of between 7.20 X 10^6 and 2.08 X 10^9 kg/day, and an average of 3.81 X 10^7 ug/day. See Appendix II for a further breakdown of the existing load calculations.

4.1.2 Reduction Target Calculation

The next step is to determine the percent reductions needed to comply with the water quality criteria. For both copper and fecal coliform in Pigeon House Branch, the allowable load was exceeded during all – low, average and high - streamflows. To calculate the necessary reduction in load, DWQ considered all violations through the use of the trend curve.

DWQ calculated the percent reduction as the difference between the average of the trend curve load estimates and the average of the allowable load estimates. For example, at each recurrence interval between 10 and 95 (again using recurrence intervals in multiples of 5) the equation of the trend curve is used to estimate the existing load; the allowable load is calculated in a similar fashion by substituting the allowable load curve. Next, DWQ took the average of these estimates and calculated the percent difference between the averages. For fecal coliform, the averages were 3.16 X 10^{10} and 7.83 X 10^9 counts/day for the existing and target loads, respectively. This equates to a 78% reduction required. For copper, the averages were 3.81 X 10^7 and 1.29 X 10^7 ug/day for the existing and target loads, respectively. This equates to a 66% reduction in load. Detailed calculations for estimating the percent reduction for each stream are provided in Appendix II.

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Figure 5.

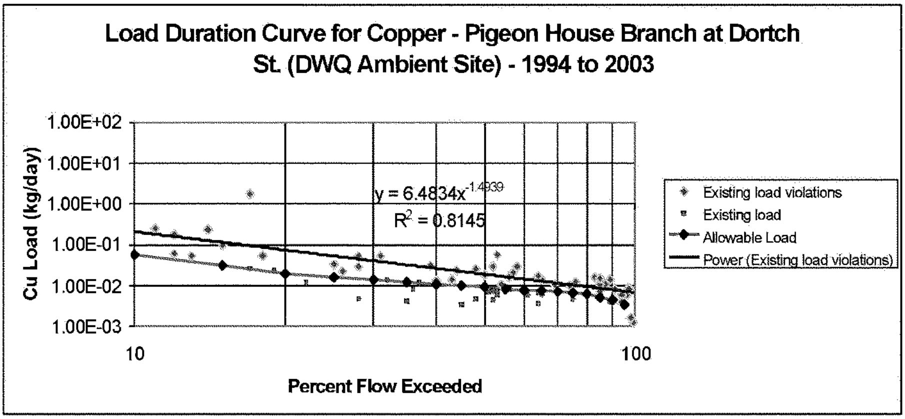
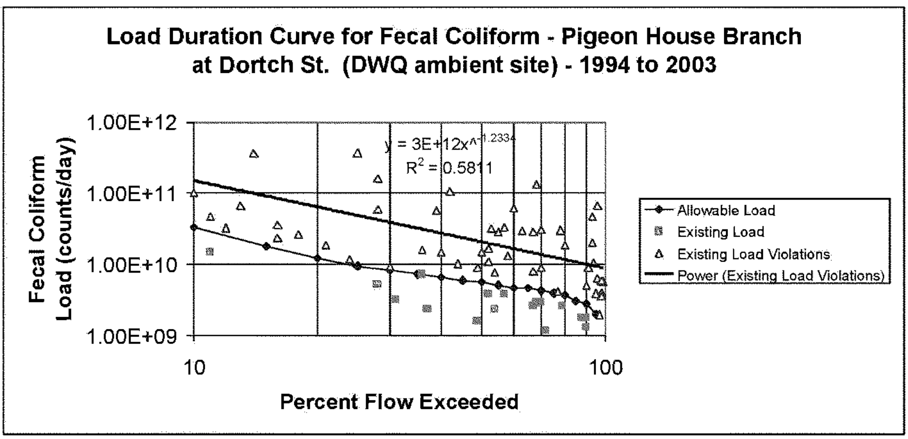


Figure 6.



4.1.3 Critical Conditions

Critical conditions are accounted for in the load curve analysis by using an extended period of streamflow and water quality data, and by examining at what flows (percent flow exceeded) the existing load violations occur. In theory, the flow range (percent flow exceeded) with the greatest difference between the existing load violations trend line and the allowable load line may be the critical condition. However, in Pigeon House Branch, the existing load violations occur at all flows, so DWQ elected to use the average difference between the exiting load violation trend line and the allowable load line.

4.2 Margin of Safety

There are two methods for incorporating an MOS in a TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, an explicit MOS was used.

To provide an explicit margin of safety, the allowable load curves above (Figures 5 and 6) use adjusted standards of 6 ug/L copper (versus the actual standard of 7 ug/L for copper) and 360 counts/100mL for fecal coliform (versus the actual instantaneous standard of 400 counts/100mL). This provides a 14% margin of safety for copper and a 10% margin of safety for fecal coliform.

4.3 TMDL Allocation

The TMDLs determined above for fecal coliform and copper must be allocated to a wasteload allocation (WLA) and a load allocation (LA).

The Pigeon House Branch watershed is, for the most part, an urban landscape that is drained by a network of stormwater pipes and sewers. Additionally, most of this stormwater network is included in NPDES stormwater permits for Municipal Separate Storm Sewer System (MS4s). Specifically, the City of Raleigh and the North Carolina Department of Transportation have Phase I MS4 permits for NPDES stormwater discharge. Wake County, which has jurisdiction over some of the stormwater network, is expected to be added to this regulatory framework in Phase II. The State of North Carolina Government Complex and some federal land has stormwater infrastructure within the Pigeon House Branch watershed that is currently not scheduled to be permitted through NPDES. This may change, however. Also, fecal coliform and copper reductions will be sought from these lands.

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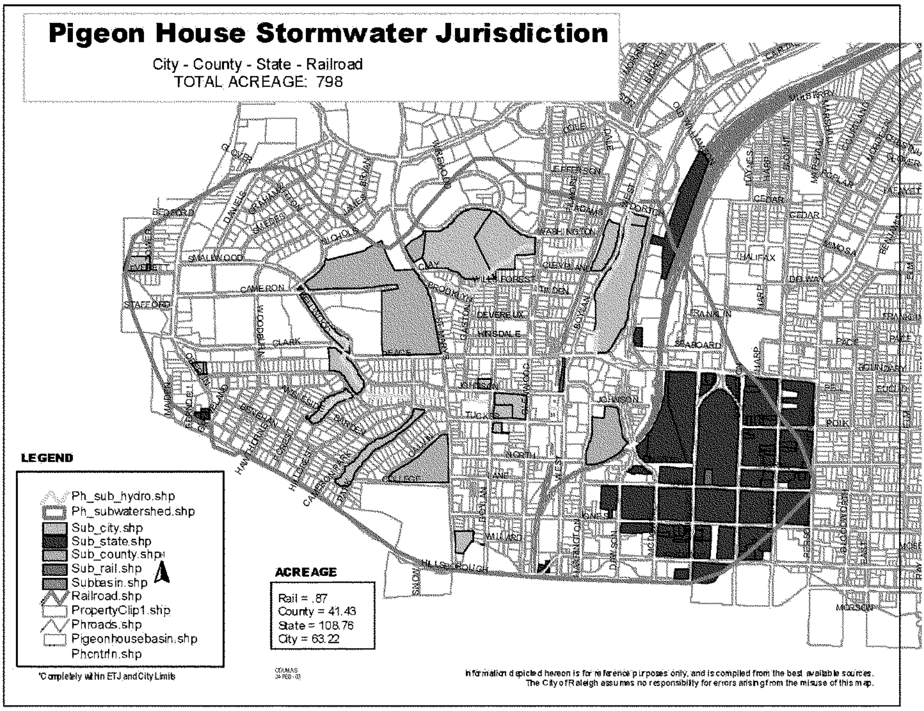
The assumption in this TMDL is that all fecal coliform and copper enters the drainage network through the storm sewer system, or via leaks in the sanitary sewer system, **except** that which travels overland in sheet flow. The latter is assumed to occur within 50 feet of open channels of the Pigeon House drainage network. Based on mapping done for the City of Raleigh by contractors, DWQ defines the open channel network in Figure 7. The rationale for this assumption is that property adjacent to streams is not likely to be piped; it is more likely that stormwater will travel overland or in shallow groundwater to the stream channel.

Figure 7.



Notes on Figure 7: 1 " = 1300 ft., watershed area is outlined
The area noted for the 'rail' category in Figure 7 is low because the area of all the railroad tracks and rights of way do not show as parcels under the county's property database. The true area for the 'rail' category is probably closer to 20 to 30 acres.

Considering that the lion's share of the watershed is drained by current or near future NPDES stormwater permit holders, the lion's share of the TMDL will be put in the WLA, per EPA guidance (personal communication, EPA Region IV). In accordance with 40 CFR §130.2 (i), it is reasonable to express allocations for NPDES-regulated stormwater discharges from multiple point sources as a single waste load allocation (WLA), rather than assigning individual WLAs to each stormwater outfall within the MS4 area. Additionally, DWQ will not attempt to separate NPDES regulated stormwater from non-NPDES regulated stormwater; they will be lumped together in the WLA because there is insufficient technical basis to separately quantify the NPDES and non-NPDES stormwater loading.

4.3.1 Load Allocations

To calculate a load allocation, DWQ assumed that the 50 feet on either side of an open drainage channel (see Figure 7 for display of open drainage channels) would drain directly to the stream network (not via the storm sewer network) and hence should be included in the LA. The open channel mapping comes from the City of Raleigh. Based on this, DWQ calculated that 0.03 square miles (8600 feet in length times 50 feet on either side of drainage) drain by means other than stormwater piping to open channels. 0.03 square miles is 0.026 **percent** of the 1.15 square miles in the Pigeon House subwatershed (up to the monitoring station at Dortch St.), so the LA portion of the TMDL, using the listed assumptions, is diminutive.

The LAs are 0.026 percent of the TMDLs, which equals 5.16×10^4 ug/day for copper, and 3.13×10^7 counts/day for fecal coliform.

4.3.2 Wasteload Allocations

For the Pigeon House Branch TMDL, the WLA consists of copper and fecal coliform loading from the stormwater system, regardless of what entity has jurisdiction over the outfall. There are no continuous NPDES discharges in the watershed. The WLA component was calculated as the difference between the TMDL and the LA components. See Table 8 for the full TMDL allocation.

Any future NDPES facility (in this case, continuous discharge) permitted to discharge fecal coliform bacteria or copper in the watershed will be required to meet permit limits. Future facilities discharging at concentrations less than the water quality standard should not cause or contribute fecal coliform bacteria or copper impairment in the watershed.

Table 8. Pigeon House Branch Fecal Coliform and Copper TMDL Components

Pollutant	WLA [1]	LA [2]	MOS [3]	TMDL	Percent Reduction[4]
Fecal Coliform	7.63E+09 counts/day	2.04E+08 counts/day	Explicit	7.83E+09 counts/day	78%
Copper	1.26E+07 ug/day	3.35E+05 ug/day	Explicit	1.29E+07 ug/day	66%

Notes:

1. All future permitted discharges shall not exceed the water quality criteria for fecal coliform bacteria maximum one-day concentration of 400 counts/100mL or a monthly average of 200 counts/100mL. WLA=TMDL – LA (see note 2).
2. LA = TMDL multiplied by area drained by unpiped flow (see 4.3.1), where TMDL is the average allowable load between the 95th and 10th percent flow exceeded.
3. Margin of safety (MOS) equivalent to 10 percent of the target concentration for fecal coliform and 14 percent for copper (see 4.2).
4. Average reduction required between the 95th and 10th percent flow exceeded estimated in the stream. Used only DWQ ambient data in calculations (see Section 1.2).

4.4 Seasonal Variation

Seasonal variation was incorporated in the load curves by using the entire period of record of flow recorded at the gages. Seasonality was also addressed by using water quality data that was collected during multiple seasons.

5.0 Implementation Plan

The TMDL analysis was performed using the best data available to specify the percent reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications in the watershed. As a class C water, the designated uses that apply to Pigeon House Branch are aquatic life propagation and maintenance of biological integrity, and secondary recreation.

Achieving reductions in copper loading may be particularly challenging as changes to the sources (brake linings, building siding and atmospheric loading) are not feasible in the near term. They would require, for instance, changes to how automobile brakes are constructed. To reduce copper loading a more likely, though still quite challenging, scenario is to treat stormwater before it enters the stream network. Stormwater from roadways, in particular, will need to be treated to maintain water quality standards. The good news in this case is that the copper impairment is not very severe. According the synoptic surveys by the City of Raleigh (see Water Quality Monitoring section on p. 9, and Appendix I) several hot spots exist, including the entrance to the Equipment Service Depot off of West St. and the culvert between West St. and Peace Street. Best management practice (BMP) installation directed at reducing copper loading, and fecal coliform as well, should probably focus on these areas.

An important component of the fecal coliform TMDL implementation plan will be the bacterial source tracking project that DWQ and the City of Raleigh are scheduled to begin this year as part of a larger EPA 319 project. Using antibiotic resistance techniques, the agencies and their contractor will categorize the sources of the bacteria found in the stream. The source categories are expected to be humans, pets and wildlife. This, along with Raleigh's source assessment efforts (see Appendix I), will provide better criteria for formulating a management strategy, and subsequently for installing BMPs, to reduce fecal coliform loading. Of course, the overall goal is to meet the designated use of allowing secondary recreation, and should the management strategy and initial BMPs fail to do that, additional BMPs will be required.

5.1 Urban Sources of Pollutant Loading

The City of Raleigh and the NC Department of Transportation were issued a NPDES Municipal Separate Storm Sewer System (MS4) permits under the Phase 1 storm water regulations. Each permittee is required to develop a Storm Water Management Program (SWMP). The SWMP covers the duration of the permit (5-year renewable) and comprises a comprehensive planning process which involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. With respect to fecal coliform and copper pollution reduction, additional activities and programs conducted by city, county, and state agencies are recommended to support the SWMP:

- Field screening and monitoring programs to identify the types and extent of fecal coliform and copper water quality problems, relative degradation or improvement over time, areas of concern, and source identification.
- Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into the storm sewer system.
- Mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the municipal separate storm sewer system.

6.0 Stream Monitoring

In order to evaluate the fecal coliform model, monitor water quality conditions and assess progress of the TMDL, an evaluation location was established for the Pigeon House Branch watershed. The evaluation location of this watershed is Pigeon House Branch at Dortch St., which is the DWQ ambient monitoring station. DWQ should consider moving the ambient monitoring station closer to Pigeon House Branch's confluence with Crabtree Creek, which defines the extent of the fecal coliform and copper impairments. Additionally, for this reason, **reductions in copper and fecal coliform loading should be sought from the entire Pigeon House Branch watershed to its confluence with Crabtree Creek.** Fixes (e.g. BMP installation) should be applied where sources have been identified, and in subwatersheds where there are high levels of fecal coliform or copper.

Continued monitoring of the fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting future reduction of loading. Monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation. In addition, monitoring efforts should be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations) and promote selective storm response (hydrograph) characterization. The Storm Water Management Program (see previous page) is a good means for achieving the continued and increased monitoring.

7.0 Future Efforts

This TMDL represents an early phase of a long-term restoration project to reduce fecal coliform and copper loading to acceptable levels (meeting water quality standards) in the Pigeon House Branch watershed. DWQ and the City of Raleigh should evaluate the progress of implementation strategies, and refine the TMDL as necessary, in the next phase (five-year cycle). This will include recommending specific implementation plans for identified problem areas. 319 nonpoint source grants may be a good source of funding for BMP implementation.

8.0 Public Participation

DWQ will publish a notice in the Raleigh newspaper, The News & Observer, outlining information on the development of this draft TMDL and will allow the public 30 days to comment on the draft. Additionally, during this public notice period, DWQ will present the TMDL to the public on May 6, 2003 and offer opportunity for questions and comments.

9.0 Further Information

Further information concerning North Carolina's TMDL program can be found on the Internet at the Division of Water Quality website:

http://h2o.enr.state.nc.us/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the DWQ Modeling/TMDL Unit:

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APPENDIX I. DWQ Ambient data for fecal coliform and copper

date	fecal coliform (cfu/100 ml)	data qualifier	copper (ug/L)	data qualifier
9/28/94	1200		26	
10/26/94	1200		14	
11/29/94	400		10	
12/27/94	70		6	
1/23/95	260		3	
2/24/95	280		6	
3/21/95	530		39	
4/12/95	870		13	
5/9/95	1700		6	
6/8/95	10	K	380	
7/26/95	7200		22	
8/8/95	1200		28	
9/12/95	430		13	
10/26/95	420		12	
12/21/95	36		4	
1/26/96	9		4	
2/6/96	10		12	
4/24/96	400		24	
5/1/96	1000		8	
6/10/96	6900		19	
7/1/96	230		21	
8/8/96	1000		16	
9/25/96	100		9	
10/2/96	2500		12	
11/5/96	240		5	
12/4/96	1100	K	5	
1/16/97	7300		32	
2/11/97	810		7	
3/5/97	690		6	
4/8/97	160		5	
5/8/97	100		3	
6/11/97	1300		12	
7/22/97	620		28	
8/27/97	3000		12	
9/25/97	6800		22	
10/14/97	230		14	
11/12/97	510		5.7	
12/5/97	560		16	
1/9/98	960		12	
2/9/98	120		6.1	
3/5/98	140		6.1	

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date	fecal coliform (cfu/100 ml)	data qualifier	copper (ug/L)	data qualifier
4/8/98	2300		4.6	
5/11/98	6000	L	21	
6/1/98	2200		20	
7/7/98	6000	L	13	
8/18/98	3100		17	
9/8/98	13000	L	22	
10/5/98	14000	L	8.1	
11/10/98	2000		7.8	
12/1/98	260		4.6	
1/12/99	2300		5.4	
2/8/99	650		3	
3/3/99	580		7.5	
4/16/99	6000	L	2	K
5/13/99	660		13	
6/2/99	11000	L	12	
8/11/99	210		14	
9/8/99	2500		23	
10/4/99	14000	L	8.4	
11/10/99	590		3.8	
12/6/99	600	L	29	
1/20/00	1100		28	
2/7/00	220		2	K
3/13/00	540		41	
4/12/00	600	L	2	
5/9/00	2700		7.4	
6/19/00	4700		22	
7/18/00	170		20	
8/17/00	710		15	
9/2/00	4100		10	
10/23/00	3200		4.7	
11/28/00	760		9.5	
12/7/00	250			
1/23/01	2600			
2/28/01	710			
5/8/01	660	B4,Q		
6/21/01	200	Q		
7/23/01	1900	B1,Q		
9/24/01	2800	Q		
10/11/01	810	Q,B4		
11/29/01	370			

Notes: Data qualifiers are: K - Actual value is known to be less than value given. L - Actual value is known to be greater than value given. B4 – Filters have counts of both > 60 or 80 and <2. Data

<u>qualifier continued</u> Reported value is a total of the counts from all countable filters reported per 100 ml. <u>Q</u> – Holding time exceeded.

APPENDIX I. City of Raleigh - Refined Sampling Program Data

DATE	LOCATION	LAND USE	Cu (mg/L)	F. C.(CFU/100mL)
6/6/01	1. W Johnson St.	comm/res.	3	2800
6/6/01	2. West St.	comm/res.	2	1900
6/6/01	3. culvert - West St. to Peace St.	comm/res.	6	14000
6/6/01	4. entrance to ESD off West St.	multi	2	11000
6/6/01	5. West St. (Thomas Concrete)	multi	3	3100
6/6/01	6. connector - Wade Ave. to Glenwood Ave.	res.	1	1600
6/6/01	7. Harris Wholesale off Capital Blvd.	multi	1	1200
6/6/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	3	2200
6/6/01	9. Crabtree Blvd.	multi	2	2100
6/6/01	10. Automotive Way	res.	1	5700
6/6/01	11. Frank St.	res.	1	2100
6/6/01	12. N Boundary St.	res.	3	950
6/13/01	1. W Johnson St.	comm/res.	2	9200
6/13/01	2. West St.	comm/res.	3	2900
6/13/01	3. culvert - West St. to Peace St.	comm/res.	5	39000
6/13/01	4. entrance to ESD off West St.	multi	1	3800
6/13/01	5. West St. (Thomas Concrete)	multi	4	1900
6/13/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	1800
6/13/01	7. Harris Wholesale off Capital Blvd.	multi	2	11000
6/13/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	2	1000
6/13/01	9. Crabtree Blvd.	multi	2	320
6/13/01	10. Automotive Way	res.	1	1900
6/13/01	11. Frank St.	res.	1	3800
6/13/01	12. N Boundary St.	res.	63	5200
6/21/01	1. W Johnson St.	comm/res.	3	7300
6/21/01	2. West St.	comm/res.	3	860
6/21/01	3. culvert - West St. to Peace St.	comm/res.	10	1500
6/21/01	4. entrance to ESD off West St.	multi	5	8000
6/21/01	5. West St. (Thomas Concrete)	multi	5	1900
6/21/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	1700
6/21/01	7. Harris Wholesale off Capital Blvd.	multi	2	22000
6/21/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	3	1100
6/21/01	9. Crabtree Blvd.	multi	2	1100
6/21/01	10. Automotive Way	res.	2	1400
6/21/01	11. Frank St.	res.	2	2200
6/21/01	12. N Boundary St.	res.	2	5800
6/27/01	1. W Johnson St.	comm/res.	3	2300
6/27/01	2. West St.	comm/res.	2	1600

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6/27/01	3. culvert - West St. to Peace St.	comm/res.	4	1600
6/27/01	4. entrance to ESD off West St.	multi	4	32000
6/27/01	5. West St. (Thomas Concrete)	multi	6	8000
6/27/01	6. connector - Wade Ave. to Glenwood Ave.	res.	1	600
6/27/01	7. Harris Wholesale off Capital Blvd.	multi	1	9000
6/27/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	4	2200
6/27/01	9. Crabtree Blvd.	multi	5	8000
6/27/01	10. Automotive Way	res.	7	2800
6/27/01	11. Frank St.	res.	4	5800
6/27/01	12. N Boundary St.	res.	7	6000
7/5/01	1. W Johnson St.	comm/res.	4	3900
7/5/01	2. West St.	comm/res.	4	4300
7/5/01	3. culvert - West St. to Peace St.	comm/res.	7	21000
7/5/01	4. entrance to ESD off West St.	multi	10	410000
7/5/01	5. West St. (Thomas Concrete)	multi	7	18000
7/5/01	6. connector - Wade Ave. to Glenwood Ave.	res.	4	6200
7/5/01	7. Harris Wholesale off Capital Blvd.	multi	3	6800
7/5/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	5	4800
7/5/01	9. Crabtree Blvd.	multi	5	5800
7/5/01	10. Automotive Way	res.	3	8800
7/5/01	11. Frank St.	res.	2	12000
7/5/01	12. N Boundary St.	res.	2	4700
7/12/01	1. W Johnson St.	comm/res.	2	1500
7/12/01	2. West St.	comm/res.	5	5800
7/12/01	3. culvert - West St. to Peace St.	comm/res.	5	2000
7/12/01	4. entrance to ESD off West St.	multi	5	58000
7/12/01	5. West St. (Thomas Concrete)	multi	5	8000
7/12/01	6. connector - Wade Ave. to Glenwood Ave.	res.	3	2000
7/12/01	7. Harris Wholesale off Capital Blvd.	multi	4	500
7/12/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	3	0
7/12/01	9. Crabtree Blvd.	multi	4	5500
7/12/01	10. Automotive Way	res.	5	1500
7/12/01	11. Frank St.	res.	3	3500
7/12/01	12. N Boundary St.	res.	2	3000
7/18/01	1. W Johnson St.	comm/res.	1	700
7/18/01	2. West St.	comm/res.	3	2200
7/18/01	3. culvert - West St. to Peace St.	comm/res.	5	700
7/18/01	4. entrance to ESD off West St.	multi	20	31500
7/18/01	5. West St. (Thomas Concrete)	multi	5	800
7/18/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	200
7/18/01	7. Harris Wholesale off Capital Blvd.	multi	10	5200
7/18/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	2	700
7/18/01	9. Crabtree Blvd.	multi	2	500
7/18/01	10. Automotive Way	res.	3	600
7/18/01	11. Frank St.	res.	1	200

7/18/08	12. N Boundary St.	res.	2	600
7/25/08	1. W Johnson St.	comm/res.	4	1700
7/25/08	2. West St.	comm/res.	5	1700
7/25/08	3. culvert - West St. to Peace St.	comm/res.	12	2700
7/25/08	4. entrance to ESD off West St.	multi	7	27000
7/25/08	5. West St. (Thomas Concrete)	multi	18	11000
7/25/08	6. connector - Wade Ave. to Glenwood Ave.	res.	5	1200
7/25/08	7. Harris Wholesale off Capital Blvd.	multi	2	3300
7/25/08	8. Gravel Service Rd. parallel to Capital Blvd.	multi	8	1500
7/25/08	9. Crabtree Blvd.	multi	6	2700
7/25/08	10. Automotive Way	res.	2	1800
7/25/08	11. Frank St.	res.	3	2000
7/25/08	12. N Boundary St.	res.	2	1000

Pigeon House Branch Locations Index (provided by the City of Raleigh)

Location 1: *Stream at West Johnson St.* This location is at Edna Metz Wells Park at the intersection of W. Johnson St and Peace St. This is a small park in an older residential neighborhood near Cameron Village. Samples were taken in the stream just upstream of the culvert under E Forest Rd. Grass, trees and other vegetation surround the creek, as well as numerous trash barrels. No sources of pollution or contamination are visible, although higher fecal coliform levels may be a result of neighborhood residents walking their dogs near the stream, as has been witnessed on numerous occasions. Much, but not all, of the stream is shaded by trees during the day.

Location 2: *Stream at West St.* Samples were taken in the creek before it enters the culvert crossing under West St; the culvert begins just north of the intersection of West St with Tucker St. This location is in a commercial area with the creek paralleling a small parking lot on the southern side of the creek. Throughout the day, trees shade the vast majority of the creek. No sources of pollution are visible, however, evidence of homeless activity is clearly visible through old shirts and jackets present, some hanging in trees, others lying in the water. Human contamination may be a partial explanation for higher fecal coliform levels.

Location 3: *Pipe discharging to culvert between West St. and Peace St.* Samples were taken from a 60-in concrete pipe approximately 450-ft into the box culvert (when measuring from the south to the north end of the culvert) that collects stormwater from the State Government Complex. Flow from this pipe is always steady and constant. No apparent pollution or contamination is visible, but homeless activity is a possibility inside the culvert.

Location 4: *Pipe discharging just upstream of entrance to ESD off West St.* The creek parallels West St and flows under the entrance to the Equipment Service Depot south of Dortch St. The sample is taken immediately from a 54-in concrete pipe running perpendicular to Capital Blvd. Shade and other factors surrounding the stream are not an influence on this sample because the sample is taken as the water leaves the pipe. It has been suggested that there may be a sanitary sewer line running parallel to Capital Blvd (this has not been confirmed), and possible sanitary sewer leaks would account for higher fecal coliform levels.

<u>Location 5</u>: *Stream at West St. (Thomas Concrete).* This site is located directly across the street from Thomas Concrete on West St. The creek is shaded by trees and much other vegetation for the majority of the day, if not all of the day. Thomas Concrete has an NPDES permitted storm drain that outlets directly into the creek; residue and chunks of concrete are clearly visible and in the morning hours, it is quite evident that this has an impact on the conditions immediately surrounding the outfall. Due to this clear contamination, samples are taken immediately upstream of the Thomas Concrete storm drainage site so the Thomas Concrete water may not contaminate the sample. NOTE: The pH of water draining from Thomas Concrete is always at least above 10.0, usually around 11.5 and reaching up to 12.2 on some days.

<u>Location 6</u>: *Stream at connector ramp from Wade Ave to Glenwood Ave.* This sample is taken from the tributary flowing from the direction of Williamson Dr, just downstream from the Glenwood Ave culvert—not from the direction of Cowper Dr (the tributaries are separate and then join together at this site). This site is not shaded, as there are no large trees to offer shade nearby. This site is at an island connector between two busy streets, which should limit the amount of human and animal activity at the site. No evidence of human activity or domestic animals is visible.

<u>Location 7</u>: *Pipe at Harris Wholesale off Capital Blvd.* Harris Wholesale is located off northbound Capital Blvd between Fairview Rd and Wake Forest Rd. Samples are taken from the 96-in concrete pipe that runs perpendicular to Capital Blvd underneath Harris Wholesale; the samples are taken directly from the pipe. No apparent causes of pollution or contamination are visible other than wildlife present in the stream. Flow is not steady; it varies between a higher, steady flow and a low flow, sometimes even a trickle.

<u>Location 8</u>: *Stream at gravel service road parallel to Capital Blvd.* As Atlantic Ave passes underneath Capital Blvd, there is a gravel service road running under the overpass between the northbound and southbound lanes of Capital Blvd above. At this point, the creek is surrounded by dense vegetation with nearby trees shading the stream in various sections. No obvious sources of pollution or contamination are visible.

<u>Location 9</u>: *Stream at Crabtree Blvd.* Samples are taken from the creek as it passes under Crabtree Blvd near its intersection with Capitol Blvd., just downstream from the Gateway Plaza Shopping Center. There are many trees and other vegetation that shade the sections of the stream. Large boulders, rocks, and other riprap are on the slope leading from the parking lot on the east bank of the stream. Many broken beer and liquor bottles can be seen along the rocks indicating possible human contamination.

<u>Location 10</u>: *Stream at Automotive Way.* The sample site is in front of a car wash located on Automotive Way as it merges into Capital Blvd. The stream flows from the direction of Plainview Ave. and then into a culvert that passes under Capital Blvd for a short time. The samples are taken from the stream before it enters the culvert. There are no trees at the site nor other vegetation offering shade to the stream. Besides the hand car wash and a nearby house, there are no visible pollution or contamination sources.

<u>Location 11</u>: *Stream at Frank St.* Samples are taken near the intersection of Frank St and Norris St, before the stream passes under Frank St. Nearby trees and vegetation do offer shade to some areas of the stream but not all. The site is in a neighborhood and alongside a large patch of grass where many people are likely to walk their dogs and other domestic pets.

<u>Location 12</u>: *Stream at North Boundary St.* This location is within Oakwood Cemetery. The creek passes through a culvert under Oakwood Ave and flows north through the cemetery. No shade is offered to the creek through the cemetery. The streambanks are covered by grass and more dense vegetation. No apparent pollution or contamination is visible.

Appendix II. TMDL Calculations

Copper load allocation at Pigeon House ambient site based on trendline equation and percent flow exceeded.

Power Eqn. Trendline: y = 6.4834x^-1.4939
where: x = percent flow exceeded

Percent Flow Exceeded	Existing Load (kg/day)	Target load (kg/day)	% Reduction
95	7.20E-03	3.28E-03	54.4%
90	7.80E-03	4.57E-03	41.5%
85	8.50E-03	4.99E-03	41.3%
80	9.31E-03	5.99E-03	35.6%
75	1.02E-02	6.46E-03	37.0%
70	1.14E-02	6.99E-03	38.5%
65	1.27E-02	7.56E-03	40.4%
60	1.43E-02	7.70E-03	46.1%
55	1.63E-02	8.42E-03	48.3%
50	1.88E-02	9.27E-03	50.6%
45	2.20E-02	9.84E-03	55.2%
40	2.62E-02	1.08E-02	58.6%
35	3.20E-02	1.20E-02	62.5%
30	4.03E-02	1.37E-02	66.0%
25	5.29E-02	1.57E-02	70.3%
20	7.38E-02	2.00E-02	72.9%
15	1.13E-01	3.00E-02	73.6%
10	2.08E-01	5.56E-02	73.2%
	average reduction		53.7%

Target load based on estimated flow and target conc of 6 ug/L
Existing load based on trendline equation - power equation
Only used DWQ ambient data for these calculations (see Section 1.2)

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avg existing load (95 to 10 interval)	3.81E-02
avg target load (95 to 10 interval)	1.29E-02
avg reduction	66%

Appendix II. TMDL Calculations continued

F.C. load allocation at Pigeon House ambient site based on trendline equation and percent flow exceeded

Power Eqn. Trendline: 3E+12* x^-1.264
where: x = percent flow exceeded

Percent Flow Exceeded	Existing Load (cnts/day)	Target load (cnts/day)	% Reduction
95	9.49E+09	1.99E+09	79.1%
90	1.02E+10	2.76E+09	72.8%
85	1.09E+10	3.02E+09	72.3%
80	1.18E+10	3.63E+09	69.2%
75	1.28E+10	3.91E+09	69.5%
70	1.40E+10	4.23E+09	69.7%
65	1.53E+10	4.58E+09	70.1%
60	1.70E+10	4.66E+09	72.5%
55	1.89E+10	5.10E+09	73.1%
50	2.14E+10	5.61E+09	73.7%
45	2.44E+10	5.96E+09	75.6%
40	2.83E+10	6.56E+09	76.8%
35	3.35E+10	7.25E+09	78.4%
30	4.07E+10	8.29E+09	79.7%
25	5.13E+10	9.50E+09	81.5%
20	6.80E+10	1.21E+10	82.2%
15	9.78E+10	1.81E+10	81.5%
10	1.63E+11	3.37E+10	79.4%
		Average reduction	75.4%

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Target load based on estimated flow and target conc of 360 counts/100mL
Existing load based on trendline equation - power equation
Only used DWQ ambient data for these calculations (see Section 1.2)

avg existing load (95 to 10 interval)	3.61E+10
avg target load (95 to 10 interval)	7.83E+09
avg reduction	78%

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Appendix III.

Responsiveness Summary for TMDLs for fecal coliform and copper to Pigeon House Branch - Raleigh, NC

NC Division of Water Quality
May, 2003

Comments from specified organizations are in italics as they appear in the delivered documents. DWQ's response follows in plain text.

The City of Raleigh would like to thank the State for the opportunity to comment on the draft Pigeon House Branch TMDL prepared by Division of Water Quality staff. We have the following comments:

1.The City of Raleigh takes exception to the placement of stormwater in the wasteload allocation (WLA) of the draft TMDL. There is, and has always been, a clear distinction between wastewater, which is a point source, and stormwater, which is a non-point source. Including stormwater in the WLA ignores this critical distinction. Placement of stormwater in the WLA contradicts the established understanding of the nature of non-point source pollution. In addition, including stormwater under the WLA may place limitations on issuance of new NPDES permits in this impaired (303(d) listed) water; may prohibit the State from issuing an NPDES Phase II Stormwater permit to Wake County; and could possibly be interpreted to require a moratorium on new development or expansions within the watershed. Such a moratorium would apply to city, state, and federally owned properties as well as private property.

DWQ agrees with the City of Raleigh that NPDES stormwater does not belong in the WLA. However, EPA has mandated that NPDES stormwater shall be put in the WLA. As far as what Raleigh has suggested for the effects of allocating the TMDL this way, DWQ will move forward by using appropriate alternatives for the management of stormwater runoff in accordance with these TMDLs. We anticipate that this will focus on the best management practices to meet these requirements, while still allowing additional activities to occur in these areas.

2.The City of Raleigh takes exception to both NPDES and non-NPDES permitted stormwater discharges being lumped together under the WLA primarily because this may become a significant issue during the implementation phase of the TMDL. The City of Raleigh would only support this arrangement if the City could be assured that those entities not identified as holding NPDES permits (such as the railroad and downtown NC Government complex) would be subject to the same restrictions and would be held accountable for reducing their pollutant loads similar to those entities that have NPDES permits.

Because there is insufficient technical basis to separately quantify the NPDES and non-NPDES stormwater loading, DWQ, with EPA's consent, decided to combine the two stormwater categories together. DWQ will seek pollutant load reductions from all sources within the watershed. Clearly, however, the regulatory agencies have more control over sources that require NPDES permits. The difference is that implementation of BMPs is mandatory for NPDES stormwater permit holders, while TMDL required load reductions are more or less voluntary for non-NPDES sources.

3. The City of Raleigh takes exception to the inference that the Department of Transportation (NCDOT) is the only State entity accountable under the State's NPDES stormwater permit. Since there are other portions of the Municipal Separate Storm Sewer System (MS4) outside of the jurisdiction of NCDOT that are owned and operated by the State, such as the downtown government complex, these areas should be included under the State's NPDES stormwater permit. In addition, it would appear that the State's NPDES stormwater permit would legally have to be issued for the State MS4 as a whole, under the signature of the State CEO, and that an individual department such as NCDOT would not qualify for separate permitting for just their portion of the MS4.

DWQ understands this concern and is continuing to investigate the issue. DWQ wants to assure that the best alternatives for addressing stormwater discharges from various activities in this area, from both a management and permitting perspective, are used.

4. The City of Raleigh would argue that under section 2.2.5, birds and other wildlife are a source of fecal coliform bacteria (FCB) throughout the watershed and not just in isolated urban areas as indicated.

This section has been changed to reflect Raleigh's comment.

5.The City of Raleigh takes exception to the statement in the 3rd paragraph of 4.3 that "Raleigh defines" the open channel network as illustrated. Raleigh has never "defined" the open channel system. There may be many more open channels within the watershed than those noted on the map. The system shown is simply based on maps prepared by contractors for the City of Raleigh.

Changed to 'Based on mapping done for the City of Raleigh by contractors, DWQ defines the open channel network in Figure 7'.

6.The City of Raleigh would take exception to the assumption in the 3rd paragraph of section 4.3 that "all fecal coliform and copper enters the drainage network through the storm sewer system". There is strong evidence from Charlotte studies that some FCB is transported directly to streams through underground flows from leaking sewers and failing septic systems. The magnitude of the contribution from these sources is unknown at this time.

Final version submitted to EPA

This sentence has been changed as follows: the assumption in this TMDL is that all fecal coliform and copper enters the drainage network through the storm sewer system or via leaks in the sanitary sewer system **except** that which travels overland in sheet flow.

7.The City of Raleigh believes that the acreage noted under the "rail" category in Figure 7 is far greater than the .87 acres noted.

The area noted for the 'rail' category in Figure 7 is low because the area of all the railroad tracks and rights of way do not show as parcels under the county's property database. The true area for the 'rail' category is probably closer to 20 to 30 acres. This will be noted below Figure 7.

8.The City of Raleigh believes that the 0.03 acres assigned to the Load Allocation in section 4.3.1 is incorrect due to a math error.

Raleigh is correct; this is a mistake in the draft TMDL. It should read 0.03 square miles, not acres. Corrections have been made in the final TMDL.

9.The City of Raleigh believes that the phrase "and the problem pollutants" in the last sentence of the 1st paragraph of section 5.0 should be removed since this would indicate that uses apply to pollutants as opposed to streams.

The phrase "and other problem pollutants" has been removed.

END OF RESPONSIVENESS SUMMARY

END OF TMDL DOCUMENT

Total Maximum Daily Load for Aquatic Weeds for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena in North Carolina

Final Report
August 2006

EPA Approved Date: September 25, 2006

Yadkin-Pee-Dee River Basin, Roanoke River Basin, and Neuse River Basin

Prepared by:
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Water Quality Section – Planning Branch
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INDEX OF TMDL SUBMITTAL

1. 303(d) Listed Water Body Information

State: North Carolina

Counties: Richmond, Halifax, Wake, and Wayne
Major River Basins: Yadkin-Pee-Dee, Roanoke, and Neuse
Watersheds: Falling Creek, Roanoke River, Sycamore Creek
Reedy Creek, and Walnut Creek

Impaired Water Body (2000 303(d) List):

Water Body Name - (Assessment Unit)	Water Quality Classification	Sub-basin	8-digit HUC	Area (Acres)
Rockingham City Lake (13-Rockingham)	WS-III CA	03-07-16	03040201	27
Roanoke Rapids Lake (23-(22.5))	WS-IV & B CA	03-06-08	03010106	4893
Big Lake (27-Big Lake_WA)	B-NSW	03-04-02	03020201	62
Reedy Creek Lake (27 Reedy Cree)	B-NSW	03-04-02	03020201	20
Lake Wackena (27 Lake Wacke)	C-NSW	03-04-05	03020202	165

Constituent(s) of Concern: Aquatic Weeds

Designated Uses: Biological integrity, water supply, propagation of aquatic life, and recreation.

Applicable Water Quality Standards:

As defined by North Carolina Aquatic Weed Control Act of 1991, noxious aquatic weed is any plant organism which grows in or is closely associated with the aquatic environment, whether floating, emersed, submersed, or ditch-bank species, and including terrestrial phases of any such plant organism; exhibits characteristics of obstructive nature and either massive productivity or choking density; and is or may become a threat to public health or safety or to existing or new beneficial uses of the waters of the State. Noxious aquatic weed is any plant organism so designated under Article 15 of Chapter 113A of the General Statutes of North Carolina.

The North Carolina Aquatic Weed Control Act of 1991 empowers the State of North Carolina to control, eradicate, and regulate plants designated as noxious aquatic weeds. The Aquatic Weed Control Act and the existing powers of the Commissioner of

Agriculture prohibit importation, sale, use, culture, collection, transportation, and distribution of these plants in North Carolina. Permits for the movement of noxious aquatic weeds may be obtained from the Commissioner of Agriculture pursuant to 2 NCAC 48A .1705 and .1706, subject to the conditions stated therein. A detail of the definition and regulation of aquatic weeds in North Carolina is given in Appendix 12.2.

Following allocations for the aquatic weeds are identified in this TMDL.

- Non-noxious native aquatic plants along shoreline, which protect bank erosion and provide special habitat for aquatic animals and wildlife: **No Control.**
- Other non-noxious native aquatic plants: **Partial Control**
- Noxious native aquatic plants or exotic aquatic plants: **Extensive Control**

2. TMDL Development

Total Maximum Daily Load (TMDL) is defined as the total amount of pollutant that can be assimilated by a receiving lake while achieving water quality standards. Assimilative capacity of a lake is determined with regards to usefulness of aquatic weeds and management goals.

Critical Conditions:

Critical conditions are determined by understanding growth patterns of aquatic weeds. Except for Brazilian elodea (*Egeria densa*), summer period is critical for many aquatic weeds. Winter period is critical for Brazilian elodea.

Seasonal Variation:

No seasonal variation is studied due to insufficient measurement data.

3. Control Level:

Lake/Watershed	**Aquatic Weeds**			**Control Level**
	Scientific Name	**North Carolina Designation**	**Category**	
Rockingham City Lake (Falling Creek)	*Eleocharis sp.* *Mayaca fluviatilis* *Myriophyllum heterophyllum* *Nymphae odorata.*	Not Noxious Not Noxious Not Noxious Not Noxious	Native Native Native Native	No Control Partial Control Partial Control Partial Control
Roanoke Rapids Lake (Roanoke River)	*Hydrilla verticillata* *Myriophyllum spicatum* *Egeria densa*	Noxious Noxious Noxious	Exotic Exotic Exotic	Extensive Control Extensive Control Extensive Control
Big Lake (Sycamore Creek)	*Hydrilla sp.*	Noxious	Exotic	Extensive Control
Reedy Creek Lake (Reedy Creek)	*Hydrilla sp.*	Noxious	Exotic	Extensive Control
Lake Wackena (Walnut Creek)	Not known	Not known	Not known	Not known

4. **Submittal Date: August 14, 2006**
5. **Establishment Date:**
6. **Public Notice Information:**

A draft of the Aquatic Weed TMDL for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena was publicly noticed through local newspapers, Richmond CO. Daily Journal, Daily Herald, The News and Observer, and Goldsboro News Argus on June 30, 2006. The TMDLs was also publicly noticed through DWQ web site at http://h20.enr.state.nc.us/tmdl/. A public comment period was through August 7, 2006.

- Did notification contain specific mention of TMDL proposals? **YES**
- Were comments received from the public? **NO**
- Was a responsiveness summary prepared? **NO**

7. **EPA Lead on TMDL (EPA or Blank):**
8. **DOT a Significant Contribution (Yes or Blank):**
9. **Endangered Species (Yes or Blank):**
10. **TMDL Considers Point Source, Nonpoint Source, or Both: NA**

Table of Contents

1. Introduction

Section 303(d) of the Clean Water Act (CWA) requires States to develop a list of water bodies that do not meet water quality standards or have impaired uses. The list, referred to as the 303(d) list, is submitted biennially to the U.S. Environment Protection Agency (USEPA) for review. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on Category 5 of the 303(d) list. This category consists of those waters that are impaired by a pollutant and the proper technical conditions exist to develop TMDLs.

As follow up of the CWA, this report presents the development of Total Maximum Daily Loads (TMDLs) for five different lakes in North Carolina: Big Lake, Reedy Creek Lake, Lake Wackena, Roanoke Rapid Lake, and Rockingham City Lake. The first three lakes are located in Neuse River Basin (NEU), while the remaining two lakes are respectively located in Roanoke River Basin (ROA), and Yadkin River Basin (YAD). As identified by the North Carolina Division of Water Quality (NC DWQ), the five lakes are impaired due to aquatic weeds and TMDLs are needed (NCDENR 2003).

The US EPA considers any aquatic plant growth in a lake to be a "pollutant" within the meaning of Section 502(6) of the Clean Water Act. In 1978, EPA decided that all pollutants, under proper technical conditions, are suitable for the calculation of TMDLs (43 Fed. Reg. 60662, December 28, 1978). EPA may reevaluate whether materials such as aquatic weeds are pollutants, generally or in individual situations, for Clean Water Act purposes.

Because of invasive nature of aquatic weed, a quantitative explanation of its reduction level is difficult and there is no clear instruction on how much control is needed for a particular weed problem. Therefore, this TMDL details types of aquatic weeds and qualitative options to control aquatic weeds in the following paragraphs.

1.1. Types of Aquatic Weeds

The staff of Division of Water Quality (DWQ) and Division of Water Resources (DWR) identified seven different aquatic plants in the following four lakes (Table 1.1): Rockingham City Lake, Roanoke Rapids Lake, Big Lake, and Reedy Creek Lake. The types of plants and the dates when the plants were identified are given in Tables 1.1 and 1. 2 respectively.

Table 1.1. Identified aquatic weeds and their classes in the North Carolina lakes

NC Lakes/Basin	**Aquatic Weeds**		**North Carolina Designation**	**Category**
	Scientific Name	**Common Name**		
Rockingham City Lake (YAD)	*Eleocharis sp.* *Mayaca fluviatilis,* *Myriophyllum heterophyllum* *Nymphae odorata.*	Spike rush Bog moss Watermilfoil Fragrant waterlily	Not Noxious Not Noxious Not Noxious Not Noxious	Native Native Native Native
Roanoke Rapids Lake (ROA)	*Hydrilla verticillata* *Myriophyllum spicatum* *Egeria densa*	Hydrilla Eurasian milfoil Brazilian elodea	Noxious Noxious Noxious	Exotic Exotic Exotic
Big Lake (NEU)	*Hydrilla sp*	Hydrilla	Noxious	Exotic
Reedy Creek Lake (NEU)	Hydrilla sp.	Hydrilla	Noxious	Exotic
Lake Wakena (NEU)	Not known	Not known	Not known	Not known

Table 1.2. Field survey periods for identifying aquatic weeds in the North Carolina lakes

NC Lakes	Data Collection Period
Rockingham City Lake	August 24, 1995
Roanoke Rapids Lake	July 22, 1999, August 24, 2003
Big Lake	July 12, 2000
Reedy Creek Lake	July 12, 2000 and August 7, 2000
Lake Wackena	July 25, 1995

A field study to identify specific aquatic weed type (macrophytes aqauatic plants) in Lake Wackena has not been performed yet. A field study is, therefore, urgent to identify exact types of weeds existed in order to determine specific management options for the lake. If aquatic weeds are not a problem, the lake can be delisted from the 303(d) list.

As shown in Table 1.1, Rockingham City Lake carried all native aquatic weeds: spike rush, bog moss, and watermilfoil. These plants naturally grow there and are integral part of the lake. The plants provide food and shelter to aquatic animals and protect shoreline from erosion. However, problems arise when the plants become so numerous that they impede recreational activities such as boating and swimming. When growth becomes very thick, they harm fisheries.

The three lakes -- Roanoke Lake, Big Lake, and Reedy Creek Lake -- carried exotic aquatic weeds. These species are sometimes available as ornamental water gardening or aquarium plants. Whether they were deliberately introduced or introduced by happenstance is unclear. Seeds of the species may have been brought to the lakes by the migratory birds. Once introduced the exotic weeds rapidly out compete native plants and form single-species stands. These monocultures reduce habitat for fish, waterfowl, aquatic mammals, and invertebrates.

North Carolina State has designated some of the identified aquatic weeds as noxious based on their invasive characteristics in NC lakes. Details of the NC Aquatic Weed Control Act of 1991 and Regulation and Designated noxious aquatic weeds are presented in Appendix 12.2. According to the Act, the plants identified in Roanoke Rapids Lake, Big Lake, and Reedy Creek Lake are noxious (Table 1.1).

1.2. Aquatic Weed Control Level

Some measures need to be implemented in order to control the identified aquatic weeds in the five lakes. There is, however, no clear instruction on how much control is needed for a particular weed problem. Based on usefulness and invasive types of weeds in the lakes, the following three levels of control are recommended for this study.

1.2.1. No Control:

Non-noxious native aquatic weeds along shoreline, which protect bank erosion and provide special habitat for aquatic animals and wildlife, should not be controlled. For instance, spikerush (*Eleocharis sp.*) is a native weed to North Carolina and grows individually or in clumps along shorelines. Seeds and stems of the plants are important food for waterfowl and mammals. Management actions targeting this species may cause more harm than good.

1.2.2. Partial Control:

Partial control of non-noxious native aquatic weeds is recommended in order to maintain lake management activities. For instance, fragrant or white water lily (*Nymphae odorata*), a native weed to NC, provides aesthetic value for the surrounding lake community. However, excessive spatial coverage on surface of lake would interfere with boating, fishing, and swimming.

Sometimes an extensive control of non-noxious aquatic weeds might be needed. Level of control depends on the nature of invasion in a lake. Therefore, selection of a control level should be done on a case by case basis.

1.2.3. Extensive Control:

Presence of noxious aquatic weeds or exotic aquatic weeds may justify extensive control. For instance, Hydrilla species (*Hydrilla verticillata*) is a very competitive exotic as well as noxious aquatic weed. This species adversely impacts aquatic ecosystems by forming dense canopies that often shade out native vegetation. Therefore, lake wide extensive control of these aquatic weeds is recommended.

1.3. Aquatic Weed Control Strategies

The identified aquatic weeds in Table 1.1 are generally characterized by rapid growth, ability to regenerate by fragmentation (production of new plants from small plant segments) or vegetative hibernating organs (tubers and turions). Factors that contribute to their rapid development are often connected with their normal pattern of succession. Therefore, if control measures are not carried out, the five lakes may eventually fill with aquatic weeds.

Normally, the following preventive measures are recommended to control aquatic weeds: Hand Pulling and Bottom Barrier Installation, Aquatic Herbicide Treatment, Triploid Grass Carp, Diver Dredging, and Water Level Drawdown. Intensity of these preventive measures, however, depends upon hydrologic characteristics of lakes and aquatic species.

When applying herbicide in a lake, one should follow the North Carolina Pesticide Law of 1971, G.S. 143-434, Article 52. The law establishes programs of pesticide management and control under the authority of the North Carolina Pesticide Board. The purpose of the Law is to protect the health, safety, and welfare of the people of this State, and to promote a more secure, healthy and safe environment for all people of the state. This is accomplished by regulation in the public interest of the use, application, sale, disposal, and registration of pesticides.

The North Carolina Pesticide Law of 1971 requires the registration of pesticide products in the state, the licensing and certification of commercial and private applicators and pest control consultants, the proper handling, transportation, storage and disposal of pesticides, and the licensing of dealers selling restricted use pesticides.

1.4. Characteristics of Lakes

The five lakes -- Roanoke Rapid Lakes, Rockingham City Lake, Big Lake, Reedy Creek Lake, and Lake Wackena -- are artificially created for water supply and recreation in North Carolina. Rivers and streams are the primary sources of water to the lakes. Water that runs off the land surface also enters the lakes. Water levels in the lakes fluctuate seasonally and annually. During summer season when rains are infrequent; run-off is minimal; and sediment loads are insignificant; sunlight penetrates deeper into the water column. The depth light that is able to penetrate the water column is called the photic zone and is measured as twice the secchi depth (measure of transparency of water column). Increased light increases productivity and fosters plant growth, especially when it reaches nutrient rich sediments. Therefore, increased photic zone allows plants to grow at greater depths, which would be normally unattainable without the increased light. Photic zone is important for plant colonization and growth is coupled with the fact that shallow systems with large surface areas are more susceptible to weed infestations than deep systems with small surface areas. Average photic zones and surface areas of the five lakes during summer period are presented in Table 1.3.

Table 1.3. Physical and Chemical Properties of the studied lakes in NC

NC Lakes	Surface Area (Acres)	Average Photic Zone During Summer Period (Meter)	Average Maximum Depth (Meter)	Average Depth (Meter)	Average Water Temperature (°C)	Average Chlorophyl *a* (ug/L)	Average Turbidity (NTU)
Rockingham City Lake	27	1.53	2	0.7	26	4.5	2.6
Roanoke Rapids Lake	4893	3.21	27	5	27	6.0	2.4
Big Lake	62	1.58	5	2	29	10.0	17.0
Reedy Creek Lake	20	2.29	4	2	29	6.0	16.0
Lake Wackena	165	1.95	5	2	32	15.0	4.2

The photic zones of the five lakes were considerably high compared to their average water depths during summer period. On average, the photic zones occupied 65% of the average depth in Roanoke Rapids Lake and 80% in Big Lake. The occupation was higher than 90% in the remaining three lakes. The result suggests that the five lakes facilitate the photosynthetic process, promoting rapid and dense growth during summer time.

Water temperature is another important factor that governs growth of plants. Although some plants can photosynthesize and grow at 2^{O} C, it is generally at higher temperatures (20 to 35 ^{O} C) that weed problems become most severe (Spencer and Bowes, 1990). Water temperature in the six lakes during summer time reached to more than 25 ^{O} C (Table 1.3). The result further suggests that the lakes provided good environment for the weeds to grow profusely during summer time.

Soil erosion and nutrient enriched runoff can also increase growth of aquatic plants. Eroded soil particles not only make a lake shallower and allow rooted plants to quickly invade, but soil particles also transport adsorbed nitrogen and phosphorus that stimulate plant growth. In addition, nutrient enriched runoff deposits nitrogen and phosphorus in the bottom soil of lake. The deposited nutrients further stimulate plant growth. However, the five lakes were not contaminated due to nutrient and sediment problems during the study periods; because the lakes did not exceed Chlorophyll *a* and turbidity values greater than the State's standard values, 40 ug/L and 50 NTU, respectively (Table 1.3 and Appendix 11.3). Therefore, a control strategy through reducing nutrient and sediment is not discussed in this aquatic weed TMDL study.

2. Rockingham City Lake

2.1. General Background

Rockingham City Lake is a secondary water supply reservoir for the City of Rockingham (Figure 2.1). The lake receives permanent water from Falling Creek and supplies water for approximately one-third of the total water use in the City. The volume of the lake is 0.02×10^6 m^3, the mean depth is 0.7 meter (two feet) and the maximum depth is two meter (7 feet). The drainage area covers 52 km^2 (20 mi^2). Observed land uses in the watershed include forested areas, agricultural areas consisting of crop production, and slight residential and urban development (Figure 2.2).

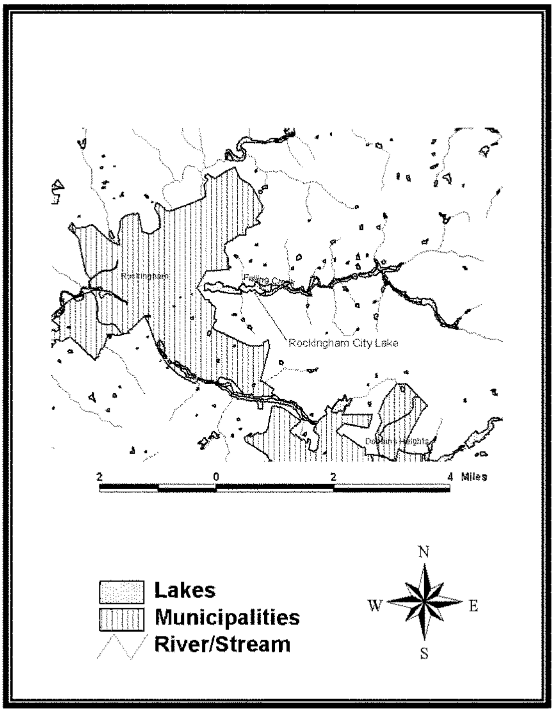

Figure 2.1. Location of the Rockingham City Lake in the Yadkin River Basin.

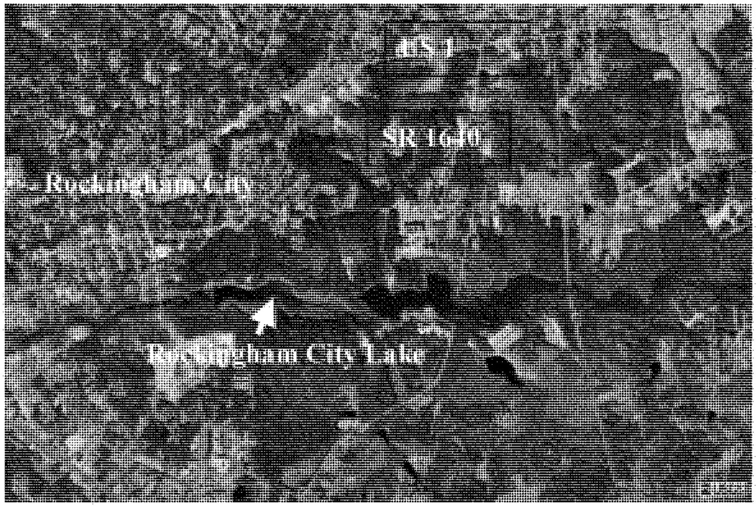

Figure 2.2. Aerial view of the Rockingham City Lake (USGS: January 30, 1993).

Rockingham City Lake is currently classified as WS-III CA. Class WS-III states that waters are used as sources of potable water where a more protective WS-I or II classification is not feasible. These waters are also protected for Class C uses. WS-III waters are generally in low to moderately developed watersheds. General discharge permits only are allowed near the water supply intake whereas domestic and nonprocess industrial discharges are allowed in the rest of the water supply watershed. The Class CA stands for critical area.

2.2. Aquatic Weed Problem

On August 24, 1995, the DWQ staff identified the following aquatic weeds in Rockingham Lake: spike rush (*Eleocharis sp.*), bog moss (*Mayaca fluviatilis*), two-leaf watermilfoil (*Myriophyllum heterophyllum*) and fragrant or white waterlily (*Nymphae odorata*). The identified plants are native to North Carolina (Godfrey and Wooten 1997 and 1981). These plants are not included on the federal or state noxious weed list (Table 1.1). However, excessive plants like watermilfoil and fragrant waterlily can limit swimming, fishing, boating, and aesthetic appreciation. Characteristics of the plants are as follows:

Spike rush (*Eleocharis sp.*): The plant can be recognized by the oval-shaped, brownish-flowering spikes at the tips of smooth, round stems. Spike-rush species grow individually or in clumps along shorelines or in shallow water, sometimes forming ankle-high turf-like mats (http://www.ecy.wa.gov/programs/wq/wqhome.html). Needle spike-rush often appears hair-like when growing underwater. Seeds and stems of the plants are important food sources for waterfowl and mammals. Spike-rushes provide habitat for amphibians and fish and help stabilize shorelines. Therefore, a TMDL to control the plant is not required.

Bog moss (*Mayaca fluviatilis*): This plant is a submersed plant (http://aquat1.ifas.ufl.edu/welcome.html). It may be found in water several feet deep. The stems of bog moss are typically several feet long. The stems are whitish-green. The leaves of bog moss are soft and mossy, like short pieces of fine thread. They are arranged spirally on the stem, and are densely crowded. Bog moss flowers are solitary, on stalks that are one to two inches long. Its massive growth can limit swimming, fishing, skiing, sailing, boating, and aesthetic appreciation. Therefore, its growth should be limited in lakes with secondary recreation uses.

Two-leaf watermilfoil (*Myriophyllum heterophyllum*): The plant is a submerged plant and flowers in the spring through the fall (http://aquat1.ifas.ufl.edu/welcome.html). Its massive growth can limit swimming, fishing, skiing, sailing, boating, and aesthetic appreciation. For this reason, management of the plant is needed.

Fragrant or white waterlily (*Nymphae odorata*): This plant is a rooted, emerged aquatic plant distinctive for its sweet-scented, white, or pink, showy flower (http://www.ecy.wa.gov/programs/wq/wqhome.html). The plant has floating leaves, which are nearly circular in shape. They are notched to the center. Leaves arise on stalks from long rhizomes in the mud. Generally, the plant is not a problem, but significant spatial coverage in the surface of the lake would interfere with boating, fishing, and swimming. Its surface covering would also physically prevent atmospheric oxygen from dissolving into the water. Although relatively slow-spreading, water lilies will eventually colonize shallow water depths to six feet deep and can dominate shorelines of shallow lakes. For this reason, the plant needs to be controlled from spreading across the entire lake surface.

2.3. Control Strategies

The Rockingham Water Treatment Plant in Richmond County manages Rockingham City Lake. The plant releases triploid grass carps every ten years to control the aquatic plants in the lake. According to the plant supervisor, Mr. Gary Johnson, the last release was in March 2001 and total number of grass carps released was 150. Nevertheless, grass carps will not eat bog moss and watermilfoil. They will consume fragrant waterlily, but the effective control of the plant is not yet well documented. The University of Washington experimented with using triploid grass carp to remove fragrant and other species of waterlilies from Chambers Lake, Thurston County by stocking very high rates of fish (http://www.ecy.wa.gov/programs/wq/plants/weeds/). However, little or no impact of the fish on waterlilies was observed in that lake.

Some of the control strategies like bottom barriers and manual harvesting could be effective to control the aquatic plants in the lake. Some lake residents have indicated that extremely persistent "picking" of emerging waterlily leaves every other day during the growing season for two to three seasons will eventually kill the plants.

Herbicide application is not necessary, because the identified plants are not noxious for the lake (see section 1.2). Improper application of herbicide could cause toxicity in the lake. Furthermore, use of sophisticated machines to cut or drag the plants from the lake is not recommended. It can result in eroding soils from banks and bottom surface of the lake.

2.4. Control Level

Because the identified aquatic weeds in Rockingham City Lake are native to North Carolina and are not listed as noxious weeds (Appendix 12.2), a partial control of these plants might be needed to attain lake management goals. However, there is no need to control spike rush, because it provides good habitat for amphibians and fish and helps stabilize shorelines of the lake. Different control levels are described in details in Section 1.2.

2.5. Critical condition

Growth patterns of the native weeds suggest summer as the critical period for the Rockingham City Lake. The identified native aquatic weeds are rooted perennial plants. Each spring new shoots appear from rhizomes and grow up through the water until they reach the surface. During summer time, their growths are further enhanced due to prolonged photosynthesis period. In Rockingham Lake, light can reach up to 1.5 meter in the lake (Table 1.3), which is a favorable condition for submerged photosynthesis.

Flowers of waterlily appear from June to September. Each blossom opens in the morning and closes in the early afternoon for two to five consecutive days. The plant senesces in fall and over winters as the rhizome.

3. Roanoke Rapids Lake

3.1. General Background

Roanoke Rapids Lake, located on the Roanoke River immediately downstream from Lake Gaston, is owned by the Virginia Electric and Power Company. This reservoir is used as a water supply and for recreation. Maximum depth is 27 meter (89 feet), mean depth is five meter (16 feet), and volume is 96 x 10^6 m^3. The Roanoke River is the major tributary to the reservoir and drains nearly all of its 21,482 km^2 (8,294 mi^2) watershed. Releases from Lake Gaston located directly upstream account for almost all of the inflow into Roanoke Rapids Lake (Figure 3.1). The watershed is characterized by rolling hills where nearly three-fourths is forested and most of the remaining land is agricultural (Figure 3.2).

Roanoke Rapids Lake is currently classified as WS-IV & B CA. Class WS-IV states that waters are used as sources of potable water where a WS-I, II or III classification is not feasible. These waters are also protected for Class C uses. WS-IV waters are generally in moderately to highly developed watersheds or Protected Areas, and involve no categorical restrictions on discharges. Class B states that waters are used for primary recreation and other uses suitable for Class C. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. There are no restrictions on watershed development or types of discharges. Class CA stands for critical area, which is the area adjacent to a water supply intake or reservoir where risk associated with pollution is greater than from the remaining portions of the watershed. The critical area is defined as extending either 1/2 mile from the normal pool elevation of the reservoir in which the intake is located or to the ridge line of the watershed (whichever comes first); or 1/2 mile upstream from and draining to the intake (or other appropriate downstream location associated with the water supply) located directly in the stream or river (run-of-the-river), or to the ridge line of the watershed (whichever comes first).

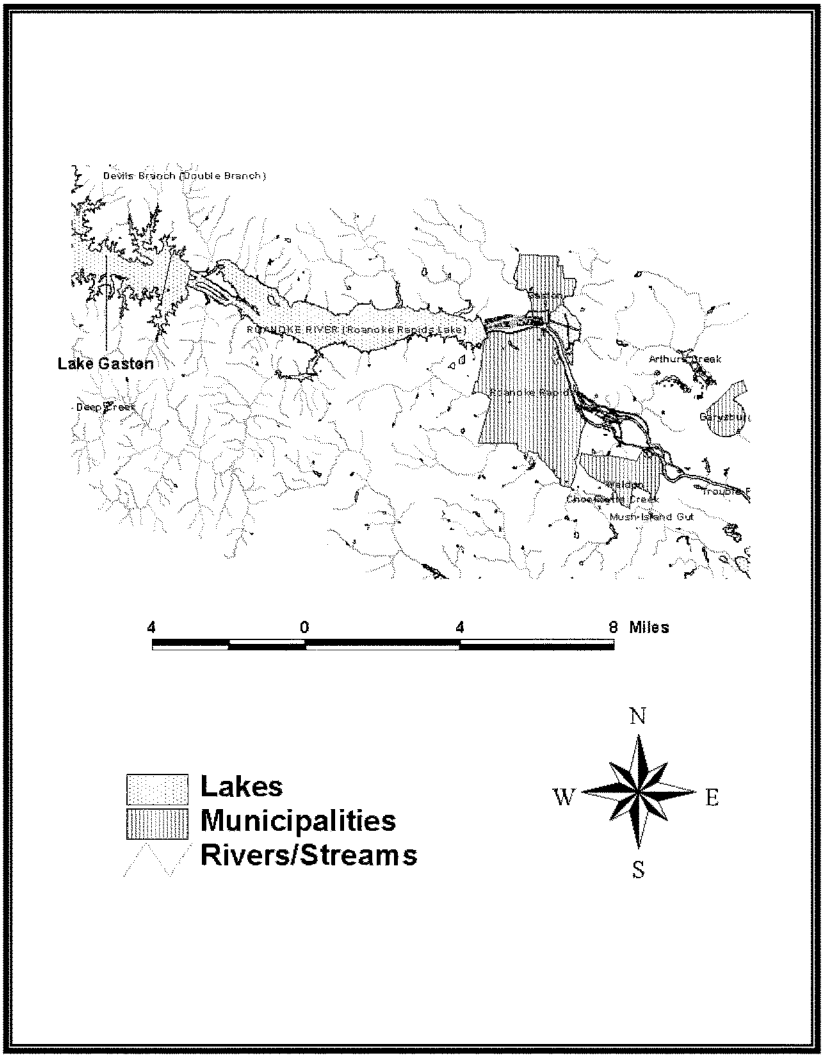

Figure 3.1. Location of the Roanoke Rapids Lake in the Roanoke River Basin.

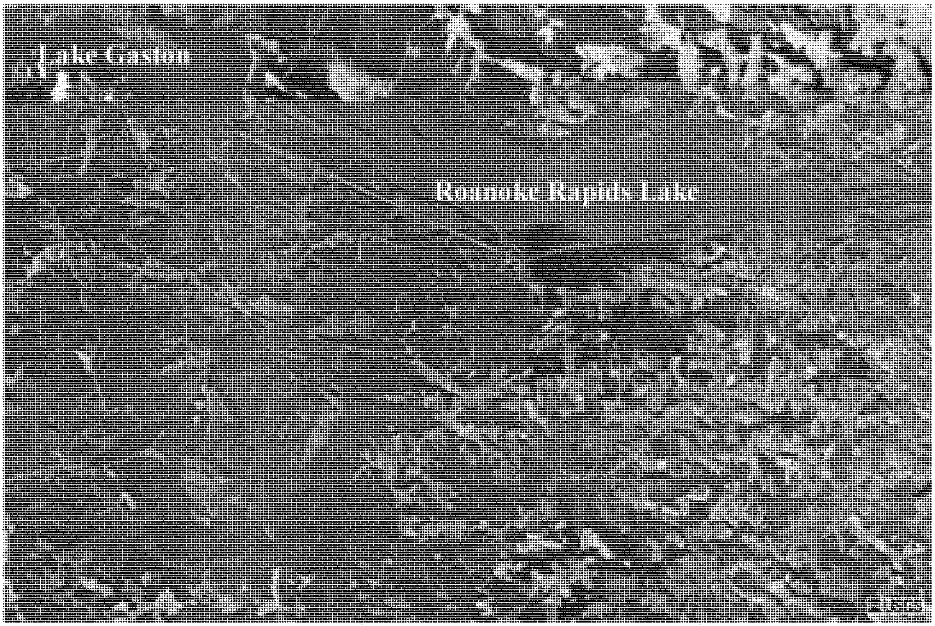

Figure 3.2. Aerial view of Roanoke Rapids Lake (USGS: February, 1994).

3.2. Aquatic Weed Problem

In 1994, aerial surveys conducted by North Carolina State University found the following composition of invasive aquatic weeds in Roanoke Rapids Lake: 90% *Myriophyllum spicatum*, 9% *Egeria densa*, and 1% *Hydrilla verticillata*. Nine years later, in August 2003, the DWR-Aquatic Weed Control program surveyed the lake to estimate the composition of invasive aquatic weeds. The program found water milfoil being dominated by hydrilla profoundly. The composition was 1% *Myriophyllum spicatum* and 99% *Hydrilla verticillata*.

All the identified aquatic weeds in Roanoke Rapids Lake were noxious to the North Carolina lakes (Appendix 12.2). Their physiological characteristics and control methods are well documented in http://www.ecy.wa.gov/programs/wq/plants/weeds/.

Hydrilla (*Hydrilla verticillata*): Hydrilla is the most competitive exotic aquatic weed identified in Roanoke Rapids Lake. The plant is a much- ranched perennial, submerged, rooted, vascular plant. It needs just a little light to grow.

Hydrilla adversely impacts aquatic ecosystems by forming dense canopies that often shade out native vegetation. Extensive monospecific stands of hydrilla can provide poor habitat for fish and other wildlife. Hydrilla mats provide good breeding grounds for mosquitoes. Hydrilla interferes with recreational activities such as swimming, boating, fishing and water skiing.

Eurasian watermilfoil (*Myriophyllum specatum*): Eurasian milfoil is a submerged, invasive, and non-native plant. It has feather-like underwater leaves and emergent floral spikes. Its stem sometimes emerges 2 to 4 inches above water; usually, the stem will have no leaves. The plant spreads rapidly, crowding out native species, clogging waterways, and blocking sunlight and oxygen from underlying waters.

Brazilian elodea (*Egeria densa*): Brazilian elodea is also a submerged, invasive, and non-native weed. The plant makes good aquarium plant and is commonly sold as in the United States and Canada. The plant can be a nuisance plant out of its native habitat. It is an underwater and sometimes floating perennial that can form tangled masses near the water surface. Dense masses interfere with recreational uses of a lake by interfering with navigation, fishing, swimming, and water skiing.

3.3. Control Strategies

The Aquatic Nuisance Plant Control Program in Halifax County manages Roanoke Rapids Lake. The program applied the herbicides, Copper and Diquat, to control the aquatic plants in the lake (from personal communication with the program manager Mr. Skip Wiegersma).

Effectiveness of herbicide application indeed varies with types of aquatic plants. There are three EPA-registered herbicides effective against hydrilla growth: Fluridone

(Sonar®), endothall (Aquathal®), and copper compounds. Fluridone is a systemic herbicide that has proven effective against hydrilla in Florida and other states. Endothall, a fast-acting contact herbicide, is used when immediate control of vegetation is needed. Copper compounds are often used in conjunction with endothall applications, although copper by itself exhibits herbicidal action against hydrilla. These herbicides do not affect hydrilla seeds, tubers, and turions and repeated applications are needed to control hydrilla regrowth.

Westerdahl and Getsinger (1988) report excellent control of Eurasian watermilfoil with 2,4-D, diquat, endothall dipotassium salt, and endothall and complexed copper. They report good control with fluridone. Westerdahl and Getsinger (1988) also report excellent control of Brazilian elodea with diquat and complexed copper, endothall dipotassium salt, and endothall and complexed copper. However, enodthall is considered by general knowledge of aquatic plant managers to be less than effective against Brazilian elodea. Good control was obtained with fluridone.

However, improper application of these herbicides can contaminate ground water and surface water. It is, therefore, important that only herbicides that are EPA approved for aquatic use are selected, and that applications strictly adhere to label specifications. It is also important that herbicides are applied only when following strategies fail to control the aquatic plants.

Drawdown can be an effective cultural method to control the aquatic weeds. The Tennessee Valley Authority (TVA) uses both winter and summer water level drawdown as an effective way of reducing Eurasian watermilfoil biomass. Poovey (1997) suggested that hydrilla in NC lakes could be managed by a short-term summer drawdown. Manning and Johnson (1975) reported that water level drawdown, in combination with 2,4-D treatment of Hydrilla on exposed substrates, plus diquat application to weed beds in areas still covered by water, formed an effective integrated approach to submerged weed control in a Louisiana reservoir. Goldsby and Sanders (1977) reported that consecutive drawdowns in Black Lake, Louisiana eradicated Brazilian elodea. They noted that consecutive drawdowns might be more effective than an individual drawdown.

Localized control of the aquatic weeds (in swimming areas and around docks) can be achieved by covering the sediment with an opaque fabric which blocks light from the plants (bottom barriers or screens).

Manual harvesting can also be an effective method to control the aquatic plants in the lake. However, a major disadvantage of harvesting Hydrilla is that the underground material is left behind. The tubers of the plant are particularly troublesome, since they serve as a source of regrowth in areas where the hydrilla shoots have been controlled by chemical or mechanical methods.

Biological control of Hydrilla by means of grass carp (Ctenopharyngodon idella) is one of the most successful methods of controlling Hydrilla in NC lakes. Species like silver carp (*Hypophthalmichthys molitrix*) and big head carp (*Aristichthys nobilis*) that consume phyto- and zooplankton, and the polyphagous Tilapia species are sometimes used in combination with grass carp for weed control. Their role in aquaculture in combination with grass carp is found to be much more effective (Zweerde, 1990).

Like Hydrilla, Brazilian elodea is highly palatable to grass carp. The crap has been successfully employed as a management tool in Devils Lake, Oregon to control plant populations (http://www.ecy.wa.gov/programs/wq/plants/weeds/). In practice, grass carp often remove the entire native aquatic community; therefore grass carp should be used with great care.

However, grass carp prefers less to eat Eurasian watermilfoil, because the plant is not a highly palatable. In situations where Eurasian watermilfoil is the only aquatic weed species in a lake, grass carp may be a management solution.

Insects can be used to control Eurasian watermilfoil. The North American weevil, *Euhyrchiopsis lecontei* (Dietz), has been found associated with declining populations of Eurasian watermilfoil in northeastern North America. A researcher at the University of Washington is conducting an evaluation of whether the milfoil weevil will be a suitable control for Eurasian watermilfoil in Washington.

The plant pathogenic fungus *Mycoleptodiscus terrestris* has been shown to significantly reduce Eurasian water milfoil biomass in laboratory studies, but not in field settings. The US Army Corps of Engineers is continuing research on plant pathogens. Similarly, recent research in Brazil has identified a fungus (*Fusarium* sp.), which damaged Brazilian elodea in laboratory tests. This may have potential as a biological control agent for Brazilian elodea.

3.4. Control Level

Because the identified aquatic weeds in the lake are noxious and non-native to North Carolina (Table 1.1), these plants should be removed to the best extent possible. Complete removal is the ultimate goal, but may not be realized due to the limited sources and methods available to combat the weeds. Different control levels are described in details in Section 1.2.

3.5. Critical Condition

Growth patterns of hydrilla and Eurasian watermilfoil suggest summer as the critical period for Roanoke Rapids Lake. Light and temperature are the key environmental factors that enhance growth of plants through photosynthesis. In the Roanoke Rapid Lake, light could penetrate to a depth of 3.2 meters (Table 1.3). The defined zone covered approximately 64 % of the mean depth of the lake. Therefore, the lake provides a favorable condition for photosynthesis to occur. In addition, water temperature during summer remained 27^{O} C on average, the temperature at which hydrilla and Eurasian watermilfoil grow profusely (Spencer and Bowes, 1990).

Hydrilla is able to survive and spread readily due to its ability to produce structures called turions and tubers. Turions are compact "buds" produced along the leafy stems. They break free of the parent plant and drift or settle to the bottom to start new plants. They are 1/4 inch long, dark green, and appear spiny. Tubers develop in the hydrosoil and form at the end of roots. They are small, potato-like, and are usually white or yellowish. Hydrilla produces an abundance of tubers and turions in the fall. Tubers may remain dormant for several years in the sediment. Hydrilla also makes tubers in the spring and will produce nondormant turions throughout the growing season.

In the spring, Eurasian watermilfoil begins to grow rapidly as water temperatures approach 15^{O} C. When the plant near the surface, shoots branch profusely, forming a dense canopy. Typically, plants flower upon reaching the surface (usually in mid to late July). After flowering, plant biomass declines as the result of the fragmentation of stems. Where flowering occurs early, plant biomass may increase again later in the growing season and a second flowering may occur. During fall, plants die back to the root crowns, which sprout again in the spring.

In contrast, Brazilian elodea behaves differently in its growth. The plant begins to deteriorate when the temperature reaches 30^{O} C (Spencer and Bowes, 1990). Its growth appears to be increased when water temperature declines to 10^{O} C. Therefore, the growth pattern of Brazilian elodea suggests winter as the critical period for Roanoke Rapids Lake.

4. Big Lake

4.1. General Background

Big Lake is located at Umstead State Park in Raleigh (northwestern Wake County), adjacent to the Raleigh-Durham International Airport. Sycamore Creek is impounded twice within the park, first forming Big Lake and then Sycamore Lake (Figure 4.1). Big Lake has a drainage basin of seven square miles (18 km^2). Land use in the watershed is primarily forest and agriculture; however, development has increased considerably over the past years (Figure 4.2). Big Lake has a maximum depth of five meters (16 feet), a mean depth of two meters (six and a half feet), a mean hydraulic retention time of 25 days and a volume of 0.05 $x10^6 m^3$. .

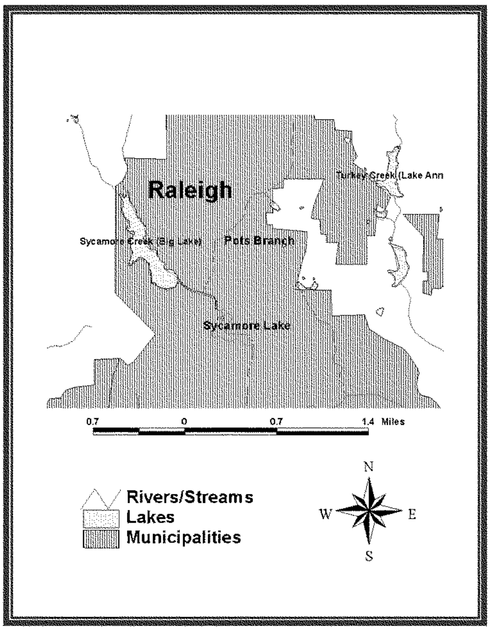

Figure 4.1 Location of Big Lake in Neuse River Basin

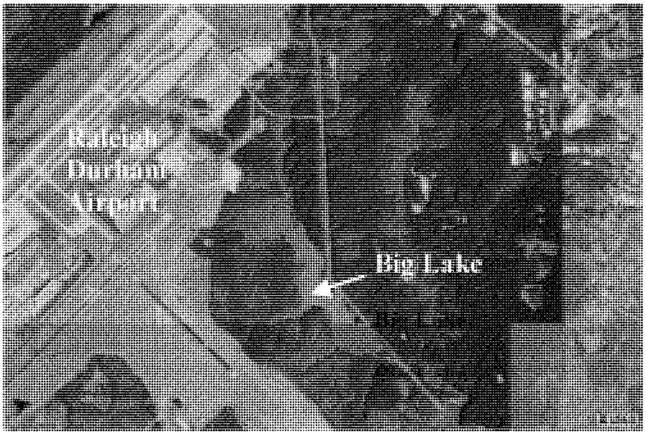

Figure 4.2. Aerial view of the Big Lake (USGS: March 29, 1998).

Big Lake is currently classified as B NSW. Class B states that water is used for primary recreation and other uses suitable for class C. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. The supplemental class NSW (Nutrient Sensitive Waters) states that water is needed for additional nutrient management due to their being subject to excessive growth of microscopic or macroscopic vegetation. This supplemental classification is associated with all waters in the Neuse River Basin. In general, management strategies for point and nonpoint source pollution control require limitation of nutrients such that excessive growths of vegetation are reduced or prevented and there is no increase in nutrients over target levels. There are no restrictions on watershed development or discharge types.

4.2. Aquatic Weed Problem

Staff of NC Division of Water Resources, noticed hydrilla covering 90 to 100% of the shoreline in Big Lake on July 18, 2000. Characteristics of the plant are described in detail in Section 3.2, above.

4.3. Control Strategies

The Umstead State Park in Wake County manages Big Lake. The park applied the herbicide Sonar to control Hydrilla. However, improper application of herbicides can contaminate ground water and surface water. It is, therefore, important that only herbicides that are EPA approved for aquatic use are selected, and that applications strictly adhere to label specifications. It is also important that herbicides are applied only when other possible strategies fail to control the aquatic plants. The possible strategies are discussed in detail in Section 3.3, above.

The park also releases grass carps every three to four years to control the plant. The total estimated grass carp released from April 1985 through April 1999 was about 2,700 (from personal communication with Mr. Rob Emens, Aqautic Weed Control, Division of Water Resources).

4.4. Control Level

Because the identified aquatic weeds in the lake are noxious and non-native to North Carolina (Appendix 12.2), these plants should be removed to the best extent possible. Complete removal is the ultimate goal, but may not be realized due to an extensive and persistent tuber bank that has developed over the last two decades. Different control levels are described in details in Section 1.2.

4.5. Critical Condition

Growth pattern of hydrilla suggests summer as the critical period for Big Lake. Light and temperature are the key environmental factors that enhance growth of the plant through photosynthesis. In Big Lake, light could penetrate up to 1.6 meter, on average (Table 1.3). The zone covered approximately 80 % of the mean depth of the lake. Furthermore, water temperature during summer remained 29^{O} C on average in Big Lake. Hydrilla grows profusely between 28 to 37^{O} C (Spencer and Bowes, 1990). Therefore, the lake provides a favorable condition for hydrilla during the summer period.

5. Reedy Creek Lake

5.1. General Background

Reedy Creek Lake is located in Umstead State Park, which is adjacent to the Raleigh Durham International Airport (Figure 5.1). The lake is relatively small with a surface area of 20 acres (eight hectares) and a volume of 0.14 $x10^6m^3$. The maximum and average depths are four meter (13 feet) and two meters (seven feet), respectively. The lake's watershed is approximately 11 km^2 (4 mi^2). Land use in the watershed is primarily forest and agriculture (Figure 5.2). Retention time for the lake is eleven days. Reedy Creek is one of three lakes (Big Lake, Reedy Creek and Sycamore) located within the park.

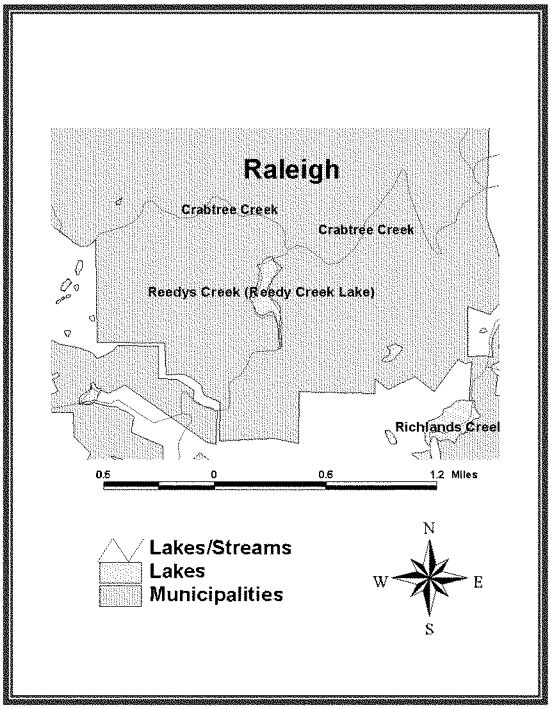

Figure 5.1 Location of Reedy Creek Lake in Neuse River Basin

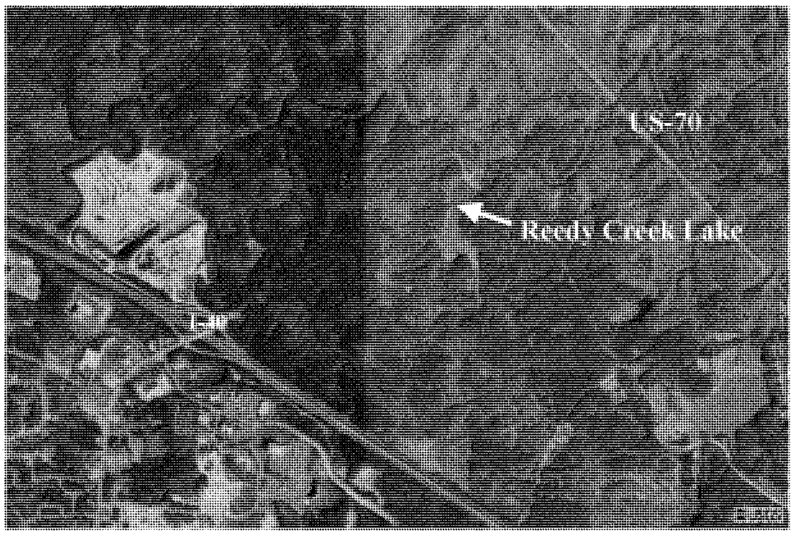

Figure 5.2. Aerial view of Reedy Creek Lake (USGS: March 29, 1998).

Reedy Creek Lake is classified as B NSW and is used primarily for educational and recreational purposes. Class B states that water is used for primary recreation and other uses suitable for Class C. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis. The supplemental class NSW (Nutrient Sensitive Waters) states that water is needed for additional nutrient management due to their being subject to excessive growth of microscopic or macroscopic vegetation. This supplemental classification is associated with all waters in the Neuse River Basin. In general, management strategies for point and nonpoint source pollution control require limitation of nutrients such that excessive growths of vegetation are reduced or prevented and there is no increase in nutrients over target levels.

5.2. Aquatic Weed Problem

Staff of NC Division of Water Resources identified the noxious aquatic weed, *Hydrilla verticillata*, in Reedy Creek Lake along the shoreline on July 14, 2000. Characteristics of the plant are described in Section 3.2, above.

5.3. Control Strategies

The Umstead State Park manages Reedy Creek Lake. The park applied herbicides like Diquat, Cutrine Plus, Aquathol, and Sonar to control Hydrilla. However, improper application of herbicides can contaminate ground water and surface water. It is, therefore, important that only herbicides that are EPA approved for aquatic use are selected, and that applications strictly adhere to label specifications. It is also important that herbicides are applied only when other possible strategies fail to control the aquatic plants. The possible strategies are discussed in detail in Section 3.3, above.

The park also releases grass carps every three to four years to control the plant. The total estimated grass carp released from September 1986 through April 1999 was about 1,650 (from personal communication with Mr. Rob Emens, Aqautic Weed Control, Division of Water Resources).

5.4. Control Level

Because the identified aquatic weeds in the lake are noxious and non-native to North Carolina (Table 1.1 and Appendix 1), these plants should be removed to the best extent possible. Complete removal is the ultimate goal, but may not be realized due to an extensive and persistent tuber bank that has developed over the last two decades. Different control levels are described in details in Section 1.2.

5.5. Critical Condition

Growth pattern of hydrilla suggests summer as the critical period for Reedy Creek Lake. Light and temperature are the key environmental factors that enhance growth of the plant through photosynthesis. In this lake, light will penetrate up to 2.3 meters (Table 1.3) promoting photosynthesis. Furthermore, water temperature during summer remained 29^{O} C on average in the Lake. Hydrilla grows profusely between 28 to 37^{O} C (Spencer and Bowes, 1990). Therefore, the lake provides a favorable condition for hydrilla to grow during the summer period.

6. Lake Wackena

6.1. General Background

Lake Wackena is a privately owned lake located near Goldsboro in Wayne County. The shoreline of the lake is comprised of a residential development (Walnut Creek Estates) and a golf course. The lake has a surface area of 165 acres (67 hectares) with a maximum depth of five meters and a mean depth of two meters. The lake's watershed is approximately 16 mi^2 (41.4 km^2), consisting mostly of forested and agricultural land.

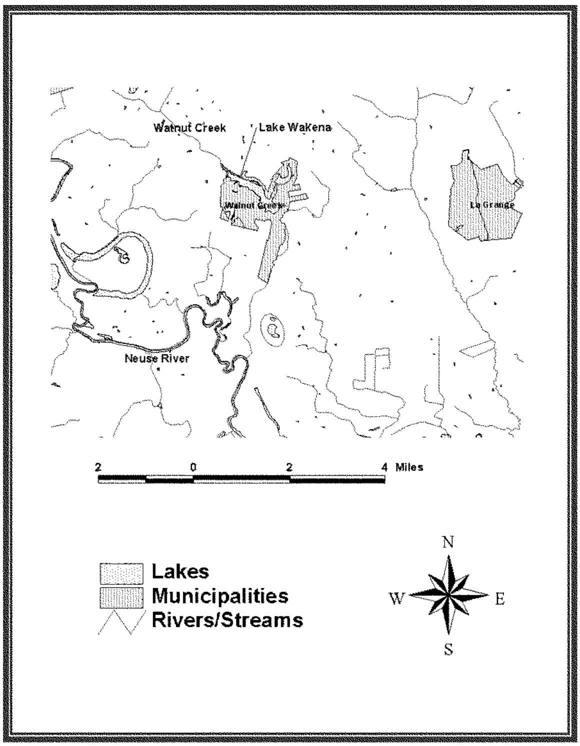

Figure 6.1 Location of Lake Wakena in Neuse River Basin

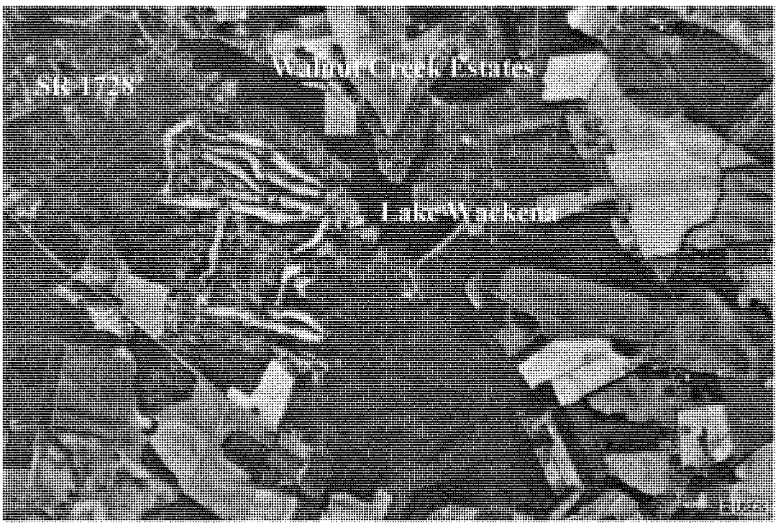

Figure 6.2. Aerial view of Lake Wackena (USGS: February 3, 1993).

Lake Wackena is currently classified as C-NSW and is used primarily for recreational purposes. Class C states that water is protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for Class C. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized or incidental manner. The supplemental Class NSW (Nutrient Sensitive Waters) states that water is needed for additional nutrient management due to it being subject to excessive growth of microscopic or macroscopic vegetation. This supplemental classification is associated with all waters in the Neuse River Basin. In general, management strategies for point and nonpoint source pollution control require limitation of nutrients such that excessive growths of vegetation are reduced or prevented and there is no increase in nutrients over target levels.

6.2. Aquatic Weed Problem

In 303(d) list, Lake Wackena is listed as an impaired waterbody due to aquatic weeds. However, neither field record indicated that the lake was impaired due to aquatic weeds, nor the 303(d) list suggested any types of aquatic weeds existed in the lake. It is, therefore, recommended to delist Lake Wackena since there is no basis for any impairment decision.

7. Summary and Future Consideration

This report presents the development of Total Maximum Daily Loads (TMDLs) for the following five lakes in North Carolina: Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena. The first two lakes are located in Yadkin River Basin and Roanoke River Basin respectively. The last three lakes are located in Neuse River Basin. All the five lakes were identified impaired due to aquatic weeds in the 303(d) list.

Available field reports on the aquatic weed types in the five lakes are reviewed and TMDLs are determined to control the aquatic weeds. Growth and development of the aquatic weeds are examined to conclude the critical periods. The necessary reduction levels of the plants to meet the TMDL requirement was then qualitatively determined based on utility of the plants in the respective lakes. The summary of the results is as follows:

- Rockingham City Lake was identified impaired due to four different native and non-noxious aquatic weeds: *Eleocharis sp. Mayaca fluviatilis, Myriophyllum heterophyllum,* and *Nymphae odorata.* The species of *Eleocharis* protects lake shorelines and provides food for aquatic animals; therefore removal of this plant is not recommended. The remaining three native plants require partial control. Use of opaque fabric for bottom screens and manual harvesting can be used to control these plants.

- Roanoke Rapids Lake was identified impaired due to three exotic and noxious aquatic weeds: *Hydrilla verticillata, Myriophyllum spicatum,* and *Egeria densa.* These plants need to be removed 100% from the lake. Different cultural practices such as herbicide application, use of opaque fabric for bottom screens, and manual harvesting can be used successfully for the plants like *Hydrilla verticillata and Myriophyllum spicatum.* Biocontrol method should be considered as an alternative, or in conjunction with methods stated above. The stocking of sterile grass carp has successfully eradicated hydrilla from some lakes in NC.

- Big Lake was identified impaired due to *Hydrilla verticillata.* The identified species is an exotic and noxious aquatic weed. It needs to be removed 100% from the lake. Different cultural practices such as herbicide application, use of opaque fabric for bottom screens, and manual harvesting can be used successfully for the plants like *Hydrilla verticillata and Myriophyllum spicatum.* Biocontrol method (i.e. stocking grass carp) should be considered as an alternative, or in conjunction with methods stated above.

- Reedy Creek Lake was identified impaired due to the exotic and noxious aquatic weed *Hydrilla verticillata.* It needs to be removed 100% from the lake. Different cultural practices such as herbicide application, use of opaque fabric for bottom screens, and manual harvesting can be used successfully for the plants like *Hydrilla verticillata and Myriophyllum spicatum.* Biocontrol method (i.e. stocking grass carp) should be considered as an alternative, or in conjunction with methods stated above.

- Lake Wackena was identified impaired due to aquatic weeds in the 303(d) list, but no specific types of plants were recorded. There is no basis for any impairment decision. It is therefore recommended to delist the lake from the 303(d) list.

7.1. Lake Monitoring

Lake monitoring for aquatic weed identification should continue on a quarterly interval. While monitoring, the following additional information should be collected for evaluation of progress towards reaching water quality standards:

- Identify types of aquatic weeds.
- Draw map of aquatic weed locations in a lake, showing distribution.
- Estimation of relative abundance of weeds, % surface area.
- Growth and development of weeds.
- Collection of sample of weed species.
- Identification of substrate types.
- Identification of sediment types
- Identification of problem areas and beneficial weed zones.

7.2. Implementation Plan

Development of a successful implementation plan to control aquatic weeds is an ongoing concern that requires long-term commitment from multiple state, federal agencies, and public participation. The plan should focus on monitoring and determining efficacy of control measures and allowing for modification as conditions change. Integration of control methods and best management practices should be implemented. The development of funding strategies and implementation of public outreach program for noxious and invasive weeds are necessary.

8. Public Participation

Many local government officials have been notified of DWQ's intention to develop the Aquatic Weeds TMDL for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena. The TMDL was publicly noticed through local newspapers, Richmond CO. Daily Journal, Daily Herald, The News and Observer, and Goldsboro News Argus on June 30, 2006 (Appendix 11.4). The TMDLs was also publicly noticed through DWQ web site at http://h20.enr.state.nc.us/tmdl/.

A public comment period was through August 7, 2006. No written comments were received.

9. Further Information

Technical questions regarding this report should be directed to the following members of the DWQ Modeling/TMDL Unit:
Narayan Rajbhandari, Environmental Modeler, (narayan.rajbhandari@ncmail.net), and Michelle Woolfolk, Supervisor (michelle.woolfolk@ncmail.net).

Further information concerning North Carolina's water quality program can be found on the Internet at the Division of Water Quality website: http://h2o.enr.state.nc.us/.

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11. Appendices

11.1. Physical parameters of lakes

Lake Name	Date (m/d/yr)	Water Temp (C)	Secchi Depth (meters)	Lake Name	Date (m/d/yr)	Water Temp (C)	Secchi Depth (meters)
Pittsboro	11-Aug-03	25.4	0.5	Rockingham City	17-Aug-00	26.8	0.7
Pittsboro	11-Aug-03	23.5	0.6	Rockingham City	8-Jun-00	25.5	0.7
Pittsboro	16-Jul-03	27.6	0.8	Rockingham City	24-Aug-95	28.6	0.5
Pittsboro	16-Jul-03	28.4	0.8	Rockingham City	19-Aug-92	23.7	1.1
Pittsboro	17-Jun-03	24.4	0.6	Roanoke Rapids	26-Aug-04	25.6	3.2
Pittsboro	17-Jun-03	24.5	0.6	Roanoke Rapids	26-Aug-04	27.2	2.1
Pittsboro	6-Aug-98	25.8	0.4	Roanoke Rapids	26-Aug-04	26.9	2.1
Pittsboro	6-Aug-98	25.6	0.4	Roanoke Rapids	29-Jul-04	25.9	2.6
Pittsboro	8-Jul-98	28.7	0.6	Roanoke Rapids	29-Jul-04	27.6	1.6
Pittsboro	8-Jul-98	29.1	0.4	Roanoke Rapids	29-Jul-04	28.2	2.1
Pittsboro	3-Jun-98	27.4	0.7	Roanoke Rapids	24-Jun-04	24.9	2.8
Pittsboro	29-Jul-93	33.4	0.4	Roanoke Rapids	24-Jun-04	26.2	2.2
Pittsboro	4-Aug-87	31.0	0.5	Roanoke Rapids	24-Jun-04	27.0	2.0
Pittsboro	4-Aug-87	31.0	0.9	Roanoke Rapids	5-Aug-99	27.2	1.7
Pittsboro	19-Aug-81	24.4	0.9	Roanoke Rapids	5-Aug-99	30.6	1.4
Pittsboro	19-Aug-81	24.3	0.9	Roanoke Rapids	5-Aug-99	30.8	1.8
Big	7-Aug-00	31.3	0.3	Roanoke Rapids	22-Jul-99	27.8	2.2
Big	7-Aug-00	30.4	0.3	Roanoke Rapids	22-Jul-99	30.0	2.2
Big	12-Jul-00	29.5	0.7	Roanoke Rapids	22-Jul-99	29.9	2.1
Big	12-Jul-00	29.7	1.3	Roanoke Rapids	2-Jun-99	23.3	2.0
Big	27-Jun-00	29.5	0.3	Roanoke Rapids	2-Jun-99	23.8	1.6
Big	27-Jun-00	29.4	1.0	Roanoke Rapids	2-Jun-99	24.1	1.5
Big	21-Aug-96	27.8	0.7	Roanoke Rapids	9-Aug-94	26.2	2.2
Big	21-Aug-96	27.7	0.7	Roanoke Rapids	9-Aug-94	26.8	1.7
Big	3-Jul-95	26.1	0.8	Roanoke Rapids	9-Aug-94	27.7	1.6
Big	3-Jul-95	25.9	0.8	Roanoke Rapids	30-Jul-87	25.6	1.4
Big	3-Jul-91	29.5	0.2	Roanoke Rapids	30-Jul-87	29.0	0.9
Big	3-Jul-91	29.7	0.6	Roanoke Rapids	30-Jul-87	29.4	1.5
Big	31-Jul-87	28.9	0.6	Roanoke Rapids	30-Jul-85	25.1	1.8
Big	31-Jul-87	29.2	0.6	Roanoke Rapids	30-Jul-85	25.0	1.6
Big	13-Aug-81	29.5	--	Roanoke Rapids	30-Jul-85	25.6	2.6
Big	13-Aug-81	29.7	1.6	Roanoke Rapids	29-Aug-84	25.8	2.0
Reedy Creek	7-Aug-00	29.8	0.2	Roanoke Rapids	29-Aug-84	25.2	1.3
Reedy Creek	12-Jul-00	29.7	0.8	Roanoke Rapids	29-Aug-84	25.7	1.0
Reedy Creek	27-Jun-00	29.4	1.2	Roanoke Rapids	12-Jul-83	25.3	1.4
Reedy Creek	10-Aug-95	26.6	0.7	Roanoke Rapids	12-Jul-83	26.0	2.0
Reedy Creek	12-Aug-91	28.0	2.0	Roanoke Rapids	12-Jul-83	26.8	1.9
Wackena	25-Jul-95	33.0	0.5	Roanoke Rapids	16-Jul-82	24.5	0.9
Wackena	25-Jul-95	32.7	1.5	Roanoke Rapids	16-Jul-82	24.5	1.1
Wackena	14-Jul-88	30.2	0.6	Roanoke Rapids	16-Jul-82	25.9	1.4
Wackena	14-Jul-88	30.4	1.3	Roanoke Rapids	6-Aug-81	27.5	1.3
				Roanoke Rapids	6-Aug-81	27.7	0.5

11.2. North Carolina Aquatic Weed Control Act of 1991

North Carolina Aquatic Weed Control Act of 1991

&

Aquatic Weed Control Regulations

(Article 15 of Chapter 113A of the General Statutes of North Carolina)

§113A-220. Short title.
This Article shall be known as the Aquatic Weed Control Act of 1991.

§113A-221. Definitions.
Unless a different meaning is required by the context, the following definitions shall apply throughout this Article:
(1) "Department" means the Department of Environment, Health, and Natural Resources.
(2) "Secretary" means the Secretary of Environment, Health, and Natural Resources or his designee.
(3) "Noxious aquatic weed" means any plant organism so designated under this Article.
(4) "Waters of the State" means any surface body or accumulation of water, whether publicly or privately owned and whether naturally occurring or artificially created, which is contained within, flows through, or borders upon any part of this State.

§113A-222. Designation of noxious aquatic weeds.
(a) The Secretary, after consultation with the Director of the North Carolina Agricultural Extension Service, the Wildlife Resources Commission, and the Marine Fisheries Commission, and with the concurrence of the Commissioner of Agriculture, may designate as a noxious aquatic weed any plant organism which:

> (1) Grows in or is closely associated with the aquatic environment, whether floating, emersed, submersed, or ditch-bank species, and including terrestrial phases of any such plant organism;
> (2) Exhibits characteristics of obstructive nature and either massive productivity or choking density; and
> (3) Is or may become a threat to public health or safety or to existing or new beneficial uses of the waters of the State.

(b) A plant organism may be designated as being a noxious aquatic weed either throughout the State or within specified areas within the State.
(c) The Secretary shall designate a plant organism as a noxious aquatic weed by rules adopted pursuant to Chapter 150B of the General Statutes.
(d) The Secretary may modify or withdraw any designation of a plant organism as a noxious aquatic weed made previously under this section. Any modification or withdrawal of such designation shall be made following the procedures for designation set out in this section.

NC Aquatic Weed Control Act of 1991 continued:

§113A-223. Powers and duties of the Secretary.
(a) The Secretary shall direct the control, Control, and regulation of noxious aquatic weeds so as to protect and preserve human health, safety, and the beneficial uses of the waters of the State and to prevent injury to property and beneficial plant and animal life. The Secretary shall have the power to:

(1) Conduct research and planning related to the control of noxious aquatic weeds;
(2) Coordinate activities of all public bodies, authorities, agencies, and units of local government in the control and Control of noxious aquatic weeds;
(3) Delegate to any public body, authority, agency, or unit of local government any power or duty under this Article, except that the Secretary may not delegate the designation of noxious aquatic weeds;
(4) Accept donations, grants, and services from both public and private sources;
(5) Enter into contracts or agreements, including cost-sharing agreements, with public or private agencies for research and development of methods of control of noxious aquatic weeds or for the performance of noxious aquatic weed control activities;
(6) Construct, acquire, operate, and maintain facilities and equipment necessary for the control of noxious aquatic weeds; and
(7) Enter upon private property for purposes of conducting investigations and engaging in aquatic weed control activities.

(b) The Secretary may control, remove, or destroy any noxious aquatic weed located in the waters of the State or in areas adjacent to such waters wherever such weeds threaten to invade such waters. The Secretary may employ any appropriate control technology which is consistent with federal and State law, regulations, and rules. Control technologies may include, but are not limited to drawdown of waters, application of chemicals to shoreline and surface waters, mechanical controls, physical removal from transport mechanisms, quarantine of transport mechanisms, and biological controls. Any biological control technology may be implemented only after the environmental review provisions of the State Environmental Policy Act have been satisfied.
(c) In determining the appropriate strategies and technologies, the Secretary shall consider their relative short-term and long-term cost-efficiency and effectiveness, consistent with a margin of safety adequate to protect public health and the resources of the State.
(d) All activities carried out by the Secretary, his designees, and others authorized to perform any function under this Article shall be consistent with all applicable federal and State law, regulations, and rules.

§113A-224. Powers of the Commissioner of Agriculture.
(a) The Commissioner of Agriculture may regulate the importation, sale, use, culture, collection, transportation, and distribution of a noxious aquatic weed as a plant pest under Article 36 of Chapter 106 of the General Statutes.
(b) This Article shall not be construed to limit any power of the Commissioner of Agriculture, the Department of Agriculture, or the Board of Agriculture under any other provision of law.

§113A-225. Responsibilities of other State agencies.
All State agencies shall cooperate with the Secretary to assist in the implementation of this Article.

§113A-226. Enforcement.
(a) Any person who violates this Article or any rule adopted pursuant to this Article shall be guilty of a misdemeanor and, upon conviction, shall be fined not less than fifty dollars ($50.00) or more than one thousand dollars ($1000), or imprisoned for not less than 10 days nor more than 180 days, or both, for each offense.

NC Aquatic Weed Control Act of 1991 continued:

(b) Whenever there exists reasonable cause to believe that any person has violated this Article or

rules adopted pursuant to this Article, the Secretary may request the Attorney General to institute a civil action for injunctive relief to restrain the violation. The Attorney General may institute such action in the name of the State upon relation of the Department in the superior court of the county in which the violation occurred. Upon a determination by the court that the alleged violation of the provisions of this Article or of rules adopted pursuant to this Article has occurred or is threatened, the court shall grant the relief necessary to prevent or abate the violation or threatened violation. Neither the institution of the action, nor any of the proceedings thereon shall relieve any party to such proceedings from any penalty otherwise prescribed for violations of this Article.

§113A-227. Adoption of rules.
The Secretary may adopt rules necessary to implement the provisions of this Article pursuant to Chapter 150B of the General Statutes.

AQUATIC WEED CONTROL REGULATIONS

(Title 15A, Chapter 2, Subchapter 2G

of the North Carolina Administrative Code)

SECTION .0600 - AQUATIC WEED CONTROL

SECTION .0601 THE AQUATIC WEED CONTROL ACT
The North Carolina Aquatic Weed Control Act of 1991 empowers the State of North Carolina to control, eradicate, and regulate plants designated as noxious aquatic weeds. The Aquatic Weed Control Act and the existing powers of the Commissioner of Agriculture prohibit importation, sale, use, culture, collection, transportation, and distribution of these plants in North Carolina. Permits for the movement of noxious aquatic weeds may be obtained from the Commissioner of Agriculture pursuant to 2 NCAC 48A .1705 and .1706, subject to the conditions stated therein.
History Note: Statutory Authority G.S. 106-420; 113A-222; 113A-223; 113A-224; Eff. September 1, 1992.

NC Aquatic Weed Control Act of 1991 continued:

SECTION .0602 NOXIOUS AQUATIC WEED LIST
The Secretary of the Department of Environment, Health, and Natural Resources has determined that the following aquatic plants exhibit characteristics which threaten or may threaten the health or safety of the people of North Carolina or beneficial uses of the waters of North Carolina:
(1) Aquatic Species Listed on the Federal Noxious Weed List.

Azolla pinnata R. Brown	Pinnate mosquitofern
Eichhornia azurea (Sw.) Kunth	Anchored waterhyacinth
Hydrilla verticillata (L. f.) Royle	Hydrilla
Hygrophila polysperma (Roxb.) T. Anderson	Indian hygrophila
Ipomoea aquatica Forsk.	Swamp morningglory, water spinach
Lagarosiphon major (Ridley) Moss	African Elodea
Limnophila sessiliflora (Vahl) Blume	Limnophila
Melaleuca quinquenervia (Cav.) Blake	Melaleuca
Monochoria hastata (L.) Solms	Arrowleaved monochoria
Monochoria vaginalis (Burm. f.) Kunth	Monochoria
Sagittaria sagittifolia L.	Arrowhead
Salvinia auriculata Aubl.	Giant salvinia
Salvinia biloba Raddi	Giant salvinia
Salvinia herzogii de la Sota	Giant salvinia
Salvinia molesta Mitch.	Giant salvinia
Sparganium erectum L.	Branched burreed
Stratiotes aloides L.	Crab's-claw

(2) Additional Noxious Aquatic Weeds.

Crassula helmsii R. Brown	Swamp stonecrop
Lagarosiphon spp. (All species)	African elodea
Salvinia spp. (All except *S. rotundifolia*)	Water fern
Trapa spp. (All species)	Water Chestnut
Ludwigia uruguayensis (Camb.) Hara	Uruguay waterprimrose
Lythrum salicaria L.	Purple loosestrife
Phragmites australis (Cav.) Trin. ex Steud.	Common reed
Alternanthera philoxeroides (Mart.) Griseb	Alligatorweed
Egeria densa Planch.	Brazilian elodea
Myriophyllum spicatum L.	Eurasian watermilfoil
Najas minor All.	Brittleleaf naiad

History Note: Statutory Authority G.S. 113A-222; Eff. September 1, 1992.

11.3. Lake Chemistry Data

1. Surface data:

Lake Name	Date m/d/yr	DO mg/L	Water Temp C	pH s.u.	Cond. umhos/cm	Secchi Depth meters	Percent SAT
BIG LAKE	7-Aug-00	10.9	31.3	8.5	86	0.3	147.5%
BIG LAKE	7-Aug-00	10.1	30.4	7.8	91	0.3	134.4%
BIG LAKE	12-Jul-00	7.4	29.5	7.6	132	0.7	97.1%
BIG LAKE	12-Jul-00	8.2	29.7	8.2	132	1.3	108.0%
BIG LAKE	27-Jun-00	6.1	29.5	7.3	127	0.3	80.2%
BIG LAKE	27-Jun-00	7.3	29.4	7.7	125	1.0	96.0%
BIG LAKE	21-Aug-96	8.7	27.8	8.5	101	0.7	110.8%
BIG LAKE	21-Aug-96	9.1	27.7	8.2	99	0.7	115.7%
BIG LAKE	3-Jul-95	5.3	26.1	6.2	83	0.8	65.5%
BIG LAKE	3-Jul-95	4.9	25.9	6.4	84	0.8	60.3%
BIG LAKE	3-Jul-91	7.4	29.5	6.8	98	0.2	97.1%
BIG LAKE	3-Jul-91	7.2	29.7	7.1	98	0.6	94.8%
BIG LAKE	31-Jul-87	7.2	29.3	7.6	112	1.0	94.1%
BIG LAKE	31-Jul-87	7.5	28.9	7.9	114	0.6	97.4%
BIG LAKE	31-Jul-87	7.4	29.2	7.7	113	0.6	96.6%
BIG LAKE	13-Aug-81	5.1	29.5	7.5	81		66.9%
BIG LAKE	13-Aug-81	5.3	29.7	7.2	79	1.6	69.8%
LAKE WACKENA	25-Jul-95	8.5	33	6.3	98	0.5	118.4%
LAKE WACKENA	25-Jul-95	9	32.7	8.2	95	1.5	124.7%
LAKE WACKENA	14-Jul-88	7.6	30.2	7.1	87	0.6	100.9%
LAKE WACKENA	14-Jul-88	8	30.4	7.2	88	1.3	106.6%
REEDY CREEK LAKE	7-Aug-00	10.4	29.8	8.2	61	0.2	136.5%
REEDY CREEK LAKE	12-Jul-00	7.3	29.7	7.4	119	0.8	96.1%
REEDY CREEK LAKE	27-Jun-00	7.6	29.4	7.7	109	1.2	99.3%
REEDY CREEK LAKE	10-Aug-95	7.3	26.6	6.6	70	0.7	91.0%
REEDY CREEK LAKE	12-Aug-91	5.8	28	6.4	62	2.0	74.1%

Surface data Continued							
			Water			Secchi	
Lake Name	Date	DO	Temp	pH	Cond.	Depth	Percent
	m/d/yr	mg/L	C	s.u.	µmhos/cm	meters	SAT
ROANOKE RAPIDS LAKE	26-Aug-04	5.6	25.6	7.2	101	3.2	68.5%
ROANOKE RAPIDS LAKE	26-Aug-04	7.9	27.2	7.6	100	2.1	99.5%
ROANOKE RAPIDS LAKE	26-Aug-04	7.8	26.9	7.5	100	2.1	97.7%
ROANOKE RAPIDS LAKE	29-Jul-04	4.4	25.9	7.3	106	2.6	54.1%
ROANOKE RAPIDS LAKE	29-Jul-04	7.1	27.6	7.4	103	1.6	90.1%
ROANOKE RAPIDS LAKE	29-Jul-04	8	28.2	7.7	103	2.1	102.6%
ROANOKE RAPIDS LAKE	24-Jun-04	6.5	24.9	7.3	96	2.8	78.5%
ROANOKE RAPIDS LAKE	24-Jun-04	8.3	26.2	7.7	96	2.2	102.7%
ROANOKE RAPIDS LAKE	24-Jun-04	8.4	27	7.9	95	2.0	105.5%
ROANOKE RAPIDS LAKE	5-Aug-99	6.4	27.2	6.9	114	1.7	80.6%
ROANOKE RAPIDS LAKE	5-Aug-99	8.2	30.6	8	113	1.4	109.6%
ROANOKE RAPIDS LAKE	5-Aug-99	7.9	30.8	7.8	113	1.8	106.0%
ROANOKE RAPIDS LAKE	22-Jul-99	6.7	27.8	7.1	110	2.2	85.3%
ROANOKE RAPIDS LAKE	22-Jul-99	8.4	30	7.8	109	2.2	111.2%
ROANOKE RAPIDS LAKE	22-Jul-99	8.4	29.9	7.9	109	2.1	111.0%
ROANOKE RAPIDS LAKE	2-Jun-99	8.4	23.3	8.4	108	2.0	98.5%
ROANOKE RAPIDS LAKE	2-Jun-99	8.6	23.8	8.6	108	1.6	101.8%
ROANOKE RAPIDS LAKE	2-Jun-99	9.1	24.1	9	109	1.5	108.3%
ROANOKE RAPIDS LAKE	9-Aug-94	5.3	26.2	7	101	2.2	65.6%
ROANOKE RAPIDS LAKE	9-Aug-94	7.5	26.8	7.1	98	1.7	93.8%
ROANOKE RAPIDS LAKE	9-Aug-94	7.5	27.7	7.1	97	1.6	95.3%
ROANOKE RAPIDS LAKE	30-Jul-87	3.8	25.6	6	103	1.4	46.5%
ROANOKE RAPIDS LAKE	30-Jul-87	7.5	29	6.8	100	0.9	97.5%
ROANOKE RAPIDS LAKE	30-Jul-87	8.1	29.4	7.1	102	1.5	106.1%
ROANOKE RAPIDS LAKE	30-Jul-85	6.6	25.1	6.9	107	1.8	80.0%
ROANOKE RAPIDS LAKE	30-Jul-85	7.8	25	6.3	108	1.6	94.4%
ROANOKE RAPIDS LAKE	30-Jul-85	8.2	25.6	7.6	105	2.6	100.4%
ROANOKE RAPIDS LAKE	29-Aug-84	5.2	25.8	6.3	99	2.0	63.9%
ROANOKE RAPIDS LAKE	29-Aug-84	5.8	25.2	6.4	96	1.3	70.5%
ROANOKE RAPIDS LAKE	29-Aug-84	7.4	25.7	6.5	97	1.0	90.7%
ROANOKE RAPIDS LAKE	12-Jul-83	7.3	25.3	6.2	96	1.4	88.9%
ROANOKE RAPIDS LAKE	12-Jul-83	7.8	26	6.6	97	2.0	96.2%
ROANOKE RAPIDS LAKE	12-Jul-83	7.6	26.8	6.6	100	1.9	95.1%
ROANOKE RAPIDS LAKE	16-Jul-82	4.7	24.5	6.2	142	0.9	56.4%
ROANOKE RAPIDS LAKE	16-Jul-82	4.7	24.5	6.2	141	1.1	56.4%
ROANOKE RAPIDS LAKE	16-Jul-82	7.1	25.9	7.2	135	1.4	87.4%
ROANOKE RAPIDS LAKE	6-Aug-81	6.2	27.5	7.1	109	1.3	78.5%
ROANOKE RAPIDS LAKE	6-Aug-81	8.3	27.7	7.7	112	0.5	105.5%
ROCKINGHAM CITY LAKE	17-Aug-00	3.2	26.8	5.3	28	0.7	40.0%
ROCKINGHAM CITY LAKE	8-Jun-00	3.9	25.5	5.7	27	0.7	47.6%
ROCKINGHAM CITY LAKE	24-Aug-95	3	28.6	5.1	32	0.5	38.7%
ROCKINGHAM CITY LAKE	19-Aug-92	2.6	23.7	4.1	21	1.1	30.7%

2. Photoc Zone Data

Lake Name	Date	TP	TN	TON	TIN	CHL a	T. Solids	TSS	Turbidity
	m/d/yr	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	NTU
BIG LAKE	7-Aug-00	0.08	0.77	0.50	0.27		100	22	45
BIG LAKE	7-Aug-00	0.07	0.75	0.48	0.27		100	15	40
BIG LAKE	12-Jul-00	0.05	0.41	0.39	0.02		110	11	7.4
BIG LAKE	12-Jul-00	0.03	0.51	0.50	0.01		100	20	3.9
BIG LAKE	27-Jun-00	0.03	0.91	0.87	0.04		95	20	11
BIG LAKE	27-Jun-00	<0.01	0.71	0.68	0.03		70	12	2.9
BIG LAKE	21-Aug-96	0.01	0.41	0.40	0.01		100	13	
BIG LAKE	21-Aug-96	0.03	0.51	0.49	0.02		94	10	5.6
BIG LAKE	3-Jul-95	0.03	0.41	0.39	0.02	9	80	2	6.4
BIG LAKE	3-Jul-95	0.03	0.41	0.39	0.02	10	82	2	5
BIG LAKE	3-Jul-91	0.05	0.41	0.27	0.14	11	100	2	35
BIG LAKE	3-Jul-91	0.03	0.21	0.17	0.04	5	89	<1.0	24
BIG LAKE	31-Jul-87	0.20	0.41	0.36	0.05	11			
BIG LAKE	31-Jul-87	0.30	0.41	0.38	0.03	11			
BIG LAKE	31-Jul-87	0.30	0.51	0.47	0.04	13			
BIG LAKE	13-Aug-81	0.03	0.51	0.50	0.01	11			
BIG LAKE	13-Aug-81	0.03	0.41	0.40	0.01	9			
LAKE WACKENA	25-Jul-95	0.18	0.61	0.55	0.06	11	150	22	6.6
LAKE WACKENA	25-Jul-95	0.02	0.41	0.35	0.06	4	110	4	1.8
LAKE WACKENA	14-Jul-88	0.13	0.72	0.67	0.05	27	83	9	4.6
LAKE WACKENA	14-Jul-88	0.05	0.51	0.48	0.03	18	83	8	3.8
REEDY CREEK LAKE	7-Aug-00	0.08	0.61	0.55	0.06		150	18	50
REEDY CREEK LAKE	12-Jul-00	0.04	0.31	0.14	0.17		99	11	5.3
REEDY CREEK LAKE	27-Jun-00	0.01	0.41	0.32	0.09		76	2	2.7
REEDY CREEK LAKE	10-Aug-95	0.04	0.41	0.40	0.01	6	68	5	7.8
REEDY CREEK LAKE	12-Aug-91	0.05	0.42	0.34	0.08	6	83	20	13
ROANOKE RAPIDS LAKE	26-Aug-04	0.02	0.34	0.24	0.10	3	86	<2.5	1.6
ROANOKE RAPIDS LAKE	26-Aug-04	0.02	0.29	0.26	0.03	6	78	<2.5	2.2
ROANOKE RAPIDS LAKE	26-Aug-04	0.02	0.31	0.27	0.04	8	82	2.5	2.1
ROANOKE RAPIDS LAKE	29-Jul-04	0.02	0.36	0.23	0.13	3	80	<2.5	1.3
ROANOKE RAPIDS LAKE	29-Jul-04	0.02	0.32	0.26	0.06	5	74	<2.5	1.7
ROANOKE RAPIDS LAKE	29-Jul-04	0.02	0.30	0.25	0.05	7	72	<2.5	1.8
ROANOKE RAPIDS LAKE	24-Jun-04	0.02	0.37	0.23	0.14	3	74	<2.5	4
ROANOKE RAPIDS LAKE	24-Jun-04	0.02	0.36	0.25	0.11	4	74	<2.5	3.1
ROANOKE RAPIDS LAKE	24-Jun-04	0.02	0.33	0.24	0.09	5	70	<2.5	2.4
ROANOKE RAPIDS LAKE	5-Aug-99	0.01	0.31	0.30	0.01		90	7	2.6
ROANOKE RAPIDS LAKE	5-Aug-99	0.01	0.41	0.40	0.01		81	6	2.6
ROANOKE RAPIDS LAKE	5-Aug-99	0.01	0.21	0.20	0.01		79	4	2.3
ROANOKE RAPIDS LAKE	22-Jul-99	0.01	0.35	0.26	0.09		81	5	1.7
ROANOKE RAPIDS LAKE	22-Jul-99	0.01	0.22	0.16	0.06		71	3	1.9
ROANOKE RAPIDS LAKE	22-Jul-99	0.01	0.21	0.16	0.05		76	2	2.3
ROANOKE RAPIDS LAKE	2-Jun-99	0.01	0.30	0.20	0.11		77	3	2.8
ROANOKE RAPIDS LAKE	2-Jun-99	<0.01	0.31	0.20	0.12		88	3	3

Photoc Zone Data Continued									
Lake Name	Date	TP	TN	TON	TIN	CHL a	T. Solids	TSS	Turbidity
	m/d/yr	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	NTU
ROANOKE RAPIDS LAKE	2-Jun-99	0.03	0.37	0.28	0.09		85	2	3
ROANOKE RAPIDS LAKE	9-Aug-94	0.02	0.27	0.18	0.09	1	79	3	1.7
ROANOKE RAPIDS LAKE	9-Aug-94	0.02	0.24	0.19	0.05	2	96	4	2.4
ROANOKE RAPIDS LAKE	9-Aug-94	0.02	0.24	0.18	0.06	2	88	3	2.2
ROANOKE RAPIDS LAKE	30-Jul-87	0.02	0.38	0.27	0.11	7	68	2	3.1
ROANOKE RAPIDS LAKE	30-Jul-87	0.02	0.31	0.29	0.02	13	76	4	4.3
ROANOKE RAPIDS LAKE	30-Jul-87	0.02	0.32	0.29	0.03	13	62	2	3
ROANOKE RAPIDS LAKE	30-Jul-85	0.01	0.36	0.27	0.09	1	110	2	2.3
ROANOKE RAPIDS LAKE	30-Jul-85	0.01	0.23	0.19	0.04	5	130	6	1.6
ROANOKE RAPIDS LAKE	30-Jul-85	0.43	0.31	0.05	0.26	4	110	3	1.1
ROANOKE RAPIDS LAKE	29-Aug-84	0.01	0.32	0.19	0.13	4	65	4	2
ROANOKE RAPIDS LAKE	29-Aug-84	0.02	0.42	0.29	0.13	6	67	4	2.9
ROANOKE RAPIDS LAKE	29-Aug-84	0.02	0.35	0.18	0.17	1	78	3	3.6
ROANOKE RAPIDS LAKE	12-Jul-83	0.03	0.25	0.19	0.06	3	75	6	2.8
ROANOKE RAPIDS LAKE	12-Jul-83	0.03	0.21	0.18	0.03	3	75	1	2.3
ROANOKE RAPIDS LAKE	12-Jul-83	0.02	0.31	0.29	0.02	6	80	3	2.3
ROANOKE RAPIDS LAKE	16-Jul-82	0.03	1.58	0.23	1.35	7	133	11	
ROANOKE RAPIDS LAKE	16-Jul-82	0.03	1.24	0.37	0.87	13	118	6	
ROANOKE RAPIDS LAKE	16-Jul-82	0.03	3.00	0.40	2.60	13	134	9	
ROANOKE RAPIDS LAKE	6-Aug-81	0.02	0.31	0.29	0.02				
ROANOKE RAPIDS LAKE	6-Aug-81	0.04	0.41	0.38	0.03	17			
ROCKINGHAM CITY LAKE	17-Aug-00	0.03	0.51	0.39	0.12		65	10	2
ROCKINGHAM CITY LAKE	8-Jun-00	0.02	0.31	0.17	0.14		46	7	2.5
ROCKINGHAM CITY LAKE	24-Aug-95	0.03	0.51	0.47	0.04	8	48	4	2.3
ROCKINGHAM CITY LAKE	19-Aug-92	0.02	0.41	0.36	0.05	1	55	2	3.6

3. Bottom Data

Lake Name	Region/Type	Date	Sampling	TP	NH3	TKN	NOx	TON
		m/d/yr	Station	mg/L	mg/L	mg/L	mg/L	mg/L
BIG LAKE	PIEDMONT	7-Aug-00	NEU035G					
BIG LAKE	PIEDMONT	7-Aug-00	NEU035H	0.10	0.87	2	0.07	1.13
BIG LAKE	PIEDMONT	12-Jul-00	NEU035G					
BIG LAKE	PIEDMONT	12-Jul-00	NEU035H					
BIG LAKE	PIEDMONT	27-Jun-00	NEU035G					
BIG LAKE	PIEDMONT	27-Jun-00	NEU035H	0.03	0.19	0.5	<0.01	0.31
BIG LAKE	PIEDMONT	21-Aug-96	NEU035G					
BIG LAKE	PIEDMONT	21-Aug-96	NEU035H	0.06	0.13	0.8	0.03	0.67
BIG LAKE	PIEDMONT	3-Jul-95	NEU035G	0.03	0.02	0.4	<0.01	0.38
BIG LAKE	PIEDMONT	3-Jul-95	NEU035H	0.03	0.10	0.5	<0.01	0.40
BIG LAKE	PIEDMONT	3-Jul-91	NEU035G	0.21	0.06	0.5	0.16	0.44
BIG LAKE	PIEDMONT	3-Jul-91	NEU035H	0.14	0.60	0.9	0.01	0.30
BIG LAKE	PIEDMONT	31-Jul-87	BL3					
BIG LAKE	PIEDMONT	31-Jul-87	NEU035G					
BIG LAKE	PIEDMONT	31-Jul-87	NEU035H					
BIG LAKE	PIEDMONT	13-Aug-81	NEU035G					
BIG LAKE	PIEDMONT	13-Aug-81	NEU035H					
LAKE WACKENA	PIEDMONT	25-Jul-95	NEU0714A					
LAKE WACKENA	PIEDMONT	25-Jul-95	NEU0717A	0.06	0.15	0.6	<0.01	0.45
LAKE WACKENA	PIEDMONT	14-Jul-88	NEU0714A					
LAKE WACKENA	PIEDMONT	14-Jul-88	NEU0717A	0.05	0.03	0.6	<0.01	0.57
REEDY CREEK LAKE	PIEDMONT	7-Aug-00	NEU035A7					
REEDY CREEK LAKE	PIEDMONT	12-Jul-00	NEU035A7					
REEDY CREEK LAKE	PIEDMONT	27-Jun-00	NEU035A7	0.02	0.40	0.6	<0.01	0.20
REEDY CREEK LAKE	PIEDMONT	10-Aug-95	NEU035A7	0.04	0.02	0.4	<0.01	0.38
REEDY CREEK LAKE	PIEDMONT	12-Aug-91	NEU035A7	0.04	0.04	0.4	0.02	0.36
ROANOKE RAPIDS LAKE	PIEDMONT	26-Aug-04	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	26-Aug-04	ROA039D					
ROANOKE RAPIDS LAKE	PIEDMONT	26-Aug-04	ROA039E					
ROANOKE RAPIDS LAKE	PIEDMONT	29-Jul-04	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	29-Jul-04	ROA039D					
ROANOKE RAPIDS LAKE	PIEDMONT	29-Jul-04	ROA039E					
ROANOKE RAPIDS LAKE	PIEDMONT	24-Jun-04	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	24-Jun-04	ROA039D					
ROANOKE RAPIDS LAKE	PIEDMONT	24-Jun-04	ROA039E					
ROANOKE RAPIDS LAKE	PIEDMONT	5-Aug-99	ROA039C	<0.01	0.01	0.2	<0.01	0.20
ROANOKE RAPIDS LAKE	PIEDMONT	5-Aug-99	ROA039D	0.01	0.01	0.3	<0.01	0.30
ROANOKE RAPIDS LAKE	PIEDMONT	5-Aug-99	ROA039E	0.01	0.01	0.3	0.01	0.30
ROANOKE RAPIDS LAKE	PIEDMONT	22-Jul-99	ROA039C	0.01	0.08	0.2	0.06	0.12
ROANOKE RAPIDS LAKE	PIEDMONT	22-Jul-99	ROA039D					
ROANOKE RAPIDS LAKE	PIEDMONT	22-Jul-99	ROA039E	0.02	0.22	0.4	0.05	0.18
ROANOKE RAPIDS LAKE	PIEDMONT	2-Jun-99	ROA039C	0.01	0.01	0.1	0.11	0.10
ROANOKE RAPIDS LAKE	PIEDMONT	2-Jun-99	ROA039D	<0.01	0.04	0.1	0.09	0.06

Bottom Data Continued

Lake Name	Region/Type	Date	Sampling	TP	NH3	TKN	NOx	TON
		m/d/yr	Station	mg/L	mg/L	mg/L	mg/L	mg/L
ROANOKE RAPIDS LAKE	PIEDMONT	2-Jun-99	ROA039E	0.04	0.04	0.2	0.11	0.16
ROANOKE RAPIDS LAKE	PIEDMONT	9-Aug-94	ROA039C	0.02	0.01	0.2	0.08	0.20
ROANOKE RAPIDS LAKE	PIEDMONT	9-Aug-94	ROA039D	0.02	0.01	0.2	0.03	0.19
ROANOKE RAPIDS LAKE	PIEDMONT	9-Aug-94	ROA039E	0.02	0.17	0.3	0.03	0.13
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-87	ROA039C	0.02	0.04	0.3	0.08	0.26
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-87	ROA039D	0.03	0.08	0.3	0.08	0.22
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-87	ROA039E	0.02	0.06	0.3	0.08	0.24
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-85	ROA039C	0.02	0.07	0.3	0.07	0.23
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-85	ROA039D	0.02	0.02	0.3	0.04	0.28
ROANOKE RAPIDS LAKE	PIEDMONT	30-Jul-85	ROA039E	0.04	0.47	0.7	<0.01	0.23
ROANOKE RAPIDS LAKE	PIEDMONT	29-Aug-84	ROA039C	0.02	0.01	0.2	0.12	0.19
ROANOKE RAPIDS LAKE	PIEDMONT	29-Aug-84	ROA039D	0.02	0.01	0.2	0.12	0.19
ROANOKE RAPIDS LAKE	PIEDMONT	29-Aug-84	ROA039E	0.02	0.01	0.2	0.09	0.19
ROANOKE RAPIDS LAKE	PIEDMONT	12-Jul-83	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	12-Jul-83	ROA039D	0.04	0.05	0.2	0.08	0.15
ROANOKE RAPIDS LAKE	PIEDMONT	12-Jul-83	ROA039E	0.05	0.13	0.4	0.2	0.27
ROANOKE RAPIDS LAKE	PIEDMONT	16-Jul-82	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	16-Jul-82	ROA039D					
ROANOKE RAPIDS LAKE	PIEDMONT	16-Jul-82	ROA039E					
ROANOKE RAPIDS LAKE	PIEDMONT	6-Aug-81	ROA039C					
ROANOKE RAPIDS LAKE	PIEDMONT	6-Aug-81	ROA039E					
ROCKINGHAM CITY LAKE	SANDHILLS	17-Aug-00	YAD265C					
ROCKINGHAM CITY LAKE	SANDHILLS	8-Jun-00	YAD265C					
ROCKINGHAM CITY LAKE	SANDHILLS	24-Aug-95	YAD265C	0.06	0.56	1.3	<0.01	0.74
ROCKINGHAM CITY LAKE	SANDHILLS	19-Aug-92	YAD265C					

11.4. Public Notice of draft Aquatic Weed TMDL for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena.

AFFIDAVIT OF PUBLICATION

NORTH CAROLINA.
Wake County. } Ss.

Public Notice
State of North Carolina
Division of Water Quality

Availability of the Total Maximum Daily Load for Aquatic Weeds for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena in North Carolina.

You are requested to review the TMDL and mail your comments to NC DWQ-Planning Branch, attn: Ms. Linda Chavis, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Linda Chavis at (919)733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl/. Written comments regarding the TMDL will be accepted until August 7, 2006.

N&O: June 30, 2006

Before the undersigned, a Notary Public of Chatham County North Carolina, duly commissioned and authorized to administer oaths, affirmations, etc., personally appeared Deborah McCullers, who, being duly sworn or affirmed, according to law, doth depose and say that she is Billing Manager-Legal Advertising of The News and Observer a corporation organized and doing business under the Laws of the State of North Carolina, and publishing a newspaper known as The News and Observer, in the City of Raleigh , Wake County and State aforesaid, the said newspaper in which such notice, paper, document, or legal advertisement was published was, at the time of each and every such publication, a newspaper meeting all of the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina, and that as such she makes this affidavit; that she is familiar with the books, files and business of said corporation and by reference to the files of said publication the attached advertisement for NC DIVISION OF WATER QUALITY was inserted in the aforesaid newspaper on dates as follows: 06/30/06

Account Number: 73350831

The above is correctly copied from the books and files of the aforesaid Corporation and publication.

Deborah McCullers

Deborah McCullers, Billing Manager-Legal Advertising
Wake County, North Carolina

Sworn or affirmed to, and subscribed before me, this 03 day of JULY , 2006 AD, by Deborah McCullers.

In Testimony Whereof, I have hereunto set my hand and affixed my official seal, the day and year aforesaid.

Janet Scroggs

Janet Scroggs, Notary Public

My commission expires 14th of March 2009

Janet Scroggs Notary Public Chatham County, NC

PAID

DENR - WATER QUALITY
Wetlands & Stormwater Branch
JUL 12 2006

Aug 14 06 03:23p Daily Herald (252)537-2314 p.3

**PUBLIC NOTICE
STATE of NORTH CAROLINA
DIVISION of WATER QUALITY**

Availability of the Total Maximum Daily Load for Aquatic Weeds for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek, and Lake Wackena in North Carolina.

You are requested to review the TMDL and mail comments to NC DWQ-Planning Branch, attn: Ms. Linda Chavis, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Linda Chavis at (919) 733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl/. Written comments regarding the TMDL will be accepted until August 7, 2006.

June 30, 2006

08/14/2006 11:33 FAX 19109974321 RICHMOND CO DAILY JOURNA

PUBLIC NOTI E
STATE OF NORTH C ROLINA
DIVISION OF WATER QU LITY

Availability of the Total M ximum Daily Load for Aquatic Wee s for Rockingham City Lake, Roa oke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena in No th Carolina.

You are requested to review the TMDL and mail your com ents to NC DWQ-Planning Branch, to: Ms.Linda Chavis, 1617 Mail Se ice Center, Raleigh, NC 27699-16 . Copies of the TMDL may be obtai ed by calling Ms. Linda Chavis at (9) 733-5083, ext. 558 or on the interne at http://h2o.enr.state.nc.us/ tmdl. Written comments re arding the TMDL will be accepted until August 7,2006.

June29,2006

ROCKIN HAM NEWSPAPERS, LLC
DBA Ric mond County Daily Journal
105 E. W shington Street
PO Box 828
Rocking am, NC 28380

NORTH CAROLINA
WAYNE COUNTY.

AFFIDAVIT OF PUBLICATION

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified, and authorized by law to administer oaths, personally appeared Teresa Bozeman who being first duly sworn, deposes and says: that he (she) is Legal Clerk (Publisher, or other officer or employee authorized to make affidavit) of WAYNE PRINTING COMPANY, INC., engaged in the publication of a newspaper known as GOLDSBORO NEWS-ARGUS, published, issued, and entered as second class mail in the city of Goldsboro in said County and State; that he (she) is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a true copy of which is attached hereto, was published in GOLDSBORO NEWS-ARGUS on the following dates:

June 30, 2006

and that the said newspaper in which such notice, paper, document, or legal advertisement was published was, at the time of each, and every such publication, a newspaper meeting all of the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

This 14 day of August, 20 06

Teresa Bozeman
(Signature of person making affidavit)

Sworn to and subscribed before me, this 14th day of August, 20 06.

[signature]
Notary Public

My Commission expires April 24, 2007

CLIPPING OF LEGAL ADVERTISEMENT ATTACHED HERE

[redacted]
STATE OF NORTH [redacted]
DIVISION OF WATER QUALITY

Availability of the Total Maximum Daily Load for Aquatic Weeds for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena in North Carolina.

You are requested to review the TMDL and mail your comments to NC DWQ-Planning Branch, attn: Ms. Linda Chavis, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Linda Chavis at (919) 733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl/. Written comments regarding the TMDL will be accepted until August 7, 2006.
Legal #568
June 30, 2006

08/14/06 16:40 FAX 919 739 7773 NEWS ARGUS ACCT.

11.5. The US EPA's Approval Letter

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

SEP 25 2006

Mr. Alan W. Klimek, P.E., Director
Division of Water Quality
North Carolina Department of Environment and
Natural Resources
1617 Mail Service Center
512 N. Salisbury Street
Raleigh, NC 27699-1617

Dear Mr. Klimek:

The United States Environmental Protection Agency (EPA) has concluded a review of the "TMDL for Aquatic Weeds for Rockingham City Lake, Roanoke Rapids Lake, Big Lake, Reedy Creek Lake, and Lake Wackena in North Carolina" in Yadkin-Pee Dee River Basin, Roanoke River Basin, and Neuse River Basin as submitted by letter on August 14, 2006, by the North Carolina Department of Environment and Natural Resources (NCDENR). Based upon our review, we have determined that the statutory requirements of the Clean Water Act (CWA), Section 303(d) have been met and hereby approve the aquatic weed TMDLs for the impaired lakes listed above.

The enclosed Decision Document summarizes the elements of the review which were found to support EPA's approval of the TMDL. If you have any comments or questions relating to the approval of this TMDL or the enclosed Decision Document, please contact Bill Melville of my staff at (404) 562-9266.

Sincerely,

James D. Giattina, Director
Water management Division

Enclosure

cc: Michelle Woolfolk

Internet Address (URL) • http://www.epa.gov
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NC Division of Water Quality
Planning Section – Modeling & TMDL Unit
Technical Memorandum

February 15, 2005

TO:	Dianne Reid	Intensive Survey Unit
	Debra Owen	Intensive Survey Unit
	Jay Sauber	Ecosystems Unit
	Mark Vanderborgh	Ecosystems Unit
	Andrea Thomas	Ecosystems Unit
	Kent Wiggins	Chemistry Laboratory
	Narayan Rajbhandari	Modeling & TMDL Unit
CC:	Michelle Woolfolk	Modeling & TMDL Unit
	Alan Clark	Planning Section
	Ken Schuster	Raleigh Regional Office
	Darlene Kucken	Basinwide Planning
	Deborah Amaral	EEP Planner

FROM: George Hunt, Modeling & TMDL Unit

RE: Monitoring Plan for Falls of the Neuse Reservoir (Neuse River Basin)

This study has been initiated at the request of the Director of the Division of Water Quality of DENR based on recent chlorophyll *a* data. Currently available data indicate that there may be violations of the chlorophyll *a* standard, therefore this plan has been designed as a TMDL study. This study will be an official study of the reservoir and is designed to fulfill the following purposes:

1. To provide data necessary to complete a TMDL study on the waterbody if the waterbody is included on the 303(d) list.
2. To provide data for parameters not normally collected as part of the lake ambient monitoring program. These data are parameters utilized heavily in modeling frameworks and are therefore necessary to complete a detailed modeling study.

This is a 22-month plan for data collection as part of a TMDL process. This monitoring study will collect data continuously from March 2005 through December 2006. This time frame will allow for the capture of spring, summer and fall seasons in two separate years, which are critical times for algal growth.

The data to be collected in this study and the subsequent modeling analysis will allow the DWQ to determine the extent of impairment of the reservoir. The study is also designed so that an approximate measure of its nutrient loading capacity may be made in order to aid DWQ in the management of both point and nonpoint sources. A summary of the scope of the monitoring plan can be found in Table 2. Please let me know immediately if some aspect of the study will be difficult or impossible to obtain.

Lake Monitoring

This special study should begin in March 2005 and continue through December 2006. Sampling events should be conducted twice each month, as close to every other week as possible, during this period, for a total of approximately 48 sampling events. At the end of the study, all special study data should be provided to the Modeling & TMDL Unit, with a transmittal memorandum at the completion of the study. Special study data should be provided in an electronic format compatible with MS Excel or MS Access. If possible, updates should be sent to the Modeling & TMDL Unit in an electronic format compatible with MS Excel approximately every three months. Information collected during the cross-section study should be provided to the Modeling & TMDL Unit in an electronic format compatible with MS Excel as soon as the data has been processed. These quarterly updates and the separate request for cross-section data are asked for so that the modeling process can begin as soon as possible, as time is critical on this project.

Spatial Coverage.
Sample all ten existing monitoring stations (i.e., NEU010, NEU013, NEU013B, NEU0171B, NEU018E, NEU019C, NEU019E, NEU019L, NEU019P, NEU020D). Coordinates (i.e. latitude and longitude) should be obtained for all sampling sites prior to beginning sampling in March to allow verification of site accessibility and latitude/longitude information. Latitude/longitude is required for all sampling points. Total number of locations: 10

Parameters.

- Physical parameters: depth profiles of dissolved oxygen, water temperature, pH, and conductivity. Secchi depth should also be included as a physical parameter. These data should be collected along with the chemical data bi-weekly, as stated previously. During the first year of the study period, one sampling event of lateral measurements of the physical parameters should be taken. Along the cross sections described in the following paragraph take three measurements of physical data, including one measurement in the middle of the waterbody, one measurement at the right side of the waterbody, and one measurement at the left side of the waterbody. This data is necessary to test a lateral-average assumption. The timing of this lateral data collection can be at the discretion of the collectors, however, it is preferred if the data is collected when the water level in the reservoir is as close to normal pool elevation as possible. If resources and time allow, a second lateral data collection should occur during the second year of sampling.

- Chemical parameters: total phosphorus, total dissolved phosphorus, orthophosphorus, ammonia, TKN, nitrite & nitrate, BOD5, total solids, total suspended solids, turbidity. Biological Parameters: chlorophyll a. All chemical and biological parameters should be taken from the photic zone, i.e. twice the secchi depth.

Cross Sections.

Measure the bathymetry at every location located on the included map. There are ten (10) cross sections shown, one at every station (See Figure 1). If resources and time are scarce, then the cross-section measurement at Beaverdam Lake should not be performed. Cross-sectional data should be taken during the first year and as close to normal pool elevation as possible. Notes describing the lake bottom should be recorded at each of the cross sections (e.g. rocky, sandy, muddy, tree stumps).

Phytoplankton Data.

Phytoplankton assemblages at four sites should be assessed for structure (i.e. taxa identification and dominance), density and biovolume. Assemblages should be assessed three times a year, once during spring (i.e. March or April), once during summer(i.e. July or August) and once during fall (i.e. October or November) for a total of six (6) sampling events. The four sites selected for assessment are: NEU013, NEU018E, NEU019P and Beaverdam Lake NEU019C. A total of twelve samples should be analyzed per year and a total of twenty four samples analyzed for the 22-month study.

Continuous Temperature Data.

Using the temperature thermistors, continuous temperature should be measured at three stations using a total of 13 thermistors. Table 1 shows a summary of requested thermistor sampling.

Table 1. Summary of Thermistor Sampling

Station	Number of Thermistor at Station	Depths to Place Thermistors (meters)
NEU010	3	1,3,5
NEU018E	4	1,3,5,7
NEU020D	6	1,3,5,7,9,11

Thermistors should be set to record temperature every two hours and should be deployed for the entire scoping period from March 2005 to December 2006. If resources are lacking for this schedule, monitoring should be conducted for a minimum of 10 weeks. It is suggested that the thermistors initially be deployed for a 1-week period after which field staff can retrieve the devices and record the data. Field staff can then evaluate the success of the field method prior to obtaining additional weeks of data.

Sediment Oxygen Demand and Nutrient Flux.

Sediment oxygen demand (SOD) and nutrient flux should be measured at four different locations on two separate occasions. The stations where SOD and nutrient flux should be measured are: NEU013, NEU018E, NEU019P, and Beaverdam Lake (NEU019C). These sites should be sampled once each in the summer of each year. Total number of sediment samples to be analyzed: 8.

Table 2. Summary of lake samples for scoping study

Media	Type of analyses	No. of sites	No. of sampling events over period	No. of samples to be processed
Surface water	All chemical parameters listed above	10	48	480
	Physicals	10	48	480
	Cross-sections & Lateral Physicals	9(10)	1	N/A
	Algae	4	6	24
	Continuous Temperature	3	Continuous, 13 *in-situ* Tidbits	N/A
Sediment	SOD	4	2	8
	Benthic nutrient flux (TN and TP)	4	2	8

Watershed Monitoring

This section includes monitoring plans for both the ambient program and Intensive Survey. There are no monitoring coalition stations within this watershed to assist with study development.

Ambient:

Duration. March 2005 to December 2006

Frequency. The minimum monitoring frequency for all stations is two times per month, with 10 to 14 days between events, for the desired parameters. If resources allow, a more ambitious weekly monitoring program should be pursued. Number of sampling events per year: 20 in 2005, 24 in 2006.

Spatial coverage. The following stations should have this enhanced monitoring: J0770000 (Eno River @ US 501 nr Durham), J0820000 (Little River @ SR1461 nr Durham), J1100000 (Flat River @ SR1004 nr Willardsville), J1210000 (Knap of Reeds Creek at WWTP Outfall nr Butner), J1330000 (Ellerbee Creek @ SR1636 nr Durham), and J1890000 (Neuse River @ SR2000 nr Falls). Figure 2 shows the locations of these stations. Total number of stations: 6

Parameters. The following parameters should be included in the enhanced monitoring: nitrogen series (ammonia-nitrogen, nitrate/nitrite-nitrogen, TKN-nitrogen), total phosphorus, and TSS. This enhanced monitoring should not replace standard ambient monitoring including physicals and metals.

Intensive Survey (or Ambient Monitoring)

Duration. March 2005 to December 2006

Frequency. The monitoring frequency for all tributary chemical stations is once every two months, as close to every other month as possible. If resources are not available for an every-other-month schedule, quarterly is acceptable.

Spatial coverage. The following stations should be monitored: Little Lick Creek at Fletcher Chapel Road, Lick Creek at Kemp Road, Ledge Creek at Peed Road, Beaverdam Creek at Horseshoe Road, and if resources allow, Horse Creek at Thomson Mill Road. Note that EEP will also be conducting a special study on Little Lick Creek. Thus, monitoring may be accomplished using a combination of resources. Total number of stations: 4(5)

Parameters. The following chemical parameters should be included: physicals (i.e., DO, pH, temperature, conductivity), nitrogen series (ammonia-nitrogen, nitrate/nitrite-nitrogen, TKN-nitrogen), total phosphorus, and TSS. Cross-section and flow information should also be collected at each site.

Hydrology. For the Knap of Reeds Creek site, establish a rating curve. This curve can then be utilized by the ambient monitoring staff, increasing the data available for this watershed. The minimum monitoring frequency for Knap of Reeds Creek (J1210000) velocity and flow is monthly. If resources allow, install a pressure transducer to measure continuous stage at this location.

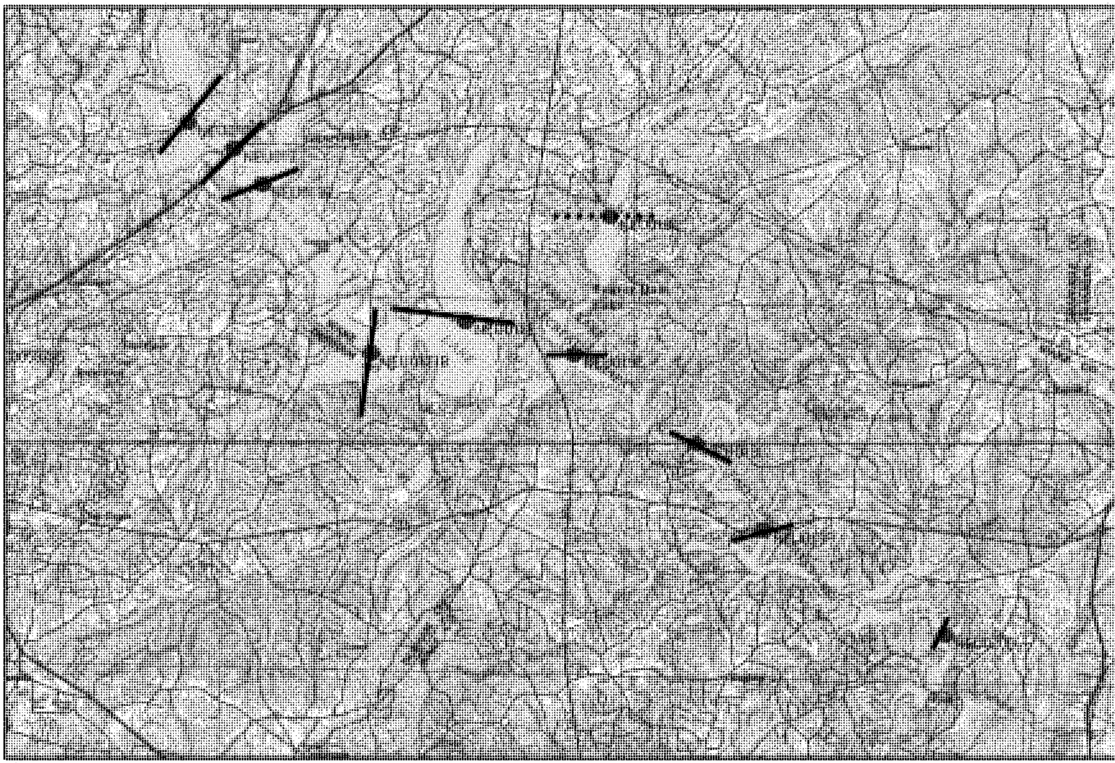

Figure 1. Falls of the Neuse Reservoir with locations of sampling sites.

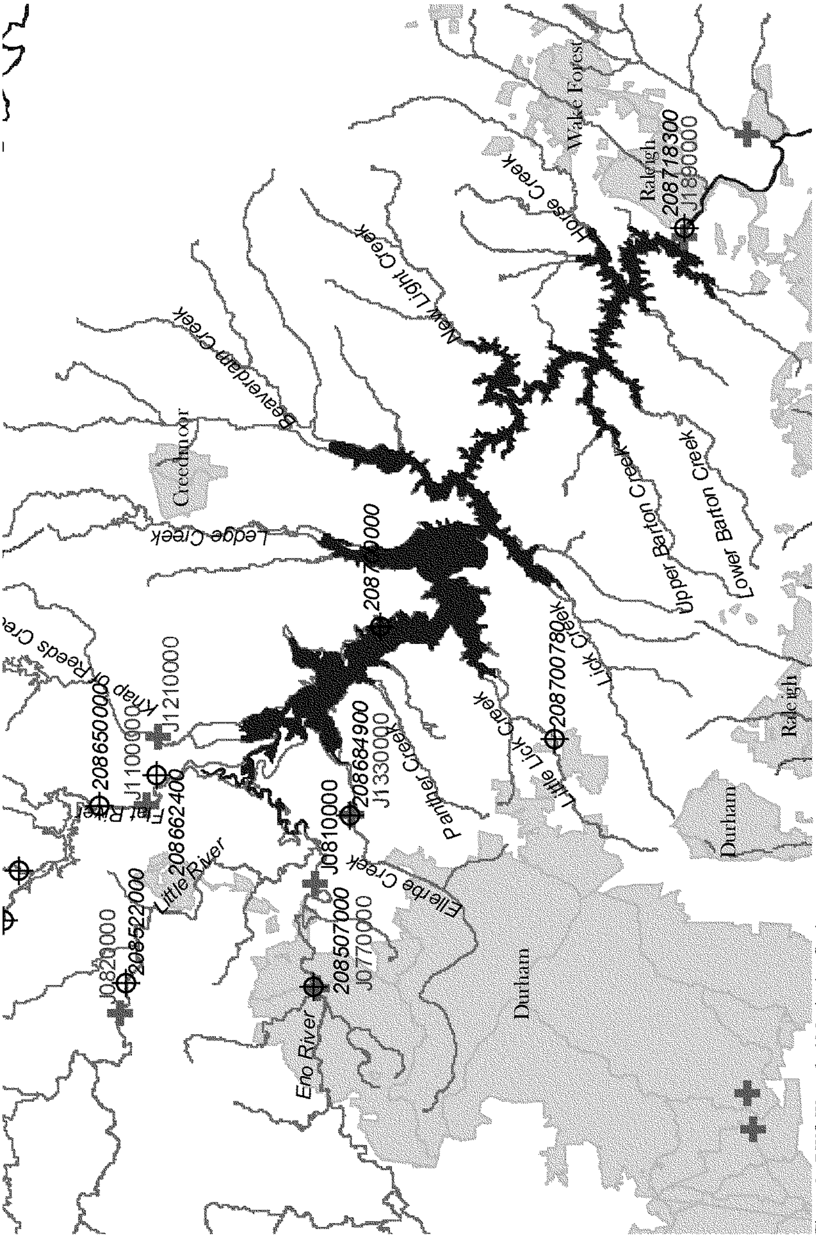

Figure 2. DWQ Watershed Monitoring Stations.

7

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
15-25-10	**The Big Narrows**	From Jinks Creek to Intracoastal Waterway	SA;HQW	03-07-59	13.4 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Closed Growing Area	2006	2006	5cs
15-25-2-11-(2)	**The Mill Pond**	From a point 1.0 mile below Brunswick County SR 1145 to Shallotte River	SA;HQW	03-07-59	2.8 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2006	5cs
15-25-2-14	**The Swash**	From source to Shallotte River	SA;HQW	03-07-59	3.9 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2006	5cs
Neuse River Basin								**Pamlico Sound**	**8-Digit Subbasin**	**03020105**		
27-149-1-3	**Barry Bay**	From source to Thorofare Bay	SA;ORW,NSW	03-04-14	606.6 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
27-149-4-1	**Great Pond**	From source to Cedar Island Bay	SA;ORW,NSW	03-04-14	3.0 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-149-1-2	**Merkle Hammock Creek**	From source to Thorofare Bay	SA;NSW,ORW	03-04-14	186.0 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
27-149-1-1	**Thorofare**	From West Thorofare Bay to Thorofare Bay	SA;HQW,NSW	03-04-14	34.9 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-149-1	**Thorofare Bay**	From source to Core Sound	SA;ORW,NSW	03-04-14	1,674.5 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
Neuse River Basin								**Upper Neuse River**	**8-Digit Subbasin**	**03020201**		
27-33-5	**Black Creek**	From source to Crabtree Lake, Crabtree Cr.	C;NSW	03-04-02	3.6 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-45-(2)	**Black Creek**	From dam at Panther Lake to mouth of Sassarixa Creek	C;NSW	03-04-04	22.6 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
27-33-4	**Brier Creek**	From source to Crabtree Lake, Crabtree Cr.	C;NSW	03-04-02	6.5 FW Miles	Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
27-57-16-(2)	**Buffalo Creek**	From dam at Robertsons Pond to a point 200 feet upstream from West Haywood Street near Wendell	B;NSW	03-04-06	5.8 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
27-33-(1)	**Crabtree Creek**	From source to backwaters of Crabtree Lake	C;NSW	03-04-02	5.1 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
27-33-(10)a	**Crabtree Creek**	From mouth of Richlands Creek to Hairsnipe Creek	C;NSW	03-04-02	2.0 FW Miles	Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
27-33-(10)b	**Crabtree Creek**	From mouth of Hairsnipe Creek to 2.75 miles upstream of Neuse River	C;NSW	03-04-02	10.9 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2004	5
						Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	4s
						Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
27-33-(10)c	**Crabtree Creek**	From 2.75 miles upstream of Neuse River to Neuse River	C;NSW	03-04-02	2.8 FW Miles	Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
27-33-(3.5)a	**Crabtree Creek (Crabtree Lake)**	From backwaters of Crabtree Lake to Cary WWTP	B;NSW	03-04-02	6.8 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
						Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	1994	1998	4s
						Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
27-33-(3.5)b	**Crabtree Creek (Crabtree Lake)**	From Cary WWTP to mouth of Richlands Creek	B;NSW	03-04-02	5.4 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	1998	5
						Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-5-(0.3)	**Ellerbe Creek**	From source to I-85 Bridge	C;NSW	03-04-01	6.1 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity FishCom	2005	1998	5
27-5-(0.7)	**Ellerbe Creek**	From I-85 Bridge to a point 0.2 mile upstream of Durham County SR 1636	WS-IV;NSW	03-04-01	5.9 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity FishCom	2005	1998	5
27-5-(2)	**Ellerbe Creek**	From a point 0.2 mile upstream of Durham County SR 1636 to Falls Lake, Neuse River	WS-IV;NSW,CA	03-04-01	0.5 FW Miles	Aquatic Life	Impaired	Standard Violation	Zinc	2008	2008	5
						Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2000	1998	4s
27-3-(8)	**Flat River**	From dam at Lake Michie to a point 0.2 miles upstream of Durham County SR 1004	WS-IV;NSW	03-04-01	1.1 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
27-3-(9)	**Flat River (including the Flat River Arm of Falls Lake)**	From a point 0.2 miles upstream of Durham County SR 1004 to Falls Lake, Neuse River	WS-IV;NSW,CA	03-04-01	0.6 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
27-52-6a	**Hannah Creek**	From source to NC 96	C;NSW	03-04-04	10.3 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2004	5
						Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	2008	4s
27-33-12-(2)	**Hare Snipe Creek**	From dam at Lake Lynn to Crabtree Creek	C;NSW	03-04-02	2.5 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5
27-33-12-(1)	**Hare Snipe Creek (Lake Lynn)**	From source to dam at Lake Lynn	B;NSW	03-04-02	2.0 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5
27-4-(6)	**Knap of Reeds Creek**	From dam at Lake Butner to a point 1.9 miles downstream of Granville County SR 1120	WS-IV;NSW	03-04-01	5.6 FW Miles	Aquatic Life	Impaired	Standard Violation	Zinc	2008	2008	5
						Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2004	1998	4c
27-4-(8)	**Knap of Reeds Creek**	From a point 1.9 miles downstream of Granville County SR 1120 to Falls Lake, Neuse River	WS-IV;NSW,CA	03-04-01	0.6 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2004	1998	5

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-11-(0.5)		**Lick Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5
From source to Wake County SR 1809									
WS-IV;NSW	03-04-01	6.5 FW Miles							
27-11-(1.5)		**Lick Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2000	2004	5
From Wake County SR 1809 to Falls Lake, Neuse River									
WS-IV;NSW,CA	03-04-01	0.7 FW Miles							
27-33-4-1		**Little Brier Creek**	Fish Consumption	Impaired	Standard Violation	PCB	2006	2008	5
From source to Brier Creek									
C;NSW	03-04-02	5.3 FW Miles							
27-43-12		**Little Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From source to Swift Creek									
C;NSW	03-04-02	11.4 FW Miles							
27-9-(0.5)		**Little Lick Creek**	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	1998	5
From source to a point 0.4 mile upstream of Durham County SR 1811			Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
WS-IV;NSW	03-04-01	7.2 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	4s
27-9-(2)		**Little Lick Creek (including portion of Little Lick Creek Arm of Falls Lake)**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	4s
From a point 0.4 mile upstream of Durham SR 1811 to Falls Lake, Neuse River			Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
WS-IV;NSW,CA	03-04-01	0.6 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
27-57-(1)b		**Little River (Moores Pond, Mitchell Mill Pond)**	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
From Big Branch to 0.2 miles upstream of Wake County SR 2368									
WS-II;HQW,NSW	03-04-06	2.9 FW Miles							
27-33-20		**Marsh Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From source to Crabtree Creek									
C;NSW	03-04-02	6.0 FW Miles							
27-43-15-(1)b1		**Middle Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	2008	5
From 0.8 miles south of US 1 to ut on west of creek 3.0 miles downstream									
C;NSW	03-04-03	3.0 FW Miles							

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-43-15-(4)a1	**Middle Creek**	From dam at Sunset Lake to small impoundment upstream of US 401	C;NSW	03-04-03	4.5 FW Miles	Aquatic Life	Impaired	Standard Violation	Zinc	2008	2008	4b
						Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
27-33-14a	**Mine Creek**	From source to Shelly Lake	C;NSW	03-04-02	3.3 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	1995	1998	5
27-33-14b	**Mine Creek**	FromShelly Lake to Crabtree Creek	C;NSW	03-04-02	1.5 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5
27-(36)	**NEUSE RIVER**	From mouth of Beddingfield Creek to a point 0.2 mile downstream of Johnston County SR 1700	WS-V;NSW	03-04-02	4.3 FW Miles	Aquatic Life	Impaired	Standard Violation	Zinc	2008	2008	5
						Aquatic Life	Impaired	Standard Violation	Copper	2008	2008	5
27-(38.5)	**NEUSE RIVER**	From a point 0.2 mile downstream of Johnston County SR 1700 to point 1.4 mile downstream of Johnston County SR 1908	WS-IV;NSW	03-04-02	9.7 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
27-(41.7)	**NEUSE RIVER**	From City of Smithfield water supply intake to a point 1.7 miles upstream of Bawdy Creek	WS-V;NSW	03-04-02	26.2 FW Miles	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
27-(56)a	**NEUSE RIVER**	From City of Goldsboro water supply intake to subhasin 030405-030412 boundary	C;NSW	03-04-12	5.8 FW Miles	Fish Consumption	Impaired	Standard Violation	Mercury	2004	2004	5
27-(56)b	**NEUSE RIVER**	From subbasin 030405-030412 boundary to a point 0.7 mile downstream of the mouth of Coxes Creek.	C;NSW	03-04-05	21.5 FW Miles	Fish Consumption	Impaired	Standard Violation	Mercury	2004	2004	5
27-(1)	**NEUSE RIVER (Falls Lake below normal pool elevation)**	From source (confluence of Eno River Arm of Falls Lake and Flat River Arm of Falls Lake) to I-85 bridge	WS-IV;NSW,CA	03-04-01	2,703.6 FW Acres	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
						Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2008	5

All NC Waters are in Category 5 due to statewide Fish Consumption Advice for Mercury Category 5 Assessments require TMDL development per Clean Water Act Section 303(d)

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-(5.5)		**NEUSE RIVER (Falls Lake below normal pool elevation)**	Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2008	5
From I-85 bridge to Dam									
WS-IV,B;NSW,CA	03-04-01	9,530.3 FW Acres							
27-25-(2)		**Perry Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From dam at Greshams Lake to Neuse River									
C;NSW	03-04-02	2.5 FW Miles							
27-25-(1)		**Perry Creek (Greshams Lake)**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	1996	1998	5
From source to dam at Greshams Lake									
B;NSW	03-04-02	2.4 FW Miles							
27-33-18		**Pigeon House Branch**	Aquatic Life	Impaired	Standard Violation	Zinc	2008	2008	5
From source to Crabtree Creek			Aquatic Life	Impaired	Standard Violation	Copper	2008		4a
C;NSW	03-04-02	2.9 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2000	1998	4s
			Recreation	Impaired	Standard Violation	Fecal Coliform (recreation)	2006	1998	4a
27-33-8		**Reedys Creek (Reedy Creek Lake)**	Aquatic Life	Impaired	Data Inconclusive	Aquatic Weeds	1998	1998	5
From source to Crabtree Creek									
B;NSW	03-04-02	28.8 FW Acres							
27-33-11		**Richlands Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	1996	2004	5
From source to Crabtree Creek									
C;NSW	03-04-02	4.7 FW Miles							
27-23-(2)		**Smith Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity FishCom	2005	2008	5
From dam at Wake Forest Reservoir to Neuse River									
C;NSW	03-04-02	5.8 FW Miles							
27-43-(1)a		**Swift Creek**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	1989	1998	5
From source to confluence with Williams Creek									
WS-III;NSW	03-04-02	2.6 FW Miles							
27-43-(1)b		**Swift Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2001	1998	5
From confluence with Williams Creek to backwaters of Lake Wheeler									
WS-III;NSW	03-04-02	5.5 FW Miles							

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-43-(1)d		**Swift Creek**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2004	2008	5
From Lake Wheeler Dam to a point 0.6 mile upstream of Wake County SR 1006									
WS-III;NSW	03-04-02	2.4 FW Miles							
27-43-(5.5)a		**Swift Creek (Lake Benson)**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2004	2008	5
From a point 0.6 mile upstream of Wake County SR 1006 to backwaters of Lake Benson									
WS-III;NSW,CA	03-04-02	0.9 FW Miles							
27-33-9		**Sycamore Creek (Big Lake)**	Aquatic Life	Impaired	Data Inconclusive	Aquatic Weeds	1998	1998	5
From source to Crabtree Creek									
B;NSW	03-04-02	61.8 FW Acres							
27-24a1		**Toms Creek (Mill Creek)**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From source to Browns Lake									
C;NSW	03-04-02	1.6 FW Miles							
27-24b		**Toms Creek (Mill Creek)**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From Browns Lake to Neuse River									
C;NSW	03-04-02	1.5 FW Miles							
27-15-(1)		**Upper Barton Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	2008	5
From source to a point 0.5 mile upstream of Wake County SR 1844									
WS-IV;NSW	03-04-01	4.9 FW Miles							
27-9-(0.5)ut2		**UT2 to Little Lick Creek**	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
From source to Little Lick Creek									
WS-IV;NSW	03-04-01	2.4 FW Miles							
27-9-(2)ut2		**UT2 to Little Lick Creek (including portion of Little Lick Creek Arm of Falls Lake)**	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
From a source to Falls Lake Little Lick Creek									
WS-IV;NSW,CA	03-04-01	0.9 FW Miles							
27-34-(1.7)		**Walnut Creek**	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity FishCom	1995	1998	5
From dam at Lake Johnson to backwaters of Lake Raleigh									
C;NSW	03-04-02	1.4 FW Miles							
27-34-(4)a		**Walnut Creek**	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
From dam at Lake Raleigh to UT 0.6 miles west of I-440									
C;NSW	03-04-02	6.4 FW Miles							

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Assessment Unit Number / Name / Description / Classification / Old DWQ Subbasin / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-34-(4)b **Walnut Creek** From UT 0.6 miles west of I-440 to Neuse River C;NSW 03-04-02 3.7 FW Miles	Aquatic Life	Impaired	Standard Violation	Copper	2008	2008	5
	Aquatic Life	Impaired	Standard Violation	Turbidity	2006	2008	5
27-43-2 **Williams Creek** From source to Swift Creek WS-III;NSW 03-04-02 2.6 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	1989	1998	5

Neuse River Basin — Middle Neuse River 8-Digit Subbasin 03020202

Assessment Unit Number / Name / Description / Classification / Old DWQ Subbasin / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-72-(0.1) **Bear Creek** From source to a point 0.3 mile downstream of Lenoir County SR 1002 C;Sw,NSW 03-04-05 12.4 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	2008	5
27-97-5a **Clayroot Swamp** From source to SR 1925 C;Sw,NSW 03-04-09 9.5 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2001	1998	5
27-90a2 **Core Creek** From upstream crossing of SR 1239 to Grape Creek C;Sw,NSW 03-04-08 3.0 FW Miles	Aquatic Life	Impaired	Severe Bioclassification	Ecological/biological Integrity Benthos	2004	2008	5
27-(75.7)b **NEUSE RIVER** From Stoneyton Creek to mouth of Contentnea Creek C;NSW 03-04-05 6.5 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
27-(96)b1 **NEUSE RIVER Estuary** From Bachelor Creek to the Trent River (River and part of Upper Model segment) SC;Sw,NSW 03-04-10 2,363.1 S Acres	Aquatic Life	Impaired	Standard Violation	Copper	2008	2008	5
27-(96)b2 **NEUSE RIVER Estuary** From Trent River to a line across Neuse River from Johnson Point to McCotter Point (part of upper model segment) SC;Sw,NSW 03-04-10 3,473.6 S Acres	Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2004	4a
27-62 **Stoney Creek** From source to Neuse River C;NSW 03-04-05 10.7 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5

Neuse River Basin — Middle Neuse River — 8-Digit Subbasin 03020202

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-97-(0.5)a1	**Swift Creek**	From source to 5.3 miles upstream of Clayroot Swamp	C;Sw,NSW	03-04-09	19.3 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	1995	1998	5
27-97-(0.5)b	**Swift Creek**	From Clayroot Swamp to mouth of Bear Branch	C;Sw,NSW	03-04-09	14.4 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
27-97-(6)	**Swift Creek**	From mouth of Bear Branch to Neuse River	SC;Sw,NSW	03-04-09	48.6 S Acres	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
27-68	**Walnut Creek (Lake Wackena, Spring Lake)**	From source to Neuse River	C;NSW	03-04-05	6.9 FW Miles	Aquatic Life	Not Rated	Data Inconclusive	Aquatic Weeds	1998	1998	4a

Neuse River Basin — Contentnea Creek — 8-Digit Subbasin 03020203

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-86-(1)a	**Contentnea Cr (Buckhorn Reservoir)**	Buckhorn Reservoir	WS-V;NSW	03-04-07	758.2 FW Acres	Aquatic Life	Not Rated	Data Inconclusive	Low Dissolved Oxygen	1998	1998	4a
27-86-(7)b1	**Contentnea Creek**	0.7 miles upstream of Toisnot Swamp to Nahunta Swamp	C;Sw,NSW	03-04-07	15.1 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2002	2008	5
27-86-8	**Hominy Swamp**	From source to Contentnea Creek	C;Sw,NSW	03-04-07	9.9 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2001	2004	5
27-86-26	**Little Contentnea Creek**	From source to Contentnea Creek	C;Sw,NSW	03-04-07	34.9 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2005	1998	5
27-86-2	**Moccasin Creek (Bunn Lake)**	From source to Contentnea Creek	C;NSW	03-04-07	22.8 FW Miles	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5

Assessment Unit Number / Description / Classification, Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-86-3-(1)a2	**Turkey Creek**	Aquatic Life	Impaired	Standard Violation	Low Dissolved Oxygen	2006	2008	5
From Old Middlesex Road to SR 1101								
C;NSW 03-04-07	2.0 FW Miles							
Neuse River Basin				**Lower Neuse River 8-Digit Subbasin**	**03020204**			
27-137-5	**Abraham Bay**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
From source to Turnagain Bay								
SA;HQW,NSW 03-04-10	96.9 S Acres							
27-128c	**Adams Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
DEH conditionally approved-closed area from source to a line crossing Adams Creek at a point 406 meters south of mouth of Kellum Creek to a point 637 meters north of mouth of Beck Creek								
SA;HQW,NSW 03-04-10	317.0 S Acres							
27-128-1a	**Adams Creek Canal (Intracoastal Waterway)**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Closed Growing Area	2006	2004	5cs
From the White Oak River Basin Boundary 0.4 miles north of boundary								
SA;HQW,NSW 03-04-10	12.5 S Acres							
27-128-1h	**Adams Creek Canal (Intracoastal Waterway)**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From 0.4 miles north of White Oak River Basin Boundary to Adams Creek								
SA;HQW,NSW 03-04-10	126.3 S Acres							
99-(5)	**Atlantic Ocean**	Fish Consumption	Impaired	Standard Violation	Mercury	2000	2000	5
From Drum Inlet to Ocracoke Inlet								
SB;NSW 03-04-14	18.6 Coast Miles							
27-128-3a	**Back Creek (Black Creek)**	Recreation	Impaired	Standard Violation	Fecal Coliform (recreation)	2006	2008	5
From source to Adams Creek excluding swimming area near mouth		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
SA;HQW,NSW 03-04-10	259.5 S Acres							
27-128-3b	**Back Creek (Black Creek)**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
Swimming area near mouth								
SA;HQW,NSW 03-04-10	2.1 S Acres							
27-150-20a	**Ball Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to 0.1 miles upstream of Pasture Creek								
SA;HQW,NSW 03-04-13	32.4 S Acres							

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-150-(9.5)a1		**Bay River**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From 27-150-(9.5)b to a line crossing the Bay River from Newton Creek to a point 0.3 miles upstream of Moore Creek									
SA;HQW,NSW	03-04-13	672.0 S Acres							
27-150-(9.5)b1		**Bay River**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
DEH closed extending 366 meters east of SC SA line									
SA;HQW,NSW	03-04-13	100.0 S Acres							
27-150-(9.5)b2		**Bay River**	Recreation	Impaired	Loss of Use	Recreation Advisory	2006	2004	4cr
DEH prohibited area along shore of Log Pond Creek area.			Recreation	Impaired	Standard Violation	Enterrococcus	2006	2008	5
SA;HQW,NSW	03-04-13	16.5 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-150-28a		**Bear Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to DEH prohibited area line 42 meters south of confluence with Bennett Creek									
SA;HQW,NSW	03-04-13	199.9 S Acres							
27-150-28b1		**Bear Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From DEH prohibited area line 42 meters south of confluence with Bennet Creek to Plum Creek									
SA;HQW,NSW	03-04-13	18.2 S Acres							
27-101-15		**Beaver Creek**	Aquatic Life	Impaired	Severe Bioclassification	Ecological/biological Integrity Benthos	2000	1998	5
From source to Trent River									
C;Sw,NSW	03-04-11	12.3 FW Miles							
27-150-28-1		**Bennett Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Bear Creek									
SA;HQW,NSW	03-04-13	15.7 S Acres							
27-123-4-1		**Big Branch**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Mitchell Creek									
SA;HQW,NSW	03-04-10	1.6 S Acres							
27-135-17a		**Big Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to DEH prohibited area line									
SA;HQW,NSW	03-04-10	59.6 S Acres							

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-135-17b		**Big Creek**		Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From DEH prohibited area line to South River										
SA;HQW,NSW	03-04-10		58.4 S Acres							
27-137-2		**Big Gut**		Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to Turnagain Bay										
SA;HQW,NSW	03-04-10		70.0 S Acres							
27-152-3		**Bills Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Jones Bay										
SA;HQW,NSW	03-04-13		8.1 S Acres							
27-134-1		**Bright Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Orchard Creek										
SA;HQW,NSW	03-04-10		10.9 S Acres							
27-137-4		**Broad Creek**		Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to Turnagain Bay										
SA;HQW,NSW	03-04-10		49.2 S Acres							
27-141a		**Broad Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to a line across Broad Creek from a point 331 meters east of mouth of Browns Creek to a point 145 meters east of mouth of Tar Creek										
SA;HQW,NSW	03-04-10		202.3 S Acres							
27-141-3		**Brown Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Broad Creek										
SA;HQW,NSW	03-04-10		122.4 S Acres							
27-135-7		**Buck Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River										
SA;HQW,NSW	03-04-10		6.4 S Acres							
27-150-12-1		**Chappel Creek**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Moore Creek										
SA;HQW,NSW	03-04-13		1.5 S Acres							
27-119		**Cherry Branch**		Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Neuse River										
SA;HQW,NSW	03-04-10		7.3 S Acres							

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Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-123		**Clubfoot Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Neuse River									
SA;HQW,NSW	03-04-10	562.6 S Acres							
27-135-13		**Coffee Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	6.1 S Acres							
27-141-3-2		**Coffee Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Brown Creek									
SA;HQW,NSW	03-04-10	7.1 S Acres							
27-125-(6)a		**Dawson Creek**	Recreation	Impaired	Standard Violation	Enterrococcus	2006	2008	5
From mouth of Tarkiln Creek to 0.03 miles upstream of Neuse River			Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2008	5cs
SA;HQW,NSW	03-04-10	121.2 S Acres							
27-137-3		**Deep Gut**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to Turnagain Bay									
SA;HQW,NSW	03-04-10	51.0 S Acres							
27-135-14		**Dixon Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	2.3 S Acres							
27-135-8		**Doe Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	4.9 S Acres							
27-135-6		**Duck Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	2.6 S Acres							
27-128-7a		**Dumpling Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to 0.1 miles upstream of Adams Creek									
SA;HQW,NSW	03-04-10	20.0 S Acres							
27-135-2		**East Fork South River**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	14.3 S Acres							

Assessment Unit Number / Description / Classification	Old DWQ Subbasin	Name / Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-123-2-2		**East Prong Mortons Mill Pond**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Mortons Mill Pond									
SA;HQW,NSW	03-04-10	3.3 S Acres							
27-135-10		**Eastman Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	95.6 S Acres							
27-135-4		**Elisha Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	2.2 S Acres							
27-125-2		**Fork Run**	Aquatic Life	Impaired	Severe Bioclassification	Ecological/biological Integrity Benthos	2005	2008	5
From source to Dawson Creek									
SC;NSW	03-04-10	15.8 S Acres							
27-150-31a		**Gale Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to DEH prohibited area line on west side of ICWW									
SA;HQW,NSW	03-04-13	29.4 S Acres							
27-150-31b1		**Gale Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From DEH prohibited area line on west side to new prohibited area line 0.25 miles west of ICWW									
SA;HQW,NSW	03-04-13	16.7 S Acres							
27-141-2		**Gideon Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Broad Creek									
SA;HQW,NSW	03-04-10	26.0 S Acres							
27-148-1-2		**Golden Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Long Bay									
SA;HQW,NSW	03-04-14	9.7 S Acres							
27-123-3		**Gulden Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Clubfoot Creek									
SA;HQW,NSW	03-04-10	34.9 S Acres							
27-135-18		**Hardy Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	24.2 S Acres							

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27-123-1		**Harlowe Canal**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From White Oak River Basin Boundary (Craven-Carteret County Line) to Clubfoot Creek									
SA;HQW,NSW	03-04-10	3.9 S Acres							
27-150-10		**Harper Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Bay River									
SA;HQW,NSW	03-04-13	32.5 S Acres							
27-152-2		**Henry Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Jones Bay									
SA;HQW,NSW	03-04-13	1.5 S Acres							
27-135-19		**Horton Bay**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	101.3 S Acres							
27-150-31-1a		**Intracoastal Waterway**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
Prohibited area at head of Jones Bay									
SA;HQW,NSW	03-04-13	2.0 S Acres							
27-152-1		**Intracoastal Waterway**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From N. C. Hwy 304 Bridge to Jones Bay									
SA;HQW,NSW	03-04-13	7.0 S Acres							
27-128-2		**Isaac Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Adams Creek									
SA;HQW,NSW	03-04-10	39.1 S Acres							
27-128-1.5		**Jerry Bay**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Adams Creek									
SA;HQW,NSW	03-04-10	52.2 S Acres							
27-152a		**Jones Bay**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to 0.2 miles downstream of ICWW									
SA;HQW,NSW	03-04-13	17.3 S Acres							
27-128-4		**Kearney Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Adams Creek									
SA;HQW,NSW	03-04-10	4.0 S Acres							

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27-135-11		**Little Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	6.2 S Acres							
27-135-3		**Miry Gut**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	0.1 S Acres							
27-123-4		**Mitchell Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Clubfoot Creek									
SA;HQW,NSW	03-04-10	117.5 S Acres							
27-150-12		**Moore Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Bay River									
SA;HQW,NSW	03-04-13	28.3 S Acres							
27-123-2		**Mortons Mill Pond**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Clubfoot Creek									
SA;HQW,NSW	03-04-10	30.6 S Acres							
27-135-16		**Mulberry Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	6.4 S Acres							
27-137-7		**Mulberry Point Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to Turnagain Bay									
SA;HQW,NSW	03-04-10	15.7 S Acres							
27-101-17		**Musselshell Creek**	Aquatic Life	Impaired	Severe Bioclassification	Ecological/biological Integrity Benthos	2005	2008	5
From souce to Trent River									
C;Sw,NSW	03-04-11	5.8 FW Miles							
27-135-5		**Neal Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	2.9 S Acres							
27-150-3-1		**Neal Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to South Prong Bay River									
SC;Sw,NSW	03-04-13	1.3 S Acres							

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27-(104)a	NEUSE RIVER Estuary	From a line across Neuse River from Johnson Point to McCotter Point to a line across Neuse River from 1.2 miles upstream of Slocum Creek to 0.5 miles upstream of Beard Creek (middle model segment)	SB;Sw,NSW	03-04-10	13,736.0 S Acres	Aquatic Life	Impaired	Standard Violation	Copper	2008	2008	5
						Aquatic Life	Impaired	Standard Violation	High pH	2006	2008	5
						Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2004	4a
27-(104)b	NEUSE RIVER Estuary	From a line across Neuse River from 1.2 miles upstream of Slocum Creek to 0.5 miles upstream of Beard Creek to a line across Neuse River from Wilkinson Point to Cherry Point (bend model segment)	SB;Sw,NSW	03-04-10	10,756.9 S Acres	Aquatic Life	Impaired	Standard Violation	High pH	2006	2008	5
						Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2004	4a
27-(118)a1	NEUSE RIVER Estuary	From a line across Neuse River from Wilkinson Point to Cherry Point to a line across the river From Adams Creek to Wiggins Point (part of lower model segment)	SA;HQW,NSW	03-04-10	17,135.4 S Acres	Aquatic Life	Impaired	Standard Violation	Copper	2008	2008	5
						Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2008	4a
27-(118)b	NEUSE RIVER Estuary	DEH prohibited area at mouth of Clubfoot Creek	SA;HQW,NSW	03-04-10	96.2 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-(118)c	NEUSE RIVER Estuary	DEH prohibited area at mouth of Green Creek	SA;HQW,NSW	03-04-10	61.7 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-(118)e	NEUSE RIVER Estuary	DEH Conditionally approved-open area at mouth of the South River	SA;HQW,NSW	03-04-10	210.0 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
27-(118)f	NEUSE RIVER Estuary	Prohibited area at Cherry Branch Minnesott Ferry Landing south side of river	SA;HQW,NSW	03-04-10	93.5 S Acres	Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2008	4a
						Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-(118)g	NEUSE RIVER Estuary	Prohibited area at mouth of Orchard Creek	SA;HQW,NSW	03-04-10	8.2 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-(118)h	NEUSE RIVER Estuary	Public Beach area at mouth of Dawson Creek	SA;HQW,NSW	03-04-10	1.7 S Acres	Recreation	Impaired	Loss of Use	Recreation Advisory	2006	2008	4cr

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27-(118)a1a		**NEUSE RIVER Estuary at Camp Don Lee**	Aquatic Life	Impaired	Standard Violation	Chlorophyll a	2006	2008	4a
Swim beach at Camp Don Lee			Recreation	Impaired	Standard Violation	Enterococcus	2006	2008	5
SA;HQW,NSW	03-04-10	1.0 S Acres							
27-150-13		**Newton Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Bay River									
SA;HQW,NSW	03-04-13	3.8 S Acres							
27-148-1-6-1a		**Old Canal**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From Turnagain Bay to 0.6 miles towards Stump Bay									
SA;HQW,NSW	03-04-14	6.4 S Acres							
27-135-15		**Old House Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to South River									
SA;HQW,NSW	03-04-10	3.2 S Acres							
27-134a		**Orchard Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to a line crossing Orchard Creek at a point 91 meters south of mouth of Bright Creek to a point 99 meters north of mouth of Pasture Creek									
SA;HQW,NSW	03-04-10	37.1 S Acres							
27-134b		**Orchard Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From a line crossing Orchard Creek at a point 91 meters south of mouth of Bright Creek to a point 99 meters north of mouth of Pasture Creek to Neuse River									
SA;HQW,NSW	03-04-10	20.4 S Acres							
27-147.5c		**PAMLICO SOUND**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
DEH prohibited area at Cedar Island Ferry Harbor in southern portion Pamlico within Neuse River Basin subbasin 030414									
SA;HQW,NSW	03-04-14	12.5 S Acres							
27-137-4-2		**Parsons Creek**	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
From source to Broad Creek									
SA;HQW,NSW	03-04-10	26.7 S Acres							
27-134-2		**Pasture Creek**	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
From source to Orchard Creek									
SA;HQW,NSW	03-04-10	20.3 S Acres							

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27-133a	**Pierce Creek**	From source to 0.04 miles upstream of Neuse River	SA;HQW,NSW	03-04-10	48.9 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-137-4-1	**Pitman Creek**	From source to Broad Creek	SA;HQW,NSW	03-04-10	2.0 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
27-135-2-1	**Rich Island Gut**	From source to East Fork South River	SA;HQW,NSW	03-04-10	0.6 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-135-12	**Royal Creek**	From source to South River	SA;HQW,NSW	03-04-10	10.1 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
27-137-1	**Sanborns Gut**	From source to Trunagain Bay	SA;HQW,NSW	03-04-10	3.7 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
27-122	**Sassafras Branch**	From source to Neuse River	SA;HQW,NSW	03-04-10	6.8 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-141-1	**Ship Creek**	From source to Broad Creek	SA;HQW,NSW	03-04-10	5.4 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-150-20-1	**Simpson Creek**	From source to Ball Creek	SA;HQW,NSW	03-04-13	8.6 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2008	5cs
27-123-4-2	**Snake Branch**	From source to Mitchell Creek	SA;HQW,NSW	03-04-10	5.7 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-150-3	**South Prong Bay River**	From source to Bay River	SC;Sw,NSW	03-04-13	27.4 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs

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27-135a	**South River**	From source to a line crossing the South River at a point 97 meters north of mouth of Southwest Creek to a point 418 meters north of mouth of Doe Creek	SA;HQW,NSW	03-04-10	415.1 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-135b	**South River**	From a line crossing the South River at a point 97 meters north of mouth of Southwest Creek to a point 418 meters north of mouth of Doe Creek t Neuse River	SA;HQW,NSW	03-04-10	2,064.8 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs
27-135-9	**Southwest Creek**	From source to South River	SA;HQW,NSW	03-04-10	151.3 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-141-3-1	**Spice Creek**	From source to Brown Creek	SA;HQW,NSW	03-04-10	4.7 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-141-4	**Tar Creek**	From source to Broad Creek	SA;HQW,NSW	03-04-10	44.3 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-150-11	**Tempe Gut**	From source to Bay River	SA;HQW,NSW	03-04-13	0.9 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-101-(31)b	**Trent River**	From boundary between subbasins 030410 and 030411 to mouth of Brice Creek	SB;Sw,NSW	03-04-10	509.7 S Acres	Aquatic Life	Not Rated	Data Inconclusive	Chlorophyll a	2006	2004	4b
27-101-(39)	**Trent River**	From mouth of Brice Creek to Neuse River	SB;Sw,NSW	03-04-10	500.1 S Acres	Aquatic Life	Not Rated	Data Inconclusive	Chlorophyll a	2006	2004	4b
27-137-6	**Tump Gut**	From source to Tumagain Bay	SA;HQW,NSW	03-04-10	20.9 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2004	5cs

Assessment Unit Number	Name	Description	Classification	Old DWQ Subbasin	Miles/Acres	Use Support Category	Use Support Rating	Reason for Rating	Parameter of Interest	Collection Year	Listing Year	IR Category
27-137	**Turnagain Bay**	From source to Neuse River	SA;HQW,NSW	03-04-10	1,556.8 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Cond Approved-Open Growing Area	2006	2008	5cs
27-135-1	**West Fork South River**	From source to South River	SA;HQW,NSW	03-04-10	35.5 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-123-2-1	**West Prong Mortons Mill Pond**	From source to Mortons Mill Pond	SA;HQW,NSW	03-04-10	8.5 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-148-2a	**West Thorofare Bay**	From source 0.4 miles downstream of source	SA;HQW,NSW	03-04-14	1.8 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-130	**Whittaker Creek**	From source to Neuse River	SA;HQW,NSW	03-04-10	96.1 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
27-150-28-2	**Win Creek**	From source to Bear Creek	SA;HQW,NSW	03-04-13	1.2 S Acres	Shellfish Harvesting	Impaired	Loss of Use	Prohibited Growing Area	2006	2004	5cs
New River Basin								**Upper New River**	**8-Digit Subbasin 05050001**			
10-1-3-(1)	**East Fork South Fork New River**	From source to Watauga County SR 1524	WS-IV;Tr:+	05-07-01	2.3 FW Miles	Aquatic Life	Impaired	Fair Bioclassification	Ecological/biological Integrity Benthos	2003	2008	5
10-1-3-(8)	**East Fork South Fork New River**	From .8 mile downstream of Watauga Co SR 1524 to S Fk New River	WS-IV;CA:+	05-07-01	0.5 FW Miles	Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2003	2008	5
10-2-20-1	**Little Buffalo Creek**	From source to Buffalo Creek	C;Tr:+	05-07-02	4.4 FW Miles	Aquatic Life	Not Rated	Data Inconclusive	Nutrients-Historic Listing	2000	2000	5
						Aquatic Life	Impaired	Poor Bioclassification	Ecological/biological Integrity Benthos	2003	2000	5

All NC Waters are in Category 5 due to statewide Fish Consumption Advice for Mercury   Category 5 Assessments require TMDL development per Clean Water Act Section 303(d)

15A NCAC 2B .0233 has been adopted as published in 14:4 NCR 287-301 as follows:

.0233 NEUSE RIVER BASIN: NUTRIENT SENSITIVE WATERS MANAGEMENT STRATEGY: PROTECTION AND MAINTENANCE OF EXISTING RIPARIAN BUFFERS

The following is the management strategy for maintaining and protecting existing riparian buffers in the Neuse River Basin.

(1) PURPOSE. The purpose of this Rule shall be to protect and preserve existing riparian buffers in the Neuse River Basin to maintain their nutrient removal functions.

(2) DEFINITIONS. For the purpose of this Rule, these terms shall be defined as follows:

(a) 'Channel' means a natural water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water. (current definition in Forest Practice Guidelines Related to Water Quality, 15A NCAC 1I .0102)

(b) 'DBH' means Diameter at Breast Height of a tree, which is measured at 4.5 feet above ground surface level.

(c) 'Ditch or canal' means a man-made channel other than a modified natural stream constructed for drainage purposes that is typically dug through inter-stream divide areas. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent streams.

(d) 'Ephemeral (stormwater) stream' means a feature that carries only stormwater in direct response to precipitation with water flowing only during and shortly after large precipitation events. An ephemeral stream may or may not have a well-defined channel, the aquatic bed is always above the water table, and stormwater runoff is the primary source of water. An ephemeral stream typically lacks the biological, hydrological, and physical characteristics commonly associated with the continuous or intermittent conveyance of water.

(e) 'Forest plantation' means an area of planted trees that may be conifers (pines) or hardwoods. On a plantation, the intended crop trees are planted rather than naturally regenerated from seed on the site, coppice (sprouting), or seed that is blown or carried into the site.

(f) 'High Value Tree' means a tree that meets or exceeds the following standards: for pine species, 14-inch DBH or greater or 18-inch or greater stump diameter; and, for hardwoods and wetland species, 16-inch DBH or greater or 24-inch or greater stump diameter.

(g) 'Intermittent stream' means a well-defined channel that contains water for only part of the year, typically during winter and spring when the aquatic bed is below the water table. The flow may be heavily supplemented by stormwater runoff. An intermittent stream often lacks the biological and hydrological characteristics commonly associated with the conveyance of water.

(h) 'Modified natural stream' means an on-site channelization or relocation of a stream channel and subsequent relocation of the intermittent or perennial flow as evidenced by topographic alterations in the immediate watershed. A modified natural stream must have the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.

(i) 'Perennial stream' means a well-defined channel that contains water year round during a year of normal rainfall with the aquatic bed located below the water table for most of the year. Groundwater is the primary source of water for a perennial stream, but it also carries stormwater runoff. A perennial stream exhibits the typical biological, hydrological, and physical characteristics commonly associated with the continuous conveyance of water.

(j) 'Perennial waterbody' means a natural or man-made basin that stores surface water permanently at depths sufficient to preclude growth of rooted plants, including lakes, ponds, sounds, non-stream estuaries and ocean. For the purpose of the State's riparian buffer protection program, the waterbody must be part of a natural drainageway (i.e., connected by surface flow to a stream).

(k) 'Stream' means a body of concentrated flowing water in a natural low area or natural channel on the land surface.

(l) 'Surface water' means all waters of the state as defined in G.S. 143-212 except underground waters.

(m) 'Tree' means a woody plant with a DBH equal to or exceeding five inches.

(3) APPLICABILITY. This Rule shall apply to 50-foot wide riparian buffers directly adjacent to surface waters in the Neuse River Basin (intermittent streams, perennial streams, lakes, ponds, and estuaries), excluding wetlands. Except as described in Sub-Item (4)(a)(iii) of this Rule, wetlands adjacent to surface waters or within 50 feet of surface waters shall be considered as part of the riparian buffer but are regulated pursuant to 15A NCAC 2H .0506. The riparian buffers protected by this Rule shall be measured pursuant to Item (4) of this Rule. For the purpose of this Rule, a surface water shall be present if the feature is approximately shown on either the most recent version of the soil survey map prepared by the Natural Resources Conservation Service of the United States Department of Agriculture or the most recent version of the 1:24,000 scale (7.5 minute) quadrangle topographic maps prepared by the United States Geologic Survey (USGS). Riparian buffers adjacent to surface waters that do not appear on either of the maps shall not be subject to this Rule. Riparian buffers adjacent to surface waters that appear on the maps shall be subject to this Rule unless one of the following applies.

(a) EXEMPTION WHEN AN ON-SITE DETERMINATION SHOWS THAT SURFACE WATERS ARE NOT PRESENT. When a landowner or other affected party believes that the maps have inaccurately depicted surface waters, he or she shall consult the Division or the appropriate delegated local authority. Upon request, the Division or delegated local authority shall make on-site determinations. Any disputes over on-site determinations shall be referred to the Director in writing. A determination of the Director as to the accuracy or application of the maps is subject to review as provided in Articles 3 and 4 of G. S. 150B. Surface waters that appear on the maps shall not be subject to this Rule if an on-site determination shows that they fall into one of the following categories.

(i) Ditches and manmade conveyances other than modified natural streams unless constructed for navigation or boat access.

(ii) Manmade ponds and lakes that are located outside natural drainage ways.

(iii) Ephemeral (stormwater) streams.

(b) EXEMPTION WHEN EXISTING USES ARE PRESENT AND ONGOING. This Rule shall not apply to portions of the riparian buffer where a use is existing and ongoing according to the following:

(i) A use shall be considered existing if it was present within the riparian buffer as of July 22, 1997. Existing uses shall include, but not be limited to, agriculture, buildings, industrial facilities, commercial areas, transportation facilities, maintained lawns, utility lines and on-site sanitary sewage systems. Ouly the portion of the riparian buffer that contains the footprint of the existing use is exempt from this Rule. Activities necessary to maintain uses are allowed provided that no additional vegetation is removed from Zone 1 except that grazed or trampled by livestock and existing diffuse flow is maintained. Grading and revegetating Zone 2 is allowed provided that the health of the vegetation in Zone 1 is not compromised, the ground is stabilized and existing diffuse flow is maintained.

(ii) At the time an existing use is proposed to be converted to another use, this Rule shall apply. An existing use shall be considered to be converted to another use if any of the following applies:

(A) Impervious surface is added to the riparian buffer in locations where it did not exist previously.

(B) An agricultural operation within the riparian buffer is converted to a non-agricultural use.

(C) A lawn within the riparian buffer ceases to be maintained.

(4) ZONES OF THE RIPARIAN BUFFER. The protected riparian buffer shall have two zones as follows:

(a) Zone 1 shall consist of a vegetated area that is undisturbed except for uses provided for iu Item (6) of this Rule. The location of Zone 1 shall be as follows:

(i) For intermittent and perennial streams, Zone 1 shall begin at the most landward limit of the top of bank or the rooted herbaceous vegetation and extend landward a distance of 30 feet on all sides of the surface water, measured horizontally on a line perpendicular to the surface water.

(ii) For ponds, lakes and reservoirs located within a natural drainage way, Zone 1 shall begin at the most landward limit of the normal water level or the rooted herbaceous vegetation and extend landward a distance of 30 feet, measured horizontally on a line perpendicular to the surface water.

(iii) For surface waters within the 20 Coastal Counties (defined in 15A NCAC 2B .0202) within the jurisdiction of the Division of Coastal Management, Zone 1 shall begin at the most landward limit of the following options, whichever is more restrictive, and extend landward a distance of 30 feet, measured horizontally on a line perpendicular to the surface water:

(A) the normal high water level;

(B) the normal water level; or

(C) the landward limit of coastal wetlands as defined by the Division of Coastal Management.

(b) Zone 2 shall consist of a stable, vegetated area that is undisturbed except for activities and uses provided for in Item (6) of this Rule. Grading and revegetating Zone 2 is allowed provided that the health of the vegetation in Zone 1 is not compromised. Zone 2 shall begin at the outer edge of Zone 1 and extend landward 20 feet as measured horizontally on a line perpendicular to the surface water. The combined width of Zones 1 and 2 shall be 50 feet on all sides of the surface water.

(5) DIFFUSE FLOW REQUIREMENT. Diffuse flow of runoff shall be maintained in the riparian buffer by dispersing concentrated flow and reestablishing vegetation.

(a) Concentrated runoff from new ditches or manmade conveyances shall be converted to diffuse flow before the runoff enters Zone 2 of the riparian buffer.

(b) Periodic corrective action to restore diffuse flow shall be taken if necessary to impede the formation of erosion gullies.

(6)TABLE OF USES. The following chart sets out the uses and their designation under this Rule as exempt, allowable, allowable with mitigation, or prohibited. The requirements for each category are given in Item (7) of this Rule.

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Airport facilities: • Airport facilities that impact equal to or less than 150 linear feet or one-third of an acre of riparian buffer • Airport facilities that impact greater than 150 linear feet or one-third of an acre of riparian buffer		 X	 X	
Archaeological activities	X			
Bridges		X		
Dam maintenance activities	X			

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Drainage ditches, roadside ditches and stormwater outfalls through riparian buffers:				
• Existing drainage ditches, roadside ditches, and stormwater outfalls provided that they are managed to minimize the sediment, nutrients and other pollution that convey to waterbodies	X			
• New drainage ditches, roadside ditches and stormwater outfalls provided that a stormwater management facility is installed to control nitrogen and attenuate flow before the conveyance discharges through the riparian buffer		X		
• New drainage ditches, roadside ditches and stormwater outfalls that do not provide control for nitrogen before discharging through the riparian buffer				X
• Excavation of the streambed in order to bring it to the same elevation as the invert of a ditch				X
Drainage of a pond in a natural drainage way provided that a new riparian buffer that meets the requirements of Items (4) and (5) of this Rule is established adjacent to the new	X			
Driveway crossings of streams and other surface waters subject to this Rule:				
• Driveway crossings on single family residential lots that disturb equal to or less than 25 linear feet or 2,500 square feet of riparian buffer	X			
• Driveway crossings on single family residential lots that disturb greater than 25 linear feet or 2,500 square feet of riparian buffer		X		
• In a subdivision that cumulatively disturb equal to or less than 150 linear feet or one-third of an acre of riparian buffer		X		
• In a subdivision that cumulatively disturb greater than 150 linear feet or one-third of an acre of riparian buffer			X	

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Fences provided that disturbance is minimized and installation does not result in removal of forest vegetation	X			
Forest harvesting - see Item (11) of this Rule				
Fertilizer application:				
• One-time fertilizer application to establish replanted vegetation	X			
• Ongoing fertilizer application				X
Grading and revegetation in Zone 2 only provided that diffuse flow and the health of existing vegetation in Zone 1 is not compromised and disturbed areas are stabilized	X			
Greenway / hiking trails		X		
Historic preservation	X			
Landfills as defined by G.S. 130A-290.				X
Mining activities:				
• Mining activities that are covered by the Mining Act provided that new riparian buffers that meet the requirements of Items (4) and (5) of this Rule are established adjacent to the relocated channels		X		
• Mining activities that are not covered by the Mining Act OR where new riparian buffers that meet the requirements or Items (4) and (5) of this Rule are not established adjacent to the relocated channels			X	
• Wastewater or mining dewatering wells with approved NPDES permit	X			

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Non-electric utility lines:				
• Impacts other than perpendicular crossings in Zone 2 only [3]		X		
• Impacts other than perpendicular crossings in Zone 1 [3]			X	
Non-electric utility line perpendicular crossings of streams and other surface waters snbject to this Rule [3]:				
• Perpendicular crossings that disturb equal to or less than 40 linear feet of riparian buffer with a maintenance corridor equal to or less than 10 feet in width	X			
• Perpendicular crossings that disturb equal to or less than 40 linear feet of riparian buffer with a maintenance corridor greater than 10 feet in width		<u>X</u>		
• Perpendicular crossings that disturb greater than 40 linear feet but equal to or less than 150 linear feet of riparian buffer with a maintenance corridor equal to or less than 10 feet in width		X		
• Perpendicular crossings that disturb greater than 40 linear feet but equal to or less than 150 linear feet of riparian buffer with a maintenance corridor greater than 10 feet in width			X	
• Perpendicular crossings that disturb greater than 150 linear feet of riparian buffer			X	
On-site sanitary sewage systems - new ones that use ground absorption				X
Overhead electric utility lines:				
• Impacts other than perpendicular crossings in Zone 2 only [3]	X			
• Impacts other than perpendicular crossings in Zone 1 [1,2,3]	X			

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Overhead electric utility line perpendicular crossings of streams and other surface waters subject to this Rule [3]: • Perpendicular crossings that disturb equal to or less than 150 linear feet of riparian buffer [1] • Perpendicular crossings that disturb greater than 150 linear feet of riparian buffer [1, 2]	 X	 X		
Periodic maintenance of modified natural streams such as canals and a grassed travelway on one side of the surface water when alternative forms of maintenance access are not practical		X		

[1] Provided that, in Zone 1, all of the following BMPs for overhead utility lines are used. If all of these BMPs are not used, then the overhead utility lines shall require a no practical alternative evaluation by the Division.

- A minimum zone of 10 feet wide immediately adjacent to the water body shall be managed such that only vegetation that poses a hazard or has the potential to grow tall enough to interfere with the line is removed.
- Woody vegetation shall be cleared by hand. No land grubbing or grading is allowed.
- Vegetative root systems shall be left intact to maintain the integrity of the soil. Stumps shall remain where trees are cut.
- Rip rap shall not be used unless it is necessary to stabilize a tower.
- No fertilizer shall be used other than a one-time application to re-establish vegetation.
- Construction activities shall minimize the removal of woody vegetation, the extent of the disturbed area, and the time in which areas remain in a disturbed state.
- Active measures shall be taken after construction and during routine maintenance to ensure diffuse flow of stormwater through the buffer.
- In wetlands, mats shall be utilized to minimize soil disturbance.

[2] Provided that poles or towers shall not be installed within 10 feet of a water body unless the Division completes a no practical alternative evaluation.

[3] Perpendicular crossings are those that intersect the surface water at an angle between 75° and 105°.

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Playground equipment:				
• Playground equipment on single family lots provided that installation and use does not result in removal of vegetation	X			
• Playground equipment installed on lands other than single-family lots or that requires removal of vegetation		X		
Ponds in natural drainage ways, excluding dry ponds:				
• New ponds provided that a riparian buffer that meets the requirements of Items (4) and (5) of this Rule is established adjacent to the pond		X		
• New ponds where a riparian buffer that meets the requirements of Items (4) and (5) of this Rule is NOT established adjacent to the pond			X	
Protection of existing structures, facilities and streambanks when this requires additional disturbance of the riparian buffer or the stream channel		X		
Railroad impacts other than crossings of streams and other surface waters subject to this Rule			X	
Railroad crossings of streams and other surface waters subject to this Rule:				
• Railroad crossings that impact equal to or less than 40 linear feet of riparian buffer	X			
• Railroad crossings that impact greater than 40 linear feet but_equal to or less than 150 linear feet or one-third of an acre of riparian buffer		X		
• Railroad crossings that impact greater than 150 linear feet or one-third of an acre of riparian buffer			X	

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Removal of previous fill or debris provided that diffuse flow is maintained and any vegetation removed is restored	X			
Road impacts other than crossings of streams and other surface waters subject to this Rule			X	
Road crossings of streams and other surface waters subject to this Rule:				
• Road crossings that impact equal to or less than 40 linear feet of riparian buffer	X			
• Road crossings that impact greater than 40 linear feet but equal to or less than 150 linear feet or one-third of an acre of riparian buffer		X		
• Road crossings that impact greater than 150 linear feet or one-third of an acre of riparian buffer			X	
Scientific studies and stream gauging	X			
Stormwater management ponds excluding dry ponds:				
• New stormwater management ponds provided that a riparian buffer that meets the requirements of Items (4) and (5) of this Rule is established adjacent to the pond		X		
• New stormwater management ponds where a riparian buffer that meets the requirements of Items (4) and (5) of this Rule is NOT established adjacent to the pond			X	
Stream restoration	X			
Streambank stabilization		X		

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Temporary roads:				
• Temporary roads that disturb less than or equal to 2,500 square feet provided that vegetation is restored within six months of initial disturbance	X			
• Temporary roads that disturb greater than 2,500 square feet provided that vegetation is restored within six months of initial disturbance		X		
• Temporary roads used for bridge construction or replacement provided that restoration activities, such as soil stabilization and revegetation, are conducted immediately after construction		X		
Temporary sediment and erosion control devices:				
• In Zone 2 only provided that the vegetation in Zone 1 is not compromised and that discharge is released as diffuse flow in accordance with Item (5) of this Rule	X			
• In Zones 1 and 2 to control impacts associated with uses approved by the Division or that have received a variance provided that sediment and erosion control for upland areas is addressed to the maximum extent practical outside the buffer		X		
• In-stream temporary erosion and sediment control measures for work within a stream channel	X			
Underground electric utility lines:				
• Impacts other than perpendicular crossings in Zone 2 only [3]	X			
• Impacts other than perpendicular crossings in Zone 1[3,4]	X			

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Underground electric utility line perpendicular crossings of streams and other surface waters subject to this Rule: [3]				
• Perpendicular crossings that disturb less than or equal to 40 linear feet of riparian buffer [4]	X			
• Perpendicular crossings that disturb greater than 40 linear feet of riparian buffer [4]		X		

[4] Provided that, in Zone 1, all of the following BMPs for underground utility lines are used. If all of these BMPs are not used, then the underground utility line shall require a no practical alternative evaluation by the Division.

- Woody vegetation shall be cleared by hand. No land grubbing or grading is allowed.
- Vegetative root systems shall be left intact to maintain the integrity of the soil. Stumps shall remain, except in the trench, where trees are cut.
- Underground cables shall be installed by vibratory plow or trenching.
- The trench shall be backfilled with the excavated soil material immediately following cable installation.
- No fertilizer shall be used other than a one-time application to re-establish vegetation.
- Construction activities shall minimize the removal of woody vegetation, the extent of the disturbed area, and the time in which areas remain in a disturbed state.
- Active measures shall be taken after construction and during routine maintenance to ensure diffuse flow of stormwater through the buffer.
- In wetlands, mats shall be utilized to minimize soil disturbance.

	Exempt	Allowable	Allowable with Mitigation	Prohibited
Vegetation management:				
• Emergency fire control measures provided that topography is restored	X			
• Periodic mowing and harvesting of plant products in Zone 2 only	X			
• Planting vegetation to enhance the riparian buffer	X			
• Pruning forest vegetation provided that the health and function of the forest vegetation is not compromised	X			
• Removal of individual trees which are in danger of causing damage to dwellings, other structures or human life	X			
• Removal of poison ivy	X			
• Removal of understory nuisance vegetation as defined in: Smith, Cherri L. 1998. Exotic Plant Guidelines. Department of Environment and Natural Resources. Division of Parks and Recreation. Raleigh, NC. Guideline #30	X			
Water dependent structures as defined in 15A NCAC 2B .0202		X		
Water supply reservoirs:				
• New reservoirs provided that a riparian buffer that meets the requirements of Items (4) and (5) of this Rule is established adjacent to the reservoir		X		
• New reservoirs where a riparian buffer that meets the reqnirements of Items (4) and (5) of this Rule is NOT established adjacent to the reservoir			X	
Water wells	X			
Wetland restoration	X			

(7) REQUIREMENTS FOR CATEGORIES OF USES. Uses designated as exempt, allowable, allowable

with mitigation and prohibited in Item (6) of this Rule shall have the following requirements:

(a) EXEMPT. Uses designated as exempt are allowed within the riparian buffer. Exempt uses shall be designed, constructed and maintained to minimize soil disturbance and to provide the maximum water quality protection practicable. In addition, exempt uses shall meet requirements listed in Item (6) of this Rule for the specific use.

(b) ALLOWABLE. Uses designated as allowable may proceed within the riparian buffer provided that there are no practical alternatives to the requested use pursuant to Item (8) of this Rule. These uses require written authorization from the Division or the delegated local authority.

(c) ALLOWABLE WITH MITIGATION. Uses designated as allowable with mitigation may proceed within the riparian buffer provided that there are no practical alternatives to the requested use pursuant to Item (8) of this Rule and an appropriate mitigation strategy has been approved pursuant to Item (10) of this Rule. These uses require written authorization from the Division or the delegated local authority.

(d) PROHIBITED. Uses designated as prohibited may not proceed within the riparian buffer unless a variance is granted pursuant to Item (9) of this Rule. Mitigation may be required as one condition of a variance approval.

(8) DETERMINATION OF "NO PRACTICAL ALTERNATIVES." Persons who wish to undertake uses designated as allowable or allowable with mitigation shall submit a request for a "no practical alternatives" determination to the Division or to the delegated local authority. The applicant shall certify that the criteria identified in Sub-Item (8)(a) of this Rule are met. The Division or the delegated local authority shall grant an Authorization Certificate upon a "no practical alternatives" determination. The procedure for making an Authorization Certificate shall be as follows:

(a) For any request for an Authorization Certificate, the Division or the delegated local authority shall review the entire project and make a finding of fact as to whether the following requirements have been met in support of a "no practical alternatives" determination:

(i) The basic project purpose cannot be practically accomplished in a manner that would better minimize disturbance, preserve aquatic life and habitat, and protect water quality.

(ii) The use cannot practically be reduced in size or density, reconfigured or redesigned to better minimize disturbance, preserve aquatic life and habitat, and protect water quality.

(iii) Best management practices shall be used if necessary to minimize disturbance, preserve aquatic life and habitat, and protect water quality.

(b) Requests for an Authorization Certificate shall be reviewed and either approved or denied within 60 days of receipt of a complete submission based on the criteria in Sub-Item (8)(a) of this Rule by either the Division or the delegated local authority. Failure to issue an approval or denial within 60 days shall constitute that the applicant has demonstrated "no practical alternatives." The Division or the delegated local authority may attach conditions to the Authorization Certificate that support the purpose, spirit and intent of the riparian buffer protection program. Complete submissions shall include the following:

(i) The name, address and phone number of the applicant;

(ii) The nature of the activity to be conducted by the applicant;

(iii) The location of the activity, including the jurisdiction;

(iv) A map of sufficient detail to accurately delineate the boundaries of the land to be utilized in carrying out the activity, the location and dimensions of any disturbance in riparian buffers associated with the activity, and the extent of riparian buffers on the land;

(v) An explanation of why this plan for the activity cannot be practically accomplished, reduced or reconfigured to better minimize disturbance to the riparian buffer, preserve aquatic life and habitat and protect water quality; and

(vi) Plans for any best management practices proposed to be used to control the impacts associated with the activity.

(c) Any disputes over determinations regarding Authorization Certificates shall be referred to the Director for a decision. The Director's decision is subject to review as provided in Articles 3 and 4 of G. S. 150B.

(9) VARIANCES. Persons who wish to undertake uses designated as prohibited may pursue a variance. The Division or the appropriate delegated local authority may grant minor variances. The variance request procedure shall be as follows:

(a) For any variance request, the Division or the delegated local authority shall make a finding of fact as to whether the following requirements have been met:

(i) There are practical difficulties or unnecessary hardships that prevent compliance with the strict letter of the riparian buffer protection requirements. Practical difficulties or unnecessary hardships shall be evaluated in accordance with the following:

(A) If the applicant complies with the provisions of this Rule, he/she can secure no reasonable return from, nor make reasonable use of, his/her property. Merely proving that the variance would permit a greater profit from the property shall not be considered adequate justification for a variance. Moreover, the Division or delegated local authority shall consider whether the variance is the minimum possible deviation from the terms of this Rule that shall make reasonable use of the property possible.

(B) The hardship results from application of this Rule to the property rather than from other factors such as deed restrictions or other hardship.

(C) The hardship is due to the physical nature of the applicant's property, such as its size, shape, or topography, which is different from that of neighboring property.

(D) The applicant did not cause the hardship by knowingly or unknowingly violating this Rule.

(E) The applicant did not purchase the property after the effective date of this Rule, and then requesting an appeal.

(F) The hardship is unique to the applicant's property, rather than the result of conditions that are widespread. If other properties are equally subject to the hardship created in the restriction, then granting a variance would be a special privilege denied to others, and would not promote equal justice.

(ii) The variance is in harmony with the general purpose and intent of the State's riparian buffer protection requirements and preserves its spirit; and

(iii) In granting the variance, the public safety and welfare have been assured, water quality has been protected, and substantial justice has been done.

(b) MINOR VARIANCES. A minor variance request pertains to activities that are proposed only to impact any portion of Zone 2 of the riparian buffer. Minor variance requests shall be reviewed and approved based on the criteria in Sub-Item (9)(a) of this Rule by the either the Division or the delegated local authority pursuant to G.S. 153A-Article 18, or G.S. 160A-Article 19. The Division or the delegated local authority may attach conditions to the variance approval that support the purpose, spirit and intent of the riparian buffer protection program. Requests for appeals of decisions made by the Division shall be made to the Office of Administrative Hearings. Request for appeals made by the delegated local authority shall be made to the appropriate Board of Adjustment under G.S. 160A-388 or G.S. 153A-345.

(c) MAJOR VARIANCES. A major variance request pertains to activities that are proposed to impact any portion of Zone 1 or any portion of both Zones 1 and 2 of the riparian buffer. If the Division or the delegated local authority has determined that a major variance request meets the requirements in Sub-Item (9)(a) of this Rule, then it shall prepare a preliminary finding and submit it to the Commission. Preliminary findings on major variance requests shall be reviewed by the Commission within 90 days after receipt by the Director. Requests for appeals of determinations that the requirements of Snb-Item (9)(a) of this Rule have not been met shall be made to the Office of Administrative Hearings for determinations made by the Division or the appropriate Board of Adjustments under G.S. 160A-388 or G.S. 153A-345 for determinations made by the delegated local authority. The purpose of the Commission's review is to determine if it agrees that the requirements in Sub-Item (9)(a) of this Rule have been met. Requests for appeals of decisions made by the Commission shall be made to the Office of Administrative Hearings. The following actions shall be taken depending on the Commission's decision on the major variance request:

(i) Upon the Commission's approval, the Division or the delegated local authority shall issue a final decision granting the major variance.

(ii) Upon the Commission's approval with conditions or stipnlations, the Division or the delegated local authority shall issue a final decision, which includes these conditions or stipulations.

(iii) Upon the Commission's denial, the Division or the delegated local authority shall issue a final decision denying the major variance.

(10) MITIGATION. Persons who wish to undertake uses designated as allowable with mitigation shall meet the following requirements in order to proceed with their proposed use.

(a) Obtain a determination of "no practical alternatives" to the proposed use pursuant to Item (8) of this Rule.

(b) Obtain approval for a mitigation proposal pursuant to 15A NCAC 2B .0242.

(11) REQUIREMENTS SPECIFIC TO FOREST HARVESTING. The following requirements shall apply for forest harvesting operations and practices.

(a) The following measures shall apply in the entire riparian buffer:

(i) Logging decks and sawmill sites shall not be placed in the riparian buffer.

(ii) Access roads and skid trails shall be prohibited except for temporary and permanent stream crossings established in accordance with 15A NCAC 1I .0203. Temporary stream crossings shall be permanently stabilized after any site disturbing activity is completed.

(iii) Timber felling shall be directed away from the stream or water body.

(iv) Skidding shall be directed away from the stream or water body and shall be done in a manner that minimizes soil disturbance and prevents the creation of channels or ruts.

(v) Individual trees may be treated to maintain or improve their health, form or vigor.

(vi) Harvesting of dead or infected trees or application of pesticides necessary to prevent or control extensive tree pest and disease infestation shall be allowed. These practices must be approved by the Division of Forest Resources for a specific site. The Division of Forest Resources must notify the Division of all approvals.

(vii) Removal of individual trees that are in danger of causing damage to structures or human life shall be allowed.

(viii) Natural regeneration of forest vegetation and planting of trees, shrubs, or ground cover plants to enhance the riparian buffer shall be allowed provided that soil disturbance is minimized. Plantings shall consist primarily of native species.

(ix) High intensity prescribed burns shall not be allowed.

(x) Application of fertilizer shall not be allowed except as necessary for permanent stabilization. Broadcast application of fertilizer or herbicides to the adjacent forest stand shall be conducted so that the chemicals are not applied directly to or allowed to drift into the riparian buffer.

(b) In Zone 1, forest vegetation shall be protected and maintained. Selective harvest as provided for below is allowed on forest lands that have a deferment for use value under forestry in accordance with G.S. 105-277.2 through 277.6 or on forest lands that have a forest management plan prepared or approved by a registered professional forester. Copies of either the approval of the deferment for use value under forestry or the forest management plan shall be produced upon request. For such forest lands, selective harvest is allowed in accordance with the following:

(i) Tracked or wheeled vehicles are not permitted except at stream crossings designed, constructed and maintained in accordance with 15A NCAC 11 .0203.

(ii) Soil disturbing site preparation activities are not allowed.

(iii) Trees shall be removed with the minimum disturbance to the soil and residual vegetation.

(iv) The following provisions for selective harvesting shall be met:

(A) The first 10 feet of Zone 1 directly adjacent to the stream or waterbody shall be undisturbed except for the removal of individual high value trees as defined provided that no trees with exposed primary roots visible in the streambank be cut.

(B) In the outer 20 feet of Zone 1, a maximum of 50 percent of the trees greater than five inches dbh may be cut and removed. The reentry time for harvest shall be no more frequent than every 15 years, except on forest plantations where the reentry time shall be no more frequent than every five years. In either case, the trees remaining after harvest shall be as evenly spaced as possible.

(C) In Zone 2, harvesting and regeneration of the forest stand shall be allowed provided that sufficient ground cover is maintained to provide for diffusion and infiltration of surface runoff.

(12) REQUIREMENTS SPECIFIC TO LOCAL GOVERNMENTS WITH STORMWATER PROGRAMS FOR NITROGEN CONTROL. Local governments that are required to have local stormwater programs pursuant to 15A NCAC 2B .0235 shall have two options for ensuring protection of riparian buffers on new developments within their jurisdictions as follows.

(a) Obtain authority to implement a local riparian buffer protection program pursuant to 15A NCAC 2B .0241.

(b) Refrain from issuing local approvals for new development projects unless either:

(i) The person requesting the approval does not propose to impact the riparian buffer of a surface water that appears on either the most recent versions of the soil survey maps prepared by the Natural Resources Conservation Service of the United States Department of Agriculture or the most recent versions of the 1:24,000 scale (7.5 minute quadrangle) topographic maps prepared by the United States Geologic Survey (USGS).

(ii) The person requesting the approval proposes to impact the riparian buffer of a surface water that appears on the maps described in Sub-Item (12)(b)(i) of this Rule and either:

(A) Has received an on-site determination from the Division pursuant to Sub-Item (3)(a) of this Rule that surface waters are not present;

(B) Has received an Authorization Certificate from the Division pursuant to Item (8) of this Rule for uses designated as Allowable under this Rule;

(C) Has received an Authorization Certificate from the Division pursuant to Item (8) of this Rule and obtained the Division's approval on a mitigation plan pursuant to Item (10) of this Rule for uses designated as Allowable with Mitigation under this Rule; or

(D) Has received a variance from the Commission pursuant to Item (9) of this Rule.

(13) OTHER LAWS, REGULATIONS AND PERMITS. In all cases, compliance with this Rule does not preclude the requirement to comply with all federal, state and local regulations and laws.

History Note: *Authority 143-214.1; 143-214.7; 143-215.3(a)(1); S. L. 1995, c. 572;*
Temporary Adoption Eff. July 22, 1997;
Temporary Amendment Eff. June 22, 1999; April 22, 1998; January 22, 1998;
Eff. August 1, 2000.

Appendix F: Estuarine Resources Restoration

Data Report

Neuse River Estuary
Oyster Reef Restoration Evaluation

Contract Number: W9212BU-04-D-0004

November 04, 2008

Prepared for:
US Army Corps of Engineers
Wilmington District
Wilmington, NC

Prepared by:
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Acknowledgements

The following people and organizations are recognized for their cooperation and sharing of relevant data that will be part of the current project.

- Mr. Robert Reed from the North Carolina State University, Center for Applied Aquatic Ecology.
- Mr. Ben Peierls from the University of North Carolina, Chapel Hill, Institute of Marine Science.
- Ms. Andrea Thomas from North Carolina Department of Water Quality.
- Mr. Mike Donehoo from USEPA Region 4.

Furthermore, support with the data base program, Water Resources Database (WRDB) was provided by Mr. Chris Wilson of Clayton Engineering.

1 Introduction

The Neuse Estuary is located on the coast of North Carolina and receives drainage from the eastern portion of the state (Figure 1). A few of the municipalities that are within this drainage area are Durham, Raleigh, Smithfield, Goldsboro, Kinston, and New Bern. The counties that are most proximate to the Neuse Estuary include Craven, Pamlico, and Carteret. The approximate drainage area of the Neuse River Watershed to the Neuse Estuary is 4,470 square miles. The longitudinal dimension of the Neuse Estuary considered in this data gathering effort is approximately 50 miles, bound by New Bern and Pamlico Sound.

This data report is part of a larger effort which has a focus on oyster area restoration feasibility in the Neuse Estuary. As such, there is real value in utilizing work performed by others on the Neuse Estuary. The EPA TMDL effort performed in approximately 2000 – 2002 was used as a starting point. A project file was built using the Water Resources Database (WRDB) package to hold the large data set from numerous sources. That historical database contained data from approximately 1994 through 2000. The database was first converted to the current version of WRDB, which is version 4.503.

The goal of the current effort was to obtain data from a variety of sources from 2001 through as recent a date as possible. The sections of this report will be organized by the source of the data. A brief description of the station locations and data will be presented.

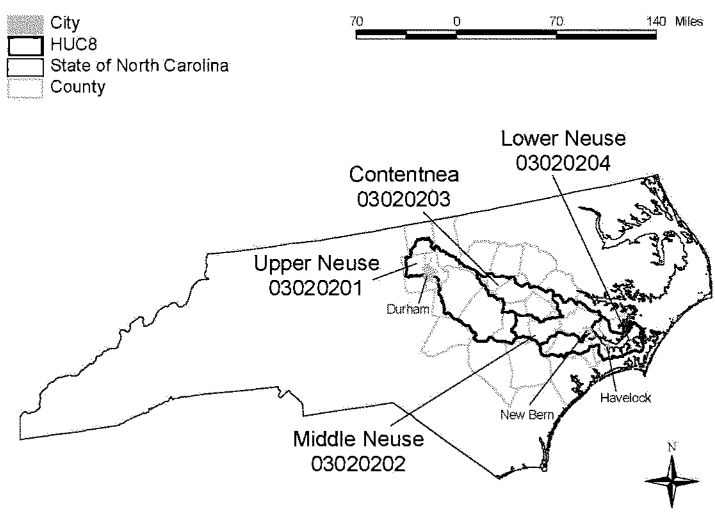

Figure 1. Location of Neuse River Estuary

2 North Carolina State University

The North Carolina State University, Center for Applied Aquatic Ecology (NCSU) has observed water quality in the Neuse Estuary since approximately 1994 through the present. The number and locations of stations has varied across this period. The data include profile and grab samples observed approximately twice per month. Figure 2 shows the locations of these stations, which are basically in the western portion of the gridded Neuse Estuary. Furthermore, the NCSU coverage captures lateral phenomena. A broad summary of the stations (Table 1) provides insight as to which stations were operational after 2000. Table 2 lists the parameters observed from the NCSU stations.

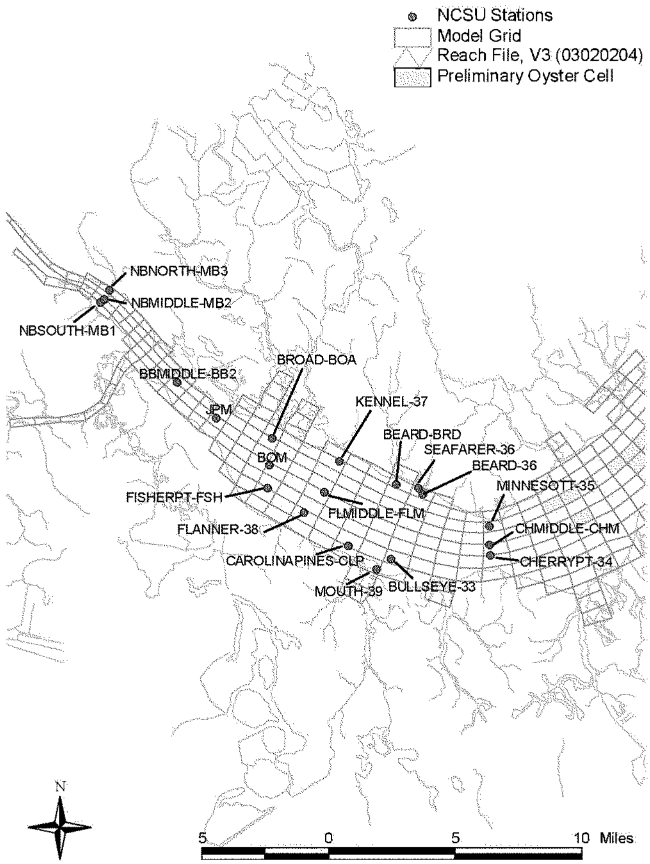

Figure 2. NCSU Monitoring Station Locations

Table 1. NCSU Station Information

Station	Station Name	First Date	Last Date	# Obs
BBMIDDLE-BB2	BB-Middle, NCSU No. BB2	3/29/2000 12:00	12/19/2006 12:00	2,608
BBNORTH-BB3	BB-North, NCSU No. BB3	3/29/2000 12:00	3/29/2000 12:00	44
BBSOUTH-BB1	BB-South, NCSU No. BB1	2/8/2000 12:00	3/29/2000 12:00	87
BEARD-36	Beard, NCSU No. 36	1/12/1994 0:00	12/15/1998 0:00	4,424
BEARD-BRD	BEARD-BRD	5/2/2000 12:00	12/19/2006 12:00	7,984
BOM	Broad-Middle NCSU BOM	4/10/2001 12:00	12/19/2006 10:39	5,624
BROAD-BOA	Broad, NCSU No. BOA	6/19/2000 12:00	12/19/2006 12:00	9,512
BULLSEYE-33	Bullseye, NCSU No. 33	1/12/1994 0:00	12/19/2006 13:19	18,329
CAROLINAPINES-CLP	Carolina Pines, NCSU No. CLP	4/5/2000 12:00	12/19/2006 13:36	12,528
CHERRYPT-34	Cherry Point, NCSU No. 34	1/12/1994 0:00	12/19/2006 12:50	15,739
CHMIDDLE-CHM	CH-Middle, NCSU No. CHM	4/18/2000 12:00	12/19/2006 12:41	14,164
FISHERPT-FSH	Fisher Point, NCSU No. FSH	6/19/2000 12:00	12/19/2006 14:08	10,169
FLANNER-38	Flanner, NCSU No. 38	1/12/1994 0:00	8/24/2000 12:00	7,552
FLMIDDLE-FLM	FL-Middle, NCSU No. FLM	4/18/2000 12:00	3/26/2001 12:00	1,519
JPM	Johnson Pt Middle NCSU JPM	2/15/2005 10:19	12/19/2006 10:14	2,169
KENNEL-37	Kennel, NCSU No. 37	1/12/1994 0:00	12/19/2006 12:00	17,271
MINNESOTT-35	Minnesott, NCSU No. 35	1/12/1994 0:00	12/19/2006 12:26	16,391
MOUTH-39	Mouth, NCSU No. 39	1/27/1999 12:00	8/26/1999 12:00	334
NBMIDDLE-MB2	NB-Middle, NCSU No. MB2	2/8/2000 12:00	12/19/2006 12:00	7,473
NBNORTH-MB3	NB-North, NCSU No. MB3	2/8/2000 12:00	12/19/2006 12:00	5,327
NBSOUTH-MB1	NB-South, NCSU No. MB1	2/8/2000 12:00	12/19/2006 12:00	5,533
SEAFARER-36	Seafarer, NCSU No. 36	1/20/1999 12:00	8/2/2000 12:00	1,068

Table 2. NCSU Parameter Information

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
BOD5U	BOD5-Uninhibited (straight)	mg/l	220	2.53	1	13	4/10/2001 12:00	10/23/2001 12:00
CHL_A-NCSU	Chlorophyll-a (NCSU fluorometric corrected)	ug/L	4709	23.36	0.03	499	1/12/1994 0:00	12/19/2006 12:00
DO	Dissolved Oxygen, measured	mg/l	16921	6.95	0	20.33	1/12/1994 0:00	12/19/2006 14:08
DOSAT	Percent Dissolved Oxygen	%	15647	79.24	0	199.9	1/12/1994 0:00	12/19/2006 14:08

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
FECAL	Fecal Coliform	#/100 ml	2312	24.82	1	1,300.00	1/12/1994 0:00	12/19/2006 12:00
LIGHT	Light (PAR Sensor)	uE/m^2/S	1369	330.9	0	2,934.00	2/9/1994 0:01	12/20/1994 13:59
LIGHTPCT	Light (PAR Sensor) %	%	1369	27.95	0	170.57	2/9/1994 0:01	12/20/1994 13:59
NH3	Ammonia as N	mgN/L	2049	0.04	0	0.75	1/12/1994 0:00	12/19/2000 12:00
NH4	Ammonium as N	mgN/L	2368	0.06	0.01	0.87	1/8/2001 12:00	12/19/2006 12:00
NO2NO3	Nitrite plus Nitrate as N	mgN/L	4483	0.1	0	1.26	1/12/1994 0:00	12/19/2006 12:00
NORG	Organic Nitrogen	mgN/L	2353	0.68	0.22	4.16	1/14/1998 0:00	12/19/2006 12:00
NTKN	Total Kjeldahl N as N	mgN/L	4412	0.77	0.25	5.29	1/12/1994 0:00	12/19/2006 12:00
NTOT	Total Nitrogen	mgN/L	3563	0.86	0	4.24	1/13/1999 12:00	12/19/2006 12:00
PH	Standard pH	pH units	18007	7.64	5.77	9.97	1/12/1994 0:00	12/19/2006 14:08
PORG	Organic Phosphorus	mgP/L	2556	0.07	0	0.38	1/14/1998 0:00	12/19/2006 12:00
PORTHO	Phosphorus, Ortho as P	mgP/L	4582	0.04	0	0.83	1/12/1994 0:00	12/19/2006 12:00
PTOT	Phosphorus, Total as P	mgP/L	4461	0.11	0.03	0.62	1/12/1994 0:00	12/19/2006 12:00
REDOX	Redox	mV	16468	433.15	-274	829	4/6/1994 0:00	12/19/2006 14:08
SAL	Salinity	ppt	17818	8.49	0	35.2	1/12/1994 0:00	12/19/2006 14:08
SECCHI	Secchi Depth meters	m	306	0.9	0.25	2	1/18/1994 0:00	12/15/1998 0:00
SOLIDTSS	Solids-Total Suspended	mg/l	4165	7.92	1.1	102.9	1/12/1994 0:00	10/31/2006 12:00
SPCOND	Specific Conductance	us/cm	16532	14,246	1	53,220	1/12/1994 0:00	12/19/2006 14:08
TEMP	Temperature, Water, measured	Deg C	18007	20.52	3.53	33.9	1/12/1994 0:00	12/19/2006 14:08
TURB	Turbidity	NTU	1172	25.16	0	699	2/8/2000 12:00	12/19/2000 12:00

3 University of North Carolina

The University of North Carolina Institute of Marine Sciences Modeling and Monitoring project (ModMon) has observed water quality in the Neuse Estuary since approximately 1998 through the present. The number and locations of stations has varied across this period. The data include profile and grab samples, observed approximately twice per month. Figure 3 and Figure 4 shows the locations of these stations, which are basically laterally centered and cover the longitudinal dimension of the gridded Neuse Estuary. A broad summary of the stations (Table 3) provides insight as to which stations were operational after 2000. Table 4 lists the parameters observed from the ModMon stations.

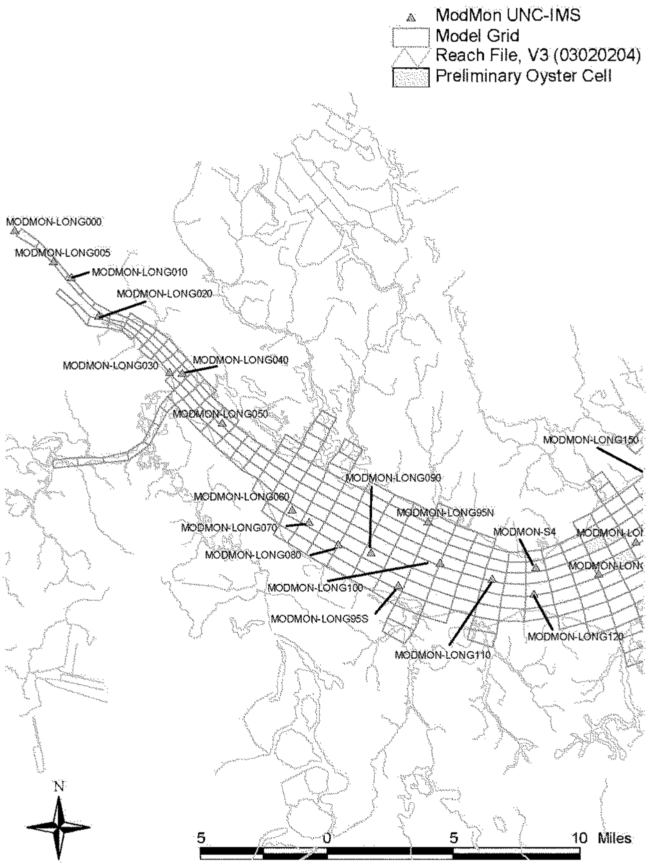

Figure 3. ModMon Monitoring Station Locations, Western Portion of Neuse Estuary

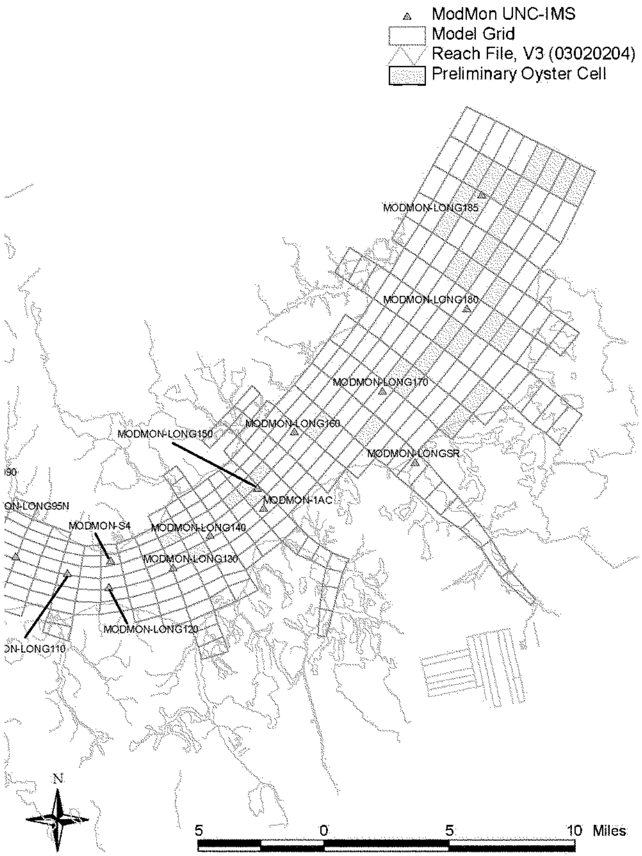

Figure 4. ModMon Monitoring Station Locations, Eastern Portion of Neuse Estuary

Table 3. ModMon Station Information

Station	Station Name	First Date	Last Date	# Obs
MODMON-LONG000	Streets Ferry Bridge	1/6/1998 15:14	12/11/2006 13:14	13,750
MODMON-LONG005	Marker 68	1/13/1998 0:00	12/13/2000 11:00	1,152
MODMON-LONG010	Marker 64	1/6/1998 14:57	12/27/2000 12:55	7,190
MODMON-LONG020	Marker 52-A	1/6/1998 14:48	12/11/2006 12:56	12,257
MODMON-LONG030	Marker 38	1/6/1998 14:21	12/11/2006 12:38	11,046

Station	Station Name	First Date	Last Date	# Obs
MODMON-LONG040	Hwy 17 Bridge	1/13/1998 0:00	12/13/2000 11:45	917
MODMON-LONG050	Marker 22	1/6/1998 13:56	12/11/2006 12:23	12,763
MODMON-LONG060	Marker 17	1/6/1998 13:36	12/11/2006 12:06	10,937
MODMON-LONG070	Marker 15	1/6/1998 13:13	12/11/2006 11:54	12,095
MODMON-LONG080	Marker 11	1/13/1998 0:00	12/13/2000 13:42	1,152
MODMON-LONG090	No Marker	1/6/1998 13:00	12/17/2001 11:10	7,621
MODMON-LONG100	No Marker	1/6/1998 0:42	12/11/2006 11:39	12,587
MODMON-LONG110	No Marker	1/6/1998 0:29	12/17/2001 11:00	8,095
MODMON-LONG120	Marker 9	1/6/1998 0:07	12/11/2006 11:25	14,304
MODMON-LONG130	No Marker	1/13/1998 0:00	12/18/2000 13:20	5,015
MODMON-LONG140	No Marker	1/13/1998 0:00	12/11/2006 11:04	12,489
MODMON-LONG150	No Marker	1/13/1998 0:00	12/18/2000 12:27	5,948
MODMON-LONG155	Station 155, also 1AC	1/03/2001 0:00	11/08/2001 0:00	1,364
MODMON-LONG160	Marker 7	1/13/1998 0:00	12/11/2006 10:44	13,818
MODMON-LONG170	No Marker	1/13/1998 0:00	12/18/2000 11:12	5,413
MODMON-LONG180	No Marker	1/13/1998 0:00	12/11/2006 10:15	8,202
MODMON-LONG185	Marker NR	1/13/1998 0:00	11/14/2000 11:20	806
MODMON-LONG95N	Near north shore, No marker	1/6/2000 9:32	12/17/2001 10:37	2,492
MODMON-LONG95S	Near south shore, No marker	1/6/2000 10:41	12/17/2001 10:58	2,425.00
MODMON-LONGSR	Marker SR, mouth of South River	2/1/2000 10:18	12/5/2001 10:57	1,634.00

Table 4. ModMon Parameter Information

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
CHL_A-DWQ	Chlorophyll-a (DWQ acidified fluorometry for phaeopigments)	ug/L	226	15.23	0.3	190	1/13/1998 0:00	12/15/1999 11:46
CHL_A-IMS	Chlorophyll-a (IMS trichromatic spectrophotometry)	ug/l	5,143	16.13	0	808.49	1/12/1998 0:02	12/11/2006 13:14
CHL_A-IMSF	Chlorophyll-a (in situ measurements with meter)	ug/L	20,501	12.17	0.1	646.3	4/10/2000 8:50	12/11/2006 13:14
CHL_A-IMSH	Chlorophyll-a (HPLC)	ug/L	3,936	8.18	0.02	257.31	1/6/2000 9:14	12/11/2006 13:14

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
CHL_A-WEY	Chlorophyll-a (WEY trichromatic spectrophotometry)	ug/L	347	12.79	0.15	149.4	1/26/1998 0:00	12/27/2000 13:13
CHL_B-WEY	Chlorophyll-a (WEY trichromatic spectrophotometry)	ug/L	185	0.3	-2.82	7.31	1/26/1998 0:00	8/9/1999 14:13
CHL_C-WEY	Chlorophyll-c (WEY trichromatic spectrophotometry)	ug/L	185	2.53	-0.17	33.6	1/26/1998 0:00	8/9/1999 14:13
CNMOLAR	Carbon-Nitrogen Molar Ratio		5,046	7.89	0.83	112.5	1/12/1998 0:02	12/11/2006 13:14
COND	Conductivity	uS/cm	19,681	10,499.73	0	52,017.00	1/6/1998 0:07	12/27/2000 13:15
CPART	Particulate Carbon	mg/l	5,064	1.61	0.02	19.12	1/12/1998 0:02	12/11/2006 13:14
DIN	Dissolved Inorganic N NOx+NH4	mgN/L	3,315	0.21	0	1.2	1/3/2001 9:58	12/11/2006 13:14
DO	Dissolved Oxygen, measured	mg/l	38,346	7.67	0	21.57	1/6/1998 0:07	12/11/2006 13:14
DOSAT	Percent Dissolved Oxygen	%	30,522	81.84	0.1	232.2	1/6/1998 0:07	12/11/2006 13:14
FLUOR	Fluorescence	%FS	1,879	3.53	0.1	29	4/10/2000 8:50	12/18/2000 13:20
KE	Light Extinction Coefficient	1/m	3,309	1.85	0.45	9.95	1/12/1998 0:02	12/11/2006 13:11
LIGHT	Light (PAR Sensor)	uE/m^2/S	9,343	247.6	0.01	4,344.00	1/12/1998 0:02	12/18/2000 13:18
NH3	Ammonia as N	mgN/L	2,480	0.05	0	1.3	1/12/1998 0:02	12/27/2000 13:13
NH4	Ammonium as N	mgN/L	3,392	0.05	0	0.96	1/3/2001 9:58	12/11/2006 13:14
NO2NO3	Nitrite plus Nitrate as N	mgN/L	5,696	0.21	0	1.13	1/12/1998 0:02	12/11/2006 13:14
NORG	Organic Nitrogen	mgN/L	2,906	0.33	0.01	2.47	1/3/2001 10:18	12/11/2006 13:14
NPART	Particulate Nitrogen	mgN/L	5,005	0.26	0	2.96	1/12/1998 0:02	12/11/2006 13:14
NTKN	Total Kjeldahl N as N	mgN/L	706	0.6	0	7.9	1/13/1998 0:00	12/27/2000 13:13
NTOT	Total Nitrogen	mgN/L	3,076	0.57	0.03	8.04	1/12/1999 0:00	12/11/2006 13:14
PH	Standard pH	pH units	37,905	7.59	5.51	12.3	1/6/1998 0:07	12/11/2006 13:14

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
PORTHO	Phosphorus, Ortho as P	mgP/L	5,449	0.03	0	0.66	1/12/1998 0:02	12/11/2006 13:14
PRIM_PROD	Primary Product	mgC/m^3*h	2,424	39.58	-0.3	528.17	1/12/1998 0:02	12/11/2006 13:11
PTOT	Phosphorus, Total as P	mgP/L	706	0.12	0.01	0.65	1/13/1998 0:00	12/27/2000 13:13
SAL	Salinity	ppt	38,482	7.67	0	33.32	1/6/1998 0:07	12/11/2006 13:14
SOLIDTSS	Solids-Total Suspended	mg/l	828	6.74	0.2	143.43	1/12/1998 0:02	12/27/2000 13:13
SPCOND	Specific Conductance	us/cm	18,799	15,338.86	0	50,870.00	1/3/2001 9:58	12/11/2006 13:14
TEMP	Temperature, Water, measured	Deg C	38,493	18.61	1	33.63	1/6/1998 0:07	12/11/2006 13:14
TURB	Turbidity	NTU	19,877	7.22	0.1	1,609.40	4/10/2000 8:50	12/11/2006 13:14

4 United States Geological Survey

The United States Geological Survey (USGS) have been observing water quality and flow data in the Neuse Watershed and Estuary since at least 1951. There are three active water quality stations included in this data report (Figure 5) and two active flow stations. The stations are located in the western portion of the Neuse Estuary. Summary information about the stations and the parameters are provided in Table 5 and Table 6. The water quality data is daily average and typically from two depths in the water column. It is more continuous than the NCSU or ModMon data.

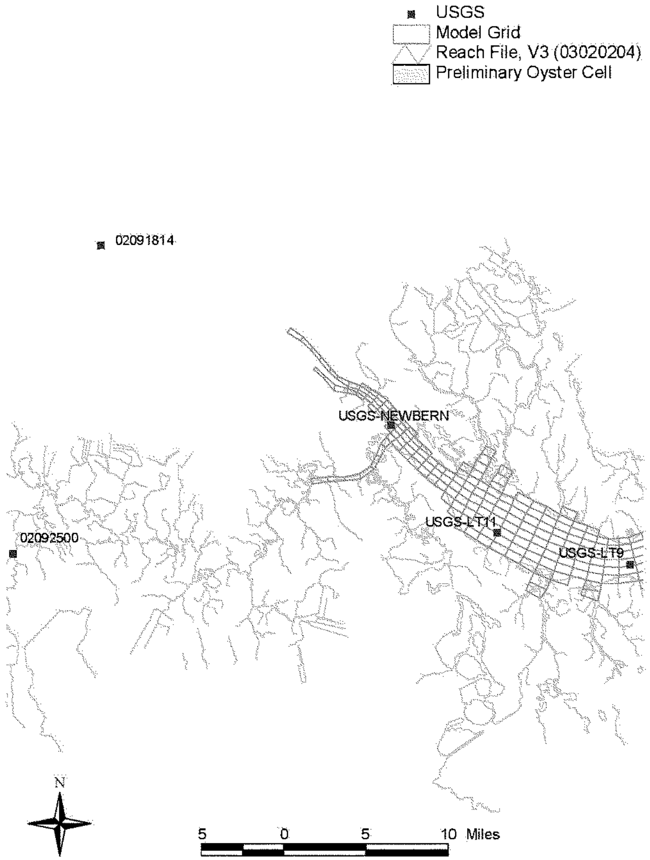

Figure 5. USGS Water Quality and Flow Monitoring Station Locations

Table 5. USGS Water Quality and Flow Station Information

Station	Station Name	First Date	Last Date	# Obs
02091814	Neuse River near Fort Barnwell NC	10/1/1996 0:00	6/11/2007 0:00	3,895
02092500	Trent River near Trenton NC	1/1/1951 0:00	6/11/2007 0:00	20,616
USGS-LT11	Neuse River at Channel LT. 11	6/28/1996 12:00	6/20/2007 12:00	43,187
USGS-LT9	Neuse River at Channel LT. 9	5/31/1989 12:00	6/19/2007 12:00	45,893
USGS-NEWBERN	Neuse River at New Bern, NC	6/28/1996 12:00	6/21/2007 12:00	44,365

Table 6. USGS Water Quality and Flow Parameter Information

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
COND	Conductivity	uS/cm	23,080	11,108	60	40,900	5/31/1989 12:00	6/21/2007 12:00
DODA	Dissolved Oxygen, daily avg.	mg/l	20,724	7	0	16	5/31/1989 12:00	6/21/2007 12:00
DOSAT	Percent Dissolved Oxygen	%	20,849	76	0	162	10/2/1989 12:00	6/21/2007 12:00
FLOWCFSDA	Stream Flow, daily average	cfs	24,511	833	0.3	57,000	1/1/1951 0:00	6/11/2007 0:00
GAGE	Gage Height	feet	1,089	1	-1	4	6/28/1996 12:00	8/2/1999 12:00
NO2NO3	Nitrite plus Nitrate as N	mgN/L	228	0.25	0.03	3.69	4/20/2001 12:00	9/9/2001 12:00
PH	Standard pH	pH units	20,672	7.4	4.7	9.8	6/28/1996 12:00	6/21/2007 12:00
SAL	Salinity	ppt	23,079	6.5	0.0	26.1	5/31/1989 12:00	6/21/2007 12:00
TEMPDA	Temperature, Water, daily avg.	Deg C	22,316	18.5	1.3	32.0	5/31/1989 12:00	6/21/2007 12:00
WDIR	Wind direction CW deg from N	CW deg fr N	703	185	20	333	2/15/2001 12:00	9/30/2003 12:00
WSPD	Wind speed	mi/h	705	16	0	1,090	2/15/2001 12:00	9/30/2003 12:00

5 North Carolina Division of Water Quality

The North Carolina Division of Water Quality (NCDWQ) performs extensive environmental sampling. The data is available from the EPA STORET web site. The data input to the WRDB project were for all stations in Craven, Pamlico, and Carteret Counties. However, the stations that overlap the model grid are highlighted in this report (Figure 6). The observations were grab samples performed approximately monthly. The NCDWQ data particularly is considered more rigorous staring in 2001. This is because NCDWQ took steps to improve their quality assurance and changed some of the analytical methods. The stations and summary parameter information are presented in Table 7 and Table 8. In Table 7, note the ModMon station that shares the same location as the NCDWQ station.

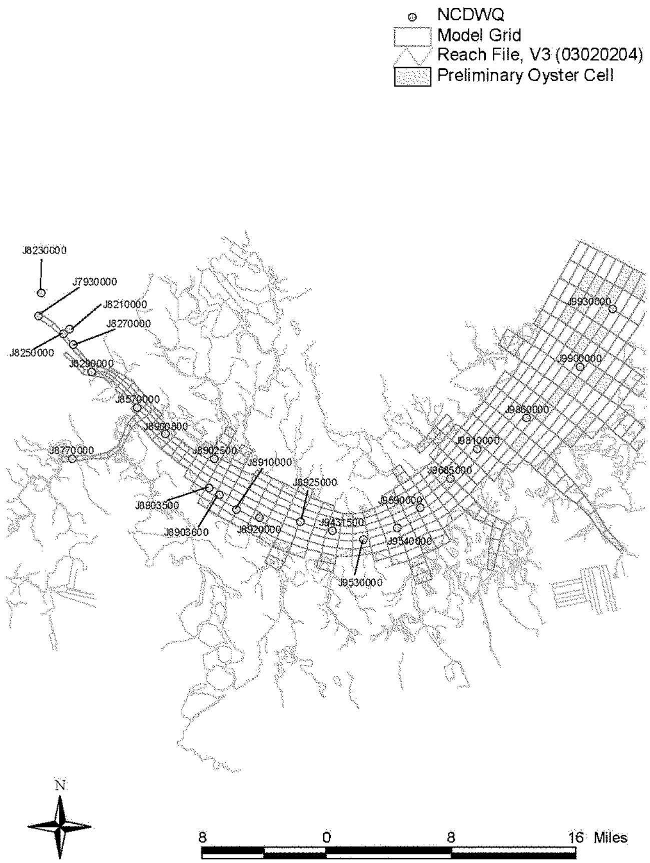

Figure 6. NCDWQ Monitoring Station Locations

Table 7. NCDWQ Water Quality Station Information

Station	Station Name	First Date	Last Date	# Obs
J7930000	J7930000 (ModMon-Long000)	1/10/2001 11:30	12/5/2006 11:22	2,292
J8210000	J8210000	1/10/2001 11:44	12/5/2006 11:36	2,136
J8230000	J8230000	1/4/2001 9:50	12/27/2006 9:35	2,370
J8250000	J8250000 (ModMon-Long005)	1/10/2001 12:22	12/5/2006 11:52	2,291
J8270000	J8270000 (ModMon-Long010)	1/10/2001 12:33	12/5/2006 11:55	1,341
J8290000	J8290000 (ModMon-Long020)	1/10/2001 12:45	12/5/2006 12:15	1,746
J8570000	J8570000	1/10/2001 12:55	12/5/2006 10:40	1,700
J8770000	J8770000	1/10/2001 13:24	12/5/2006 12:54	1,748
J8900800	J8900800 (ModMon-Long050)	1/10/2001 10:20	12/5/2006 10:09	1,901
J8902500	J8902500	1/10/2001 10:02	12/5/2006 9:36	1,610
J8903500	J8903500 (ModMon-Long060)	1/10/2001 10:26	12/5/2006 15:06	1,371
J8903600	J8903600 (ModMon-Long070)	1/10/2001 10:35	12/5/2006 14:58	1,400
J8910000	J8910000 (ModMon-Long080)	1/10/2001 10:45	12/5/2006 14:46	1,994
J8920000	J8920000	1/10/2001 11:03	12/5/2006 14:38	1,565
J8925000	J8925000 (ModMon-Long100)	1/10/2001 11:17	12/5/2006 14:28	1,537
J9431500	J9431500 (ModMon-Long110)	1/10/2001 11:30	12/5/2006 14:18	1,635
J9530000	J9530000	1/10/2001 11:40	12/5/2006 14:05	1,724
J9540000	J9540000 (ModMon-Long130)	1/10/2001 12:00	12/5/2006 13:54	1,732
J9590000	J9590000 (ModMon-Long140)	1/10/2001 12:13	12/5/2006 13:42	1,809
J9685000	J9685000 (ModMon-Long150)	1/10/2001 12:30	12/5/2006 13:29	2,003
J9810000	J9810000	1/10/2001 12:42	12/5/2006 13:11	1,910
J9860000	J9860000 (ModMon-Long170)	1/10/2001 13:19	12/5/2006 12:53	1,986
J9900000	J9900000 (ModMon-Long180)	2/6/2001 10:55	12/5/2006 12:30	2,044
J9930000	J9930000	2/6/2001 10:40	12/5/2006 12:02	1,732

Table 8. NCDWQ Water Quality Parameter Information

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
CHL_A-DWQ	Chlorophyll-a (DWQ acidified fluorometry for phaeopigments)	ug/L	845	15.2	0.1	240.0	1/10/2001 10:02	12/5/2006 14:46
DO	Dissolved Oxygen, measured	mg/l	8,710	8.1	0.0	17.7	1/4/2001 9:50	12/18/2006 9:47
NH3	Ammonia as N	mgN/L	1,198	0.050	0.010	1.500	1/4/2001 9:50	12/27/2006 9:35
NO2NO3	Nitrite plus Nitrate as N	mgN/L	1,198	0.320	0.010	2.000	1/4/2001 9:50	12/27/2006 9:35
NTKN	Total Kjeldahl N as N	mgN/L	1,197	0.620	0.100	16.000	1/4/2001 9:50	12/27/2006 9:35
PH	Standard pH	pH units	8,896	7.48	3.20	11.50	1/4/2001 9:50	12/27/2006 9:35
PTOT	Phosphorus, Total as P	mgP/L	1,198	0.100	0.010	1.000	1/4/2001 9:50	12/27/2006 9:35
SAL	Salinity	ppt	8,873	7.5	0.0	31.3	1/4/2001 9:50	12/27/2006 9:35
SECCHI	Secchi Depth meters	m	1,661	0.9	0.1	3.3	1/10/2001 10:02	12/5/2006 15:06
TEMP	Temperature, Water, measured	Deg C	8,910	18	3	33	1/4/2001 9:50	12/27/2006 9:35
TURB	Turbidity	NTU	891	6.8	0.1	70.0	1/10/2001 10:02	12/5/2006 14:46

6 Point Source Dischargers

Three major point source dischargers were considered in the 1998 – 2000 EPA TMDL work. These dischargers are approximately located in the western portion of the model grid (Figure 7). The monthly Discharge Monitoring Reports were retrieved from the EPA Envirofacts services for NPDES permitted facilities. These data were processed to pull out the monthly average data for the respective dischargers. The discharger and summary parameter information are presented in Table 9 and Table 10.

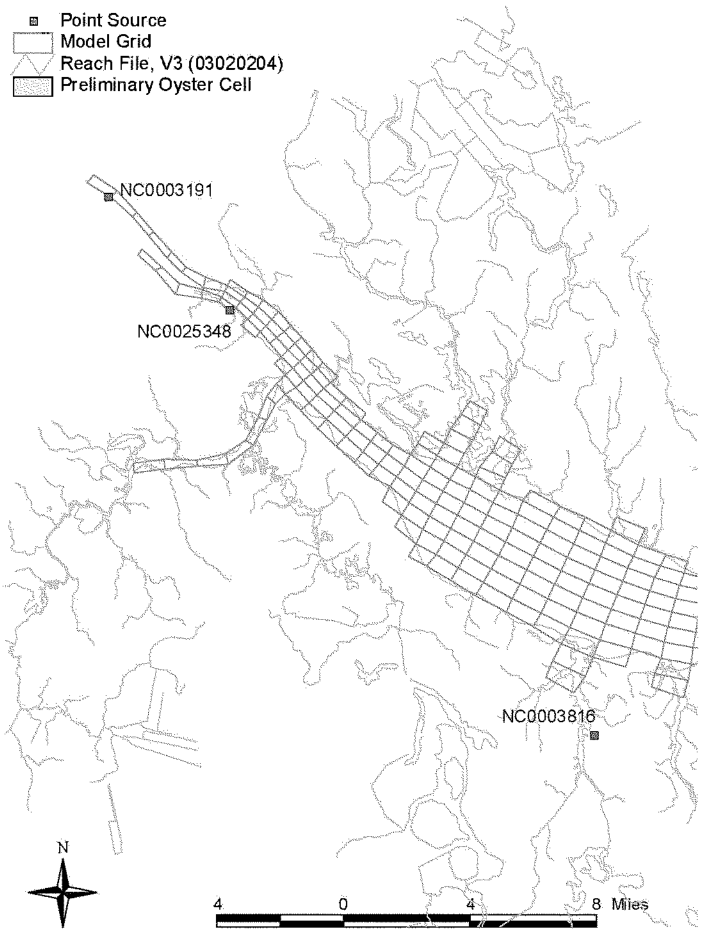

Figure 7. Point Source Discharge Locations

Table 9. Point Source Discharger Information

Station	Station Name	First Date	Last Date	# Obs
NC0003191-0011	Weyerhaeuser New Bern Mill 0011	1/31/1989 0:00	5/31/2007 0:00	1,337
NC0003191-0031	Weyerhaeuser New Bern Mill 0031	8/31/2004 0:00	12/31/2006 0:00	26
NC0003816	Cherry Point WWTP	8/31/1989 0:00	3/31/2007 0:00	1,448
NC0025348	New Bern WWTP	1/31/1989 0:00	4/30/2007 0:00	1,428

Table 10. Point Source Parameter Information

PCode	Parameter Name	Units	# Obs	Mean	Min	Max	First Date	Last Date
BOD5	BOD5 concentration	mg/L	420	12.0	0.0	88.8	1/31/1989 0:00	4/30/2007 0:00
BOD5LOAD	BOD5 load	lb/d	218	2,592.4	0.0	6,227.6	1/31/1989 0:00	5/31/2007 0:00
DODA	Dissolved Oxygen, daily avg.	mg/l	412	8.1	0.0	23.7	1/31/1989 0:00	4/30/2007 0:00
DOLOAD	Dissolved oxygen	lb/d	62	136.9	0.0	233.1	3/31/2002 0:00	5/31/2007 0:00
FLOWMGDDA	Facility Flow, daily average	MGD	667	8.5	0.0	35.9	1/31/1989 0:00	5/31/2007 0:00
NH3	Ammonia as N	mgN/L	419	5.02	0.00	22.13	1/31/1989 0:00	4/30/2007 0:00
NO2NO3	Nitrite plus Nitrate as N	mgN/L	66	1.20	0.00	4.05	4/30/1994 0:00	5/31/2007 0:00
NTKN	Total Kjeldahl N as N	mgN/L	68	3.78	0.00	8.01	8/31/1993 0:00	5/31/2007 0:00
NTOT	Total Nitrogen	mgN/L	513	9.79	0.00	39.40	1/31/1989 0:00	5/31/2007 0:00
PTOT	Phosphorus, Total as P	mgP/L	584	1.26	0.00	6.80	1/31/1989 0:00	5/31/2007 0:00
TEMPDA	Temperature, Water, daily avg.	Deg C	640	20.8	0.0	32.6	1/31/1989 0:00	5/31/2007 0:00
TNH3LOAD	Total Ammonia as N	lb/d	170	293.2	0.0	821.5	3/31/1993 0:00	5/31/2007 0:00

7 Discussion

The substantial data sources are NCSU, ModMon, USGS, and NCDWQ. These along with the other data will be used to help inform model forcings as well as revisit calibration and enhance model validation. Since the primary focus of the past modeling effort was 1998 – 2000, it is anticipated that by extending the dataset through basically 2006, the model performance and utility will be improved.

A couple of concerns are noted from this data gathering effort. First is the need for water surface elevation (WSE) forcings for the open boundary of the model in Pamlico Sound. The EPA TMDL effort utilized observations at ModMon 1AC with adjustments. At the time of this report, inquiries have been made to learn of available observed or calculated WSE forcings however a resolution has not yet been reached. The second concern has to do with assigning water quality forcing to the small tributary areas immediately adjacent to the Neuse Estuary. It is noted that this nonpoint forcing is expected to be negligible for the system at-large as the input from the Neuse River, draining approximately 3900 square miles, should dominate the loading into the estuary.

There were two primary methods of analyzing chlorophyll-a from the samples, in vitro fluorescence and HPLC. NCSU, ModMon and NCDWQ used in vitro fluorescence while only ModMon also used HPLC.

A new parameter code was added to the WRDB project files for ammonium (NH4). In practice, when pH ranges are within what is expected fro natural systems observations of ammonium and total ammonia are basically similar. However, for the 2001 – 2006 data that were collected, when it was noted that the observations was ammonium, it was added to the WRDB project files under the code NH4. A user should be aware that it is reasonable to group data entered in the WRDB project under the codes of NH3 and NH4.

8 References

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USGS, 2007. http://www.usgs.gov/. Daily Average Stream Flow and Water Quality Information. United States Geological Survey. Washington D.C.

Model Report

Neuse River Estuary
Oyster Reef Restoration Evaluation

Contract Number: W9212BU-04-D-0004

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US Army Corps of Engineers
Wilmington District
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Acknowledgements

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- Mr. Tim Wool, US EPA Region 4.
- Mr. Jerad Bales and Mr Jason Fine from the United States Geological Survey, Raleigh, North Carolina.

1 Introduction

The Neuse River Estuary is located on the coast of North Carolina and receives drainage from the eastern portion of the state (Figure 1). Among the municipalities that are within this drainage area are Durham, Raleigh, Smithfield, Goldsboro, Kinston, and New Bern. The counties that are most proximate to the Neuse River Estuary include Craven, Pamlico, and Carteret. The approximate drainage area of the Neuse River watershed to the Neuse River Estuary is 4,470 square miles (11,577 square kilometers). The longitudinal dimension of the Neuse River Estuary considered in this study is approximately 50 miles (80 kilometers), bound by New Bern and Pamlico Sound.

This model report is part of a larger effort which is focused on oyster area restoration feasibility in the Neuse River Estuary. As such, there is real value in utilizing work performed previously on the Neuse River Estuary. The EPA TMDL modeling performed in approximately 2000 – 2002, which simulated 1998 – 2000, was used as a starting point. Furthermore, work performed by Dr. J Bowen (UNC-C) was considered for the benefit of approach and input requirements.

The model was extended for the simulation period of 2001 – 2006. However, upon review of past work and in consideration of new data, lessons learned from past experience, and goals of the current study, some components of the original 1998 – 2000 work were revised.

The objective of the current study was to create a model framework that can be used to investigate oyster reef restoration feasibility.

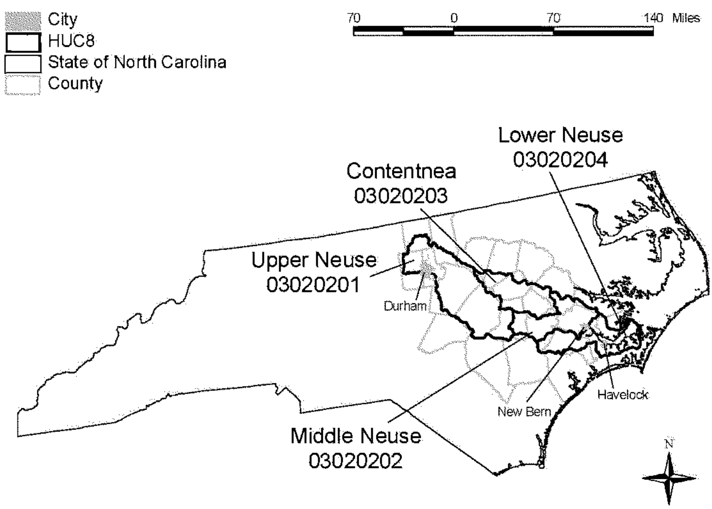


Figure 1. Location of Neuse River Estuary

2 Model Development

The Neuse River Estuary (NRE) is a well studied and monitored waterbody (Bales, 1999). EPA Region 4 performed a TMDL study on the NRE for simulation years 1998 – 2000 (EPA 2001, Wool 2003). The modeling work coupled the Environmental Fluid Dynamics Code (EFDC) (Hamrick 1996) with Water Quality Analysis Simulation Program (WASP) (Ambrose 1993, EPA 2006b). Since that work was performed both EFDC and WASP have been released in updated versions. The original EPA TMDL work will be used as a starting point. Next, work performed by Dr. J. Bowen (UNC-C) will be evaluated for further influence regarding approach of the current work. And lastly, the data compiled during the gathering task (USACE 2007a) will be used for assigning forcings and extending time series.

2.1 Environmental Fluid Dynamics Code

The Environmental Fluid Dynamics Code (EFDC) is a robust 3-dimensional hydrodynamic model. It is capable of simulating salinity, temperature, atmospheric interactions, circulation and more. It was used to represent the complex hydrodynamics (Martin 1999) of the NRE and pass those to the water quality application.

2.1.1 Model Grid

The model grid from the EPA TMDL work was adopted for this study. There was no modification to the horizontal or vertical cell definitions of the grid at-large or the number of cells. However, there was minor adjustment to dimensions of select cells in order to get the model running.

2.1.2 Weather

Weather forcing information for an EFDC application is contained in the ASER.INP and WSER.INP input files. The ASER.INP file contains atmospheric pressure, air temperature, relative humidity, rainfall, solar radiation, and cloud cover. Evapotranspiration was internally calculated in this EFDC application. The WSER.INP file contains the wind speed and direction information. The weather data were processed using the MetADAPT tool from the USEPA Region 4 TMDL Tool Box (EPA 2006a). Five weather stations were reviewed to develop the weather forcing for the model applications (Figure 2 and Table 1).

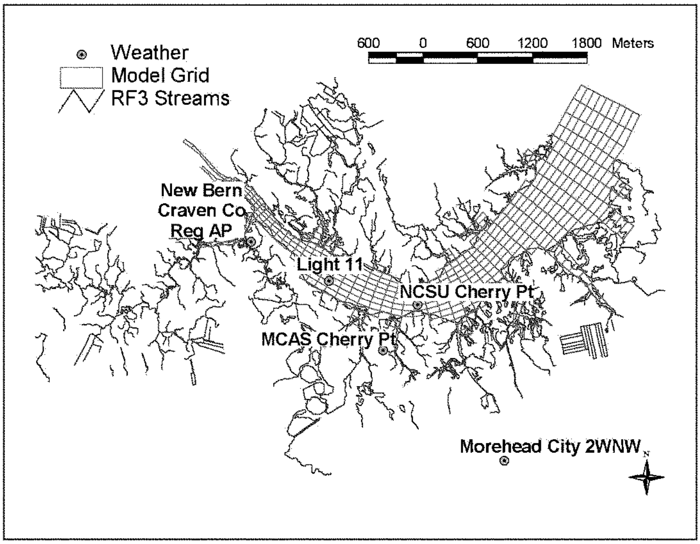


Figure 2. Weather Stations for Model Development

Table 1. Weather Station Summary Information

Name	ID 1	ID 2	Lattitude	Longitude	Agency
New Bern Craven Co. Reg. AP	93719	316108	35.06666700	-77.05000000	NCDC
Neuse River at Channel Light 11	USGS-LT11	0209262905	34.99916700	-76.94305600	USGS
NCSU Cherry Point	NCSU-CP	-	34.94742533	-76.81589317	NCSU CAAE
Morehead City 2WNW	315830	-	34.73333300	-76.73333300	NCDC
MCAS Cherry Point	13754	-	34.90000000	-76.88333300	NCDC

2.1.2.1 Rainfall

Rainfall information was gathered from the National Climate Data Center (NCDC 2007, EarthInfo 2007) for New Bern Craven County Regional Airport (Coops ID 316108). The rainfall from the Summary of the Day (SOD) record was first patched for missing data by using the SOD record for Morehead City 2WNW (Coops ID 315830). Next, it was disaggregated to hourly by using the hourly rainfall record at New Bern Craven County Regional Airport (WBAN 93719). If a disagreggation template was not found in the index station, the SCS Type II distribution was used. The SOD record was used as a starting point instead of the WBAN record because historically those rainfall records are of more integrity than the hourly record since approximately 1996.

Table 2. Rainfall Station Information

Raw Station for Rainfall	Index Station for Patching Missing Periods	Index Station for Disaggregation to Hourly
New Bern Craven County Regional AP (Coops ID 316108)	Morehead City 2WNW (Coops ID 315830)	New Bern Craven County Regional AP (WBAN 93179)

Figure 3 shows the annual totals of rainfall after the patching process at New Bern Craven County Regional AP (Coops ID 316108). The long-term average is also plotted for reference in assessing above and below average rainfall years. The long-term average was developed from average the annual totals from years that were 100 percent complete, that is, no impaired flagging. 39 years were averaged which were 1959 – 1964, 1966 - 1993, and 2002 – 2006. The long-term annual average rainfall for New Bern Craven County Regional AP (Coops ID 316108) is 54.73 inches. 2001 and 2002 were approximately 13 and 5 inches below average, respectively, while 2003 had approximately 18 inches of above average rainfall.

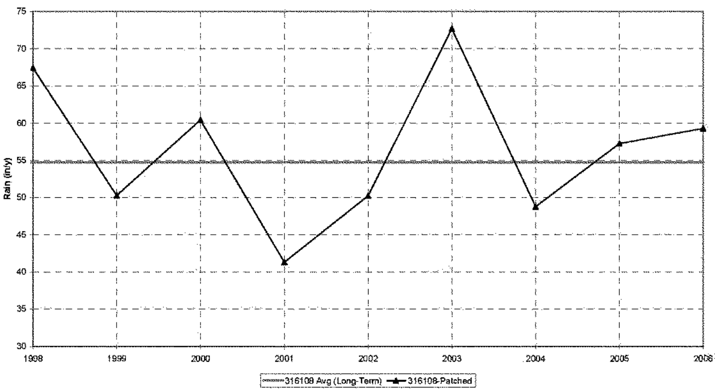


Figure 3. Patched Annual Rain at New Bern Craven County Regional AP (Coops ID 316108)

2.1.2.2 Wind

The NRE is a relatively shallow system with poor connectivity to the open ocean. As such, the wind forcing becomes a primary factor affecting circulation and water level. When the original EPA TMDL work was performed, there were no wind observation stations over the estuary, thus the wind recorded at the MCAS Cherry Point (WBAN 13754) station was the primary source for the wind forcing.

Since approximately 2000, hourly wind recording devices were placed in the field over the estuary. Table 3 lists the stations used to form the wind forcing for the model. The order presented in the table is similar to the priority given during the construction of the continuous wind forcing for the model.

Table 3. Wind Station Information

Station Name	ID	Agency	Begin Date	End Date	Comment
NCSU Cherry Point	NCSU-CP	NCSU – CAAE	3/16/2000	9/18/2003	
Neuse River at Channel Light 11 near Flanner Beach NC	USGS-LT11	USGS	2/14/2001	12/31/2006	Provisional
MCAS Cherry Point	WBAN 13754	NCDC	1/1/1997	12/31/2006	Significant periods of no observations
New Bern Craven County Regional AP	WBAN 93719	NCDC	3/1/1999	12/31/2006	WSPD adjusted +2.9 mph

The magnitudes of the wind records were developed into monthly averages. The NCSU Cherry Point, NCDC MCAS Cherry Point, and USGS Light 11 values were similar, but New Bern Craven County Regional AP showed a consistent lower magnitude. Thus, a constant adjustment of 2.9 miles per hour was added to the reported magnitudes of wind speed. Table 4 summarizes the monthly averages for the wind forcing record developed for this model.

Table 4. Model Wind Forcing Averages by Month

Month	Wind Speed (mph)	Wind Direction (degrees from North)
January	10.1	290
February	10.2	325
March	10.7	294
April	11.5	252
May	9.9	242
June	8.6	218
July	7.9	218
August	7.8	157
September	9.4	46
October	8.1	6
November	8.4	322
December	9.1	311

Generally, the wind blows out of the northwest from approximately November to March; out of the southwest from April to July; out of the southeast in August; and out of the northeast from September to October.

2.1.2.3 Remaining Weather Constituents

The remaining weather constituents were developed from the New Bern Craven County Regional AP (93719) station. These included pressure, air temperature, humidity, cloud cover estimate, and solar radiation estimate (Hamon method).

2.1.3 Freshwater Flow

The freshwater flow forcings were developed from daily average observations by the USGS (USGS 2007). The freshwater flows for the EFDC application are defined in the QSER.INP input file. All freshwater flow inputs were distributed equally across the four layers at the given horizontal location. Freshwater flows are dominated by the Neuse River entering the estuary at approximately New Bern. There is a flow gage station on the Neuse River near Fort Barnwell (02091814). The other daily average observation record was on Trent River near Trenton (02092500). The location of these stations and summary information are presented in Figure 4 and Table 5. The USGS water quality stations are also presented since the common agency for these five are the USGS.

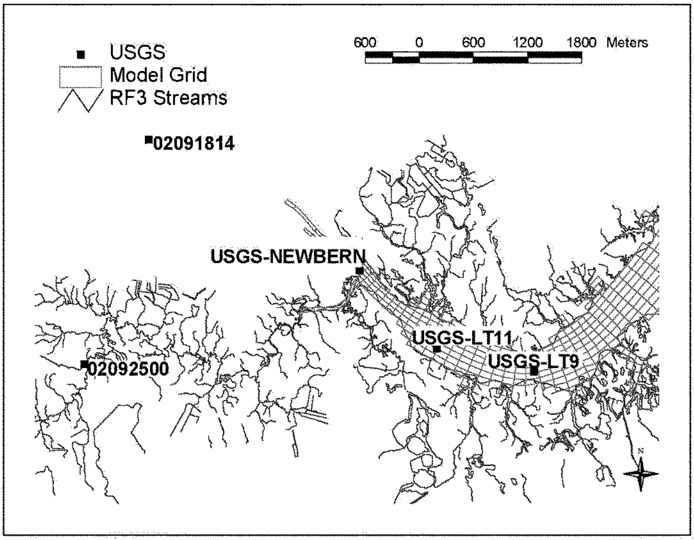


Figure 4. USGS Flow and Water Quality Station Locations

Table 5. USGS Flow and Water Quality Station Summary Information

Name	ID 1	ID 2	Type	Drainage Area (sq mi)
Neuse River near Fort Barnwell NC	02091814	-	Flow	3900
Trent River near Trenton NC	02092500	-	Flow	168
Neuse River at New Bern NC	USGS-NewBern	02092162	Water Quality	4470
Neuse River at Channel Light 11 near Flanner Beach NC	USGS-LT11	0209262905	Water Quality	-
Neuse River at Channel Light 9 at Cherry Point NC	USGS-LT9	0209265810	Water Quality	-

These records were developed into time series of 30-day moving averages to view more significant durations of high and low flow periods. These are presented in Figure 5. Generally, there was a distinctive difference in the 30-day moving average before and after approximately January 2003. Before January 2003, the period was marked by frequent and substantive low flow. Two particular notes are made for 1) the hurricane in September 1999 which followed closely to a relatively sustained period of low flows and 2) the lowest 30-day moving average noted at each station in 2002. After January 2003 the range of the 30-day moving average was mostly smaller and more consistent.

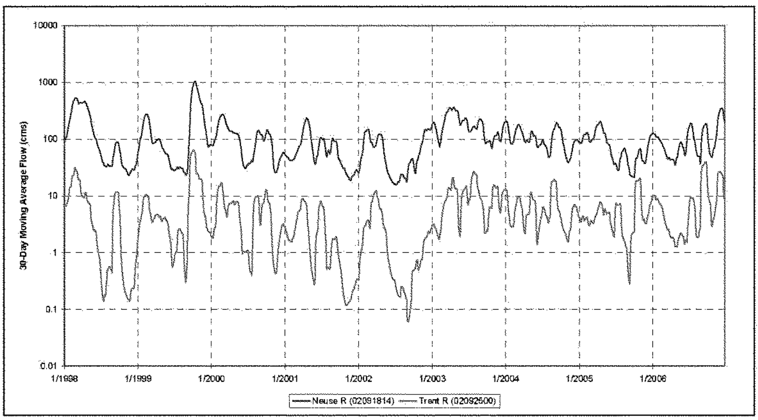


Figure 5. 30-Day Moving Average of Flow from Stations 02091814 and 02092500

The Trent River near Trenton, due only to its long-term record (1951 – 2006) and acknowledging that it has a drainage area of only 168 square miles, was reviewed to infer whether a given year may be above average, average, or below average with respect to flow volume. Figure 6 indicates that 1998, 2000, 2004, and 2005 were near average annual average flow years while 2001 and 2002 represented consecutive below average years.

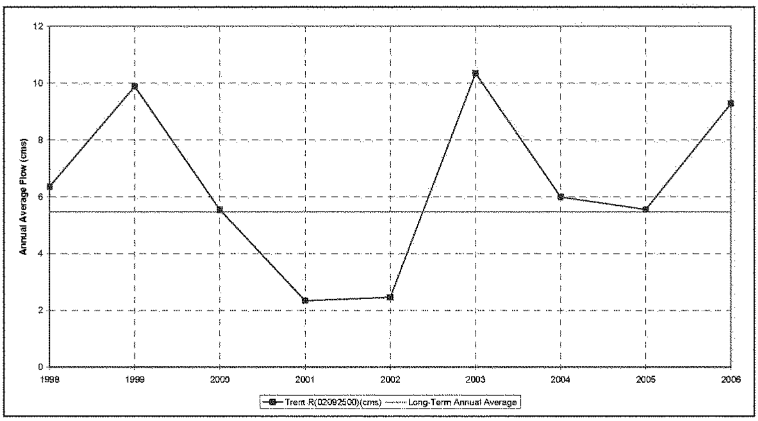


Figure 6. Annual Average Flow at Trent River near Trenton NC (02092500)

The Neuse River near Fort Barnwell, NC station began flow observations in 1996. As such, the long-term annual average may not be reflective of the actual long-term average. Given generally drier hydrologic regime in the area since 1996, the long-term annual average from the record may be an under-estimate. However, Figure 7 indicates consecutive below average years from 2000 through 2002. 2002, 2004, and 2006 appear to be near average years.

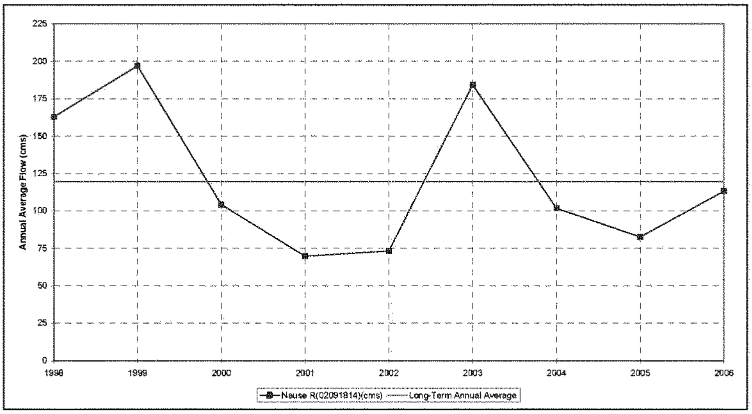


Figure 7. Annual Average Flow at Neuse River near Fort Barnwell NC (02091814)

The Watershed Characterization System (WCS) was used for the GIS based development of input for the study (EPA 2007). The areas immediately adjacent to the NRE were referred to as tributaries. The flow assignments for these tributaries were area weighted form the Trent River near Trenton NC (02092500) flow gaging station. The tributary areas and factors are presented in Table 6. This approach was used for the complete simulation period of 1998 – 2006.

Table 6. Area Weighting Factors for Flow Estimation of Tributary Areas

Tributary	Area (sq mi)	Area Weighting Factor
Broad Creek	17.8	0.11
Greens Creek	19.4	0.12
Dawson Creek	26.0	0.15
Beard Creek	19.6	0.12
Goose Creek	43.6	0.26
Upper Broad Creek	82.4	0.49
South River	49.6	0.30
Adams Creek	43.6	0.26

Tributary	Area (sq mi)	Area Weighting Factor
Clubfoot Creek	24.9	0.15
Hancock Creek	26.1	0.16
Slocum Creek	49.1	0.29
Trent River (d/s)	111.3	0.66
Trent River (mid)	267.1	1.59
Bachelor Creek	56.1	0.33
Swift Creek	321.6	1.91

2.1.4 Point Sources

Four point sources were input into the QSER.INP file. The point sources were assigned to the bottom-most cell of a horizontal location. They are presented in Table 7. They consist of one pulp discharge and three wastewater treatment discharges. The Weyerhaeuser and New Bern WWTP discharges are near the headwaters of the model grid, near New Bern. The MCAS Cherry Point WWTP and Havelock WWTP discharges are near Slocum Creek.

Table 7. Point Source Summary Information

Name	NPDES ID	Average Discharge (cms)	Average Discharge (mgd)
Weyerhaeuser Pulp	NC0003191	0.710	16.2
New Bern WWTP	NC0025348	0.176	4.0
MCAS Cherry Point WWTP	NC0003816	0.101	2.3
Havelock WWTP	NC0021253	0.066	1.5

The approximate long-term annual average of the sum of the Neuse River near Fort Barnwell (02091814) and Trent River near Trenton (02092500) is 2,853 mgd (125 cms), which does not consider the tributary flow. The relative contribution of the flow from these point sources at approximately 24 mgd (1 cms) is small. However, the constituent loadings may have an impact, this will be considered in the WASP application.

2.1.5 Water Surface Elevation

The open boundary for the model grid was approximately where the mouth of the NRE confluences with Pamlico Sound, just seaward of Maw Point and Point of Marsh. There is a paucity of observed water surface elevation in the NRE/Pamlico Sound. This has been a concern for the scientific community for many years. Bob Christian of East Carolina University has sponsored a workshop to address this issue and the USACE – Wilmington has explored the potential of benchmarking one or more than one station in the NRE/Pamlico Sound. Furthermore, the NRE/Pamlico Sound is complex in addition to being shallow in nature and poorly connected to the open ocean. As such past modeling efforts including the EPA TMDL work as well as the current body of work have been challenged in the ability to represent the open boundary, which is important. The observed data available is typically depth via pressure transducers, which means the atmospheric component must be subtracted out. However, there is still the conundrum of linking the depth to a vertical datum. The adopted approach was to determine the average of the observed record and consider it the mean tidal depth.

Robert Reed, PhD of NCSU-CAAE has developed a statistical approach to hindcasting daily water surface elevation based on a limited observed water surface elevation series on the area of interest, a regional long-term water surface elevation gage, and a wind forcing (Reed 2007). For this application, the discontinuous depth observations at ModMon 180 were developed into water surface elevations. The long-term regional water surface elevations were used from Oregon Inlet Marina (8652587) and Beaufort (8656483). The wind record, which was developed into u-v vector format with a 40-degree clockwise shift was developed as described in Section 2.1.2.2.

The water surface elevation forcing series, which was entered in the input file called PSER.INP, was composed of the EPA TMDL 1998 – 2000 sub-daily record along with the 2001 – 2006 hindcasted daily record. This decision was made with respect to no credible continuous observed time series available. The daily hindcasting technique showed a reasonable ability to capture wind effects, storm surge and astronomical components of the open boundary. Since the output of interest in this work is on the scale of a day or days, it was deemed acceptable to force the open boundary with a daily record.

2.1.6 Salinity

The salinity forcing information is placed in the SSER.INP input file. The initial condition for all model grid cells are defined in the SALT.INP input file. The Adams Creek tributary is an intracoastal waterway and was assigned a constant value of 12 g/L for salinity. The open boundary assignment from the EPA TMDL 1998 – 2000 simulation was used to begin the file for this work. This was done to capitalize on the processing that was already performed to represent the salinity of the open boundary. After 2000, the frequency of observations at ModMon 180 increased to twice per month. Thus the record was considered sufficient to process and append to the previous work. The processing involved reducing the observed profile to four average values by depth that would then be used to force each of the four layers at that specific time. The observations were generally made twice a month and the profiles typically had 6 or more observations.

2.1.7 Water Temperature

The water temperature forcing information was placed in the TSER.INP input file. The initial condition was defined in the TEMP.INP input file. At the open boundary the longitudinal water temperature gradient was much less, typically, than the longitudinal salinity gradient. Thus ModMon 160 and ModMon 180 were used to create a forcing that goes from 1998 through 2006. ModMon 160 was used particularly because the frequency of observation to ModMon 180 is less for the period of 1998 – 2000, a supplement was desired.

The headwater forcing was determined from the ModMon 0 station. The frequency of observation was approximately twice per month for the simulation period of 1998 – 2006. It was processed into forcings for four layers and assigned to the headwaters. Furthermore, it was assigned to the tributary flow definitions.

The DMR data for the four point sources were used to develop unique water temperature forcings for each of the point sources, however, they were basically similar.

2.2 Water Quality Analysis and Simulation Program

The WASP6 program was used for the EPA TMDL work. The current version, WASP72, was used for this work. The past work was used to inform the assignments of constants, input parameters, and other input information. In the past, separate applications had to be built one year at a time. However, since time has passed and the models have improved, this limitation is not present anymore for the NRE application. This represents a significant advancement in management of input files and time savings.

2.2.1 Hydrodynamic Linkage File

WASP requires a hydrodynamic linkage file which is produced by EFDC. The hydrodynamic linkage file is referred to as the HYD file. The HYD file contains information such as cell geometry, velocity, water temperature, salinity, depth and more which is passed to the WASP application and coupled to the water quality simulation. The HYD file tends to be a large file, for the Neuse River estuary application it is over 4 gigabytes.

2.2.2 Simulation Time and Print Interval

The simulation time and print interval are initially read into WASP when the HYD file is loaded. The time step is also set during this process. For the NRE, the print interval was changed to 1 day since the scale of interest for the oyster work will be day or days.

2.2.3 State Variables

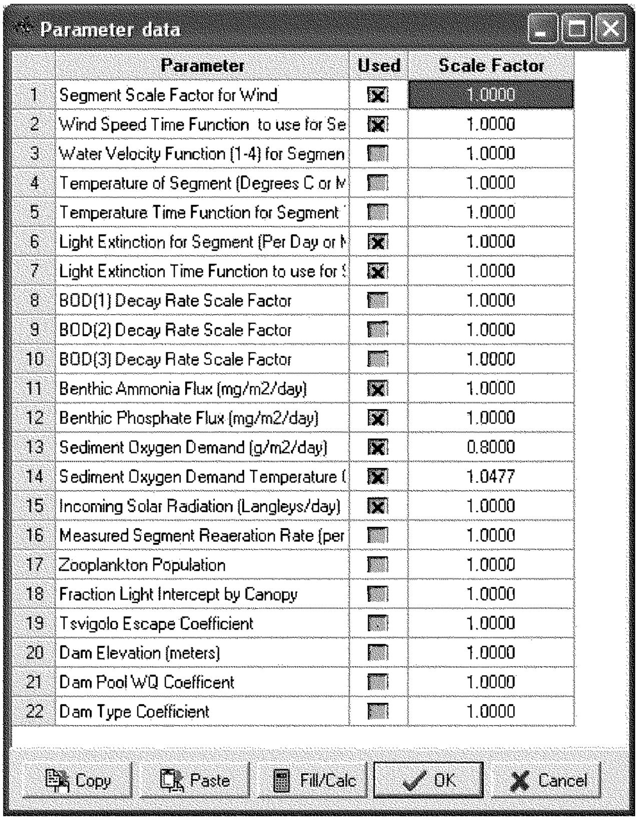
The state variables selected for the NRE application are presented in Table 8. This selection reflects the past EPA TMDL work and basic eutrophication. Salinity is not selected as it is already passed to WASP by the HYD file.

Table 8. State Variables (Systems) Used in WASP for Neuse River Estuary Application

System Number	Name	Symbol	Units
1	Ammonia	NH4	mgN/L
2	Nitrate+Nitrite	NOx	mgN/L
3	Organic Nitrogen	OrgN	mgN/L
4	Orthophosphate	PO4	mgP/L
5	Organic Phosphorus	OrgP	mgP/L
6	Chlorophyll *a*	Chla	µg/L
7	Dissolved Oxygen	DO	mg/L
8	Ultimate Carbonaceous Biochemical Oxygen Demand	CBODu1	mg/L

2.2.4 Parameter Data

The parameter settings in the NRE applications are seen in Figure 8. They represent the wind, light extinction, benthic ammonia flux, sediment oxygen demand, and solar radiation; all inherited from the EPA TMDL work.



Parameter data

	Parameter	Used	Scale Factor
1	Segment Scale Factor for Wind	X	1.0000
2	Wind Speed Time Function to use for Se	X	1.0000
3	Water Velocity Function (1-4) for Segmen		1.0000
4	Temperature of Segment (Degrees C or M		1.0000
5	Temperature Time Function for Segment '		1.0000
6	Light Extinction for Segment (Per Day or M	X	1.0000
7	Light Extinction Time Function to use for S	X	1.0000
8	BOD(1) Decay Rate Scale Factor		1.0000
9	BOD(2) Decay Rate Scale Factor		1.0000
10	BOD(3) Decay Rate Scale Factor		1.0000
11	Benthic Ammonia Flux (mg/m2/day)	X	1.0000
12	Benthic Phosphate Flux (mg/m2/day)	X	1.0000
13	Sediment Oxygen Demand (g/m2/day)	X	0.8000
14	Sediment Oxygen Demand Temperature (	X	1.0477
15	Incoming Solar Radiation (Langleys/day)	X	1.0000
16	Measured Segment Reaeration Rate (per		1.0000
17	Zooplankton Population		1.0000
18	Fraction Light Intercept by Canopy		1.0000
19	Tsvigolo Escape Coefficient		1.0000
20	Dam Elevation (meters)		1.0000
21	Dam Pool WQ Coefficent		1.0000
22	Dam Type Coefficient		1.0000

Figure 8. Parameter Settings for WASP Application of Neuse River Estuary

2.2.5 Constants

The assignment of constants was performed by first using the values from the EPA TMDL work. The values were revised if required through the iterative process of checking calibration/validation.

2.2.6 Loads

The four point sources were assigned constituent contributions through the Loads step of the pre-processor. The data was developed in units of kg/d and an f-ratio of 2 was assumed to convert all BOD5 values to CBODu (Chapra 1997, Thomann 1987). All four point sources were assigned a loading series for NH4, NOx, OrgN, PO4, and CBODu. Only two, Weyerhaeuser Pulp and New Bern WWTP, were input for organic phosphorus loading. The dissolved oxygen assignment to these waste streams were defined in the Boundary Conditions step of the pre-processor (Section 2.2.8).

2.2.7 Time Functions

The Time Functions step of the pre-processor is where time series of weather and other variables are defined. The weather series entered here include the daily solar radiation, daily fraction of light, daily wind speed, and daily air temperature. The remaining time series defined in this step include the benthic ammonia flux, benthic orthophosphate, and light extinction.

2.2.8 Boundary Concentrations

The development and assignment of boundary conditions in the Boundaries step of the pre-processor represents a significant level of effort. There are 96 cells which require definition, each for the 8 state variables used. This represents 768 time series that must be defined. However, the primary cells are given the dominant attention. These may be considered in order as headwater, open boundary, point sources, and remaining freshwater flow input.

The headwater cell representing the Neuse River input to the estuary is by far the largest fresh flow contributor. Thus, particular effort was made to process and assign the boundary conditions using ModMon 0.

The open boundary which is near Pamlico Sound was forced with monthly averages or constant values. ModMon 180 was primarily used to develop the open boundary forcing.

As noted earlier, the water quality of the point sources were primarily entered as loads. However, dissolved oxygen assignment was entered as a concentration. Furthermore, chlorophyll-*a* was assigned as zero µg/L.

Lastly, the remaining freshwater flow cells were assigned boundaries for the state variables as constants by reviewing average characteristics observed at station NCDWQ J8770000.

3 Model Calibration and Validation

The models were run for a simulation period of 1998 – 2006. The comparisons were prioritized to first match the performance of the EPA TMDL simulation period of 1998 – 2000 and then compare to the extended period of 2001 – 2006. The particular area of interest for model performance was from approximately the bend, eastward to the open boundary. This was the primary area of interest related to oyster restoration evaluation.

3.1 ENVIRONMENTAL FLUID DYNAMIC CODE

3.1.1 Salinity

The salinity simulation was compared to observed data at multiple locations. These were USGS stations Light 9 and Light 11 (Figure 9 through Figure 12); NCSU-CAAE stations Cherry Point 34 and Minnesott 35 (Figure 13 through Figure 16); and UNC-CH IMS stations ModMon 100 and ModMon 180 (Figure 17 through Figure 20). The salinity simulation captures the trends observed in the estuary reasonably well. The model captures the fresh water pulses and the rebuilding of salinity in the estuary across a 9 year simulation. The most dynamic salt flushing is observed during the hurricane season of 1999 which the simulation captured. It can be seen that generally near the area of the bend the salinity was completely flushed out. By station ModMon 180, there was very little salinity remaining from this pulse. The salinity concentrations build back across 2000 through 2002, and then 2003 is a wet year (Section 2.1.3) and the salinity reflects that through decreased concentrations.

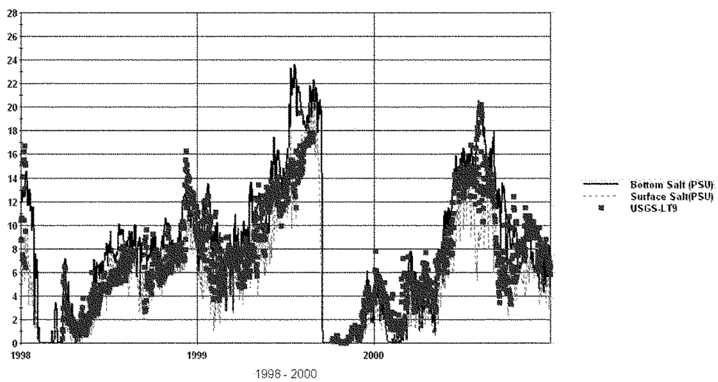


Figure 9. Salinity Calibration Comparison for 1998 – 2000 at USGS Light 9

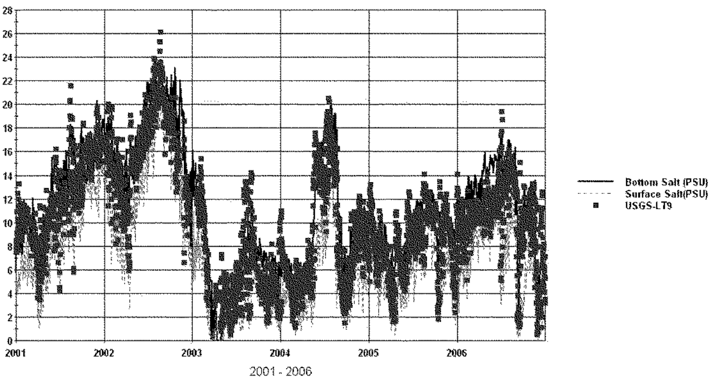


Figure 10. Salinity Validation Comparison for 2001 – 2006 at USGS Light 9

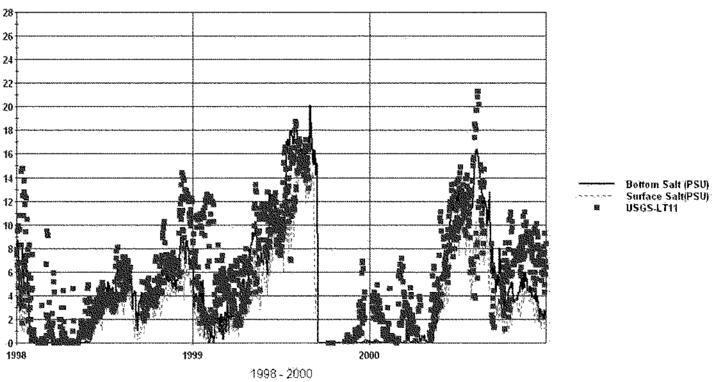


Figure 11. Salinity Calibration Comparison for 1998 – 2000 at USGS Light 11

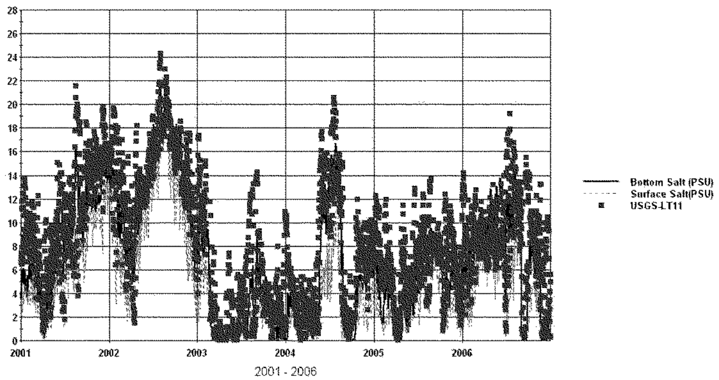


Figure 12. Salinity Validation Comparison for 2001 – 2006 at USGS Light 11

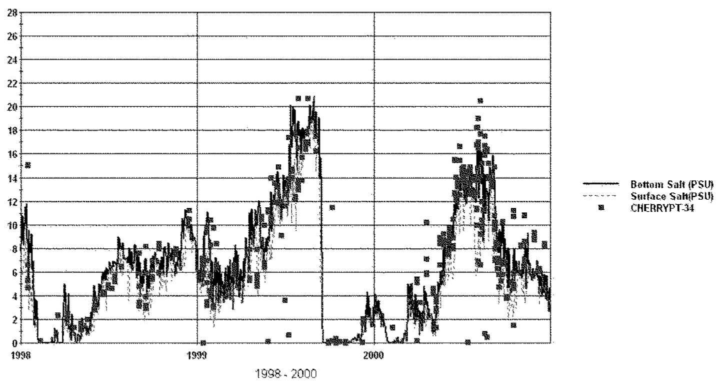


Figure 13. Salinity Calibration Comparison for 1998 – 2000 at NCSU Cherry Point 34

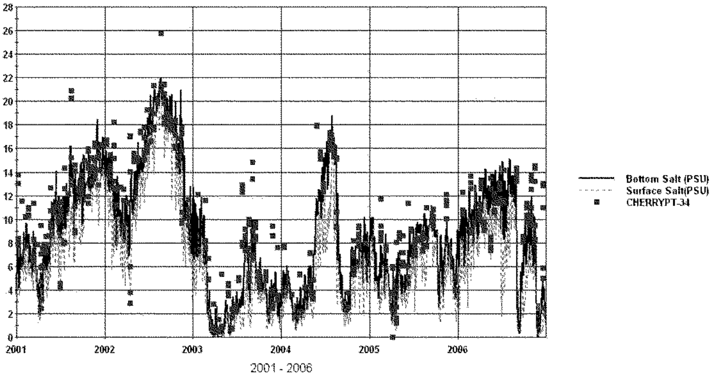


Figure 14. Salinity Validation Comparison for 2001 – 2006 at NCSU Cherry Point 34

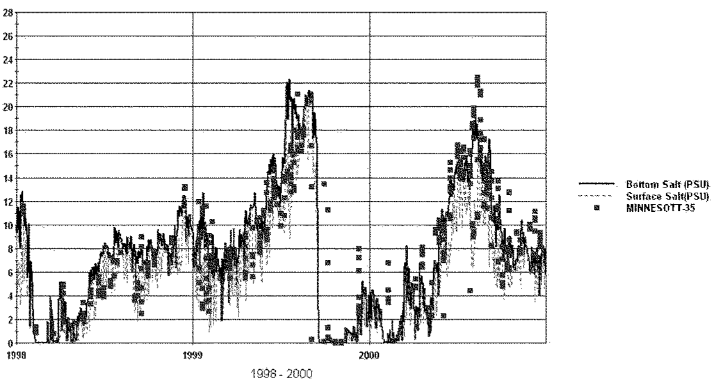


Figure 15. Salinity Calibration Comparison for 1998 – 2000 at NCSU Minnesott 35

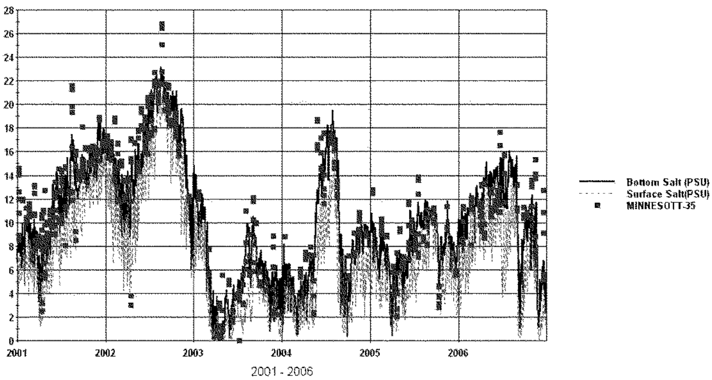


Figure 16. Salinity Validation Comparison for 2001 – 2006 at NCSU Minnesott 35

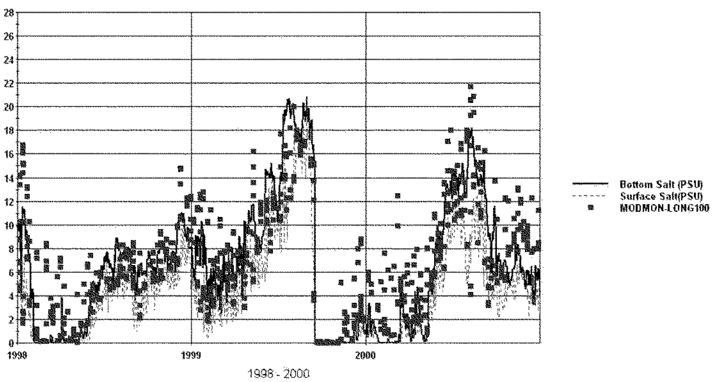


Figure 17. Salinity Calibration Comparison for 1998 – 2000 at ModMon 100

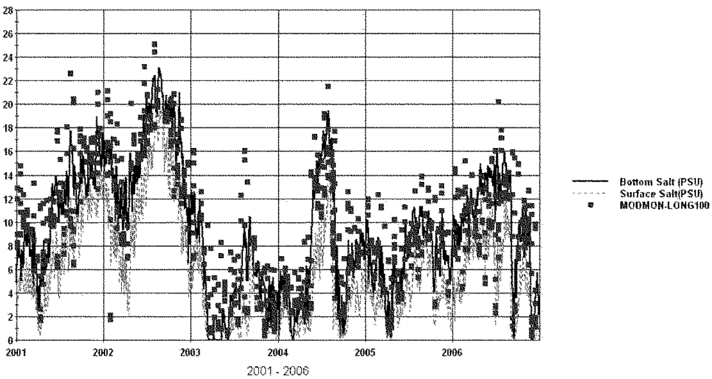


Figure 18. Salinity Validation Comparison for 2001 – 2006 at ModMon 100

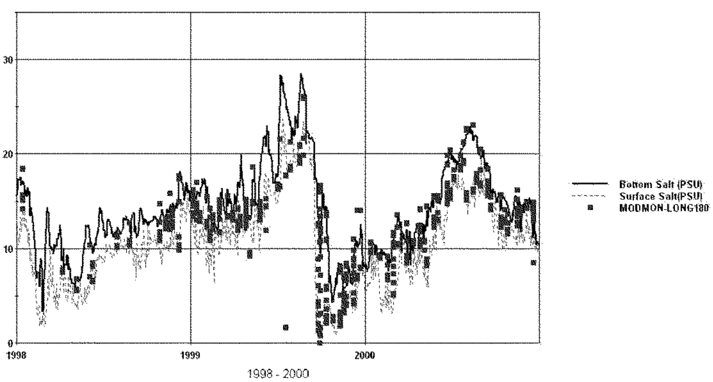


Figure 19. Salinity Calibration Comparison for 1998 – 2000 at ModMon 180

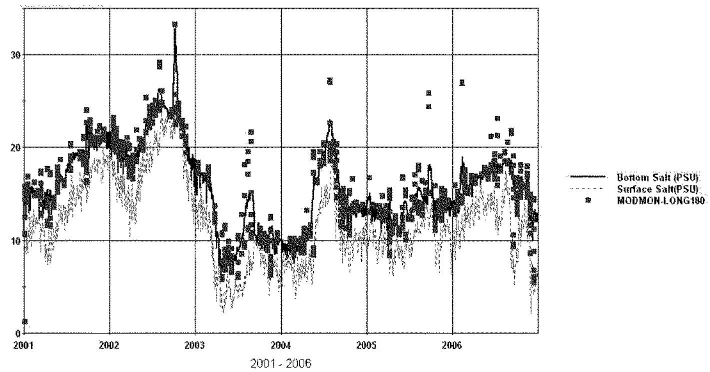


Figure 20. Salinity Validation Comparison for 2001 – 2006 at ModMon 180

Statistics were developed for ModMon 100 and ModMon 180 in Table 9 and Table 10. These were selected as ModMon 100 is located near the bend and ModMon 180 is located near Pamlico Sound. The observed data were manipulated to make one representative value per each model layer. The statistics indicate good agreement with the observed data. The EPA TMDL statistics are repeated in Table 9 to allow comparison.

Table 9. EFDC Simulation Salinity (ppt) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 – 2000**
Count	154	152	154	152	277
Mean Predicted	6.4	9.4	4.2	5.5	3.9
Mean Observed	8.4	12.1	5.2	7.6	5.1
Standard Deviation Predicted	5.4	5.2	4.0	4.4	3.7
Standard Deviation Observed	5.1	4.8	4.0	4.7	3.9
Mean Error (ME)	2.0	2.7	1.0	2.1	-1.2
ME Percent of Mean Obs.	23.8%	22.3%	19.6%	28.0%	
Root Mean Square Error (RMSE)	3.3	3.6	1.9	2.8	0.3
RMSE Percent of Mean Obs.	39.7%	29.4%	37.6%	36.5%	
R^2 Correlation	0.76	0.80	0.83	0.86	0.85

Table 10. EFDC Simulation Salinity (ppt) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**
Count	75	134	75	134
Mean Predicted	14.7	16.1	10.5	11.8
Mean Observed	14.1	17.0	11.2	14.8
Standard Deviation Predicted	4.9	4.6	4.9	4.8
Standard Deviation Observed	4.0	4.4	4.6	4.8
Mean Error (ME)	-0.6	0.9	0.7	2.9
ME Percent of Mean Obs.	-4.3%	5.3%	6.4%	19.9%
Root Mean Square Error (RMSE)	2.3	1.5	1.9	3.4
RMSE Percent of Mean Obs.	16.4%	8.8%	17.0%	22.8%
R^2 Correlation	0.80	0.93	0.87	0.88

3.1.2 Water Temperature

The water temperature observed data shows less vertical stratification than salinity. This may in part be due to the generally shallow nature of the estuary. Furthermore, while the long-term trend of water temperature in the estuary is anticipated to be generally consistent, the model does represent the subtle variations that occur from time to time, for example the summer of 2002. That period is coincident to low flow, thus perhaps shallower depths and higher water temperature.

Figure 21 through Figure 26 present time series comparisons of the water temperature simulations against data collected by the USGS and UNC-CH IMS.

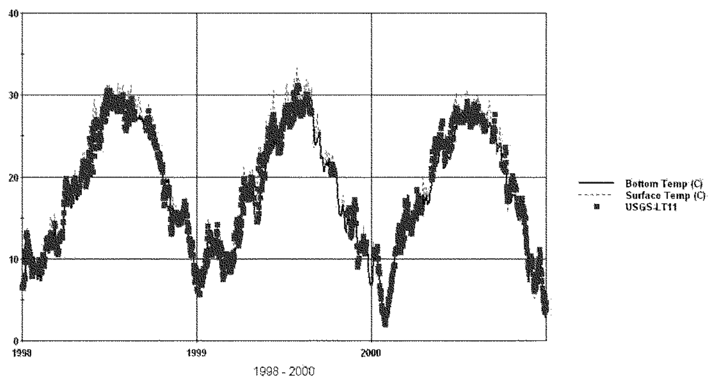


Figure 21. Water Temperature Calibration Comparison for 1998 – 2000 at USGS Light 11

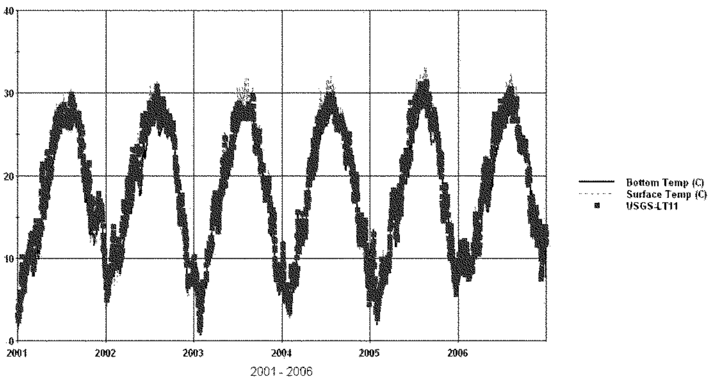


Figure 22. Water Temperature Validation Comparison for 2001 – 2006 at USGS Light 11

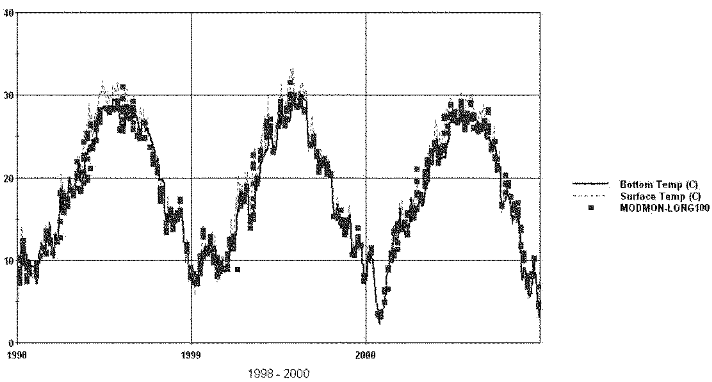


Figure 23. Water Temperature Calibration Comparison for 1998 – 2000 at ModMon 100

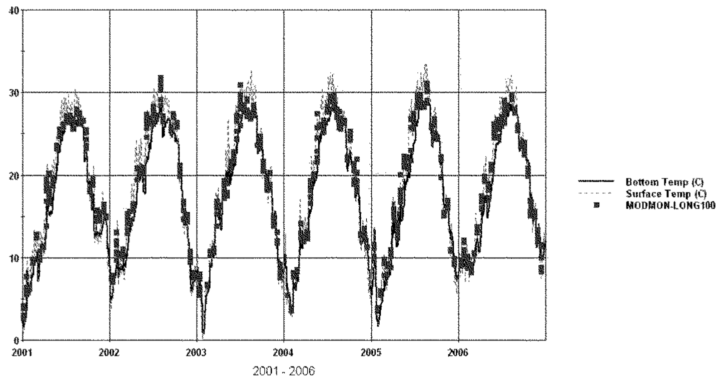


Figure 24. Water Temperature Validation Comparison for 2001 – 2006 at ModMon 100

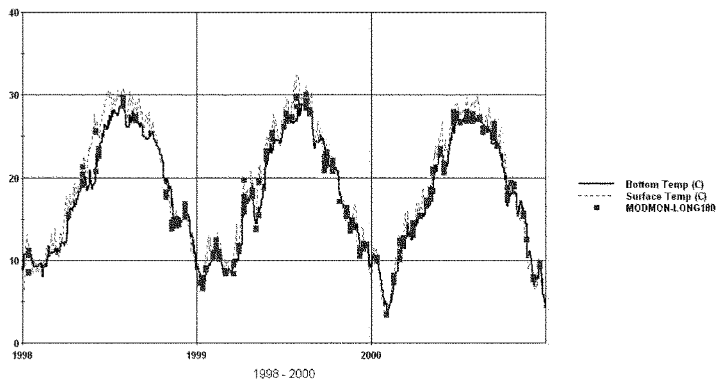


Figure 25. Water Temperature Calibration Comparison for 1998 – 2000 at ModMon 180

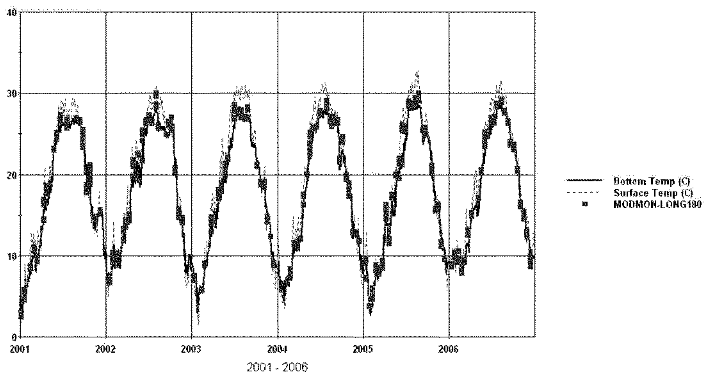


Figure 26. Water Temperature Validation Comparison for 2001 – 2006 at ModMon 180

Two ModMon stations were selected for the development of model performance statistics. The stations were ModMon 100 and ModMon 180. The statistics are presented in Table 11 and Table 12. The statistics from the EPA TMDL work for ModMon 100 surface layer are also included in Table 11.

Table 11. EFDC Simulation Water Temperature (deg C) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 – 2000**
Count	154	152	154	152	273
Mean Predicted	18.1	17.8	18.9	19.0	19.2
Mean Observed	17.9	18.5	18.6	19.0	18.7
Standard Deviation Predicted	7.1	7.4	7.7	8.1	7.4
Standard Deviation Observed	7.0	7.2	7.3	7.6	7.2
Mean Error (ME)	-0.2	0.7	-0.4	0.0	0.6
ME Percent of Mean Obs.	-1.1%	3.8%	-2.0%	0.0%	
Root Mean Square Error (RMSE)	1.1	1.3	1.3	1.0	0.0
RMSE Percent of Mean Obs.	6.4%	7.2%	6.9%	5.2%	
R^2 Correlation	0.97	0.98	0.98	0.99	0.98

Table 12. EFDC Simulation Water Temperature (deg C) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	Calibration 1998 - 2000	Validation 2001 - 2006	Calibration 1998 - 2000	Validation 2001 - 2006
Count	75	134	75	134
Mean Predicted	17.9	18.1	19.0	19.1
Mean Observed	17.9	18.4	18.4	18.7
Standard Deviation Predicted	6.7	7.2	7.2	7.9
Standard Deviation Observed	6.9	7.3	6.9	7.4
Mean Error (ME)	0.0	0.3	-0.6	-0.4
ME Percent of Mean Obs.	-0.2%	1.5%	-3.2%	-2.1%
Root Mean Square Error (RMSE)	0.9	1.0	1.0	1.0
RMSE Percent of Mean Obs.	5.0%	5.2%	5.2%	5.2%
R^2 Correlation	0.98	0.98	0.99	0.99

3.2 Water Quality Analysis and Simulation Program

3.2.1 Nitrate+Nitrite

The simulation of nitrate+nitrite is generally capturing the observed trend. There is build up of concentration in approximately December – March period and then near complete removal during the growing season. Figure 27 and Figure 28 show the time series comparison at ModMon 100 which is just west of the bend. There is higher nitrate+nitrite concentrations in the upper reaches of the estuary and much less in the lower reaches. This is noted in Figure 29 and Figure 30 for ModMon 180 which is near Pamlico Sound. The bend NCSU-CAAE stations of Cherry Point 34 and Minnesott 35 (Figure 31 and Figure 32) compare well to the observed data.

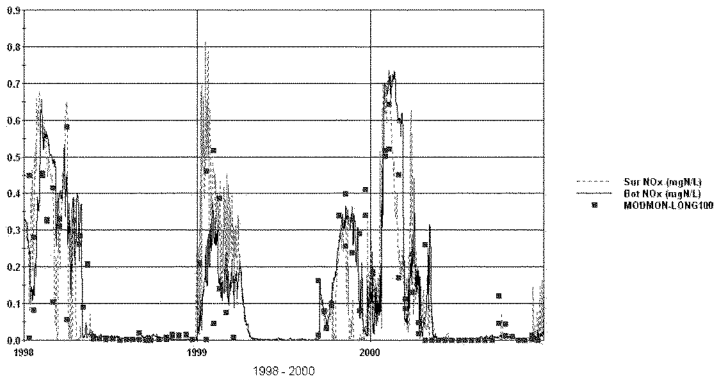


Figure 27. NOx Calibration Comparison for 1998 – 2000 at ModMon 100

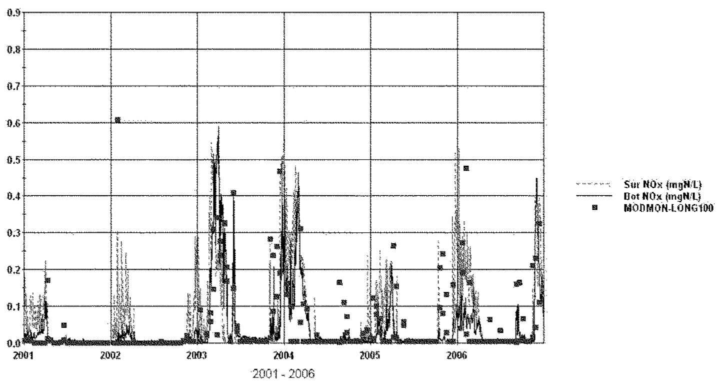


Figure 28. NOx Validation Comparison for 2001 – 2006 at ModMon 100

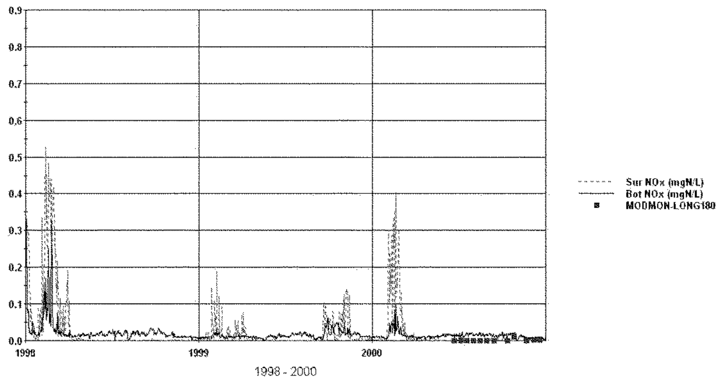


Figure 29. NOx Calibration Comparison for 1998 – 2000 at ModMon 180

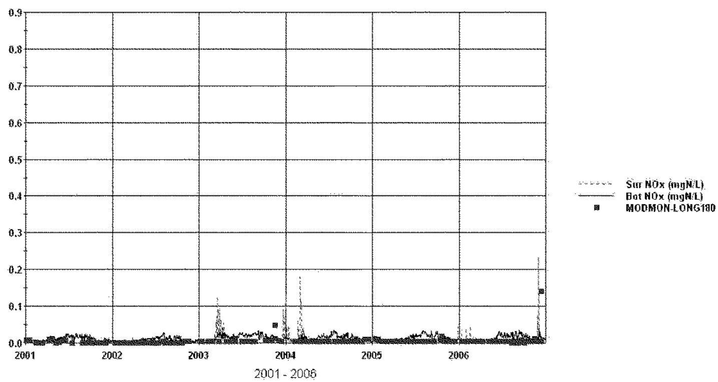


Figure 30. NOx Validation Comparison for 2001 – 2006 at ModMon 180

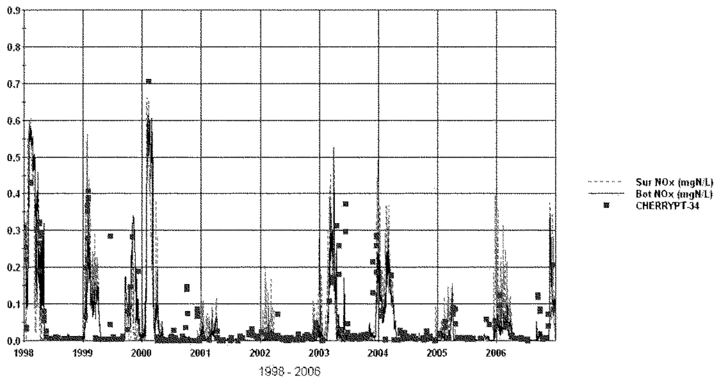


Figure 31. NOx Validation Comparison for 1998 – 2006 at Cherry Point 34

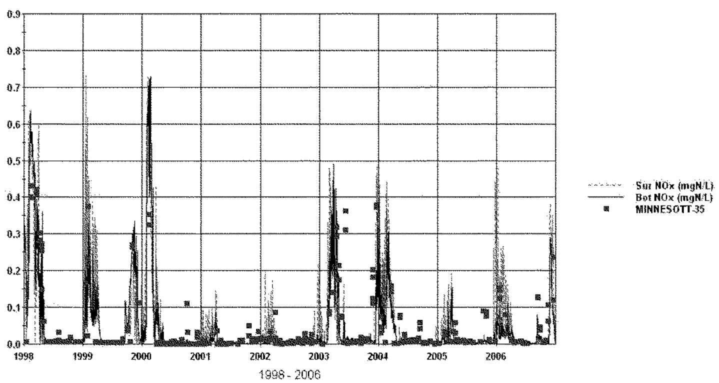


Figure 32. NOx Validation Comparison for 1998 – 2006 at Minnesott 35

Model performance statistics are presented in Table 13 and Table 14. The surface simulation was better than the bottom simulation. The EPA TMDL statistics are presented for comparison.

Table 13. WASP72 Simulation Nitrate+Nitrite (mgN/L) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 – 2000**
Count	52	139	52	139	63
Mean Predicted	0.132	0.039	0.132	0.057	0.16
Mean Observed	0.098	0.023	0.154	0.061	0.15
Standard Deviation Predicted	0.196	0.088	0.207	0.101	0.23
Standard Deviation Observed	0.147	0.057	0.185	0.110	0.18
Mean Error (ME)	-0.033	-0.017	0.022	0.004	0.01
ME Percent of Mean Obs.	-33.7%	-74.9%	14.3%	7.3%	
Root Mean Square Error (RMSE)	0.129	0.077	0.125	0.099	0.00
RMSE Percent of Mean Obs.	131.5%	342.1%	81.4%	161.5%	
R^2 Correlation	0.59	0.28	0.65	0.32	0.48

Table 14. WASP72 Simulation Nitrate+Nitrite (mgN/L) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**
Count	12	132	12	132
Mean Predicted	0.013	0.012	0.001	0.002
Mean Observed	0.002	0.004	0.002	0.005
Standard Deviation Predicted	0.006	0.007	0.001	0.006
Standard Deviation Observed	0.003	0.003	0.003	0.013
Mean Error (ME)	-0.011	-0.008	0.001	0.003
ME Percent of Mean Obs.	-453.3%	-206.3%	68.4%	66.4%
Root Mean Square Error (RMSE)	0.013	0.011	0.003	0.014
RMSE Percent of Mean Obs.	520.9%	277.0%	157.5%	265.7%
R^2 Correlation	0.06	0.00	0.00	0.02

3.2.2 Ammonium

The model is generally oversimulating in the bottom layer of the water column. This is more evident in ModMon 100 (Figure 33 and Figure 34) and ModMon 180 (Figure 35 and Figure 36), perhaps due to a combination of the benthic NH4 forcing and/or depth of cell. The comparisons at Cherry Point 34 (Figure 37) and Minnesott 35 (Figure 38) appear to perform better than the other two locations from time series inspection.

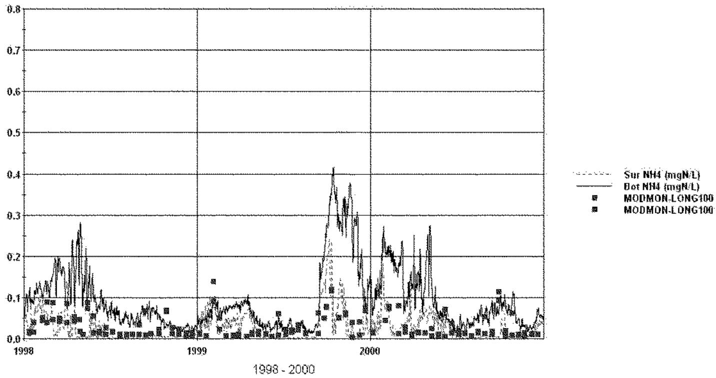


Figure 33. NH4 Calibration Comparison for 1998 – 2000 at ModMon 100

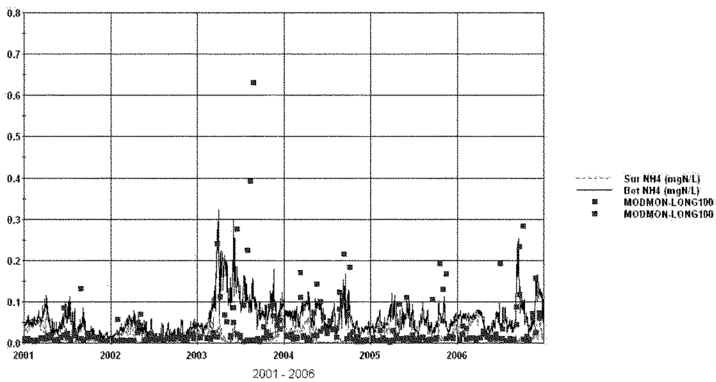


Figure 34. NH4 Validation Comparison for 2001 – 2006 at ModMon 100

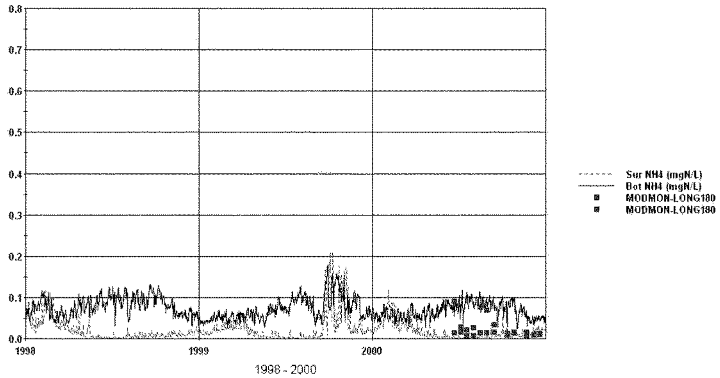


Figure 35. NH4 Calibration Comparison for 1998 – 2000 at ModMon 180

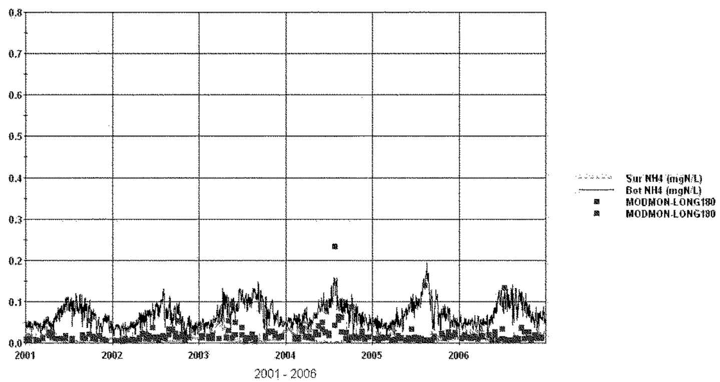


Figure 36. NH4 Validation Comparison for 2001 – 2006 at ModMon 180

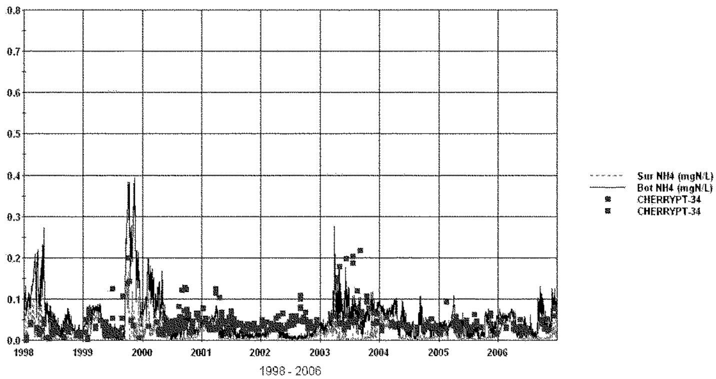


Figure 37. NH4 Validation Comparison for 1998 – 2006 at Cherry Point 34

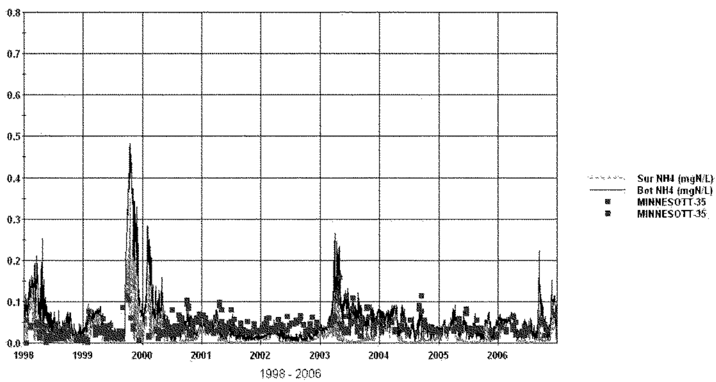


Figure 38. NH4 Validation Comparison for 1998 – 2006 at Minnesott 35

Model performance statistics are presented in Table 15 and Table 16 for ModMon 100 and ModMon 180. The EPA TMDL statistics are presented in Table 15 for comparison.

Table 15. WASP72 Simulation Ammonium (mgN/L) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 – 2000**
Count	77	150	77	150	75
Mean Predicted	0.092	0.063	0.031	0.014	0.05
Mean Observed	0.035	0.049	0.025	0.019	0.02
Standard Deviation Predicted	0.077	0.043	0.039	0.016	0.04
Standard Deviation Observed	0.029	0.082	0.027	0.026	0.03
Mean Error (ME)	-0.057	-0.014	-0.006	0.005	0.03
ME Percent of Mean Obs.	-161.2%	-29.2%	-25.4%	27.6%	
Root Mean Square Error (RMSE)	0.088	0.074	0.035	0.030	0.00
RMSE Percent of Mean Obs.	251.5%	150.7%	141.2%	156.7%	
R^2 Correlation	0.22	0.21	0.25	0.00	0.00

Table 16. WASP72 Simulation Ammonium (mgN/L) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**
Count	12	132	12	132
Mean Predicted	0.075	0.070	0.008	0.009
Mean Observed	0.034	0.022	0.012	0.014
Standard Deviation Predicted	0.025	0.027	0.008	0.009
Standard Deviation Observed	0.028	0.027	0.004	0.009
Mean Error (ME)	-0.041	-0.048	0.004	0.006
ME Percent of Mean Obs.	-119.5%	-222.6%	35.2%	39.1%
Root Mean Square Error (RMSE)	0.049	0.055	0.010	0.014
RMSE Percent of Mean Obs.	144.3%	255.9%	79.3%	100.8%
R^2 Correlation	0.17	0.25	0.03	0.00

3.2.3 Orthophosphate

The observed data generally shows a similar and consistent annual trend in orthophosphate, likely due to benthic releases coincident to high temperature and low oxygen periods of the bottom water in the estuary. However, the magnitudes of the simulation are generally less than the spikes shown in the observed data. Figure 39 and Figure 44 show the time series comparisons.

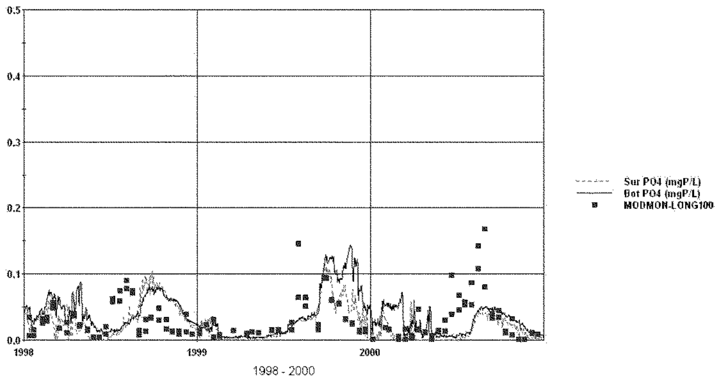


Figure 39. PO4 Calibration Comparison for 1998 – 2000 at ModMon 100

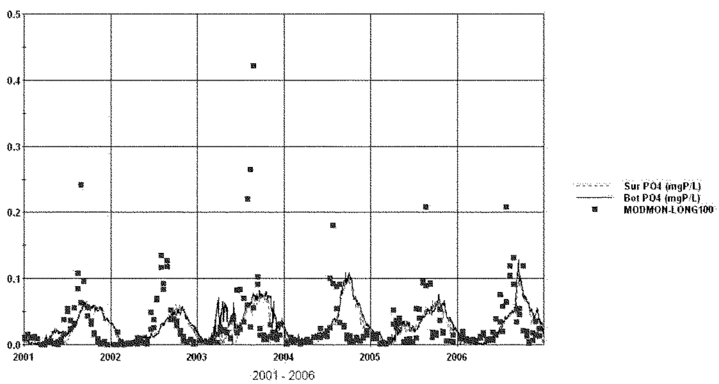


Figure 40. PO4 Validation Comparison for 2001 – 2006 at ModMon 100

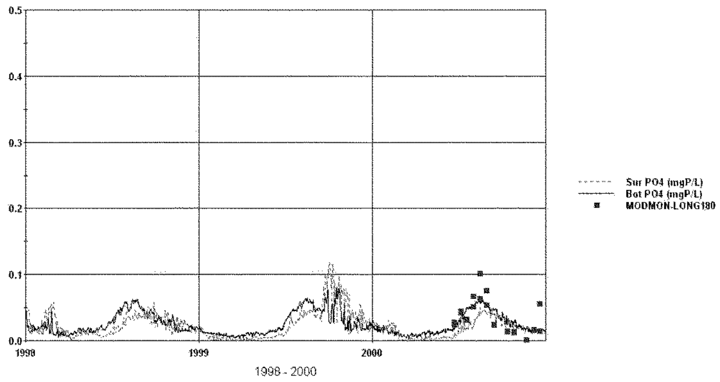


Figure 41. PO4 Calibration Comparison for 1998 – 2000 at ModMon 180

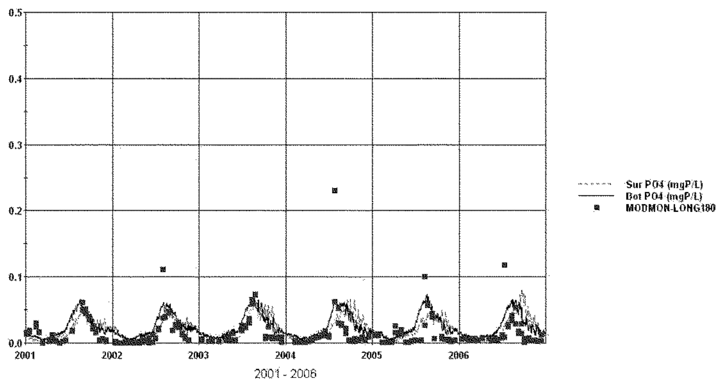


Figure 42. PO4 Validation Comparison for 2001 – 2006 at ModMon 180

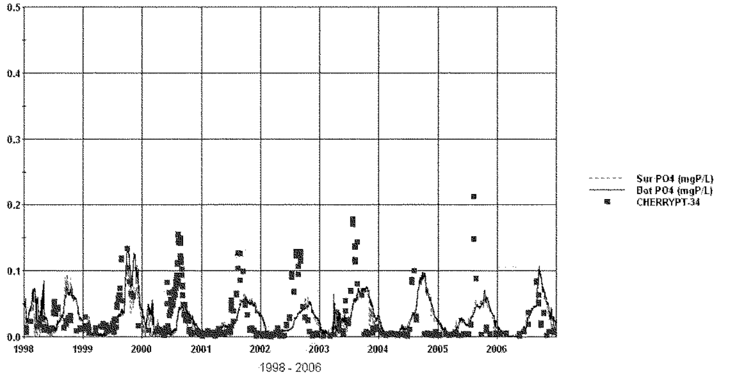


Figure 43. PO4 Validation Comparison for 1998 – 2006 at Cherry Point 34

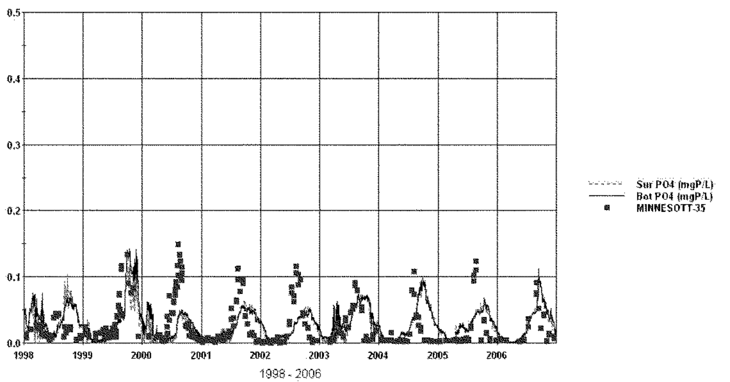


Figure 44. PO4 Validation Comparison for 1998 – 2006 at Minnesott 35

3.2.4 Dissolved Oxygen

The dissolved oxygen simulation appears reasonable (Figure 45 and Figure 50). The vertical stratification is frequently bound in the observed profiles. It is noted that for the four locations reviewed across 9 years, there is frequent and recurring low dissolved oxygen in the bottom portions of the water column as well as depressed surface values.

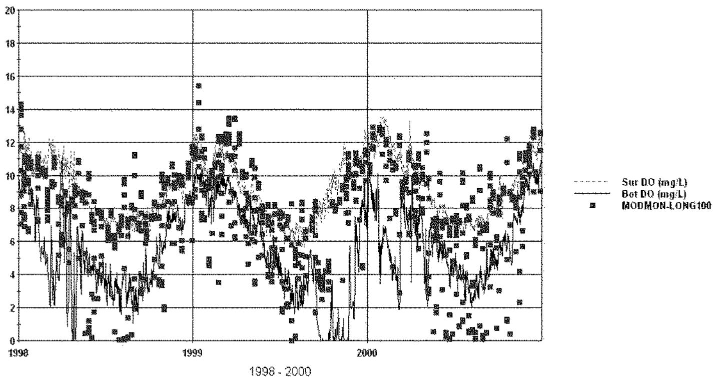


Figure 45. DO Calibration Comparison for 1998 – 2000 at ModMon 100

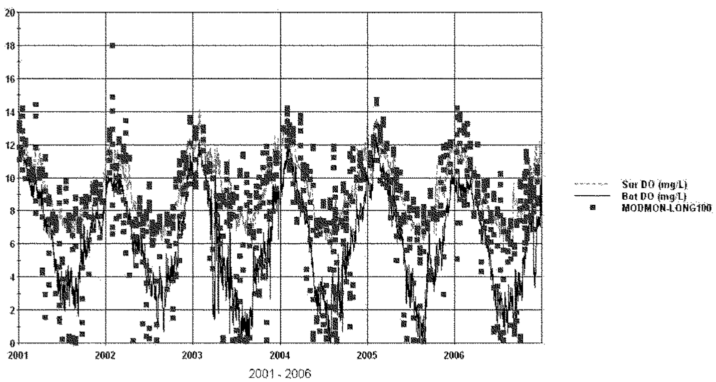


Figure 46. DO Validation Comparison for 2001 – 2006 at ModMon 100

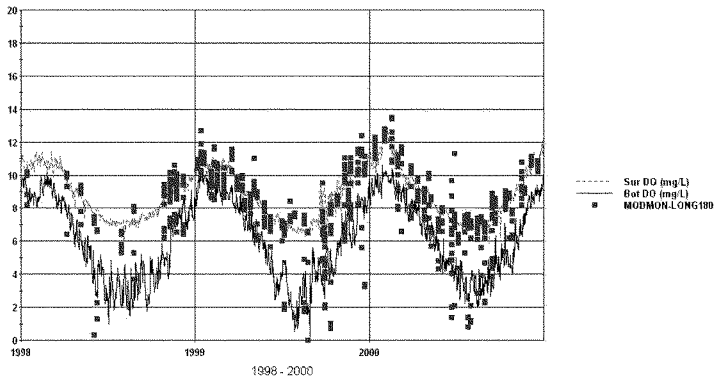


Figure 47. DO Calibration Comparison for 1998 – 2000 at ModMon 180

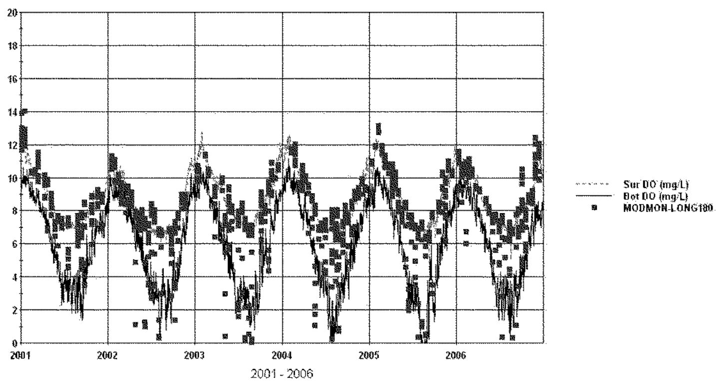


Figure 48. DO Validation Comparison for 2001 – 2006 at ModMon 180

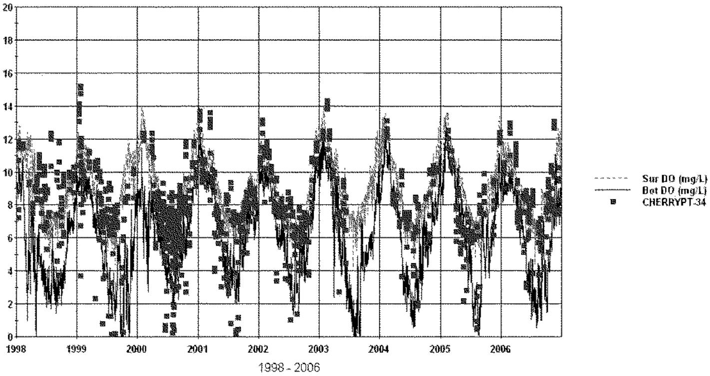


Figure 49. DO Validation Comparison for 1998 – 2006 at Cherry Point 34

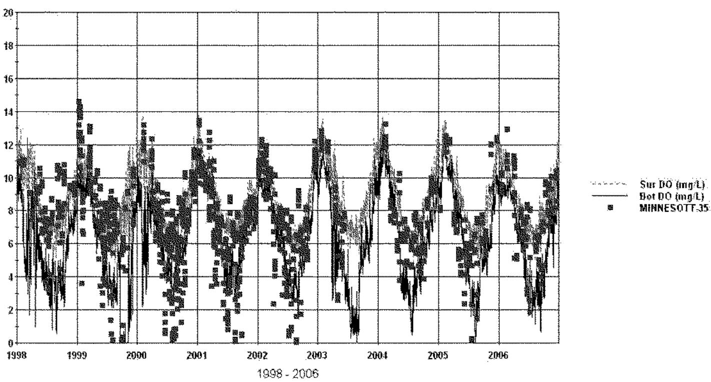


Figure 50. DO Validation Comparison for 1998 – 2006 at Minnesott 35

The statistics (Table 17 and Table 18) indicate better agreement in the surface layer of the water column than the bottom layer.

Table 17. WASP72 Simulation Dissolved Oxygen (mg/L) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 - 2000**
Count	154	152	154	152	268
Mean Predicted	5.5	6.0	9.3	9.3	9.1
Mean Observed	5.9	5.8	9.3	9.9	9.2
Standard Deviation Predicted	2.8	3.0	1.8	1.8	1.6
Standard Deviation Observed	3.1	3.6	2.1	2.1	2.1
Mean Error (ME)	0.4	-0.2	0.0	0.6	-0.1
ME Percent of Mean Obs.	6.3%	-3.1%	-0.5%	6.5%	
Root Mean Square Error (RMSE)	3.1	2.0	1.4	1.4	0.1
RMSE Percent of Mean Obs.	52.6%	35.1%	15.0%	14.2%	
R^2 Correlation	0.21	0.67	0.58	0.63	0.56

Table 18. WASP72 Simulation Dissolved Oxygen (mg/L) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**
Count	75	132	75	132
Mean Predicted	6.1	5.8	8.9	8.7
Mean Observed	7.0	7.3	9.2	9.0
Standard Deviation Predicted	2.6	2.6	1.5	1.5
Standard Deviation Observed	2.5	2.7	1.8	1.6
Mean Error (ME)	0.9	1.5	0.3	0.2
ME Percent of Mean Obs.	12.8%	21.0%	3.7%	2.5%
Root Mean Square Error (RMSE)	1.7	2.0	1.0	0.6
RMSE Percent of Mean Obs.	24.9%	27.3%	11.3%	6.3%
R^2 Correlation	0.68	0.78	0.68	0.90

3.2.5 Chlorophyll-*a*

The NRE is a complex waterbody with algal activity. Four stations were reviewed for chlorophyll-*a* observations, they were ModMon 100, ModMon 180, NCSU-CAAE Cherry Point 34, and Minnesott 35.

Three of those four stations are near the bend. The bend observations indicate algal activity that exceeds 40 µg/L, with some values of two, three, and more times that value.

The chlorophyll-*a* simulations show some of the trends present in the observed data but lacks in capturing the spikes of the observations (Figure 51 through Figure 56). The statistics indicate a slightly better simulation in the bottom layer (Table 19 and Table 20).

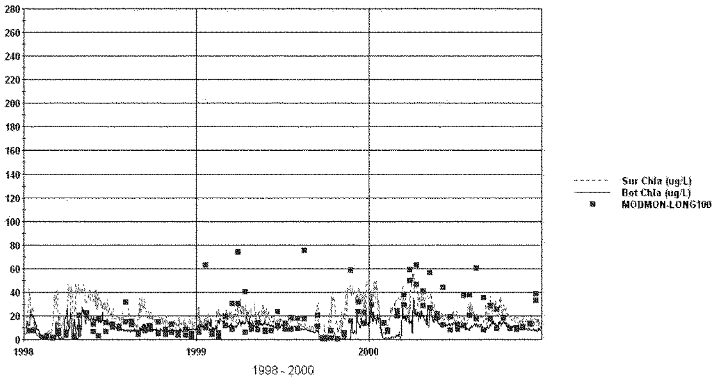


Figure 51. Chla Calibration Comparison for 1998 – 2000 at ModMon 100

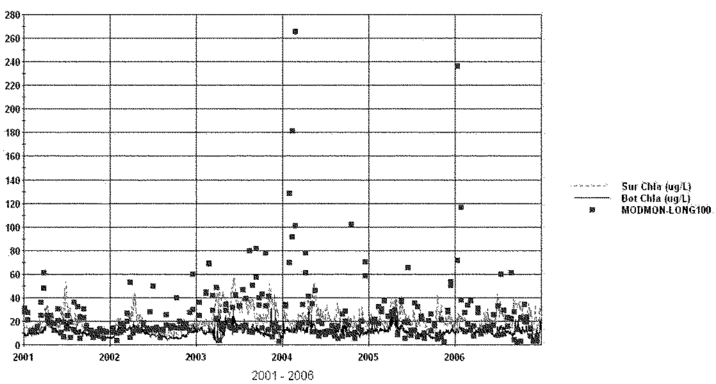


Figure 52. Chla Validation Comparison for 2001 – 2006 at ModMon 100

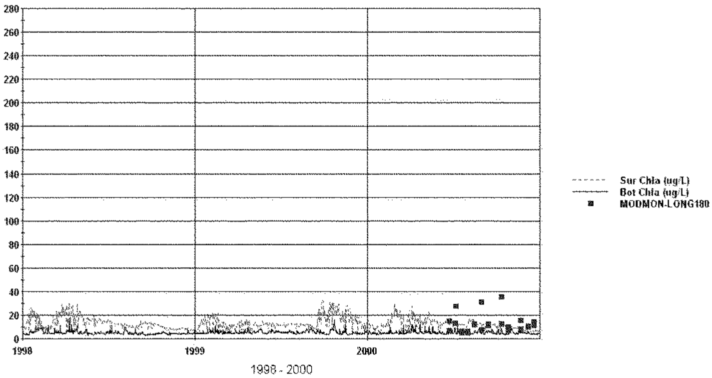


Figure 53. Chla Calibration Comparison for 1998 – 2000 at ModMon 180

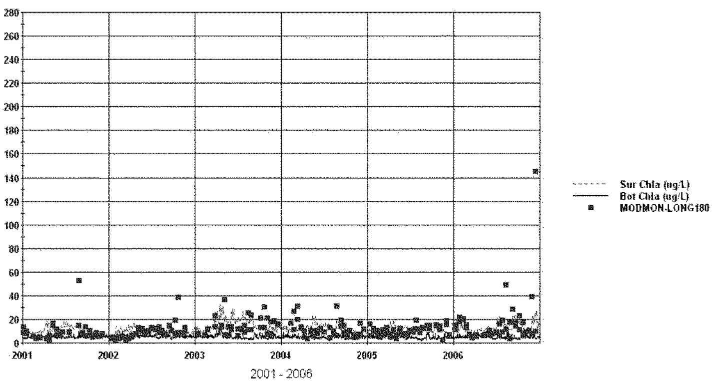


Figure 54. Chla Validation Comparison for 2001 – 2006 at ModMon 180

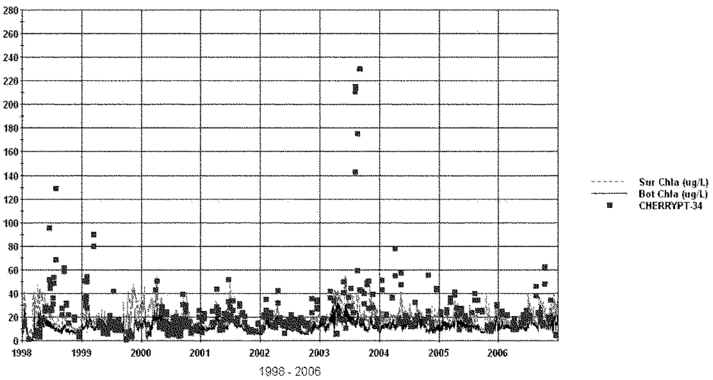


Figure 55. Chla Validation Comparison for 1998 – 2006 at Cherry Point 34

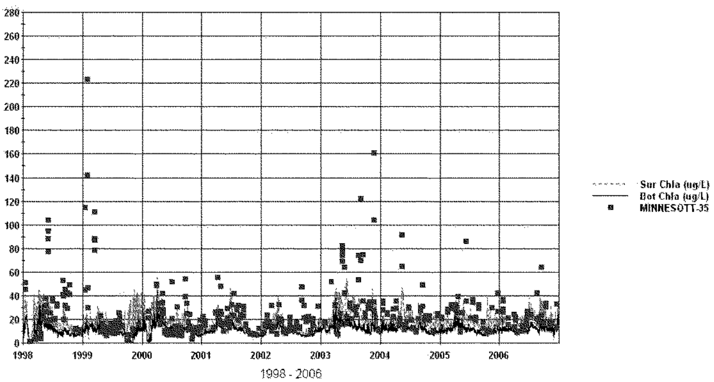


Figure 56. Chla Validation Comparison for 1998 – 2006 at Minnesott 35

Table 19. WASP72 Simulation Chlorophyll-*a* (µg/L) Statistics, ModMon 100

	ModMon 100 Bottom		ModMon 100 Surface		ModMon 100 Surface
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**EPA TMDL 1998 - 2000**
Count	77	150	77	150	75
Mean Predicted	10.5	11.2	20.7	22.0	16.3
Mean Observed	13.9	23.3	18.8	27.9	19.1
Standard Deviation Predicted	5.8	0.0	10.5	0.0	9.1
Standard Deviation Observed	12.5	28.3	17.5	28.0	17.5
Mean Error (ME)	3.4	12.1	-1.9	5.9	-2.8
ME Percent of Mean Obs.	24.6%	51.9%	-10.1%	21.1%	
Root Mean Square Error (RMSE)	11.8	30.7	16.0	29.1	2.6
RMSE Percent of Mean Obs.	85.2%	131.7%	84.9%	104.3%	
R^2 Correlation	0.17	0.00	0.19	0.01	0.21

Table 20. WASP72 Simulation Chlorophyll-*a* (µg/L) Statistics, ModMon 180

	ModMon 180 Bottom		ModMon 180 Surface	
Statistic	**Calibration 1998 - 2000**	**Validation 2001 - 2006**	**Calibration 1998 - 2000**	**Validation 2001 - 2006**
Count	12	132	12	132
Mean Predicted	5.3	5.2	10.9	12.6
Mean Observed	9.2	10.2	16.1	13.3
Standard Deviation Predicted	1.1	1.3	2.6	3.9
Standard Deviation Observed	2.8	5.2	9.7	14.2
Mean Error (ME)	3.9	5.0	5.2	0.7
ME Percent of Mean Obs.	42.1%	49.1%	32.4%	5.4%
Root Mean Square Error (RMSE)	4.6	7.3	10.3	13.3
RMSE Percent of Mean Obs.	49.7%	71.6%	63.9%	100.1%
R^2 Correlation	0.20	0.00	0.09	0.12

4 Discussion

The EPA TMDL work for the simulation period of 1998 – 2000 was used as a starting point to develop a modeling system for use in evaluating oyster reef restoration feasibility. The EPA TMDL work coupled the EFDC model with the WASP model to simulate the complex hydrodynamics of the NRE and eutrophication. The first task was to convert the EPA TMDL applications to the current versions of the respective models. This was a significant task as each model has had more than half a decade in which code revisions and enhancements were made which improved the models, but also increased the effort to port over. Next, the simulation period was extended from 2000 to 2006, and the observed data set to achieve this increased significantly, except for water surface elevation observations.

The EFDC simulations appear reasonable based on salinity and water temperature. This was important as the hydrodynamics alone are significant, while they were also the core underpinning for the WASP application through the HYD file.

The WASP simulations captured dissolved oxygen the best, which was important for the oyster considerations. However, the chlorophyll-*a* simulation, and perhaps the related nutrient simulation were reasonable regarding magnitudes and trends, but lacked in consistently representing observed spikes. WASP simulation improvements may be related to the benthic assignments, constants, or other input function. It is noted that the NRE is a complex environment and more than one assemblage of phytoplankton may dominate in different portions, for example in the upper reaches where the environment is more fresh as compared to the area near Pamlico Sound which has higher salt.

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Postprocessor and Habitat Suitability Index Report

Neuse River Estuary Oyster Reef Restoration Evaluation

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1 Introduction

The Neuse River Estuary is located on the coast of North Carolina and receives drainage from the eastern portion of the state (Figure 1). Among the municipalities within this drainage area are Durham, Raleigh, Smithfield, Goldsboro, Kinston, Havelock and New Bern. The counties that are most proximate to the Neuse River Estuary include Craven, Pamlico, and Carteret. The approximate drainage area of the Neuse River watershed to the Neuse River Estuary is 4,470 square miles (11,577 square kilometers). The longitudinal dimension of the Neuse River Estuary considered in this study is approximately 50 miles (80 kilometers), bound by New Bern and Pamlico Sound.

Tetra Tech, Inc developed the hydrodynamic and water quality models of the Neuse River Estuary that generate the information for detailed analysis of oyster habitat suitability of the estuary. The applications are based on the EFDC and WASP v7.2 models. The output of the models contains detailed information about the following state variables in each cell of the model's computational grid: salinity, water temperature, velocity, depth, phytoplankton, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, BOD, and dissolved oxygen. The output files are binary with the extension *.BMD. The WASP standard postprocessor (MOVEM) enables generation of graphs of the simulated state and output variables for each eell, as well as animations over each vertical layer of the model. This information does not allow for a simple and clear approach to water resourees decision making regarding oyster habitat. Tetra Tech developed a postprocessing tool for the three-dimensional hydrodynamic (EFDC) and water quality (WASP) models, which allows integration of simulations into a set of specific tables, figures, statistics and spatial-temporal plots to support the alternative analysis and decision making. The postprocessor extracts the information from the EFDC and/or WASP output *.BMD files, mathematically analyzes it and generates numerous tables and figures with extremes, averages and percentiles of specified variables, and areas of suitable habitat.

This report discusses the development of a customized and flexible postprocessor and the evaluation of the Habitat Suitability Index (HSI). The postprocessor is a suite of FORTRAN based tools combined with a graphical user interface (GUI). The HSI is an analysis method used to assess if certain environmental conditions are suitable for the persistence of oysters. The requirements of oyster habitat suitability were developed and presented by the USACE Wilmington District. The HSI algorithm is built into the postprocessor, and flexible architecture was employed in order to enable revision of parameterization and future use of the tool.

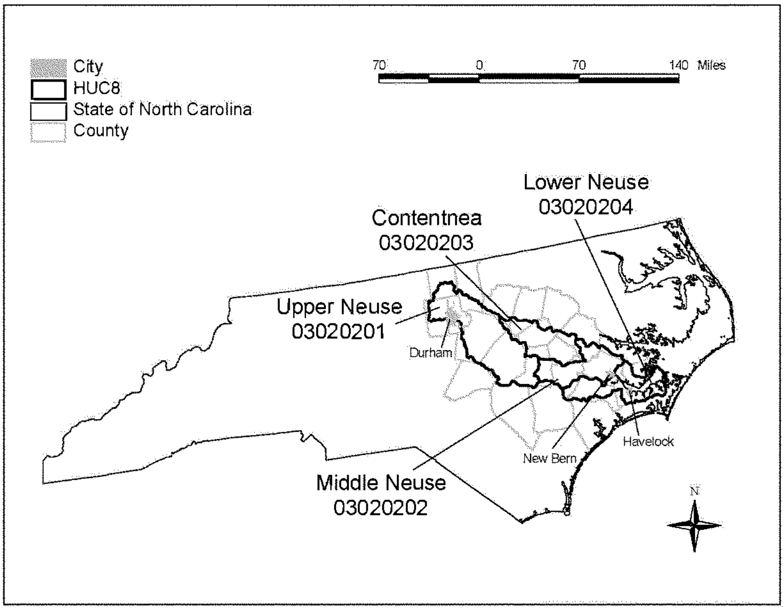


Figure 1. Location of Neuse River Watershed

2 Postprocessor

The Water Assessment and Management Support – Neuse River Estuary postprocessor extends the water quality and habitat assessment tools that were created in 2006 – 2008 for the evaluation of alternatives of the Savannah Harbor Expansion Project (Tetra Tech 2006, Tetra Tech 2007, Tetra Tech 2008). The WAMS-NRE postprocessor enables the analysis of hydrodynamic and water quality simulation outputs to create statistics and other metrics used to assess oyster habitat.

The WASMS-NRE postprocessor is a tool developed to work with each the EFDC (Hamrick 1996) and WASP (Ambrose 1993, EPA 2006) *.BMD files which contain hydrodynamic and water quality simulation output. It can, however, be revised to read output provided by water resource models in ASCII format. The tool links to a suite of FORTRAN based executable files and performs analysis and processing based on input from the user. The following sections will provide further explanation regarding the interface, modules, running and reviewing the postprocessor.

2.1 INTERFACE

The postprocessor can be started by selecting the file <WAMS-Neuse.exe> in the root directory of the postprocessor. The postprocessor has one control interface, shown in Figure 2. It is relatively simple to use once a user has become familiar with the functionality. The user has the discretion to select one *.BMD (EFDC or WASP) file or each of the *.BMD files. The <Browse> button enables the user to navigate to a respective *.BMD file. A unique scenario name should be entered which will be part of the name of each output file created by the postprocessor. The respective <Diagnose> button(s) must be selected to execute a routine which will read the *.BMD file for summary information such as state variables, number of segments, time period of simulation and more. This summary information will be conveyed to the respective input files for the modules. The ASCII files with the summary information are stored in the <\BMD_files_Inventory\> subfolder.

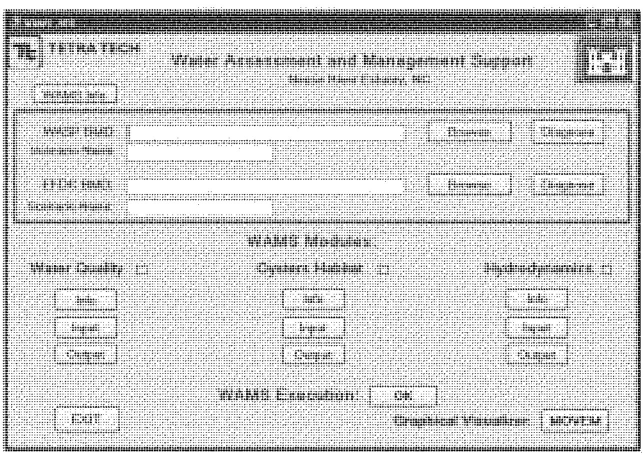


Figure 2. Postprocessor Interface, WASP and EFDC *.BMD Selection

2.2 WATER QUALITY MODULE

The Water Quality module of the postprocessor will evaluate the WASP *.BMD output file if the user has the check box selected. The <Info> button will call up an ASCII text file with relevant summary information regarding the current module. Execution of the module will create comma delimited ASCII files of percentile tables for the respective state variables and *.BMD files that allow visualization of the percentiles distribution for specified vertical layers and state variables. The <Input> button calls up the file <WQ%ile.inp>, which is located in the <\Input\> subfolder. The user can edit this file to affect the selection of the analyzed period of the simulations, vertical layer, state variables, and percentiles calculated by the postprocessor.

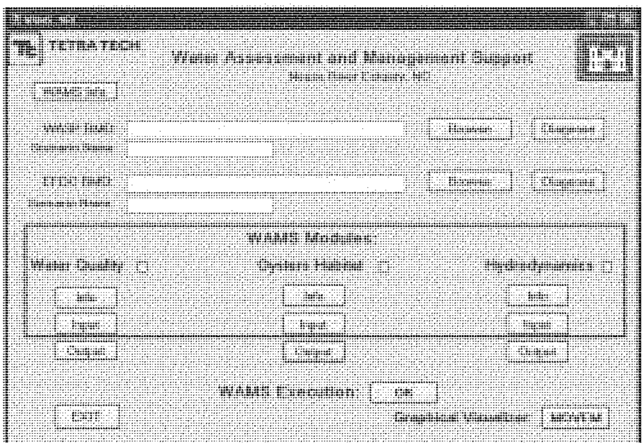


Figure 3. Postprocessor Interface, Modules

2.3 OYSTERS HABITAT MODULE

The Oysters Habitat module computes the habitat suitability index as well as analyzing other relevant components. The <Info> button calls up the ASCII file <Oys_Analysis.txt>. The file provides descriptive summary information regarding the oysters habitat module. The <Input> button calls up the file <Oyster_Analysis.inp>. This file prescribes all the relevant information pertaining to the Habitat Suitability Index, which will be discussed in detail later in this report.

2.4 EFDC ANALYSIS MODULE

The EFDC Analysis module of the postprocessor will evaluate the EFDC *.BMD output file if the user has the check box selected. The <Info> button will call up an ASCII text file <EFDC_Analysis.txt> with relevant summary information regarding the current module. Execution of the module will create comma delimited ASCII files of percentile tables for the respective variables and dye distributions as a surrogate for oyster larvae transport as well as *.BMD files that allow visualization of the selected percentile distributions in MOVEM. The <Input> button will access the file <EFDC_Analysis.inp> where the user can select the analyzed period, vertical layer, variables, and percentiles as well as parameters of larvae transport calculated by the postprocessor.

2.5 EXECUTE AND REVIEW

The last general area of the postprocessor interface is shown in Figure 4. Once the user has selected and specified the desired variables for the modules, they can run the postprocessor. The button labeled <OK>, next to the phrase "WAMS Execution" will execute the postprocessor. The <MOVEM> button launches the MOVEM postprocessor tool which can read and visualize the generated output *.BMD files. The <Output> buttons launch a window to view the *.CSV ASCII files generated from the postprocessor execution.

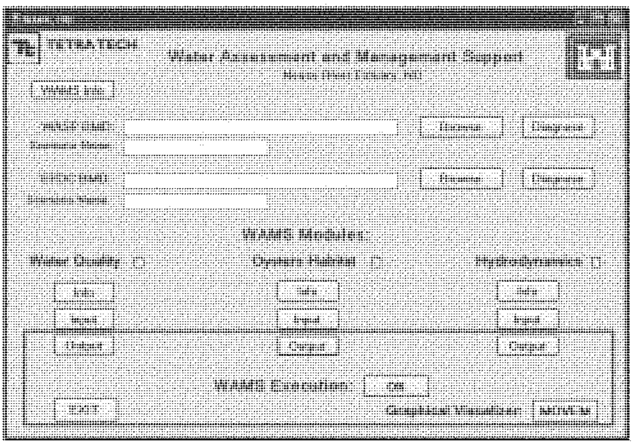


Figure 4. Postprocessor Interface, Execution and Link to MOVEM

2.6 POSTPROCESSOR SUBFOLDER STRUCTURE

The postprocessor utilizes subfolders to store and manage input and output. Table 1provides summary descriptions of the various subfolders. The postprocessor has buttons to launch a user to the primary information, however, it is recommended to understand the subfolder structure.

Table 1. Subfolder Descriptions

Subfolder Name	Description
BMD_files_Inventory	ASCII text file with summary information regarding a specific *.BMD file. These files are generated from selecting the <Diagnose> button.
Docs	General description of the postprocessor files and functionality.
EFDC_Analysis	Output tables and *.BMD files from execution of EFDC Analysis module.

Subfolder Name	Description
GIS	GIS coverages for use with MOVEM.
INFO	ASCII text files with information regarding each of the three modules. These files are accessed by selecting the <Info> button.
Ini	Templates of the postprocessor's input files
Input	Input files for the postprocessor's modules
MOVEM LayOut	Starter *.SLF layout files for GIS plan view of the postprocessor outputs in MOVEM.
Oyster	Output tables and *.BMD files from execution of Oysters Habitat module.
WQ%ile	Output tables and *.BMD files from execution of Water Quality module.

3 Habitat Suitability Index

The habitat suitability index (HSI) is a tool to help assess whether a given location is suitable for the persistence of oysters. The parameterization of the HSI was prescribed by the USACE oyster biologist and the postprocessor was coded such that the prescribed parameters used in the calculation could be revised. The model simulation was for 9 years, but a user can prescribe any temporal subset of that period at their discretion. The HSI ranges from 0 for unsuitable to 1 for optimal suitable habitat.

3.1 General Equation

The HSI uses the following formula:

$$HSI = \frac{\sum_{i=1}^{5} W_i \, C_i}{\sum_{i=1}^{5} W_i},$$

Where C_i is the *i*th component of the HSI; W_i is the weight assigned to the *i*th component

The HSI uses 5 components that outline the following impacts to oyster habitat (Cake 1983, Kennedy 1996, and Mazzotti 2007):

1. Killing event (i=1).
2. Historical mean salinity (i=2).
3. Summer mean salinity (i=3).
4. Mean water temperature (adult and larvae) (i=4).
5. Low dissolved oxygen (i=5).

Each HSI component has a value between 0 (unsuitable habitat) and 1 (optimal habitat). Weights assigned to the components reflect the opinion of the user about the component's importance for the HSI. The weights must sum to 1.

3.1.1 Killing Event

Killing events, C_1, are considered by four types (Cake 1983 and Kennedy 1996).

1. Dissolved oxygen: less than 1 mg/L for 3 days.
2. Dissolved oxygen: less than 2 mg/L for 5 days.
3. Salinity: less than 2 ppt for 30 days.
4. Salinity: less than 1 ppt for 5 days.

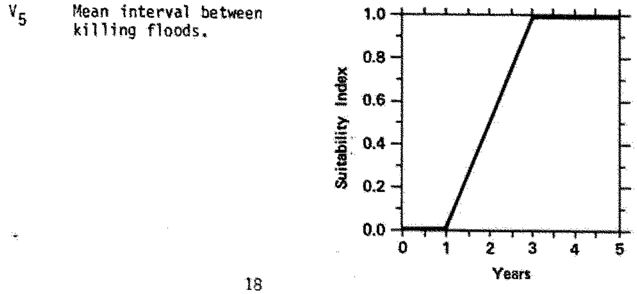


Figure 5. Piecewise Function Describing Mean Interval Between Killing Events (Cake 1983)

The killing event component can be considered as a minimum or mean interval at the user's discretion. Two executable files were delivered which a user must decide between. The use of the piecewise function as minimum presents the worst case scenario and may increase the defensibility of the decision making, however it may not reflect observed conditions. Killing events (C_1), Figure 5, can be described as follows, using the minimum interval for illustrative purposes.

- The HSI would be zero if the minimum period between killing events was one year or less.
- The HSI would be between zero and one if the period between killing events was between one and three years.
- The HSI would be one if the period between killing events was greater than three years.

In accordance to USACE guidance, the requirements for identification of the killing event component (C_1) if the interval between the end of the first killing event and the beginning of the next killing event is less than N days the postprocessor calculates the killing event as one using the beginning of the first killing event and the end of the second killing event as bookends. N is flexible and can be defined in the input file <\Input\Oyster_Analysis.inp>, this option is used for HSI calculations only. The *.CSV files in the <\Oyster\Tables\> subfolder contain information with actual dates and durations of killing events. A user can review these files to further investigate specific cells on the basis of the HSI analysis.

The number of killing events per years is calculated based on the minimum interval between killing events. The postprocessor goes through all killing events for each cell of the computational grid and selects the minimum time period between the end of the previous and the beginning of the next killing event. The selected minimum period is analyzed by comparison with the oyster reproductive season, September-October of each year. If the minimum interval begins before the reproductive period and ends after the reproductive period, the minimum interval has been decreasing by the number of days between the beginning of the minimum interval and the beginning of the reproductive period. The following considerations and examples can help understand the algorithm of the HSI coding.

- Example of three killing events. Consider 2 months between the end of the first killing event and the beginning of the second killing event and 1.5 years between the end of the second killing event and the beginning of the third killing event. The controlling interval is the 2 months (0.167 years), where 2 killing events occurred in 1 year. Therefore according to Figure 5 this component of the HSI would be zero, it is the worst case situation.
- Example of two killing events. Consider with 1.5 years between the end of the first killing event (i.e. February of the second year) and beginning of the second killing event (i.e. July of the third year). Oysters can begin the spawning process only in September of the second year, but recall

there was a killing event in February of the second year. This means that the actual period of life without the killing events is September of the second year through July of the third year, 11 months. It is less than the required 1 year, so the cell will be labeled as unsuitable. The control file <\Input\Oyster_Analysis.inp> contains user specified variables for the Julian day of the beginning of the growth period corresponding to September 01 of each of the 9 years of the WASP simulation period.

3.1.2 Salinity and Water Temperature

The historical mean salinity, historical summer (May through October), mean salinity and mean water temperature are calculated based on salinity and water temperature outputs for each cell of the computational grid during a selected multi-year period. The longest multi-year period for the NRE model is 9 years (1998 – 2006). The components of the HSI for these variables have been calculated based on piecewise functions that were received from the USACE oyster biologist.

V_4 Historic mean water salinity.

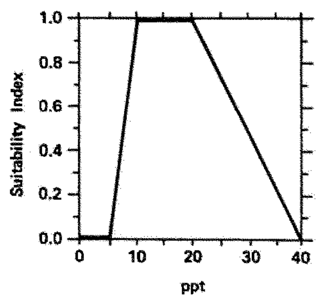


Figure 6. Piecewise Function Describing the Effect of Historic Mean Water Salinity (C_2) (Cake 1983)

The historic mean water salinity component (C_2), Figure 6, can be described as follows.

- The HSI would be zero if the historic mean were zero to five ppt.
- The HSI would be between zero and one if the historic mean were between five and 10 ppt.
- The HSI would be one if the historic mean were between 10 and 20 ppt.
- The HSI would be between one and zero if the historic mean were between 20 and 40 ppt.

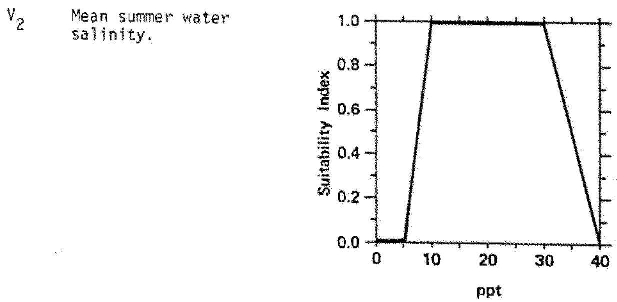


Figure 7. Piecewise Function Describing the Effect of Mean Summer Water Salinity (C_3) (Cake 1983)

The mean summer (May through October) water salinity component (C_3), Figure 7, can be described as follows.

- The HSI would be zero if the mean were zero to five ppt.
- The HSI would be between zero and one if the mean were between five and 10 ppt.
- The HSI would be one if the mean were between 10 and 30 ppt.
- The HSI would be between one and zero if the mean were between 30 and 40 ppt.

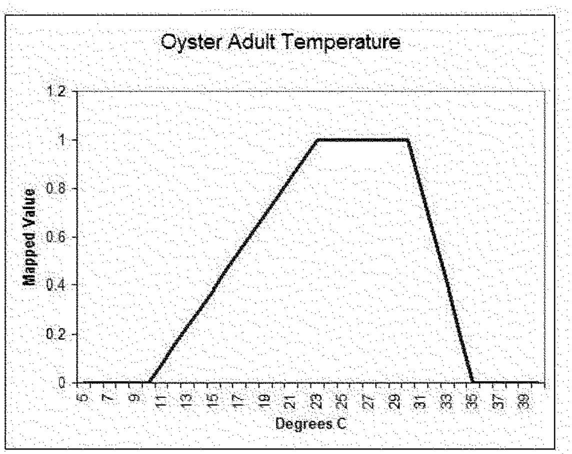


Figure 8. Piecewise Function Describing the Effect of Mean Water Temperature for Adult Oyster (C_4) (Mazzotti 2007)

The mean water temperature for adult oyster component (C_4), Figure 8, can be described as follows.

- The HSI would be zero if the mean were zero to 10.5 degrees C.
- The HSI would be between zero and one if the mean were between 10.5 and 23.5 degrees C.
- The HSI would be one if the mean were between 23.5 and 29.5 degrees C.
- The HSI would be between one and zero if the mean were between 29.5 and 35.5 degrees C.
- The HSI would be zero if the mean were 35.5 degrees C or greater.

The fourth component, (C_4), is also considered with respect to larvae.

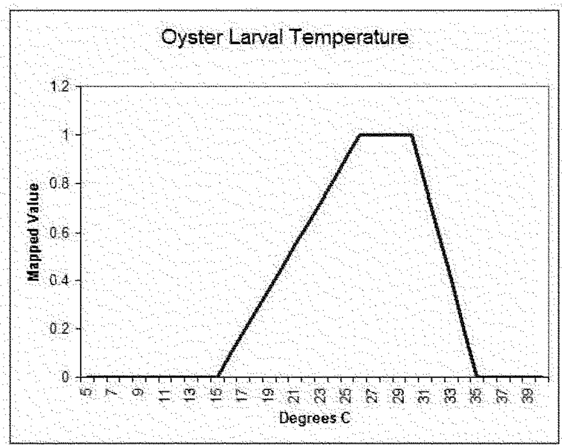


Figure 9. Piecewise Function Describing the Effect of Mean Summer Water Temperature for Larvae (C_4) (Mazzotti 2007)

The mean summer (May through October) water temperature for larvae oyster component (C_4), Figure 9, can be described as follows.

- The HSI would be zero if the mean were zero to 15.5 degrees C.
- The HSI would be between zero and one if the mean were between 15.5 and 26.5 degrees C.
- The HSI would be one if the mean were between 26.5 and 30.5 degrees C.
- The HSI would be between one and zero if the mean were between 30.5 and 35.5 degrees C.
- The HSI would be zero if the mean were 35.5 degrees C or greater.

If any one of the components of the HSI is equal to zero, the postprocessor marks the correspondent cell as unsuitable for oysters.

3.1.3 Dissolved Oxygen

The dissolved oxygen impact on oyster habitat (C_5) has been evaluated by calculating the percentage of simulation period with DO greater than or equal to 3 mg/L. The user's estimates of an acceptable percentage of the simulation period with DO greater than or equal to 3 mg/L allows the determination of the cells with unacceptable DO regime.

3.2 SETTING HSI CALCULATION PARAMETERS

Based on the USACE oyster biologist's piecewise functions summarized in the previous sections, the postprocessor calculates two HSI values– for adult and larvae oysters. The HSI built into the postprocessor has a control file in which the user can easily change the parameters of all the piecewise functions and related parameters to the HSI calculation. The weightings assigned to each component also allows removing a component from the HSI calculation.

The habitat suitability index parameterization can be edited through the ASCII control file <Oyster_Analysis.inp>. This file is accessed by selecting the <Input> button under the Oysters Habitat module. A portion of the file is presented in Figure 10. By reviewing the figure along with the previous sections it should be noted how this input file can be revised by a user to affect the piecewise functions.

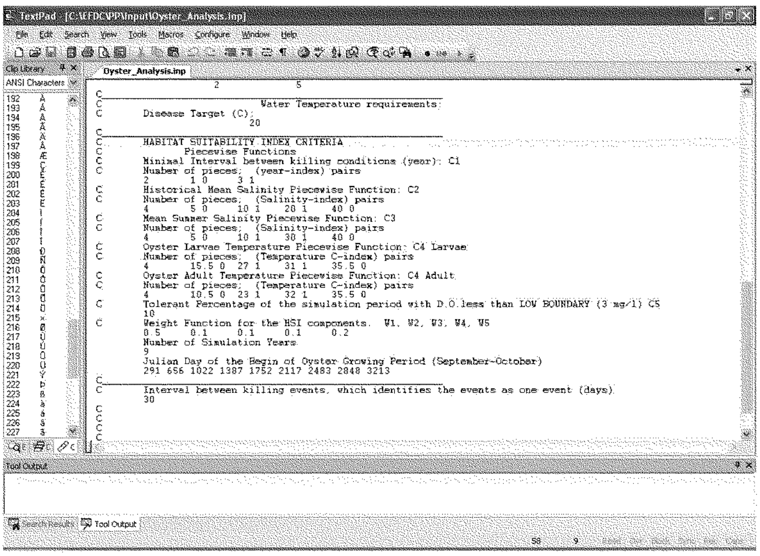


Figure 10. Screen Capture of File <Oyster_Analysis.inp>

4 Review Postprocessor Output

Once the postprocessor has been executed a variety of output is created. This section will discuss some of the output. The WASP postprocessor tool, MOVEM, is used to review output.

4.1 *.BMD FILES

The postprocessor creates a variety of output *.BMD files. They are located and generally described as follows.

- The output *.BMD files from the Water Quality module are located in the <\WQ%ile\MOVEM\> subfolder. The files allow visualization of selected percentiles for a horizontal layer using the MOVEM tool. The Water Quality module reads the WASP *.BMD file.
    - The files are created by layer and state variable that the user prescribed through the file accessed by the <Input> button for the module.
- The output *.BMD files from the Oysters Habitat module are located in the <\Oyster\MOVEM\> subfolder. The files allow visualization of selected distributions for a horizontal layer or the whole water column using the MOVEM tool. The Oysters habitat module reads the WASP *.BMD file.
    - The files are for adult and larvae oysters.
- The output *.BMD files from the EFDC Analysis module are located in the <\EFDC_Analysis\MOVEM\> subfolder. The files allow visualization of selected percentiles for a horizontal layer using the MOVEM tool. This module was also developed to analyze dye output from a unique set of EFDC input files used as a surrogate for larvae transport. The EFDC Analysis module reads the EFDC *.BMD file.
    - The files are created by EFDC layer and variable that the user prescribed through the file accessed by the <Input > button for the module.

EFDC and WASP use different numbers of horizontal grid cells. The difference is the open boundary cells defined in the EFDC application, they are removed from the WASP application. This means there were 414 horizontal cells for the EFDC application and 405 horizontal cells for the WASP application. The same (i,j,k) convention is used for each EFDC and WASP. The user must be aware of the source *.BMD being read for a respective module, because that informs the user about which GIS coverage to access while in MOVEM for either the source *.BMD or the *.BMDs generated by that module of the posprocessor. The GIS coverages in the <\GIS\> subfolder have been specifically named to aid the user in selecting the correct one. The names of the GIS coverages were intended to be obvious and are <neuse-efdc-grid.shp> and <neuse-wasp-grid.shp>.

The MOVEM tool is accessed by selecting the <MOVEM> button from the lower right portion of the postprocessor interface. Once the tool is open, the user can navigate to select the GIS coverage in the <\GIS\> subfolder and then any combination of the postprocessor output *.BMD files summarized above. After the desired files have been loaded, the user can access the layout files <*.SLF> in the <\MOVEM LayOut\> subfolder. The layouts are summarized in Table 2. These layouts are presented as starter files as the use of layouts is rudimentary regarding MOVEM. The user needs to pay attention to the *.BMD and variables selected, as well as revising the legend which will quicken the learning process. The user can easily create layouts that are more suitable for their scenarios and applications.

Table 2. Plan View Layout Descriptions

Layout Name	*.BMD from Module	Description
DO.SLF	Water Quality	Dissolved Oxygen percentiles for the period of simulation analyzed by the user
Oyster.SLF	Oysters Habitat	The HSI value for the period analyzed by the user
Phyto.SLF	Water Quality	Chlorophyll-a percentiles from the period of simulation analyzed by the user
Salinity.SLF	Water Quality	Salinity percentiles from the period of simulation analyzed by the user
Temperature.SLF	Water Quality	Water temperature percentiles from the period of simulation analyzed by the user
Velocity.SLF	Water Quality	Water velocity percentiles from the period of simulation analyzed by the user

4.2 TABLES

The postprocessor creates a variety of output tables as *.CSV ASCII files. The information contained in the files includes averages, percentiles, HSI component values, durations, and more. The detailed information about all generated tables is presented in the file <\DOCs\ReadMe.doc>. The data are presented with WASP segment number and EFDC (I,J,K) identifiers as well as any required clarification for condition, such as the two conditions for low dissolved oxygen.

- The postprocessor output *.CSV files from the Water Quality module are located in the <\WQ%ile\Tables\> subfolder.
    - The files are created by layer and percentiles that the user prescribed using the <Edit> button to access file <\Input\WQ%ile.inp> for the following available variables; salinity, DO, water temperature, velocity, and chlorophyll-a.
- The postprocessor output *.CSV files from the Oysters Habitat module are located in the <\Oyster\Tables\> subfolder.
    - The files are summaries of the components of the HSI as well as other relevant variables.
- The postprocessor output *.CSV files from the EFDC Analysis module are located in the <\EFDC_Analysis\Tables\> subfolder.
    - The files are created by EFDC variable and layer that the user prescribed using the <Edit> button for the module.

4.3 SURROGATE FOR LARVAE TRANSPORT

Larvae transport was investigated by using the dye state variable in the EFDC model. The dye was used as a conservative tracer with no decay, there were no representation of suspension or settling velocity. The dye was released for a 24-hour period on September 01 of each of the 9 simulation years. Thus the dye was used as a surrogate in order to review how the turbulent and other characteristics of the NRE dilute and move the dye. There were 35 cells considered for oyster investigation (Figure 11), however 4 of them were located on the open boundary of the model grid and thus were removed from the consideration of dye release. The model was coded with 31 dye release cells, they are noted in Table 3. The dye was released in the second layer from the bottom (EFDC K = 2). The EFDC model files constructed for the surrogate larvae investigation were unique and were not used to create the hydrodynamic linkage file (*.HYD) used to drive the WASP application. The EFDC model run creates a *.BMD output file which can be used with MOVEM. The output can be reviewed in plan view animation by discrete layer. Furthermore, the output can be reviewed in time series at specific spatial locations determined by the user.

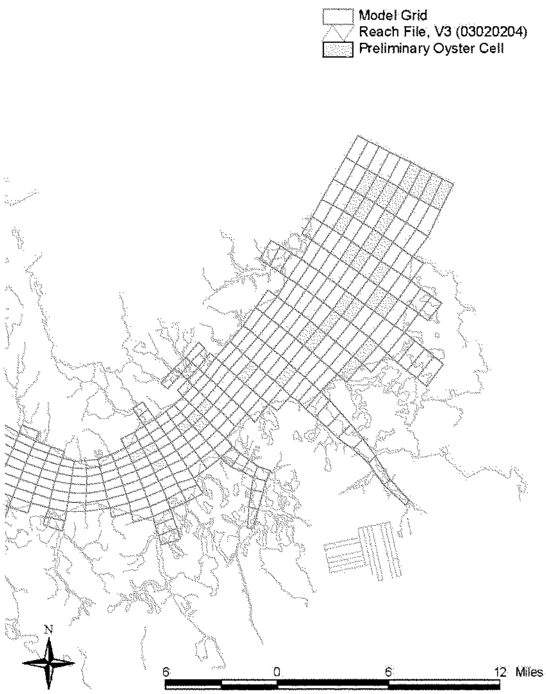


Figure 11. Location of Cells for Consideration of Oyster Habitat Suitability

Table 3. WASP Segment Number and Corresponding EFDC (I, J, K) Identifier for Model Grid Cells of Interest for Oyster Habitat Investigation

WASP Segment Number	EFDC I	EFDC J	EFDC K	WASP Segment Number	EFDC I	EFDC J	EFDC K
25	71	9	4	835	71	9	2
26	72	9	4	836	72	9	2
39	74	10	4	849	74	10	2
55	74	11	4	865	74	11	2

WASP Segment Number	EFDC I	EFDC J	EFDC K	WASP Segment Number	EFDC I	EFDC J	EFDC K
81	73	12	4	891	73	12	2
83	75	12	4	893	75	12	2
111	69	13	4	921	69	13	2
113	71	13	4	923	71	13	2
114	72	13	4	924	72	13	2
115	73	13	4	925	73	13	2
118	76	13	4	928	76	13	2
150	71	14	4	960	71	14	2
154	75	14	4	964	75	14	2
155	76	14	4	965	76	14	2
156	77	14	4	966	77	14	2
157	78	14	4	967	78	14	2
182	60	15	4	992	60	15	2
197	75	15	4	1007	75	15	2
200	78	15	4	1010	78	15	2
236	64	16	4	1046	64	16	2
240	68	16	4	1050	68	16	2
249	77	16	4	1059	77	16	2
250	78	16	4	1060	78	16	2
281	59	17	4	1091	59	17	2
282	60	17	4	1092	60	17	2
285	63	17	4	1095	63	17	2
286	64	17	4	1096	64	17	2
287	65	17	4	1097	65	17	2
298	76	17	4	1108	76	17	2
299	77	17	4	1109	77	17	2
300	78	17	4	1110	78	17	2
430	71	9	3	1240	71	9	1
431	72	9	3	1241	72	9	1
444	74	10	3	1254	74	10	1

WASP Segment Number	EFDC I	EFDC J	EFDC K	WASP Segment Number	EFDC I	EFDC J	EFDC K
460	74	11	3	1270	74	11	1
486	73	12	3	1296	73	12	1
488	75	12	3	1298	75	12	1
516	69	13	3	1326	69	13	1
518	71	13	3	1328	71	13	1
519	72	13	3	1329	72	13	1
520	73	13	3	1330	73	13	1
523	76	13	3	1333	76	13	1
555	71	14	3	1365	71	14	1
559	75	14	3	1369	75	14	1
560	76	14	3	1370	76	14	1
561	77	14	3	1371	77	14	1
562	78	14	3	1372	78	14	1
587	60	15	3	1397	60	15	1
602	75	15	3	1412	75	15	1
605	78	15	3	1415	78	15	1
641	64	16	3	1451	64	16	1
645	68	16	3	1455	68	16	1
654	77	16	3	1464	77	16	1
655	78	16	3	1465	78	16	1
686	59	17	3	1496	59	17	1
687	60	17	3	1497	60	17	1
690	63	17	3	1500	63	17	1
691	64	17	3	1501	64	17	1
692	65	17	3	1502	65	17	1
703	76	17	3	1513	76	17	1
704	77	17	3	1514	77	17	1
705	78	17	3	1515	78	17	1

5 EXAMPLES

The postprocessor handles a substantial amount of model output and converts it to useful forms at the user's direction. The following section will illustrate uses of the postprocessor as an education opportunity.

5.1 HABITAT SUITABILITY INDEX

The habitat suitability index was developed with 5 components as described in Section 3. The weighting assigned to each component is flexible as requested by the USACE and can therefore be modified to match observed data and the user's opinion. This section will provide an example of executing the Oysters Habitat module under two arbitrary weightings for the components.

5.1.1 HSI Example A Weightings

The weightings are found in file <\Input\Oyster_Analysis.inp>, a screen capture is provided in Figure 12. Example A used equal weightings to the five components, recall that component 4 (C_4) is considered as adult and larvae. The postprocessor was executed for the Oysters Habitat module for the nine year simulation period and reviewed.

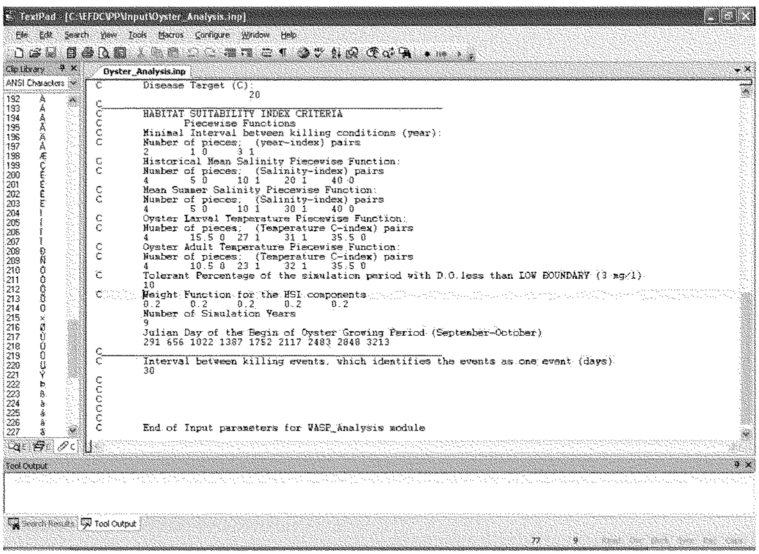


Figure 12. Screen Capture for HSI Example A Weightings

EFDC cell (60,15) was arbitrarily selected for illustrative purposes of these examples from the list of preliminary cells of interest for oyster habitat evaluation. Cell (60,15) is shown in Figure 13.

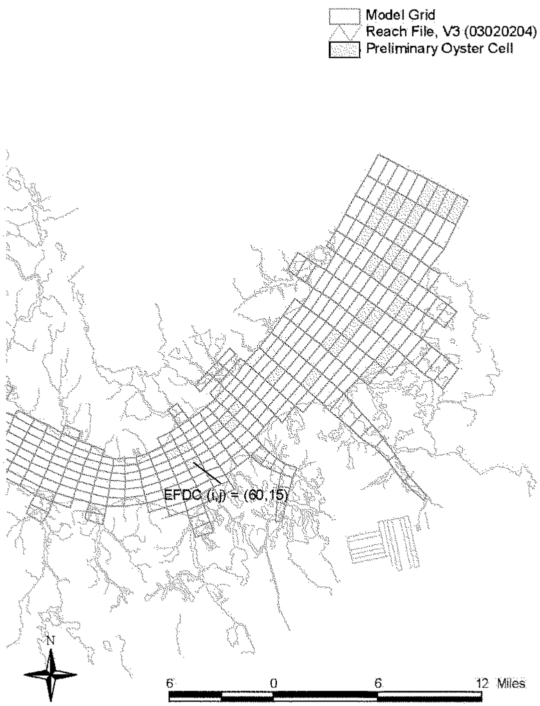


Figure 13. Location of Cell (60,15) Used for Illustrative Purposes with Examples

Once the postprocessor has completed its run, there is a variety of output available for the user. Some of these outputs will be discussed here for learning purposes, once a user has done this, it will be intuitive regarding how to use the other output. Figure 13 presents a plan view of layer 1 (k=1, bottom) HSI values. This figure was developed by following these steps.

- Select the <MOVEM> button from the lower right of the postprocessor interface.
- Select Open and navigate to the <\Oyster\MOVEM\> subfolder and select the *.BMD file with "adult" in the file name.
- Select Open and navigate to the <\GIS\> subfolder and select the coverage <neuse-wasp-grid.shp>.
- From pulldown menu View, select GIS Plot.
- In the lower left portion of the Spatial Plot Parameters dialog box, select Load Layout and navigate to the <MOVEM LayOut> subfolder.
- Select file <Oyster-K1.slf>

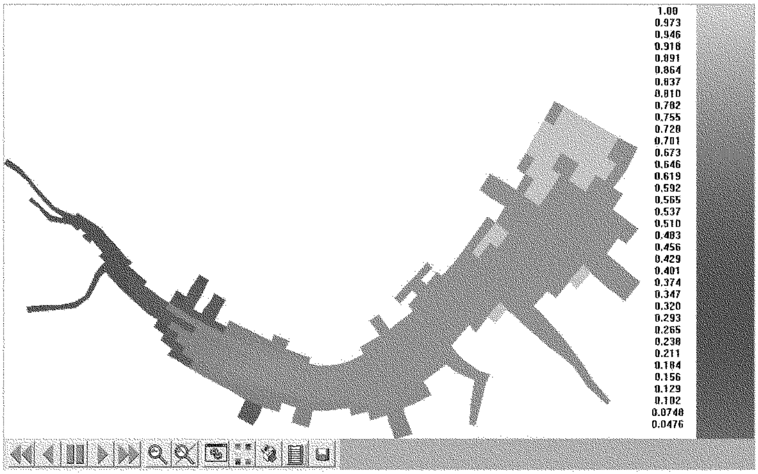


Figure 14. Example A Adult HSI for K=1, Bottom

The plan view can be modified to use outline mode and then zoom in to an area of interest. Doing this for cell (60,15) reveals an HSI value of 0.752. This value can also be reviewed from the XY Plot feature of MOVEM, then review of the table in MOVEM. It is also output to a *.CSV file.

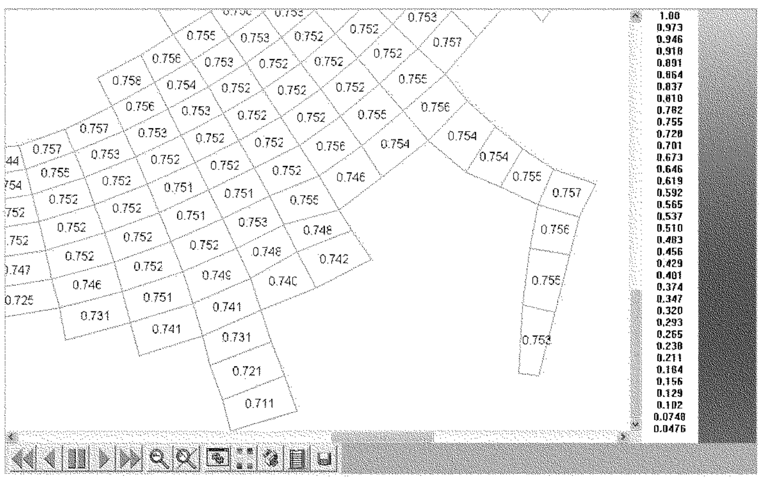
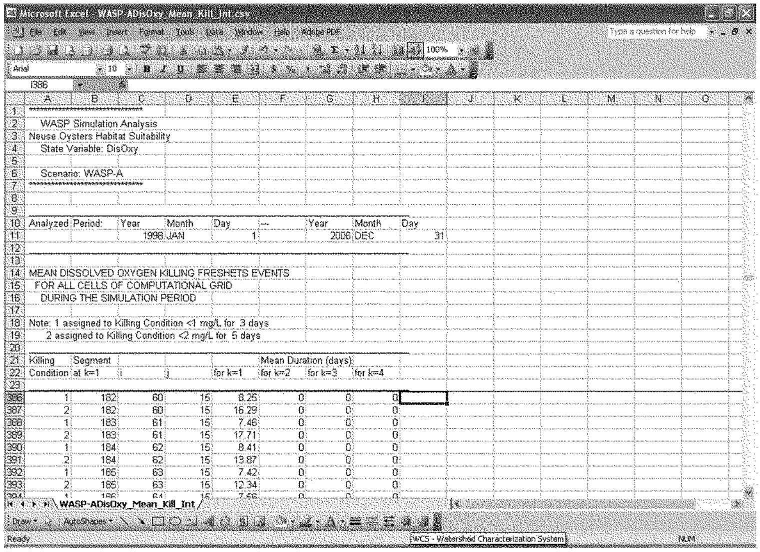


Figure 15. Example A Zoom In of Adult HSI for K=1, Bottom, Outline Mode

Next, the tabular data provided in ASCII *.CSV files will be reviewed, they are stored in the <\Oyster\Tables\> subfolder. There are many tables to be reviewed. They are named with the scenario name prescribed by the user and descriptions intended to be reflective of the content of the file.

File <*DisOxy_Mean_Kill_Int.csv> contains the mean duration of a DO killing event. Figure 16 shows that for condition 1 (DO <1 mg/L for 3 days) the average duration in the bottom layer was 8 days. For condition 2 (DO <2 mg/L for 5 days) the average duration in the bottom layer was 16 days. For either condition for layers 2 through 4, there were never any durations within the criteria.



Microsoft Excel - WASP-ADisOxy_Mean_Kill_Int.csv

WASP Simulation Analysis
Neuse Oysters Habitat Suitability
State Variable: DisOxy

Scenario: WASP-A

Analyzed	Period:	Year	Month	Day	--	Year	Month	Day
		1998	JAN	1		2006	DEC	31

MEAN DISSOLVED OXYGEN KILLING FRESHETS EVENTS
FOR ALL CELLS OF COMPUTATIONAL GRID
DURING THE SIMULATION PERIOD

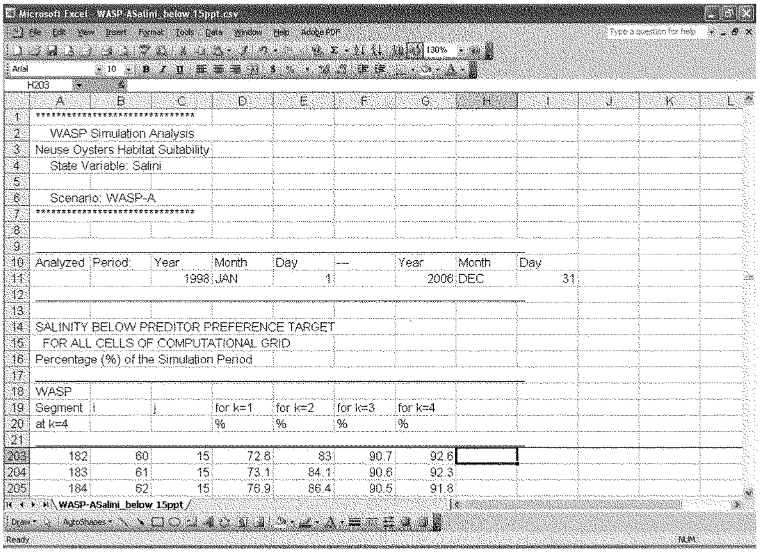
Note: 1 assigned to Killing Condition <1 mg/L for 3 days
2 assigned to Killing Condition <2 mg/L for 5 days

Killing	Segment			Mean Duration (days)			
Condition	at k=1	i	j	for k=1	for k=2	for k=3	for k=4
1	182	60	15	8.25	0	0	0
2	182	60	15	16.29	0	0	0
1	183	61	15	7.46	0	0	0
2	183	61	15	17.71	0	0	0
1	184	62	15	8.41	0	0	0
2	184	62	15	13.87	0	0	0
1	185	63	15	7.42	0	0	0
2	185	63	15	12.34	0	0	0

WASP-ADisOxy_Mean_Kill_Int

Figure 16. Tabular Output of Dissolved Oxygen Killing Events

File <*Salini_below 15ppt.csv> presents the salinity simulation as percent of simulation below a salinity of 15 ppt. Generally, bottom waters have more salinity than surface waters in the area of the bend. Thus the table (Figure 17) shows that of the four layers, the bottom has the least percent (73 percent) of values below 15 ppt.

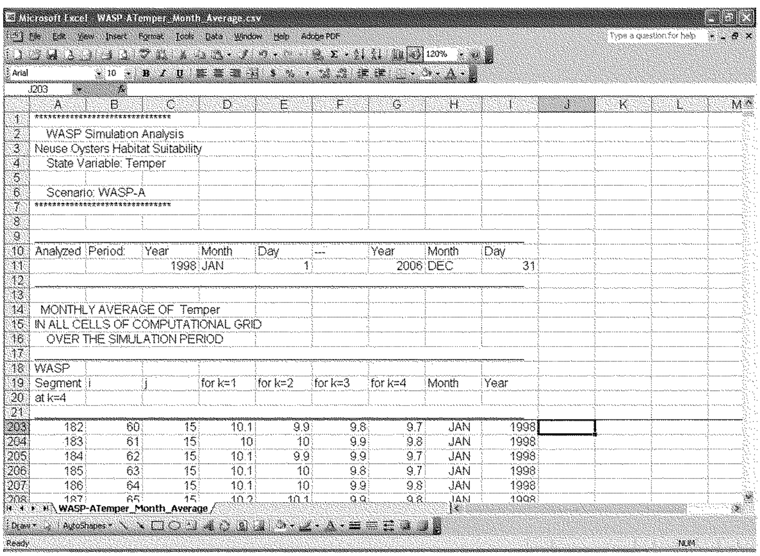


Microsoft Excel - WASP-ASalini_below 15ppt.csv

	A	B	C	D	E	F	G	H	I
1	******************************								
2	WASP Simulation Analysis								
3	Neuse Oysters Habitat Suitability								
4	State Variable: Salini								
5									
6	Scenario: WASP-A								
7	******************************								
8									
9									
10	Analyzed	Period:	Year	Month	Day	---	Year	Month	Day
11			1998	JAN	1		2006	DEC	31
12									
13									
14	SALINITY BELOW PREDITOR PREFERENCE TARGET								
15	FOR ALL CELLS OF COMPUTATIONAL GRID								
16	Percentage (%) of the Simulation Period								
17									
18	WASP								
19	Segment	i	j	for k=1	for k=2	for k=3	for k=4		
20	at k=4			%	%	%	%		
21									
203	182	60	15	72.6	83	90.7	92.6		
204	183	61	15	73.1	84.1	90.6	92.3		
205	184	62	15	76.9	86.4	90.5	91.8		

Figure 17. Tabular Output of Percent of Simulation Below Salinity of 15 ppt

Figure 18 presents monthly average summaries of water temperature from file <*Temper_Month_Average.csv>. The figure shows just January 1998 for cell (60,15).



Microsoft Excel - WASP-ATemper_Month_Average.csv

	A	B	C	D	E	F	G	H	I
1	******************************								
2	WASP Simulation Analysis								
3	Neuse Oysters Habitat Suitability								
4	State Variable: Temper								
5									
6	Scenario: WASP-A								
7	******************************								
8									
9									
10	Analyzed	Period:	Year	Month	Day	---	Year	Month	Day
11			1998	JAN	1		2006	DEC	31
12									
13									
14	MONTHLY AVERAGE OF Temper								
15	IN ALL CELLS OF COMPUTATIONAL GRID								
16	OVER THE SIMULATION PERIOD								
17									
18	WASP								
19	Segment	i	j	for k=1	for k=2	for k=3	for k=4	Month	Year
20	at k=4								
21									
203	182	60	15	10.1	9.9	9.8	9.7	JAN	1998
204	183	61	15	10	10	9.9	9.8	JAN	1998
205	184	62	15	10.1	9.9	9.9	9.7	JAN	1998
206	185	63	15	10.1	10	9.8	9.7	JAN	1998
207	186	64	15	10.1	10	9.9	9.8	JAN	1998
208	187	65	15	10.2	10.1	9.9	9.8	JAN	1998

Figure 18. Monthly Average Water Temperature

5.1.2 HSI Example B Weightings

The arbitrary weightings for example B of the HSI are shown in Figure 19. They were not equally distributed as was done for example A. It can also be noted that if a user wants to remove one of the components from the calculation, they can assign a weighting of zero as long as the remaining four components sum to a weighting of one.

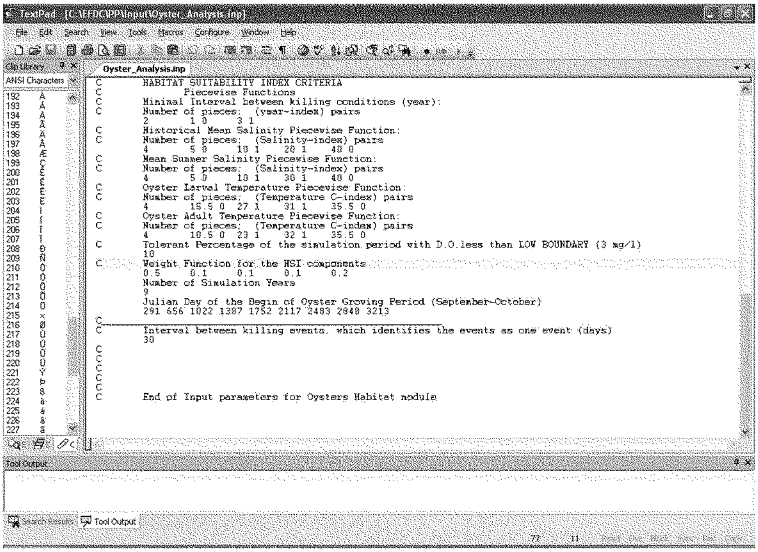


Figure 19. Screen Capture for HSI Example B Weightings

Figure 20 and Figure 21 show plan view plots of the adult HSI, and for cell (60,15) the HSI was 0.476. This was lower than for example A, recall that the weighing of component 1 (killing event C_1) was 0.2 for example A and 0.5 for example B.

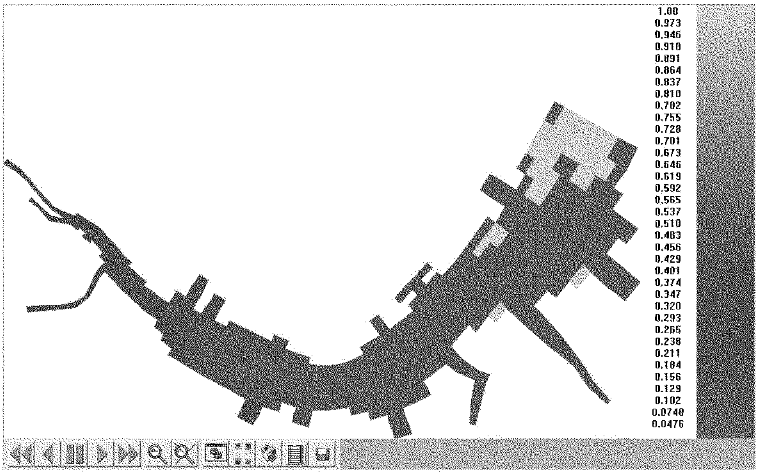


Figure 20. Example B Adult HSI for K=1, Bottom

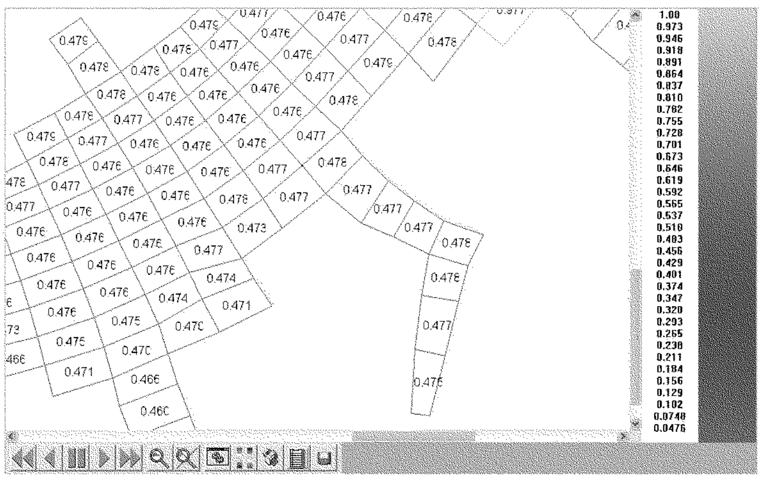


Figure 21. Example B Zoom In of Adult HSI for K=1, Bottom, Outline Mode

The tabular information presented for example A is the same for example B. The only change was the weighting assignments to the HSI components. If there had been a change to the piecewise functions and/or threshold values, then the HSI would further be changed and the tables would hold different values.

5.2 Dye as Surrogate for Larvae

The EFDC model has a state variable for dye. This was used as a conservative substance as a surrogate for larvae transport. There was no representation of suspension of settling velocity. The EFCD input files developed for the dye transport do not correspond with the WASP (*.WIF) files. Cell (61,16) will be used for illustrative discussion in this section. It is one cell east and one cell north of the cell used in the HSI discussions, furthermore, the goal of the dye as a surrogate for larvae transport is to evaluate where larvae ends up from the cell of release (60,15). The input file <\Input\EFDC_Analysis.inp> is shown in Figure 22. Note the input near the end of the file as it is related to the postprocessing of the dye. The Julian dates must agree with what the user has prescribed in the EFDC input files (EFDC.INP card 24 and DSER.INP).

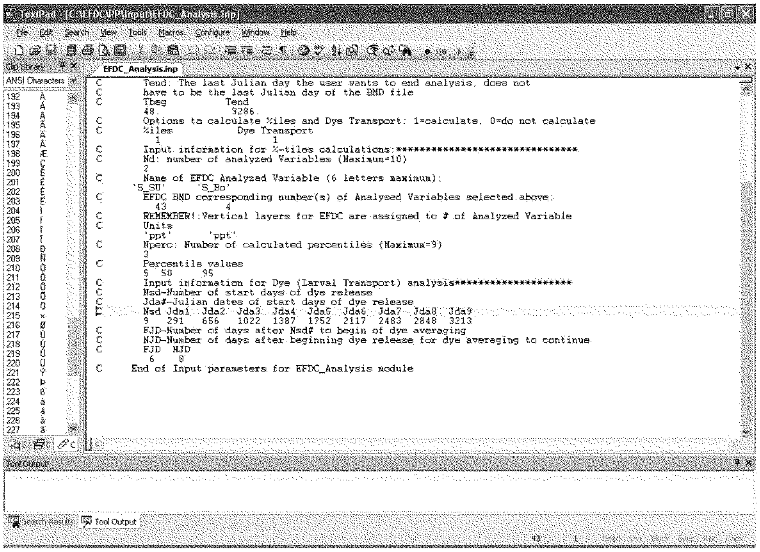


Figure 22. Input File EFDC_Analysis.inp for EFDC Analysis Module

The following steps were used to generate Figure 23.

- Select the <MOVEM> button from the lower right of the postprocessor interface.
- Select Open and navigate to the <\EFDC_Analysis\MOVEM\> subfolder and select the *.BMD file with "k=2" in the file name.
- Select Open and navigate to the <\GIS\> subfolder and select the coverage <neuse-efdc-grid.shp>. **Note** this is different than the GIS file selected for reviewing the Oyster Habitat module *.BMD files. This is due to the different number of horizontal cells.
- From pulldown menu View, select GIS Plot.
- In the lower left portion of the Spatial Plot Parameters dialog box, select Load Layout and navigate to the <MOVEM LayOut> subfolder.
- Select file <Dye-07d.slf>

Figure 23 shows the average of nine Sep 07s for layer 2. Figure 24 is zoomed in to the area of (61,16) and presents a Sep 07 layer 2 average value of 67.5 percent. However, it can also be seen that there is a trend of higher values to the north/northeast of that location. The user can assess this information relatively as well as investigating the 8th, 9th, etc. days after larvae release in order to draw conclusions on which locations represent the best opportunities for alternative considerations.

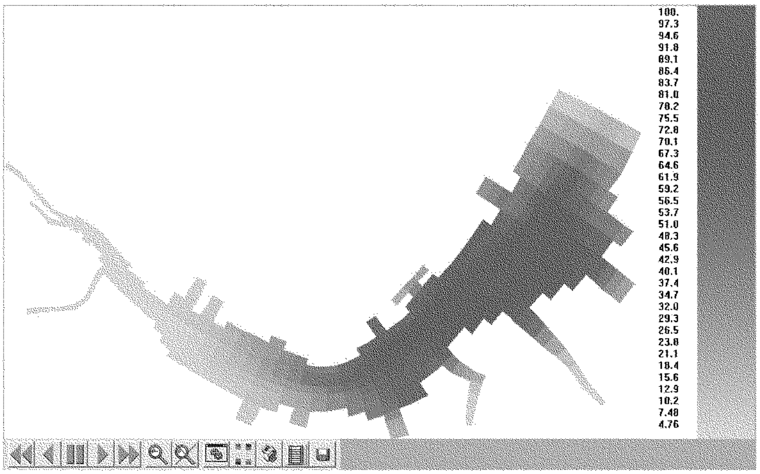


Figure 23. Average 7th Day Dye Value for Layer 2

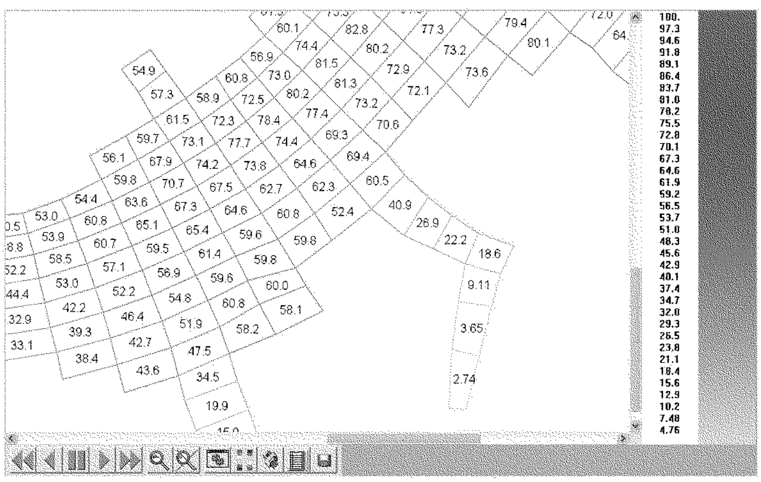
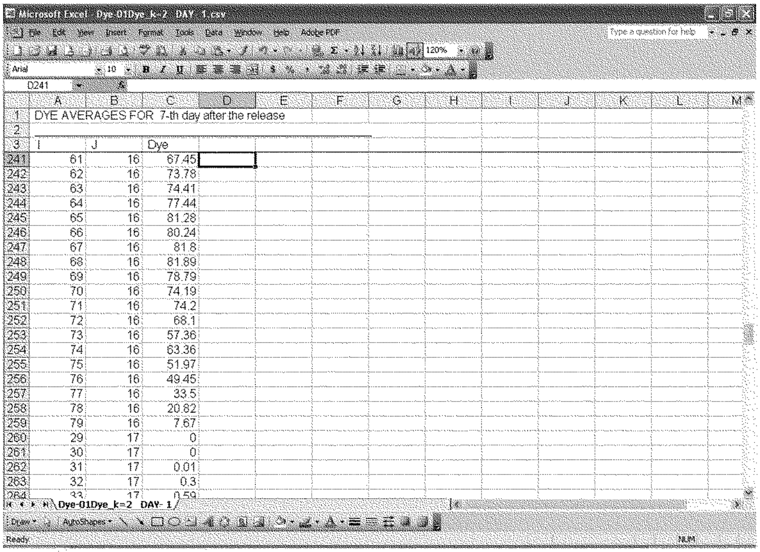


Figure 24. Average 7th Day Dye Value for Layer 2, Outline Mode

The data is also available in tabular format. File <*Dye_k=2 DAY- 7.csv> in subfolder <\EFDC_Analysis\Tables\> is presented in Figure 25.



	A	B	C
1	DYE AVERAGES FOR 7-th day after the release		
2			
3	I	J	Dye
241	61	16	67.45
242	62	16	73.78
243	63	16	74.41
244	64	16	77.44
245	65	16	81.28
246	66	16	80.24
247	67	16	81.8
248	68	16	81.89
249	69	16	78.79
250	70	16	74.19
251	71	16	74.2
252	72	16	68.1
253	73	16	57.36
254	74	16	63.36
255	75	16	51.97
256	76	16	49.45
257	77	16	33.5
258	78	16	20.82
259	79	16	7.67
260	29	17	0
261	30	17	0
262	31	17	0.01
263	32	17	0.3
264	33	17	0.59

Figure 25. Average 7th Day Dye Value for Layer 2 from File *Dye_k=2 DAY- 7.csv

6 Discussion

The development of the postprocessor with the HSI algorithm was a highly customized and challenging task. It was purposefully coded with flexibility such that the components of the HSI may be revised at the user's discretion. The architecture of the postprocessor capitalizes on the MOVEM tool which provides significant utility in reviewing output in time series plot, plan view animation, plan view plot, and tabular formats as well as more useful features. The output from the postprocessor is substantial, therefore requiring a user to spend time to learn to operate the postprocessor and then discriminate the settings of the control ASCII input files for a respective module. This will result in more manageable postprocessor outputs and thus interpretations for use in the consideration of oyster reef restoration decision making.

7 References

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6 January 2006

U. S. Army Corps of Engineers
Engineer Research and Development Center
Vicksburg, MS 39180

Neuse River Fishery Hydroacoustics Pilot Study

PURPOSE AND STUDY OBJECTIVES: This document briefly summarizes the results of field efforts to evaluate the potential effectiveness of fishery hydroacoustics in surveying fish utilization of both natural and artificial oyster reefs in the Neuse River, North Carolina. Fisheries hydroacoustic surveys were used to determine spatial distributions of fishes in proximity to the reefs and off-reef bottoms, densities of fish targets in the surveyed areas, and size distributions of fishes in each area. Fish assemblages associated with areas undergoing reef construction and nearby undisturbed areas were also examined. Due to weather conditions the pilot study was limited to a single day of data collection at two natural and one man-made reef sites. Consequently the data are presented solely to exemplify available technology and are not intended to represent quantitative assessments. Rigorous comparisons of fish assemblages between the reef types and non-reef areas will require a larger survey effort. Results briefly describe the types of data obtainable through hydroacoustic surveys.

STUDY AREA: The Neuse River is formed by the confluence of the Eno and Flat Rivers, about 8 miles north of the City of Durham, flowing approximately 195 miles (325 km) before emptying into the Pamlico Sound at New Bern (Figure 1). The Neuse River Basin covers approximately 11 percent of the entire State of North Carolina and consists of all or portions of 16 counties. The Neuse River Basin has a drainage area of nearly 5,710 square miles.

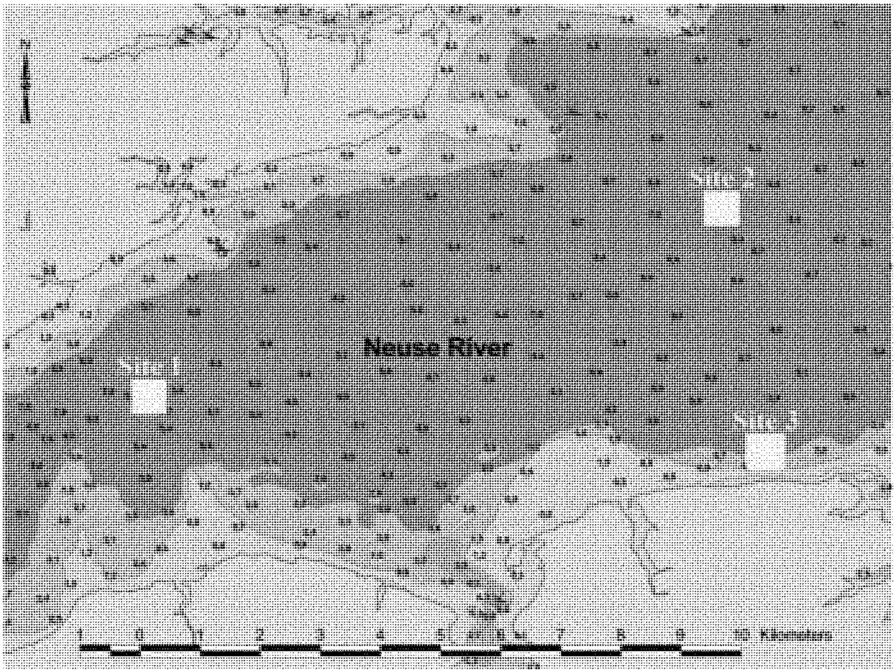

Figure 1. Neuse River study sites. Depths are given in meters.

Three data collection sites were chosen for the pilot study and are depicted in Figure 1. Site 1 is a natural high-profile reef located at 35° 01.02' N and 76° 38.97' W. Site 2 is located approximately 10 miles east of Site 1 at 35° 03.21' N and 76° 32.37' W, near the point where the Neuse River empties into the Pamlico Sound. Site 3 is an artificial reef consisting of 2,300 tons of Class B rip-rap located in the downstream reach of the Neuse River approximately 5 miles south of Site 2 at 35° 00.35' N and 76° 31.95' W. Depth contour plots of each of the study areas are presented in Figures 2 through 4. Note the difference in the vertical and horizontal scales. There is an exaggerated "z axis" in relation to the horizontal plane.

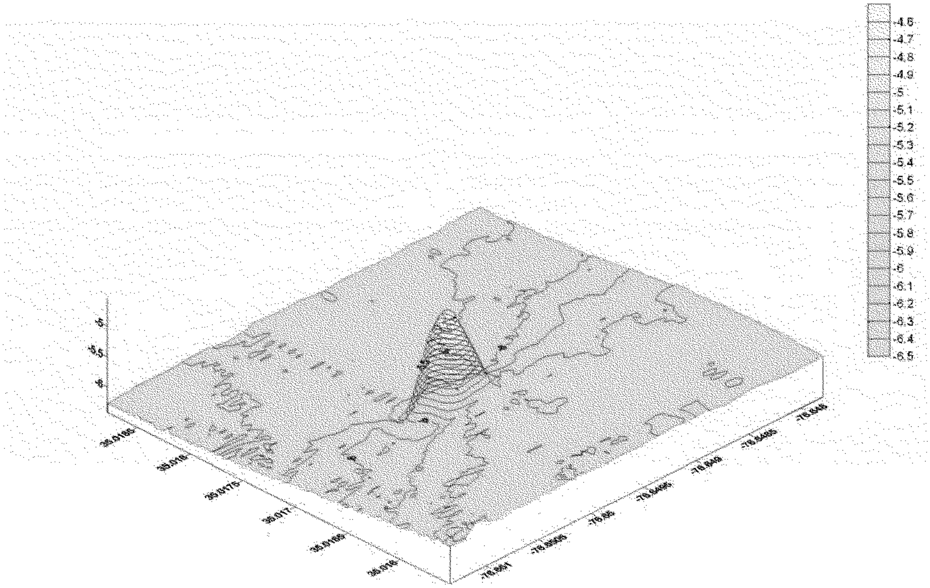

Figure 2. Depth contour plot of Site 1 showing a natural high profile reef located west of Point of Marsh.

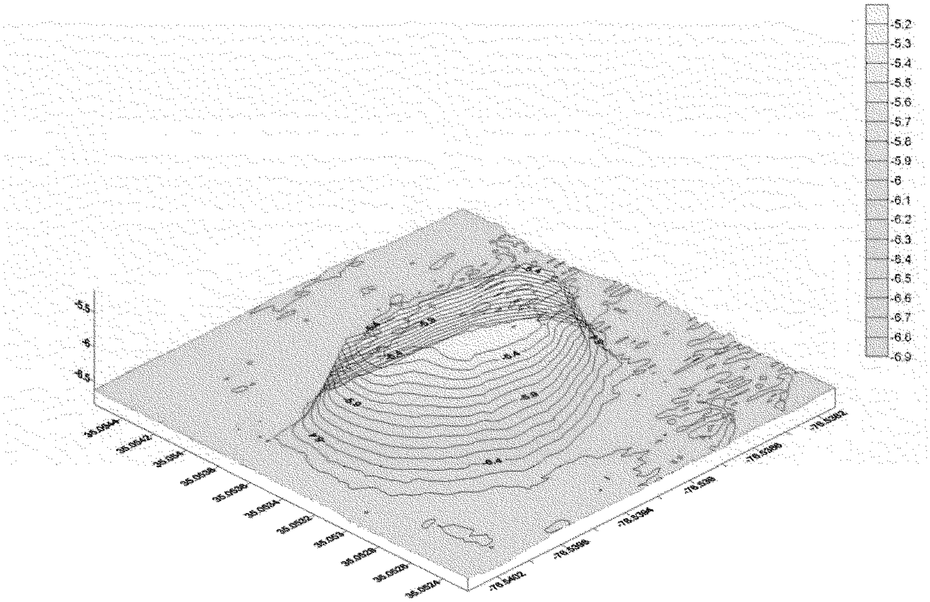

Figure 3. Depth contour plot of Site 2 showing a natural oyster reef near the point where the Neuse River empties into the Pamlico Sound.

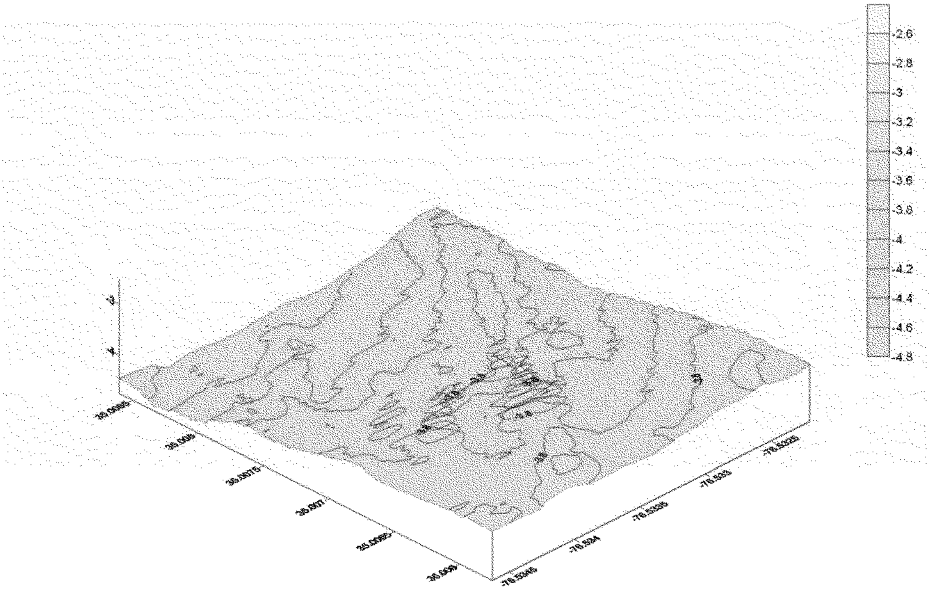

Figure 4. Depth contour plot of Site 3 showing a state constructed oyster sanctuary located in Neuse River.

METHODS

Water Quality

Water quality data were collected using a Hydrolab® unit to record depth (m), temperature (°C), and salinity (ppt). Vertical profiles of the water column were taken in 1-m depth increments from bottom to surface and examined for evidence of stratification. Water quality data were collected opportunistically to provide data necessary to calibrate the scientific echo sounding equipment used in the fishery resource surveys.

Fishery Hydroacoustics

A DT 6000 split-beam scientific-grade echosounder, manufactured by BioSonics, Inc., was used in this study. The system consists of a 200-kHz digital transducer, signal processor, interface box, and data logging equipment. A differential Global Positioning System (DGPS) was interfaced with the surface unit so that hydroacoustic target data would have synchronous latitudinal and longitudinal coordinates (datum NAD83). The DT 6000 split-beam transducer has a 6-degree beam angle, configured to provide precise locations of fish targets within the beam, enabling target strength correction as well as active and passive tracking of individual fish targets. The transducer is mounted in a vertical, downward orientation by fixed-mount to the gunnels of the survey vessel. All surveys were conducted aboard the 26-foot U. S. Army Corps of Engineers survey vessel *Jim Butler*. The transducer was submerged slightly below the water's surface and towed from the side of the vessel to avoid effects of the vessel's wake. Survey speed was maintained at approximately 2 knots.

Field data were recorded using BioSonics data acquisition software operated on a laptop computer. Data were collected along transects at water depths ranging from 1 to 10 meters at a threshold of –80 dB squared at a rate of 10 pings per second (pps). All survey data were subjected to echo integration and single target analyses. Echo integration and single target analysis was performed using HydroAcoustic Data Analysis Software (HADAS) developed by the U.S. Army Engineer Research and Development Center. HADAS outputs ASCII files containing individual target data including target strength in dB, depth, time, sample volume calculations, echogram files in standard Microsoft Windows BMP format and latitude/longitude. Echo integration is necessary when fish targets are sufficiently congregated in space, as in dense schools, that individual echoes cannot be distinguished. Echo integration estimates fish densities or biomass based on the total energy of the returned echo signal. Echo integration estimates can be correlated with catch-per-unit effort data from conventional fish-sampling protocols (Thorne 1983). Patterns in the overall vertical distributions of fish density or biomass in the water column can thereby be examined. Single targets analysis generates x, y and z coordinates for all individual fish targets.

Estimates of individual target fish length are calculated by HADAS using a modified version of an equation by Love (1971), which is based on dorsal aspect target strength. Love's (1971) equation was derived from field data for several fish species including bay anchovy (*Anchoa mitchilli*), and seatrout (*Cynoscion* sp.). Output files were then entered into ARCView or Excel to produce spatial displays of survey data.

Target data were output as densities (number of fish per 100 cubic meters). To display these data, each survey line was divided into 10 m segments, hereafter referred to as "cells", along their entire length. This spatial scale was selected to provide sufficient resolution to observe changes in overall patterns as influenced by the presence or absence of natural and man-made reefs. At all three sites spacing between individual parallel transects was set at 15 m. Number of transects per survey varied from 14 (Site 2) to 21 (Site 1). Total transect number at each site was predetermined to provide adequate coverage of both the reef area and an adjacent off-reef reference area.

Determination of Target Vertical Distribution
Split beam hydroacoustics records precise depths of single targets in the water column, which allows discrimination of targets among predetermined depth strata. Although not performed as a part of this pilot study, this capability is potentially very useful in differentiating fished based on their habitat preferences. For example, Witherell and Kynard (1990) determined the vertical distribution of upstream migrating adult shad in the Connecticut River, where 80% of shad were captured in the lower half of the water column, but not directly on the bottom. This capability

can also be useful in differentiating bottom-oriented fishes such as catfishes from migratory forms.

Determination of Fish Target Size

The amount of acoustic energy in an echo return from a fish target is dependent on physical size and morphological characteristics of the fish target, including the presence or absence of a gas-filled swimbladder, and orientation of the fish in relation to the acoustic transducer. Intensities of echoes, termed their target strength, are measured and converted to estimates of fish length. A minimum target strength detection threshold was set at a decibel level (-52.6 dB) equivalent to an estimated fish total length of 4 cm. This filtering process is applied to ensure that the energy from a variety of noises (e.g., air bubbles from surface waves or boat wakes that would give an acoustic return) is not incorporated in the data analyses. Therefore minimum detected fish lengths are equivalent for all transects in the study.

RESULTS

Water Quality

Water quality profiles were obtained for temperature, salinity and dissolved oxygen at all three survey sites. There was no evidence of thermal stratification of the water column as vertical profiles of water temperature generally varied by less than 1 °C from surface to bottom. Highest average water temperature (16.5 °C) was found at Site 2 as compared to Site 1 (15.8 °C) or Site 3 (15.7 °C), but this largely reflected differences in surface water (1ft) readings, which had risen to 18.1°C in the later part of the day.

A slight halocline was observed at Site 3 where a 3.5 ppt shift in salinity occurred at a depth of approximately 3 to 4 m. Echograms from Site 3 recorded the salinity shift as line running the length of the echogram display at that depth. Surface to bottom salinity also differed by approximately 3 ppt at Site 1, however the change was gradual and no evidence of stratification was found. Surface to bottom salinity changes were least apparent at Site 2, located nearest the entrance to the Pamlico Sound, where values differed by only 1.3 ppt. At all sites, lowest salinity values were found in the upper water column. Depth-averaged values indicated that during the surveys slightly lower salinities prevailed at Site 3 (mean = 9.6 ppt) as compared to Site 1 (mean = 10.7 ppt) and Site 2 (mean = 12.2 ppt).

Waters were generally well-mixed with respect to dissolved oxygen concentration (DO) readings at Sites 2 and 3. Depth-averaged DO concentration was 7.7 mg/l at both sites. Slightly lower values were found in the deeper water strata, ranging from 6.6 to 7.3 mg/l. Highest values did not exceed 8.3 mg/l. At Site 1, DO ranged from 4.8 mg/l at depths greater than 3 m to 8.4 mg/l for the upper water column (1-3 m). The depth-averaged DO concentration was 6.5 mg/l at Site 1, 1.2 mg/l lower than at Sites 2 and 3.

Fishery Hydroacoustics

Fish Densities at Site 1 (Natural Reef)

The first survey was completed during the morning hours on 3 November 2005, and consisted of 21 parallel transects at 15 m intervals. Site 1 is a natural high profile reef and was the farthest upstream of the three sites surveyed (Figures 1 and 2). The surveyed area was divided into 3 sections for the purpose of discussion. These include the elevated reef "proper" between the side slopes, and two reference areas, one located north and the other south of the natural reef. As presented in Figure 5 the fish densities over the reef are shaded in red and the densities in the north and south reference areas shaded in blue and yellow respectively. Note that the lighter shade of red represents the area of highest reef relief, rising 1-m above the normal river bathymetry. Individual transect echograms for Site 1 can be found in Appendix A. Note that odd numbered transects ran from south to north, whereas even numbered transects ran north to south. A review of the echograms indicates a somewhat softer bottom type for the area north of the reef as indicated by the bluish/green return at > -25 dB. The natural reef and the area south of the reef have a harder bottom type as indicated by the yellow/orange return in the -10 to -20 dB range.

Echo integrated fish density estimates ranged from <1 fish to 750-fish per 100 cubic meters (Figure 5). Almost 40% of all cells contained less than 1 fish per 100 cubic meters. Cells in which fish density ranged from 1 to 25-fish/100 cubic meters accounted for 49.5 % of the total sample. Individual cells (n = 15) where density was greater than 100-fish per 100 cubic meters accounted for only 2.1% of the total sample and were found only over the natural reef and in the north reference area. Only two large schools of small fishes were detected at Site 1. One school was located on Transect 7, north of the natural reef where fish density reached 750 fish per 100 cubic meters. The second school occurred on Transect 11 along the northern side slope of the reef, where density estimates approached 500 fish per 100 cubic meters (Figure 6).

Lowest average echo integrated fish density was found in the area surveyed south of the reef at 7.1 fish/100 cubic meters, whereas the reef proper and the area north of the reef had densities of 13.8 and 15.4 fish/100 cubic meters respectively (Figure 7). Two large and several smaller groups of schooling fishes, largely absent south of the reef, contributed substantially to the higher observed average densities in areas north of and along the reef. Fish targets in Site 1 were predominantly found in the lower 2 meters of the water column.

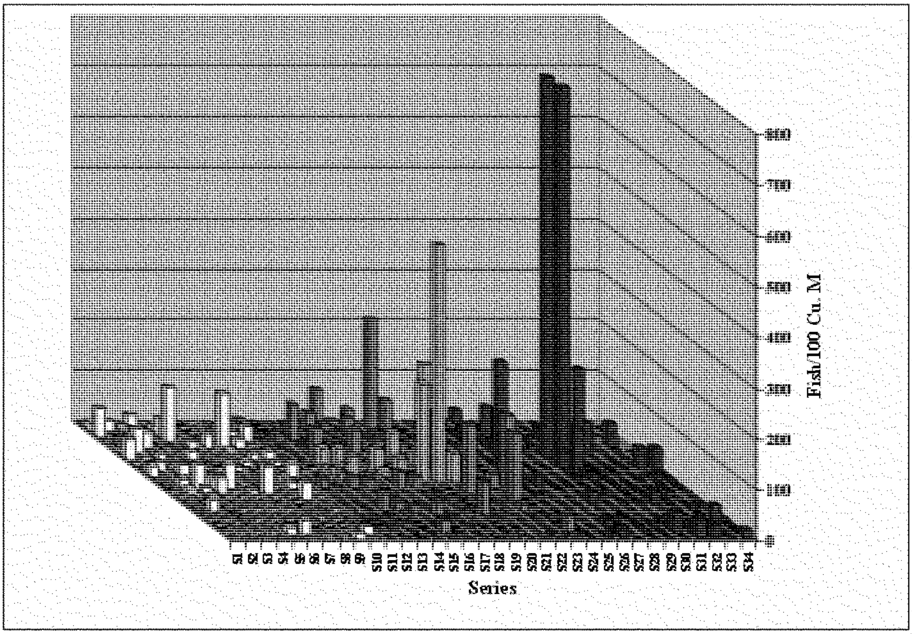

Figure 5. Fish densities (fish/100 cu m) associated with a natural oyster reef in the Neuse River, North Carolina. Reef transects are identified by the red shading, with lighter red shading indicating the most elevated relief of the reef above the prevailing river bathymetry. The blue shaded area is north of the reef, and the area shaded in yellow is south of the reef.

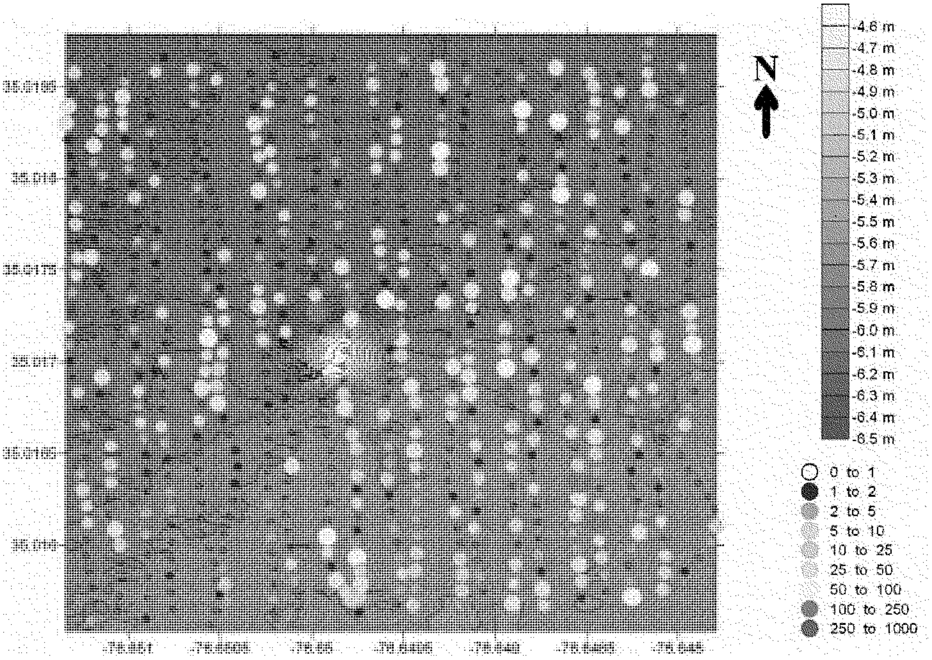

Figure 6. Depth-averaged echo integration density estimates (fish/100 cubic meters) overlaid on a depth contour plot of Site 1. (Note that each cell or colored dot represents 10 m of surveyed distance.)

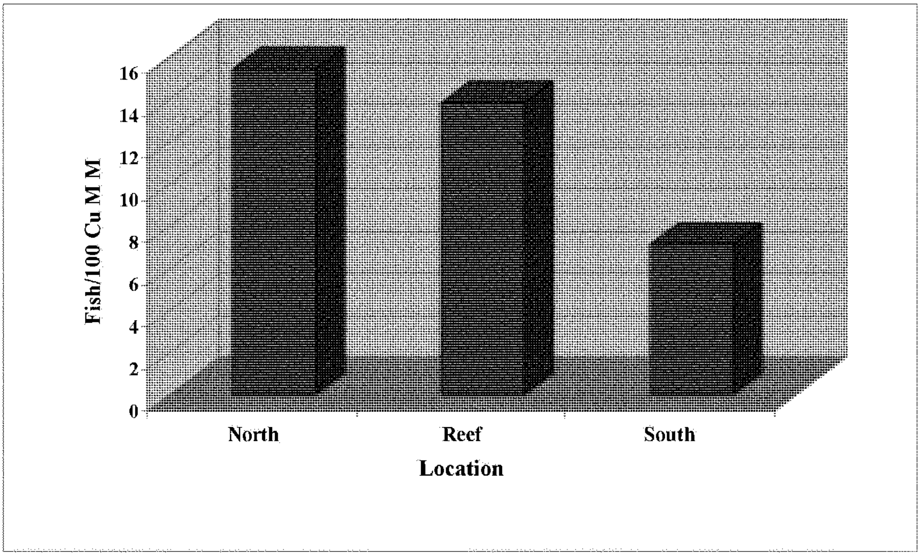

Figure 7. Average echo integrated fish densities (fish/100 cu m) by area surveyed at Site 1.

Fish Densities at Site 2 (Natural Reef)

A second survey was conducted at a natural oyster reef (Site 2, Figures 1 and 3) during the afternoon hours on 3 November 2005, consisting of 14 parallel transects separated at 15 m intervals. Following the same protocol as the earlier survey, Site 2 was divided into 3 sections as depicted in Figure 8. The area shaded in purple represents the reef including the side slopes. The blue and yellow shading represent areas south and north of the reef. Bathymetry at both north and south reference areas were uniformly 7 m in depth. Echograms for the entire series of Site 2 transects are given in Appendix B. Note that the width of the reef begins to increase by Transect 4, requiring an increase in transect length. Although the total area surveyed in each of the three sections differed, fish densities were normalized to 100 cubic meters of sampled water volume for comparison. As with the first survey, odd numbered transects ran south to north, while even numbered transects ran north to south.

Schooling fishes were more prevalent at Site 2 than at Site 1. Individual cells with fish densities above 100 fish per 100 cubic meters accounted for 6.1% (n = 18) of the total sample, compared to 2.1% at Site 1. Highest individual cell density was estimated at 907 fish per 100 cubic meters in a school detected along the northern side slope of the reef on Transect 8. A second group of schooling fishes was found along the northern reef side slope on Transect 7, where density reached nearly 450 fish per 100 cubic meters. With minor exceptions, schooling fishes or areas of higher fish density were found associated with the oyster reef surface and side slopes (Figure 9).

Approximately half (46.7%) of all cells surveyed had a density less than 1 fish per 100 cubic meters. Low-density cells were common in areas surveyed south of the reef and along the southern side slope of the reef. Only two small schools (densities of 115 and 180 fish/100 cu m) were found south of the reef (Figure 9). Cells of "moderate" density ranging from 1 to 25 (n= 104, 35.5%) and 25 to 100 (n=34, 11.6%) fish per 100 cubic meters were found almost exclusively north of the reef. Echograms from Site 2 (Appendix B) clearly show a well-defined pattern of fish targets favoring the northern side slope and areas north of the reef.

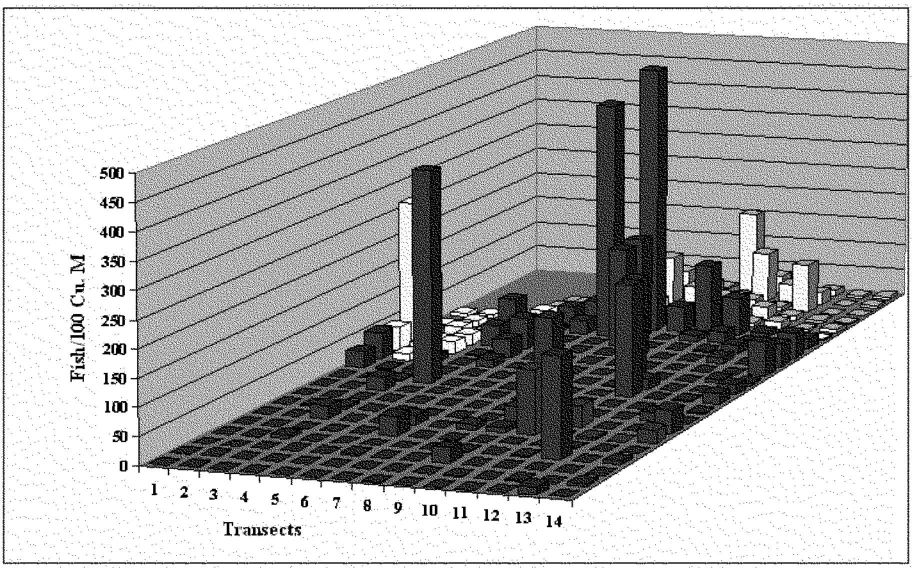

Figure 8. Fish densities (fish/100 cu m) at a natural oyster reef in the Neuse River, North Carolina. Sampling cells south of the reef are shaded in blue, the reef proper and its side slopes shaded in purple, and north of the reef shaded in yellow.

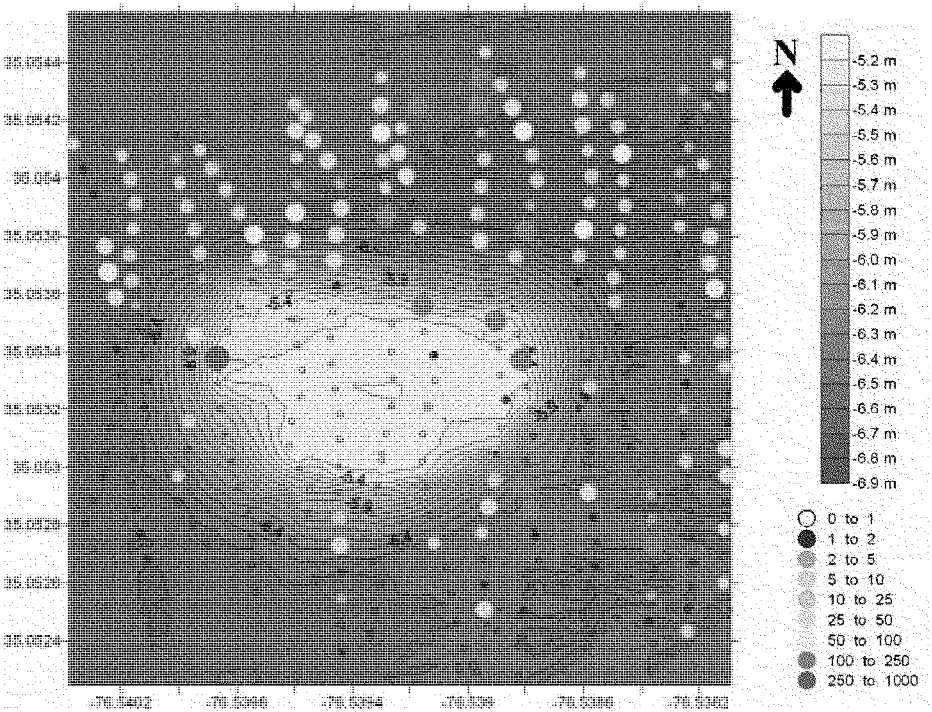

Figure 9. Depth-averaged echo integration density estimates (fish/100 cubic meters) overlaid on a depth contour plot of Site 2. (Note that each cell or colored dot represents 10 m of surveyed distance.)

Average fish density was calculated for each of the three sections surveyed at Site 2 (Figure 10). Fish density south of the reef (mean = 5.2 fish/100 cu. m.) was markedly lower than in either the area surveyed north of the reef (mean = 29.4 fish/100 cu m) or over the reef itself (mean = 26.2 fish/100 cu m). Distribution of fishes also differed within each section. Over the reef, average density was influenced by a small number of cells with large groups of schooling fishes at densities exceeding 400-fish/100 cu m. These dense fish schools were absent to the south and north of the reef. Smaller schools of fishes (100-200 fish/100 cu. m) were scattered throughout the study area, but most numerous along the northern perimeter of the reef and least prevalent south of the reef. North of the reef fish density across cells tended to be rather uniform, not exceeding 400 fish per 100 cubic meters. In contrast to the area south of the reef and over the reef, the northern area rarely had cells with densities less than 1 fish per 100 cubic meters.

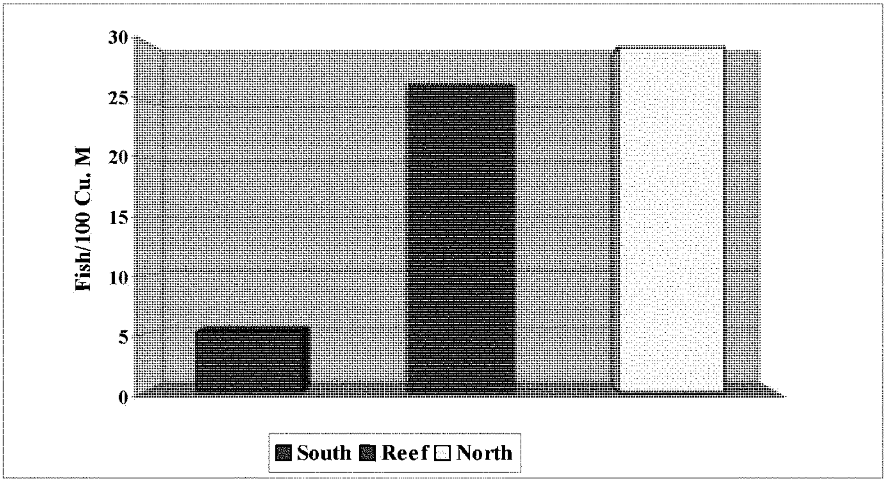

Figure 10. Average echo integrated fish density (fish/100 cu m) by area surveyed at Site 2.

Fish Densities at Site 3 (Artificial Reef)

A third survey was completed in the afternoon hours of 3 November 2005, and consisted of 15 parallel transects spaced at 15 m intervals. Site 3 (Figures 1 and 4) is the shallowest of the three sites surveyed, characterized by generally flat bathymetry with water depths ranging from 3 to 4 meters. Transects were established using the same protocol as in the prior surveys. The complete Site 3 echogram series is given in Appendix C. Note that odd numbered transects run north to south and even numbered transects run south to north. Site 3 was subdivided into 6 sections for examination of density patterns. Section nomenclature is based on relative position with reference to the reef. The first section is the artificial reef containing 15 Class B rip-rap mounds, located in the southwest corner of the oyster sanctuary. This area is highlighted in yellow in Figure 11. Section 2 is the remaining portion of the sanctuary (red shading) in which mounds may be constructed at a later date. Sections 3 and 4 are located north (purple shading) and south (blue shading) of the sanctuary respectively, and Sections 5 and 6 are located to the east (amber shading and west (green shading) respectively. Although the total area surveyed in each of the six sections differed, fish densities were normalized to 100 cubic meters of sampled water volume for comparison. In the future surveys, if reef construction expands, the east and west sections of the study area would need to be enlarged.

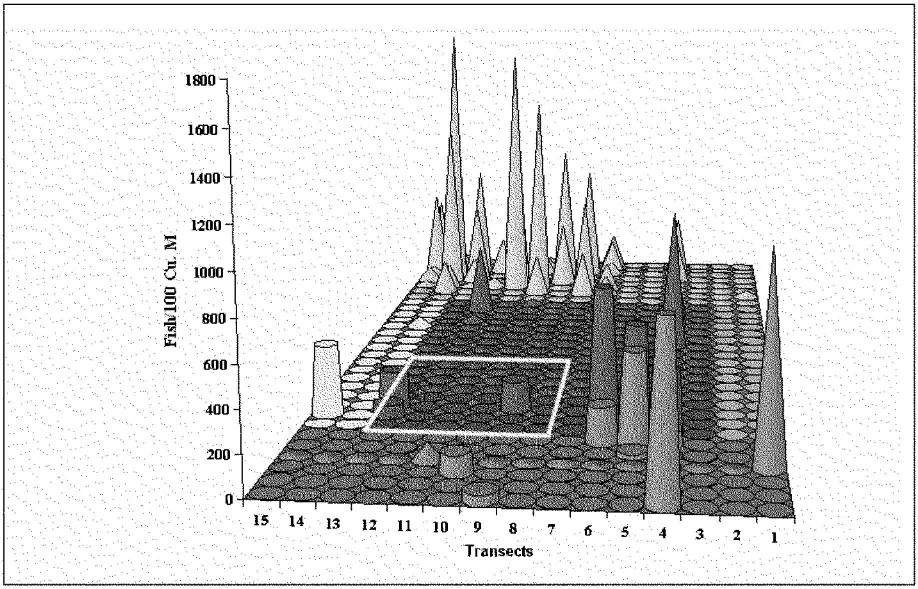

Figure 11. Echo integrated fish density (fish/100 cu m) at an artificial reef constructed from Class B rip-rap in the Neuse River, North Carolina.

Slightly more than 60% of cells (n = 273) surveyed at Site 3 had echo integrated fish density estimates of less than 1 fish per 100 cubic meters, the highest percentage of the three sites surveyed. Cells (n = 115) with densities in the 1 to 25-fish/100 cubic meter range accounted for 25.3 % of the total sample, the lowest percentage of the three sites surveyed. Slightly more than 10% of the total sample was comprised of cells in which density exceeded 100 fish per 100 cubic meters. Of these, 5 cells (1.1%) had densities exceeding 1,000-fish/100 cu m. Highest individual cell density was slightly less than 1,700 fish/100 cubic meters recorded on the northern end of Transect 14.

Spatial distribution of fish targets clearly favored the northwestern section of the study area at Site 3 as illustrated in Figure 12. Echograms from Site 3 indicated that the majority of targets detected were schooling fishes, located predominantly near the northern terminus of Transects 7 through 15. Echo integrated fish density for the northern section of Site 3 averaged 147-fish/100 cubic meters, considerably higher than values found elsewhere at Site 3 (Figure 13). Schooling fishes, the densest exceeding 1,000 fish per 100 cubic meters, accounted for the majority of acoustic detections in the southern section as well, but were more likely to be found in the southeastern corner of the study area. Density across the southern portion of the study area averaged slightly more than 40 fish per 100 cubic meters.

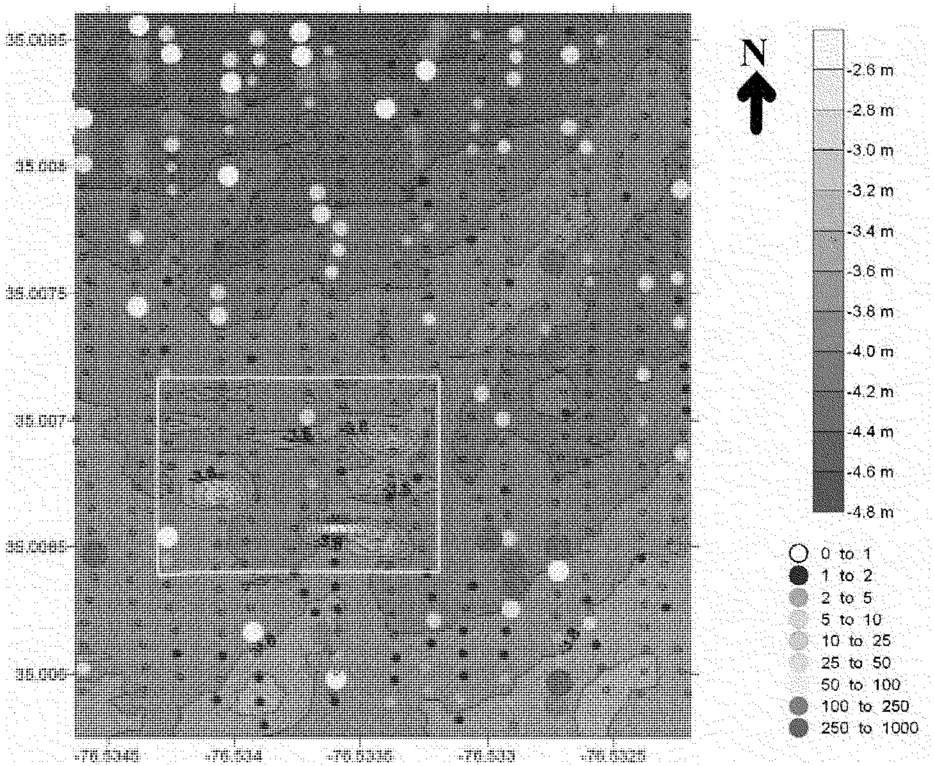

Figure 12. Depth-averaged echo integration density estimates (fish/100 cubic meters) overlaid on a depth contour plot of Site 3. (Class B rip-rap mounds are highlighted in yellow. Each cell or colored dot represents 10 m of surveyed distance.)

Distribution of fishes throughout the sanctuary was similar to that observed in adjacent areas. That is, fish density in the majority of cells averaged less than 1 fish per 100 cubic meters. The few schools detected consisted of large numbers of small fishes. Three schools, detected on Transects 4-6 were found to the east of the artificial reef bordering the southern section of the study area. Fish density within these schools ranged from 500 to 800 fish per 100 cubic meters. Overall density estimates within the sanctuary averaged 19.3 fish per 100 cu m. Note that the area described as the sanctuary excludes the man-made reef located in the southwest corner. This partitioning of the data allows comparisons between areas with constructed reefs and those areas slated for construction. At the reef, three smaller fish schools were observed with densities range from 70 to 200 fish per 100 cubic meters; otherwise most cells had very low densities (< 1 fish/100 cu m). Fish density across the artificial reef averaged 7.9 fish per 100 cubic meters.

Sampling coverage of the eastern and western sections of Site 3 was minimal. Future surveys should expand these sections for better representation. Fish density averaged only 2.1 fish per 100 cu m east of the sanctuary, but 14.4 fish per 100 cubic meters to the west, attributable to one school (365 fish/100 cu m) near the southern terminus of Transect 1.

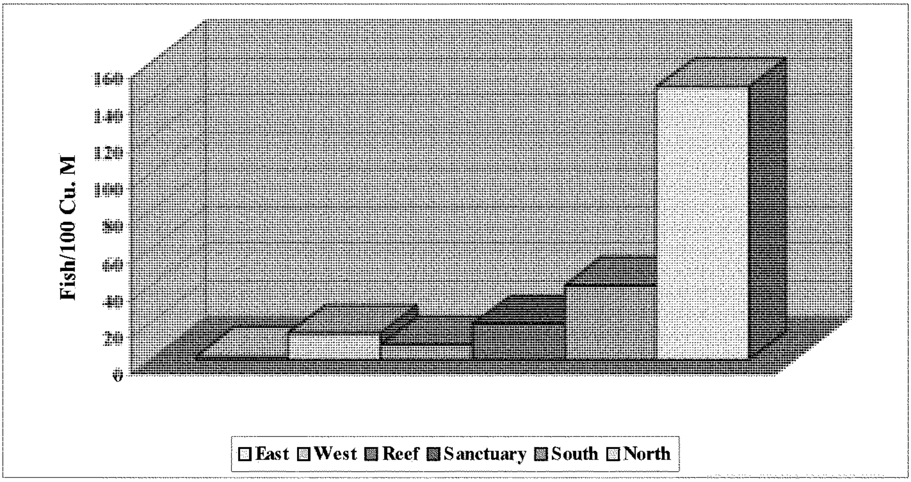

Figure 13. Averaged echo integrated fish densities (fish/100 cu m) by area surveyed at Site 3.

Fish Size Distribution

A size frequency plot of all single targets detected in the three surveys is given in Figure 14. A large majority of targets present during the single day's sampling effort were schooling fishes. A relatively small number (n = 207) of single target fishes were detected. Approximately 60 % of single targets were detected at Site 1, followed by Site 2 with 31.9%, and Site 3, the artificial reef, at 8.2 %. Single targets fishes ranged in size from 4 to 35 cm. Fishes < 10 cm total length (n = 136) accounted for 65.7% of the total sample. An additional 25% of the single targets ranged in length from 10 to 15 cm. Only 13 fish were detected in the 15 to 20 cm size class, accounting for 6.3% of the total sample. All other size class categories (e.g., 30-35, 1.9%) accounted for less than 2% each of the total sample.

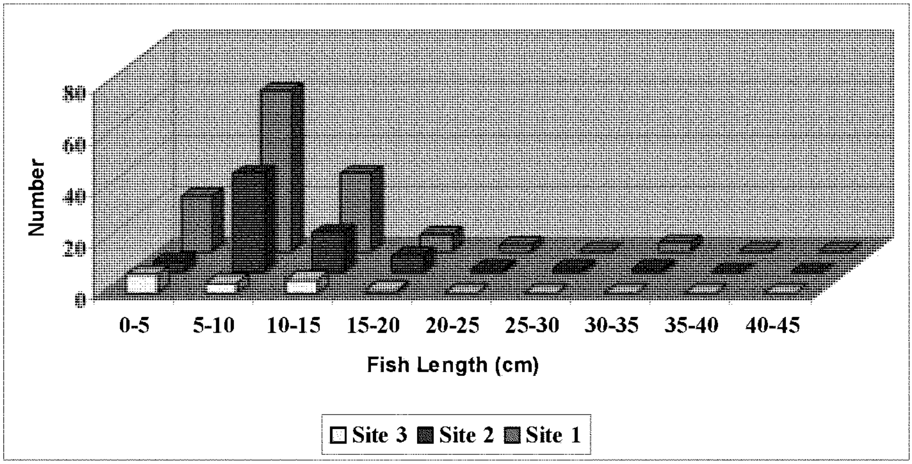

Figure 14. Acoustically determined length frequency distribution of fishes detected at three study sites in the Neuse River, NC.

Vertical Distribution

Due to the limited number of single targets detected along with preliminary observations indicating that the majority of fish targets were located within the bottom 2-meters of the water column, a full scale vertical distribution analysis was not performed. However to demonstrate this type of result, Transect 5 from Site 1 was chosen and divided into six 1-meter depth strata. Individual strata were divided into 33 cells representing 10 m of survey distance. Figure 15 provides the results for Transect 5 occupied at Site 1. The two upper strata are nearly devoid of fish targets. Averaged fish density for Strata 1 and 2 were 0.02 and 1.03-fish/100 cubic meters, respectively. Fish density increased at mid-water depths although the majority of fish targets were schooling fishes found in a small number of cells. Strata 3 (2-3 m) had the highest density of the two mid-water strata at 31-fish/100 cubic meters. Highest echo integrated fish density was found in the bottom two strata at 51.6 (Strata 5) and 57.9 (Strata 6) fish/100 cubic meters. Note that Strata 6 sampled the water column from 5 to 6 meters. This water depth was only available on the northern end of Transect 5 (far right of Figure 15).

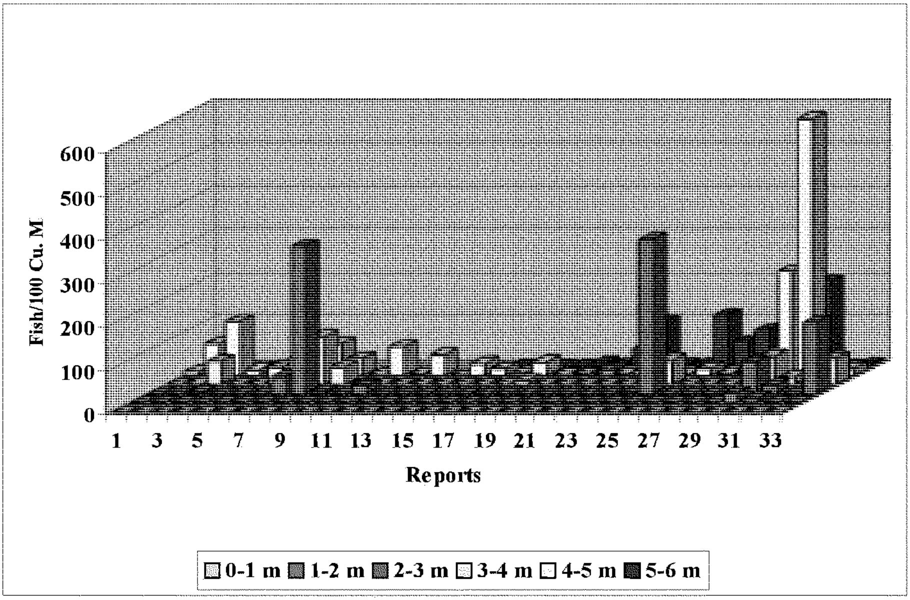

Figure 15. An example profile of vertical distribution of fish target density by depth strata for Transect 5 at Site 1. (Note that the water column was divided into one-meter strata from surface to bottom.)

CONCLUSIONS

A pilot study was undertaken in November 2005 to evaluate the feasibility of fishery hydroacoustics techniques to examine fish distributions around natural and artificial reefs. A major objective of further field data collections would be monitoring the success of oyster reef restoration efforts in terms of providing habitat functions for desirable species (e.g., striped bass, seatrout). Some advantages of using fishery hydroacoustics to satisfy this objective include: 1) the ability to survey fish distributions over large areas in relatively short periods of time, 2) provision of quantitative data on fish density, size, and location, and 3) its non-destructive of resources as compared to conventional netting techniques.

Three sites were selected in the Neuse River that represented natural and artificial reef sites. All surveys were conducted on a single day in November 2005. Sites 1 and 2 were natural reefs, whereas Site 3 was constructed from 2,300 tons of Class B rip-rap. Reference areas adjacent to each natural and constructed reef were surveyed for comparison.

The data collected indicated that the majority of fishes present during the pilot study were small, schooling fishes, perhaps anchovies, silversides, and/or juvenile menhaden. The number of non-schooling, single targets fishes present was relatively low. Site 1, a comparatively high profile natural reef had the largest number of single fishes detected, whereas the artificial reef at Site 3, was predominantly occupied by small schooling fishes.

Water column distribution indicated that the majority of fishes present, either in schools or as individuals, were found in the deepest 2-meters of the water column. This was particularly the case at Sites 1 and 2. At Site 3 "pockets" of schooling fishes often extended from near the surface to just off the river bottom.

The highest numbers of observed fishes occurred in the reference area north of the artificial reef sanctuary at Site 3, although relatively large fish schools were present throughout the study area. Fishes also were observed in comparatively high numbers in the area north of and along the northern side slope of the natural reef at Site 2. Patterns were less distinct at Site 1. The area north of the high profile natural reef and the reef itself had higher fish densities than in the reference area south of the reef due largely to the presence of two large schools of fishes. In general, smaller fish schools and single targets fishes were evenly distributed at Site 1.

The results herein give some indication of the potential applications of fishery hydroacoustics for assessment of reef construction in the Neuse River. However, the caveat must be stated that the results represent a very brief "snapshot" of conditions at these three sites on a single day in November. Recommendations for full implementation of fishery hydroacoustics would necessarily include:

1) Seasonal sampling. Surveys should be linked to specific objectives. Occupation of the reefs by resident and transient fishes could only be assessed by timing the surveys to coincide with occurrences of predetermined target species, such as striped bass. One option might be intensive surveys during the expected season of peak utilization by target species. A viable objective would be comparison of reefs of various vertical profiles and spatial footprints in terms of their utilization by off-bottom fishes. Results could be used to guide design and construction of "most effective" reef structures.
2) Diel sampling. Ideally, surveys would be timed to assess occupation of the reefs and non-reef areas during day, night, and twilight periods. Target species may preferentially use reef habitat for foraging, refuge, nursery, and other functions at certain times. For example, striped bass may move onto reefs to forage at twilight. Interactions between the distributions of small forage fish in prevalent schools and predators could also be examined by diel sampling.
3) Water quality monitoring. Future hydroacoustic surveys should include sufficient water quality sampling to support interpretation of findings. For example, if hypoxia is known to be a frequently occurring phenomenon in the subject reaches of the Neuse River, fishery hydroacoustics could be used to assess the potential value of high relief structures as refugia for fishes from low DO bottom waters.
4) Ground truth data. Fishery hydroacoustics must be interpreted based upon adequate knowledge of the identities of the acoustic targets. This can be accomplished with reasonable allocation of effort toward conventional netting techniques. For example, if striped bass is a high priority species, gill nets could be used to verify their presence as well as other targets of similar size frequencies. In off-reef areas bottom and mid-water

trawls could be used to verify acoustic target identities. Other existing sources (e.g., diver visual surveys) of ground truth data could be used effectively.

In summary, based upon the results of the pilot study, useful information on the occupation of various natural and artificial reef configurations in the Neuse River could be obtained through fishery hydroacoustics surveys. These techniques do have limitations that must be acknowledged. Inappropriate selection of target species would reduce the value of the invested effort. For example, fishery hydroacoustics cannot assess the presence of cryptic species that within interstitial spaces of the reef structure or bottom-oriented species such as flounder. However, associations between off-bottom forage fishes, off-bottom predators, and reef physical features could definitely be examined.

ACKNOWEDGEMENTS: This pilot study represents a joint effort by the U. S. Army Corps of Engineers Wilmington District and the U. S. Army Engineer Research and Development Center, Vicksburg, MS. Funding was provided by the Dredging Operations and Environmental Research (DOER) Program. The authors wish to express their thanks to Mr. Charles Wilson (CESAW-TS-PE) of the Environmental Resource Section of the Wilmington District for providing logistical support for field efforts. Our appreciation is extended to Mr. Kevin Allred and Mr. Scott Bertrand, survey crew of the Corps Vessel *Jim Butler*.

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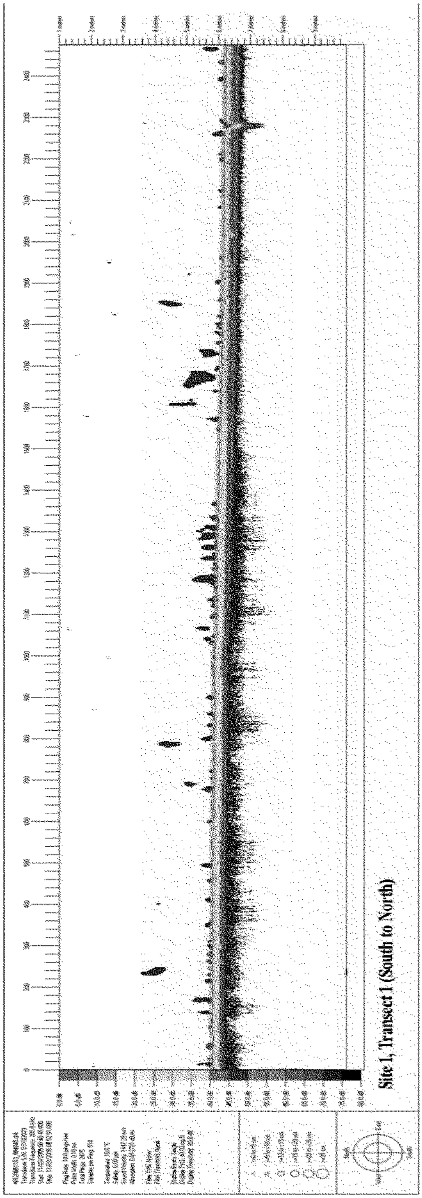
Witherell, D. B. and Kynard, B. (1990). Vertical distribution of adult American shad in the Connecticut River. *Transactions of the American Fisheries Society* 119:151-155.

APPENDIX A



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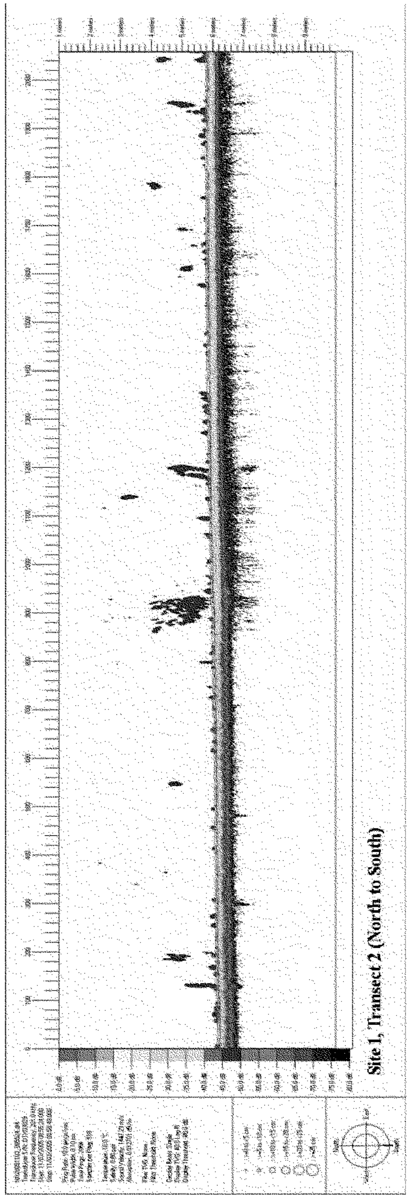

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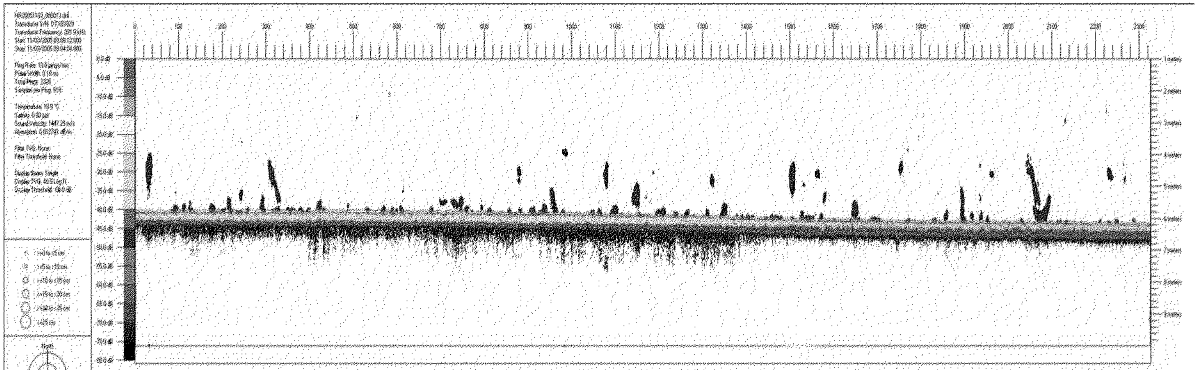

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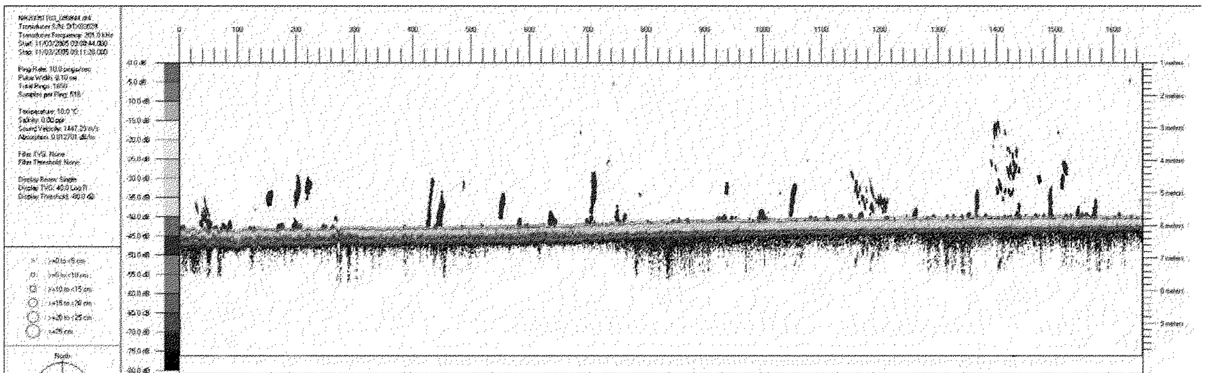

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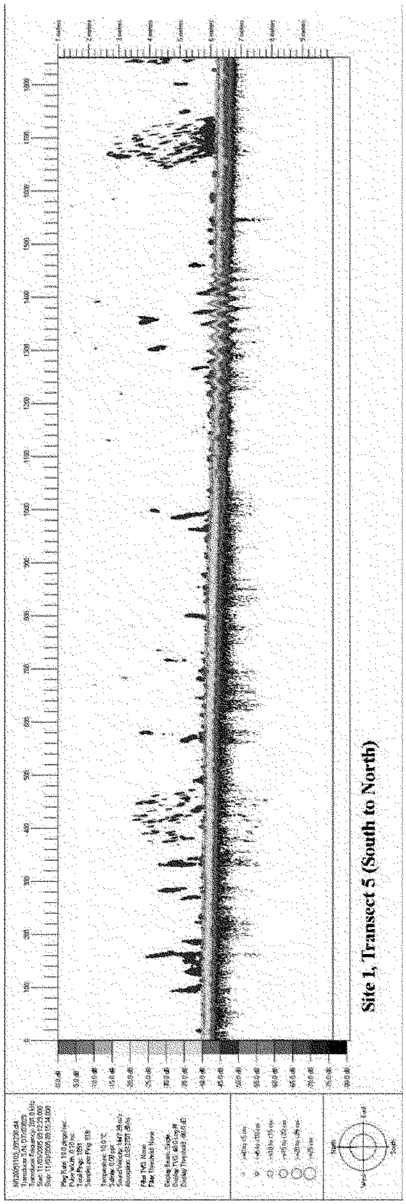

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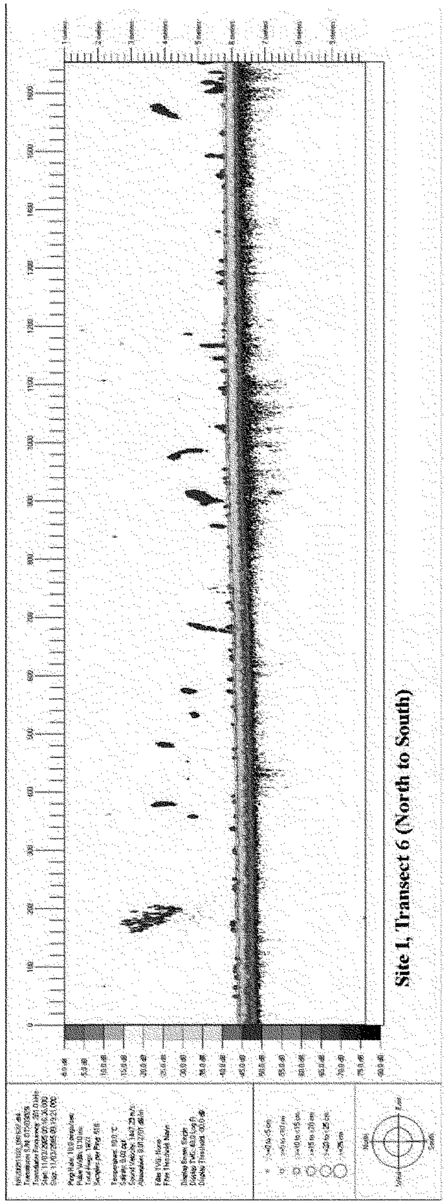

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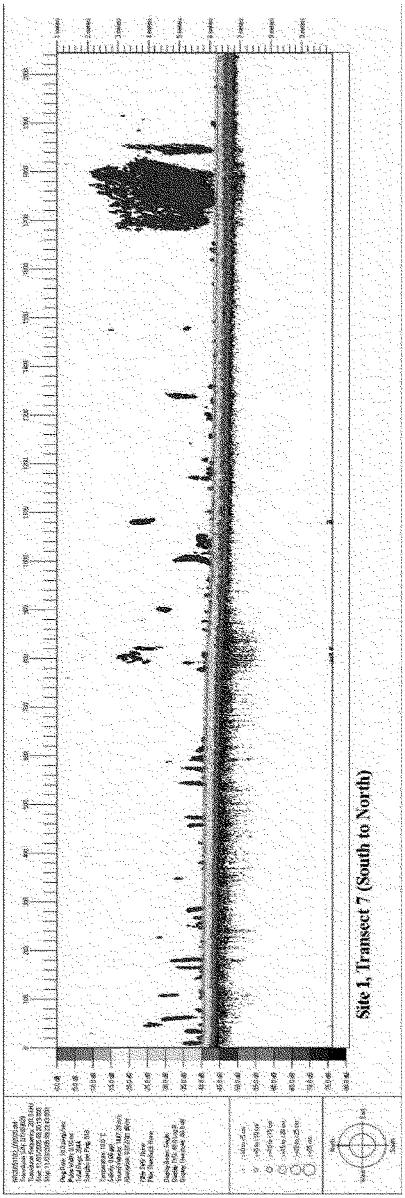

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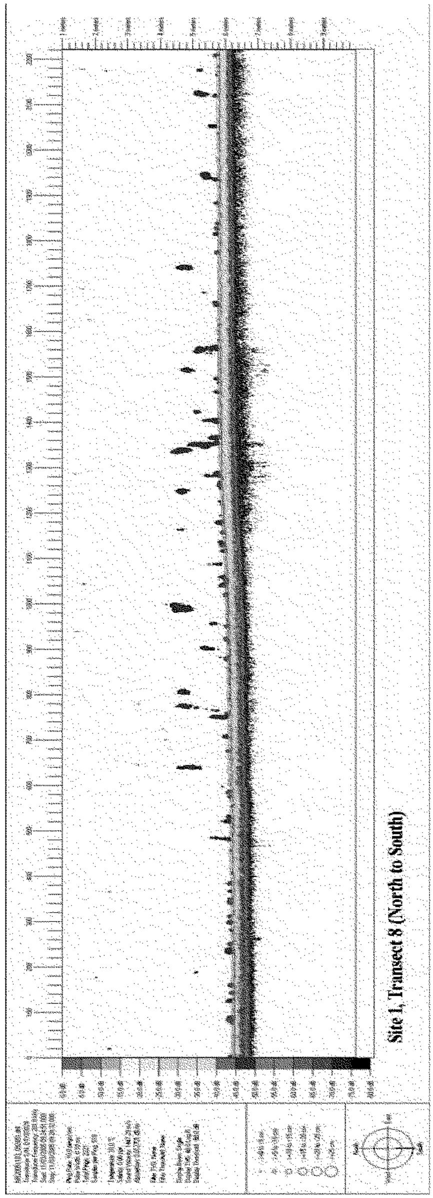

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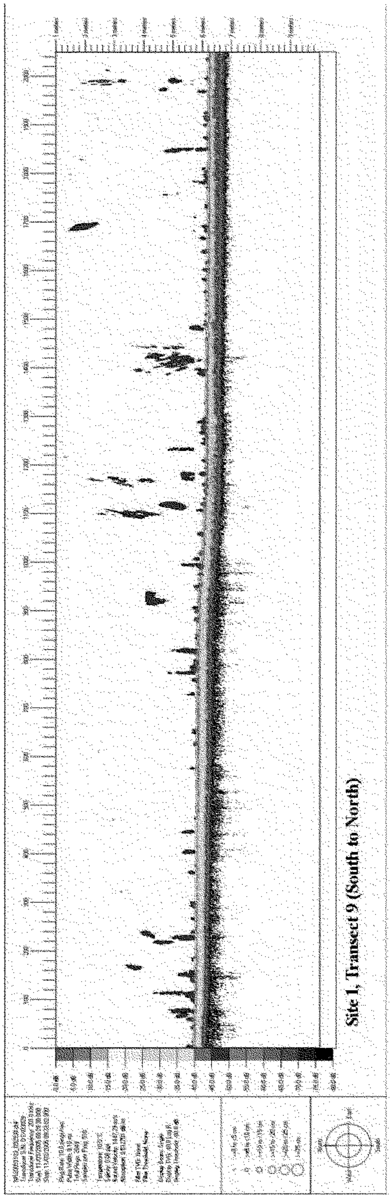

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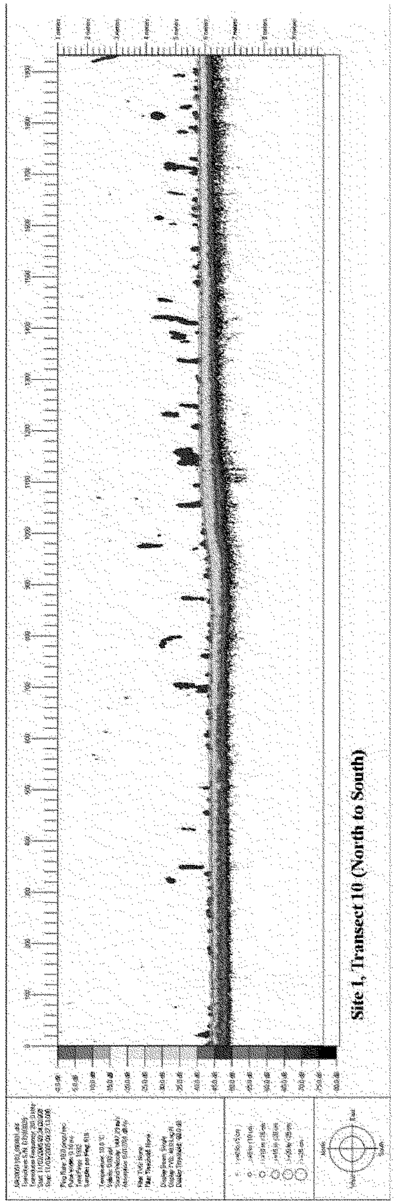

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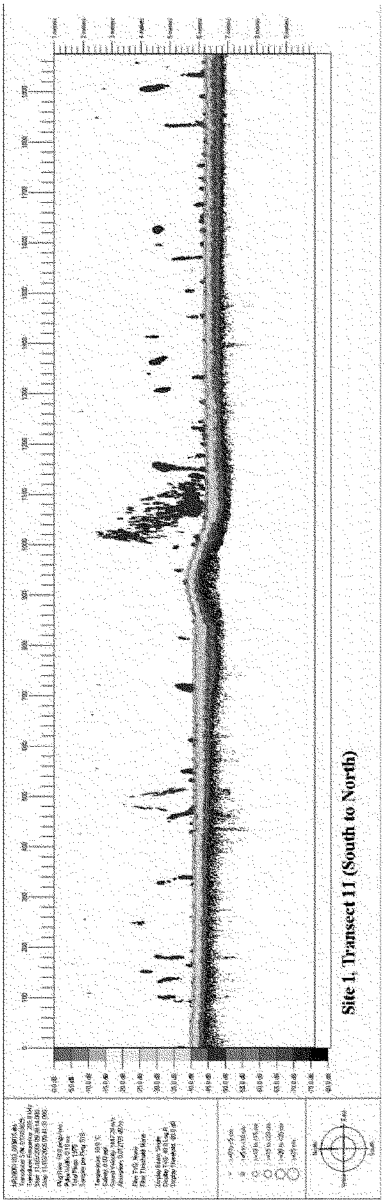

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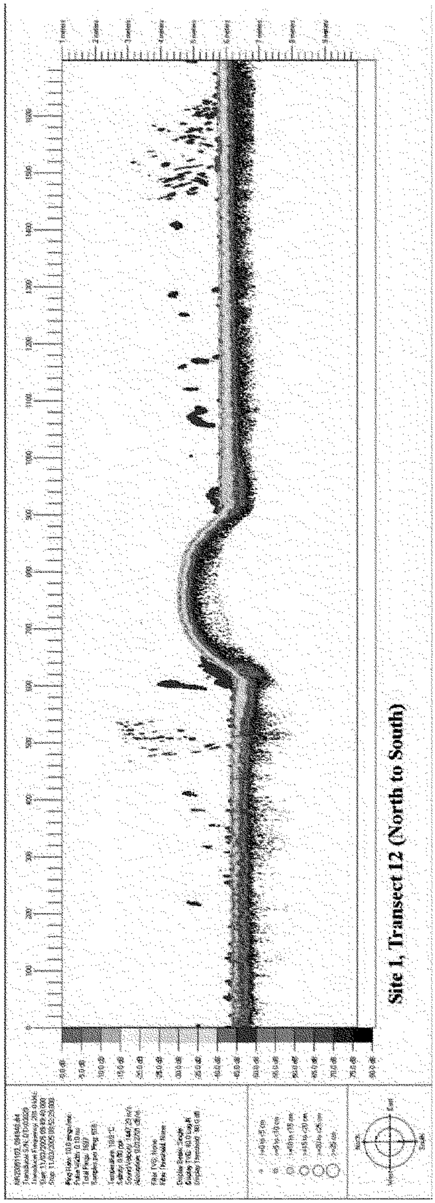

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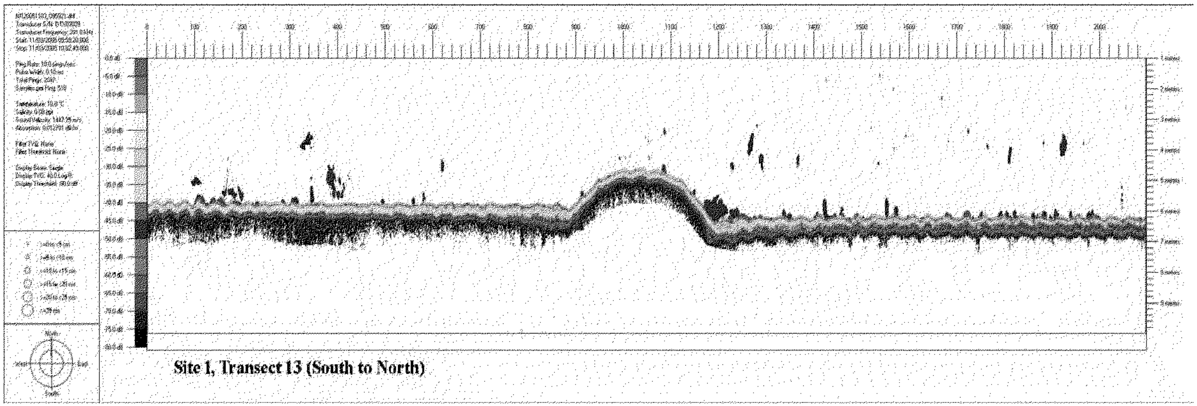

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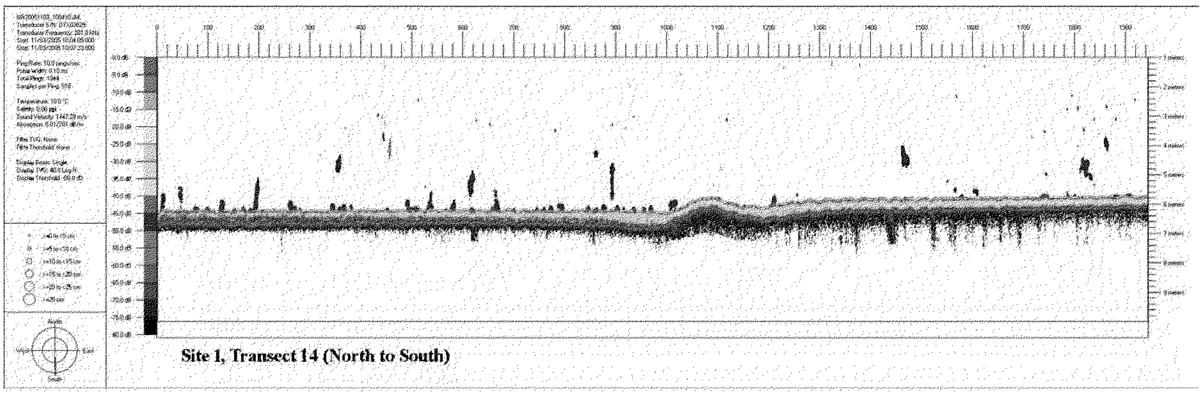

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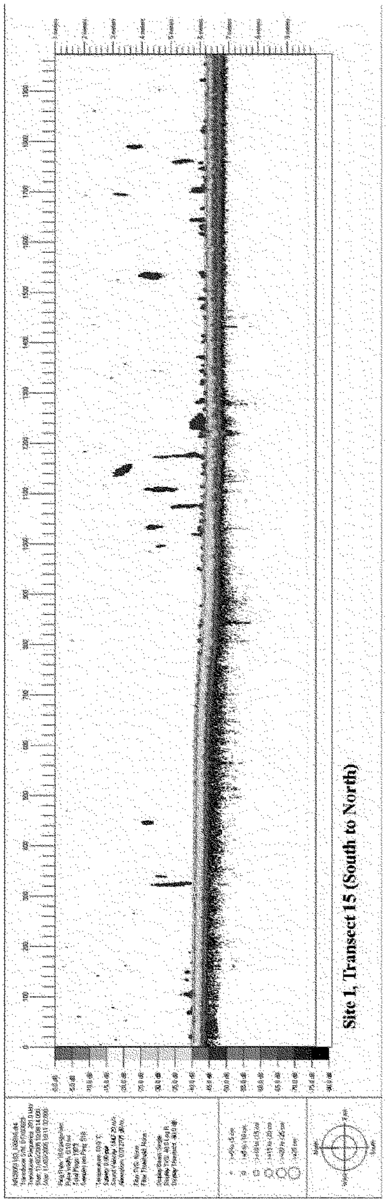

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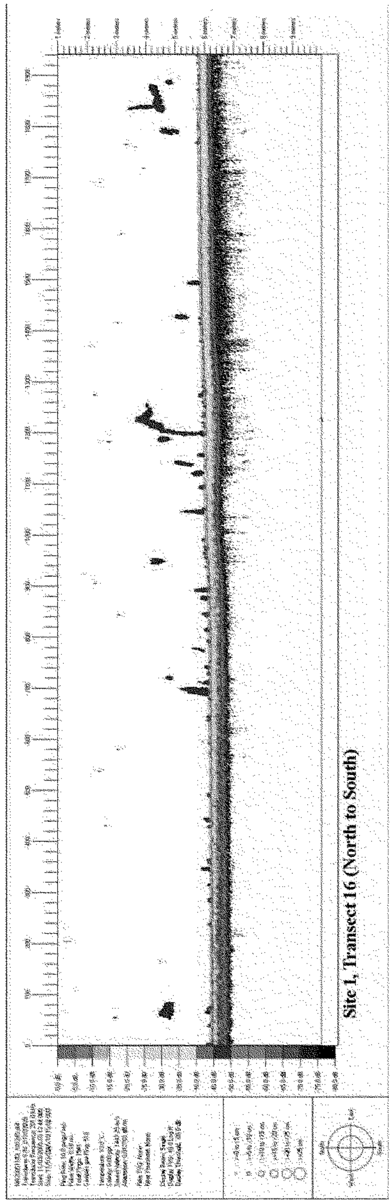

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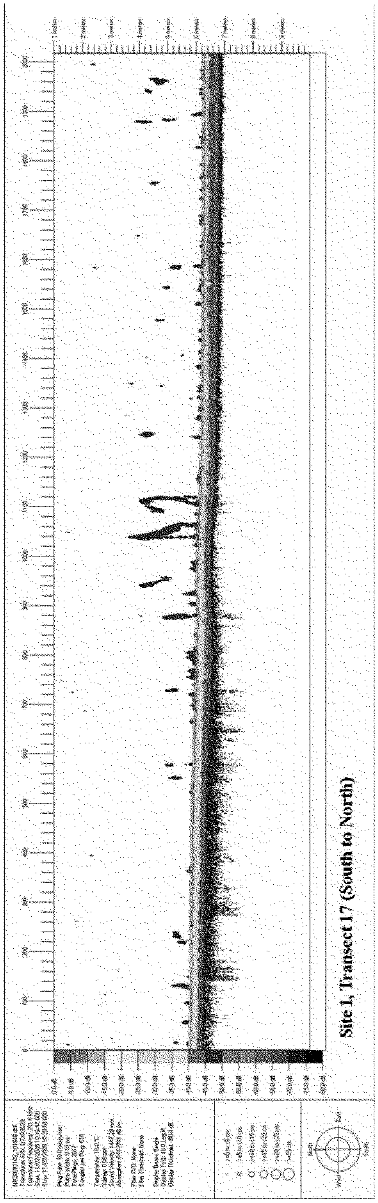

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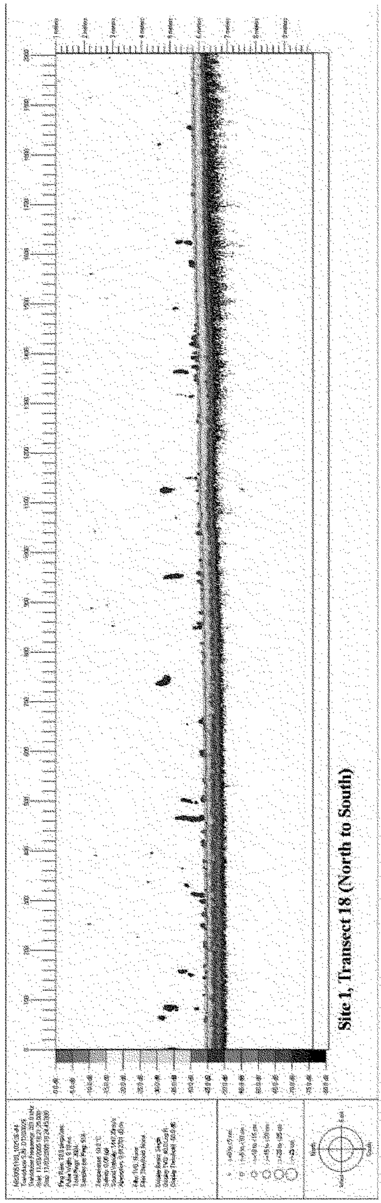

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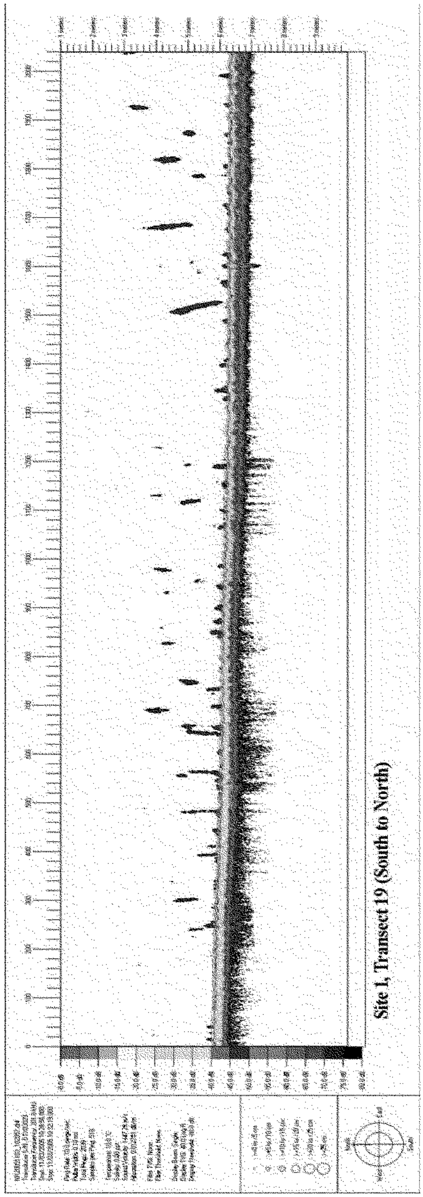

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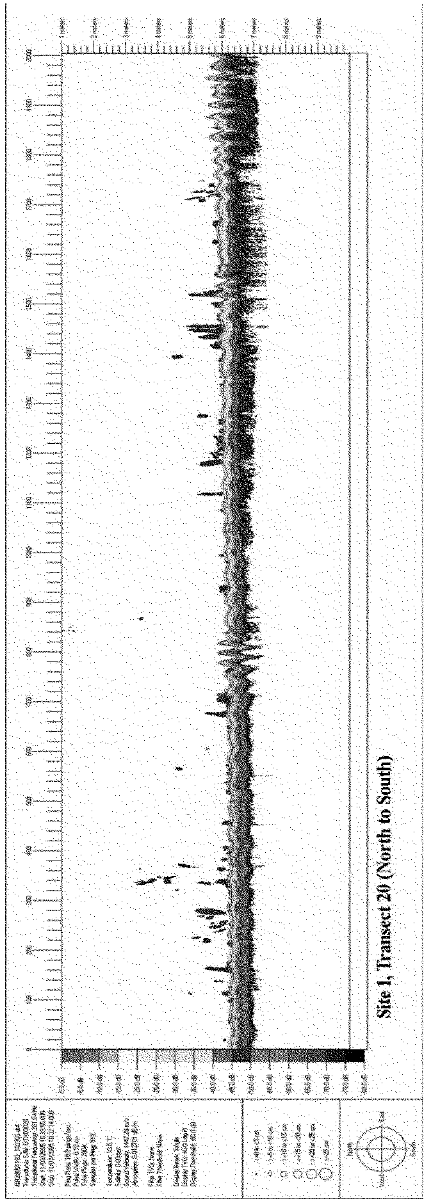

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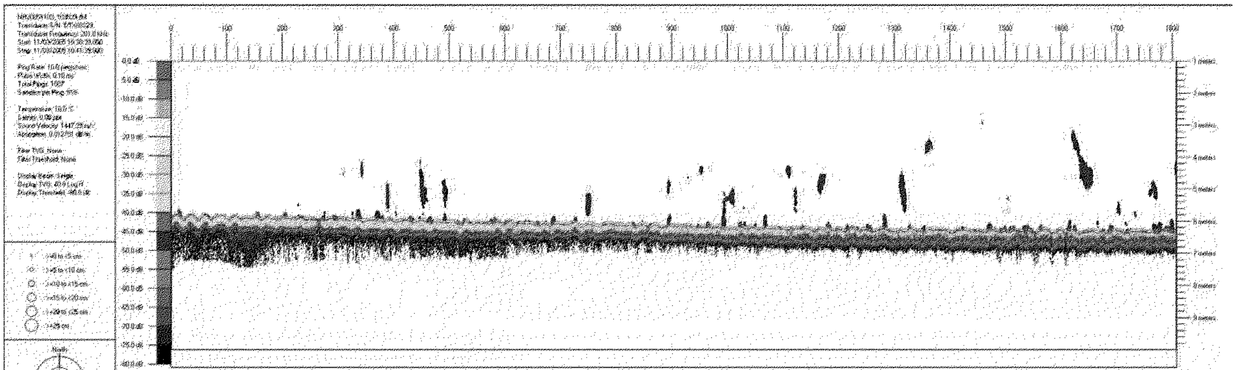
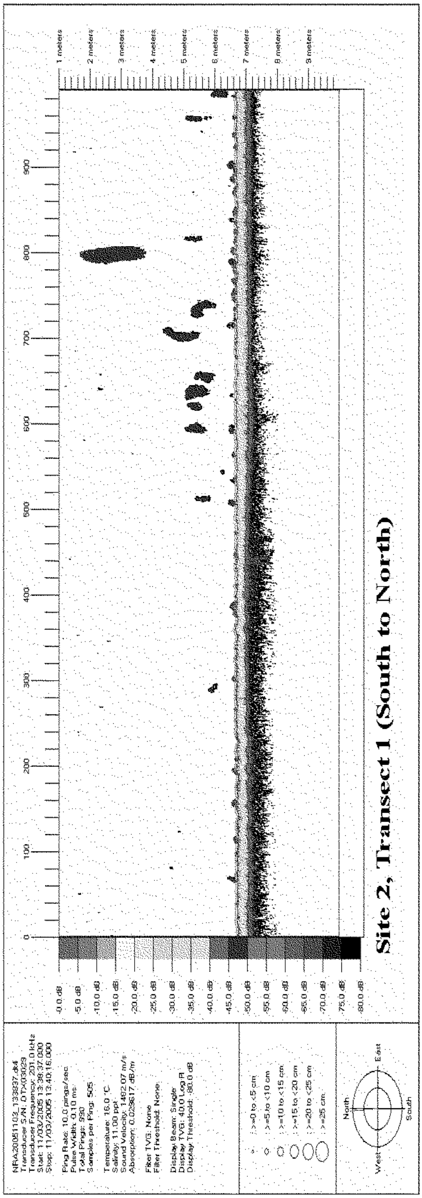


Site 1, Transect 21 (South to North)

APPENDIX B



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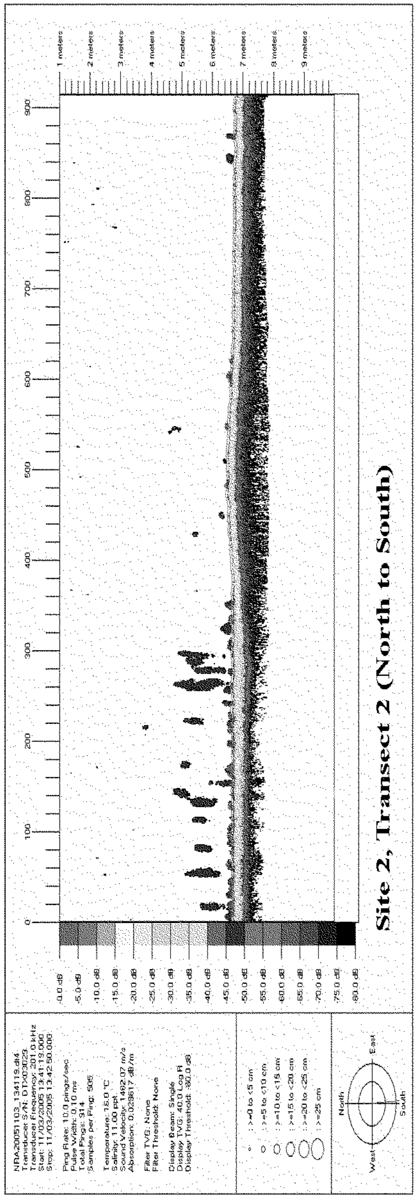

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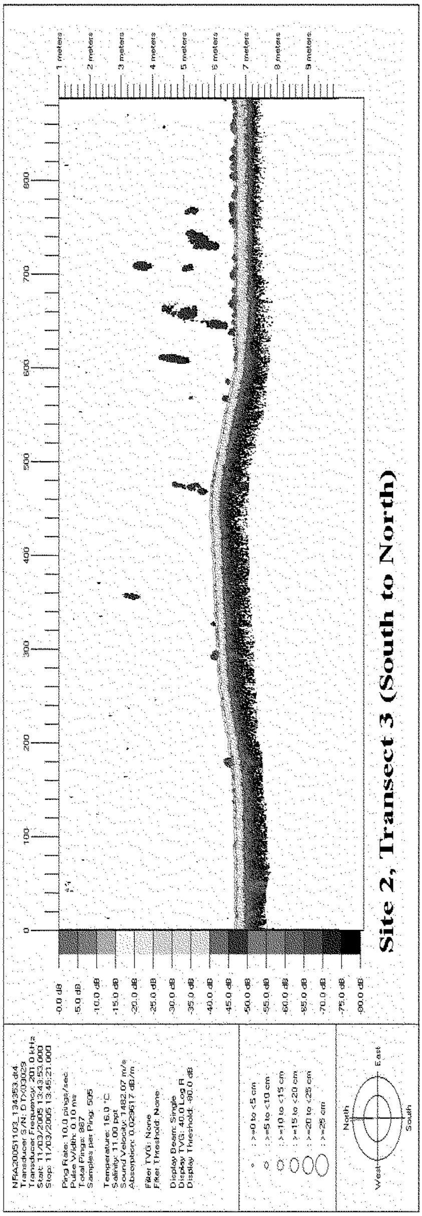

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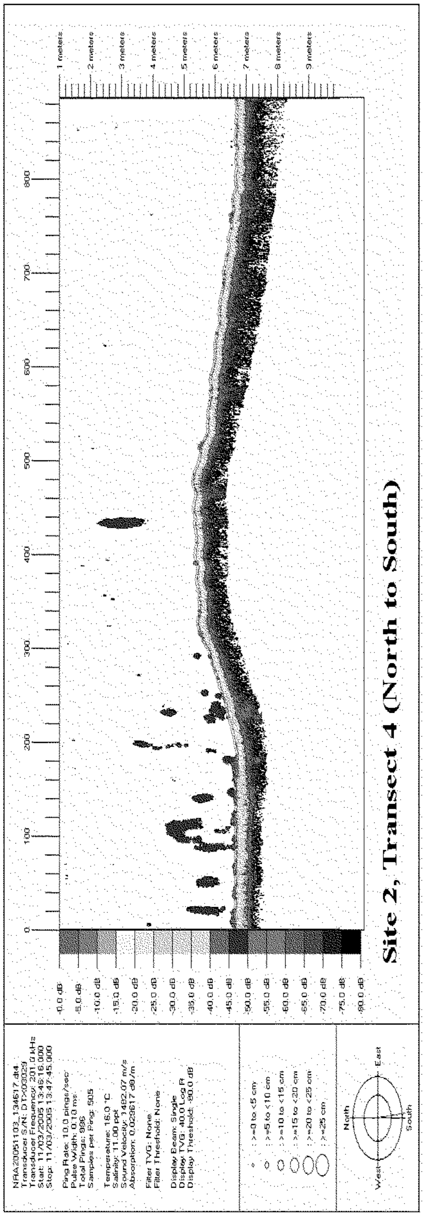

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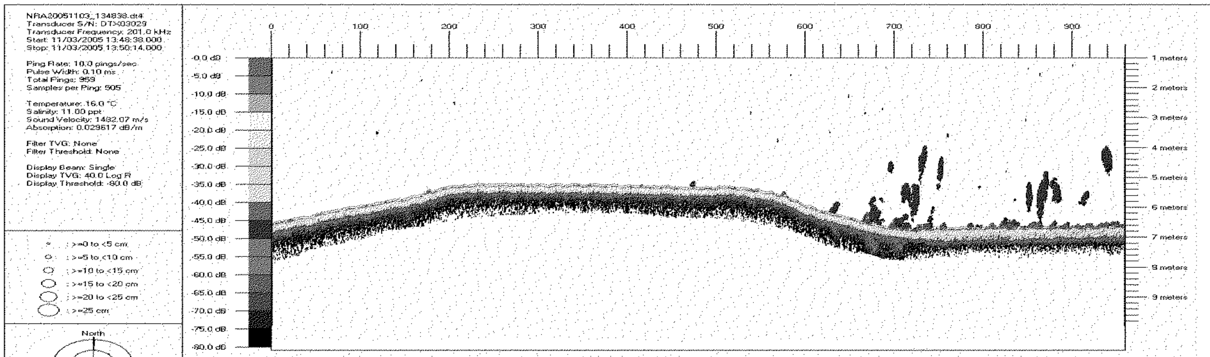

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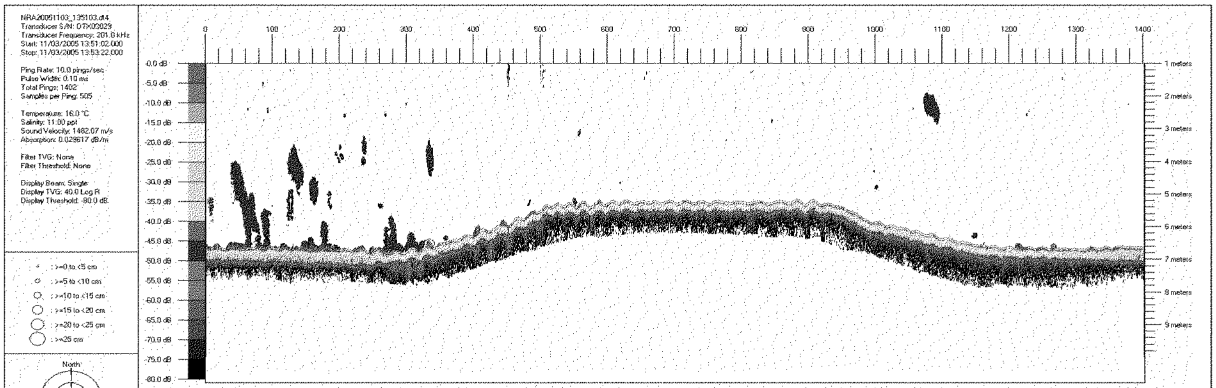

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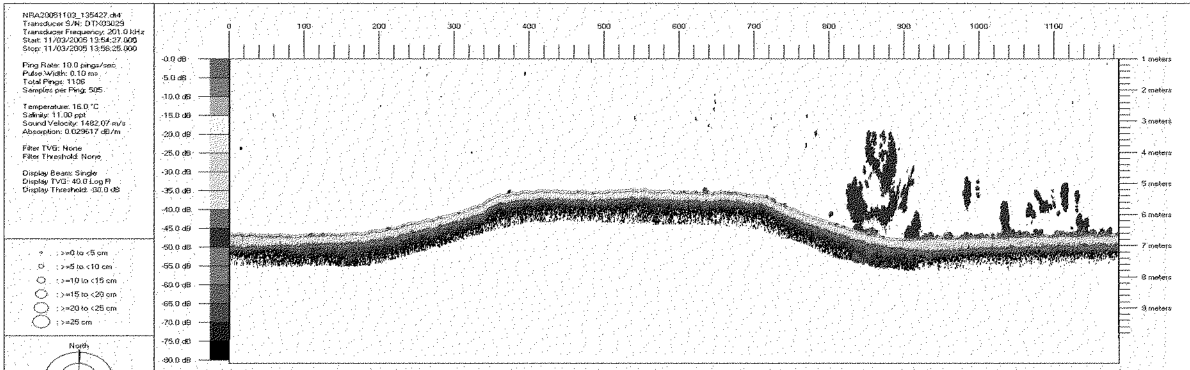

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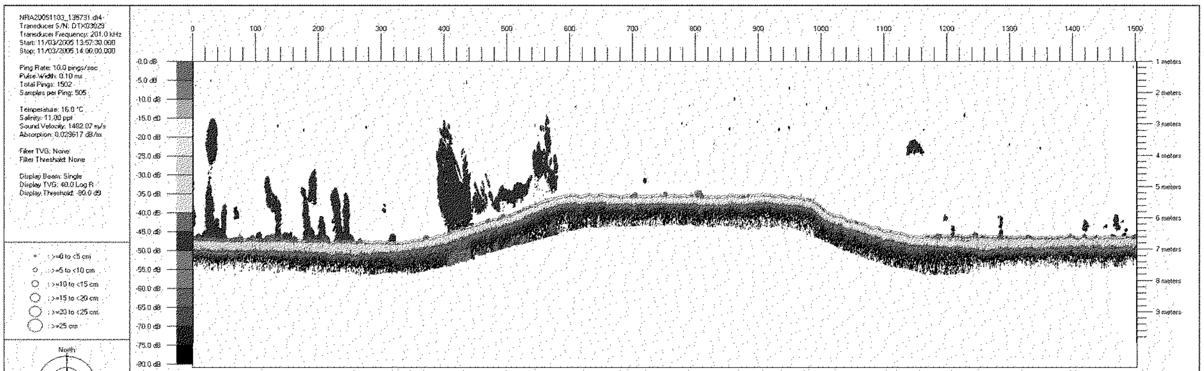

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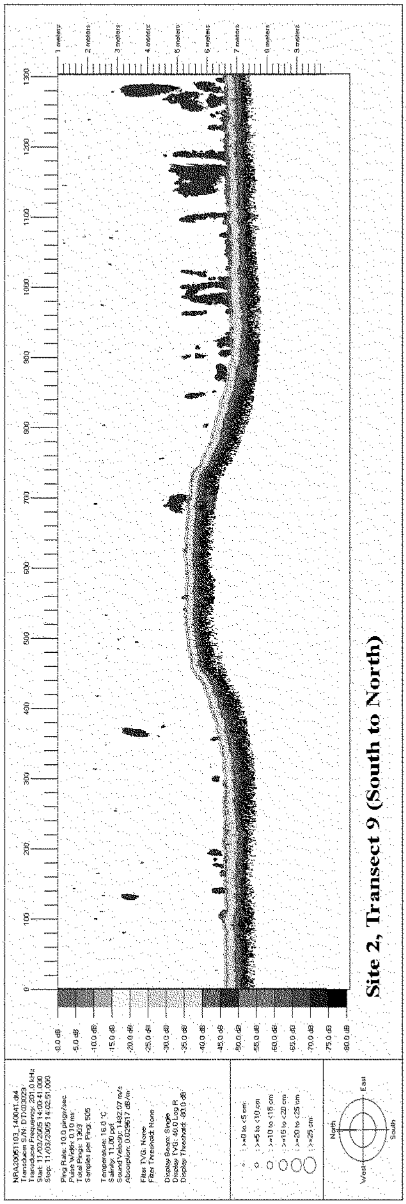

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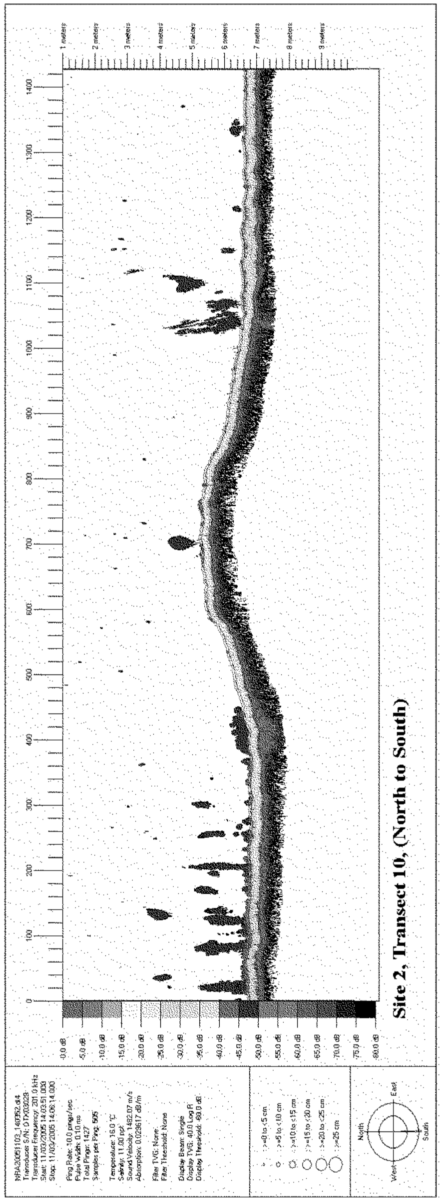

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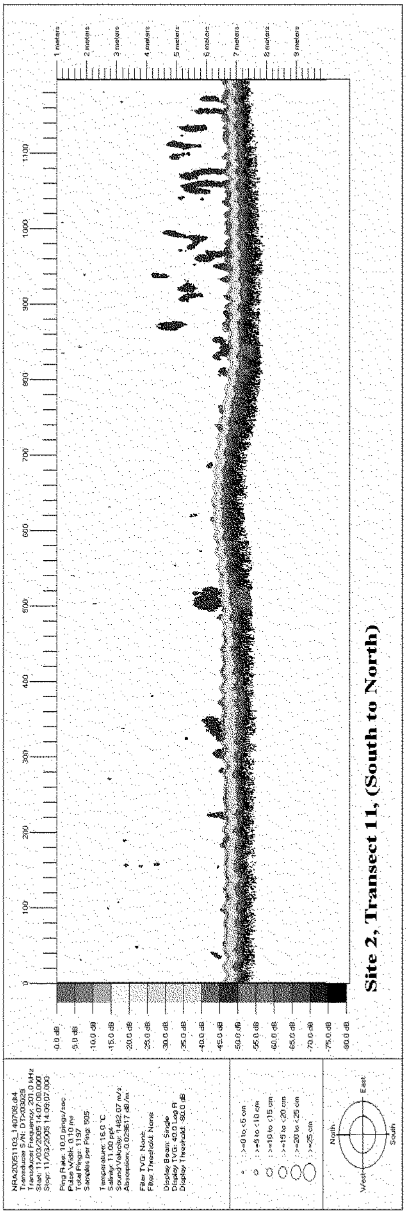

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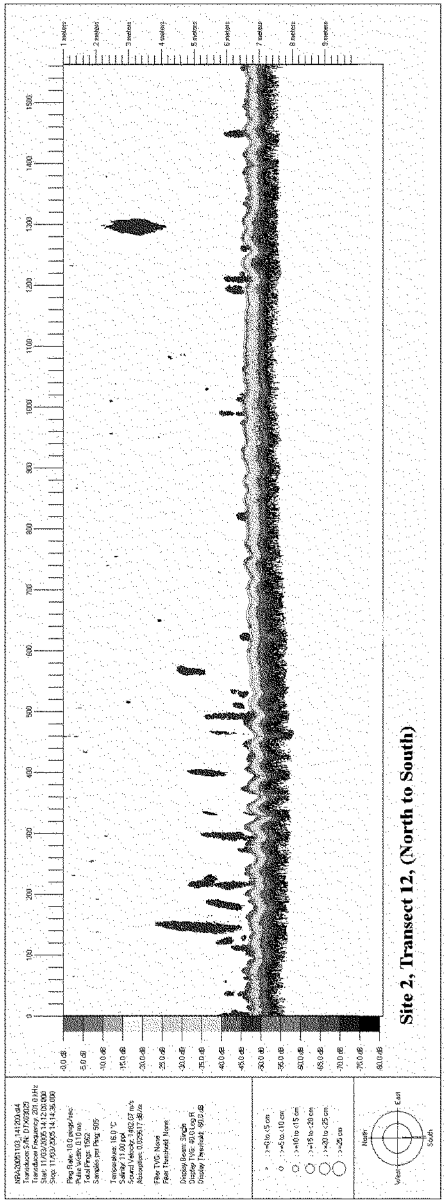

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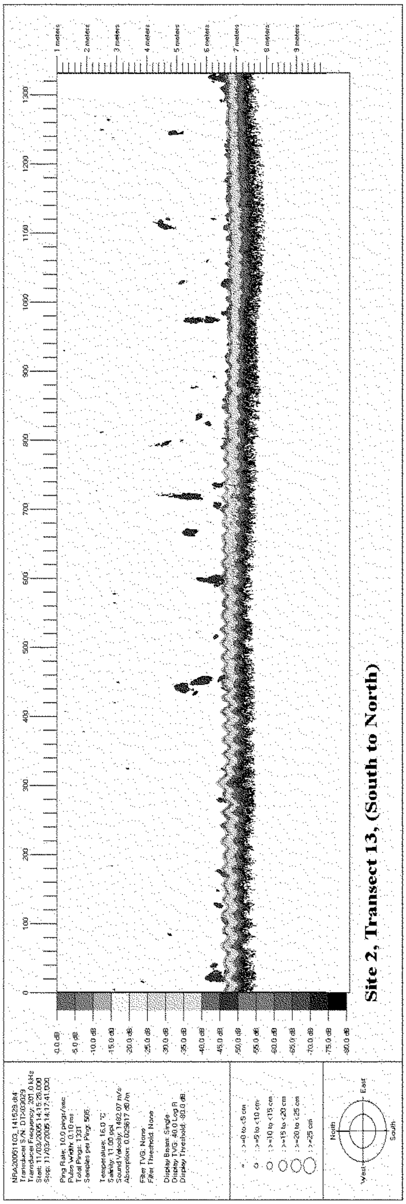

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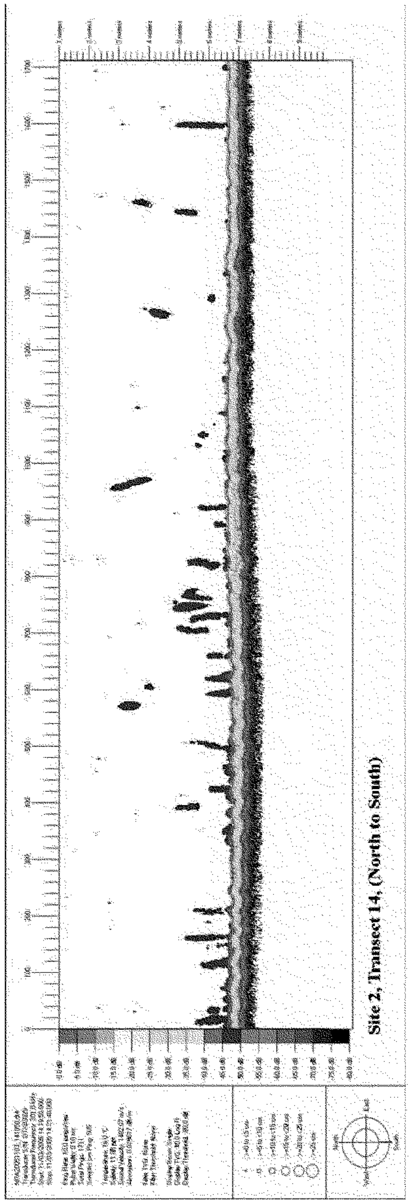
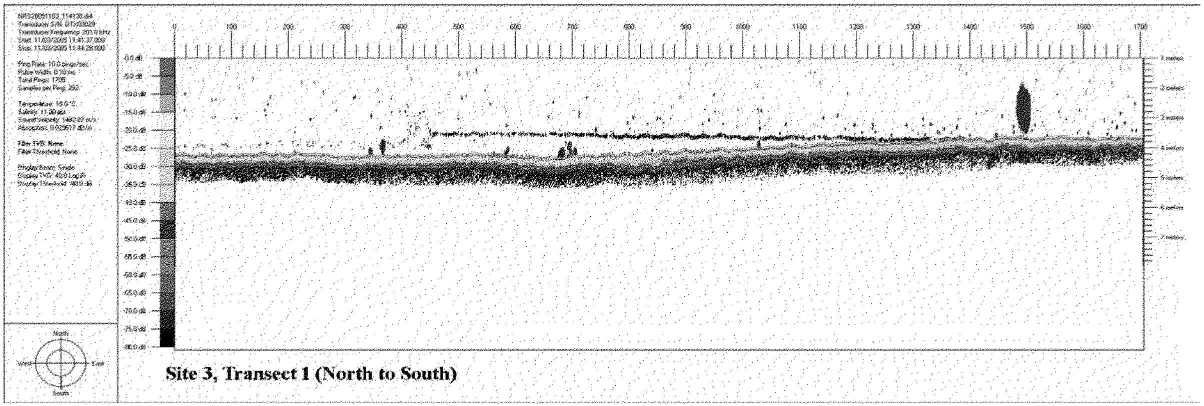


Site 2, Transect 14, (North to South)

APPENDIX C



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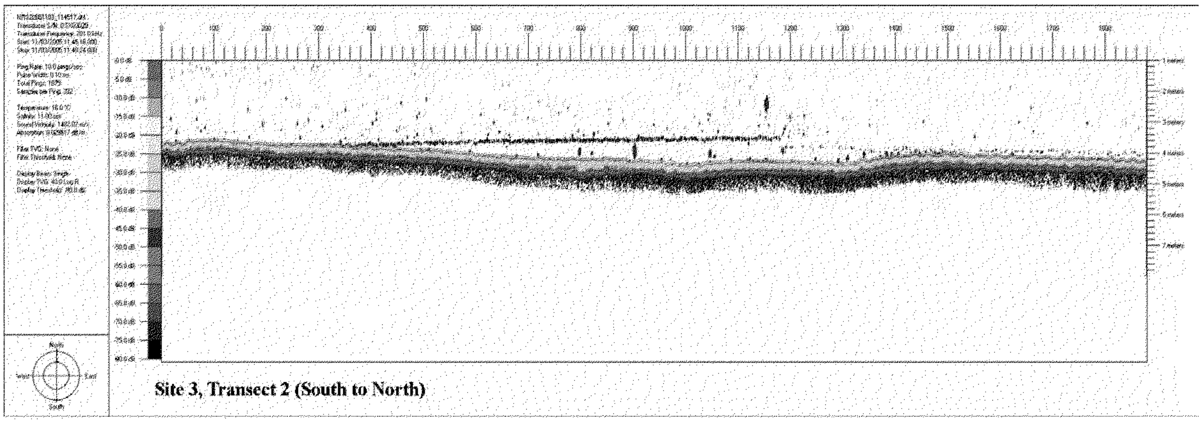

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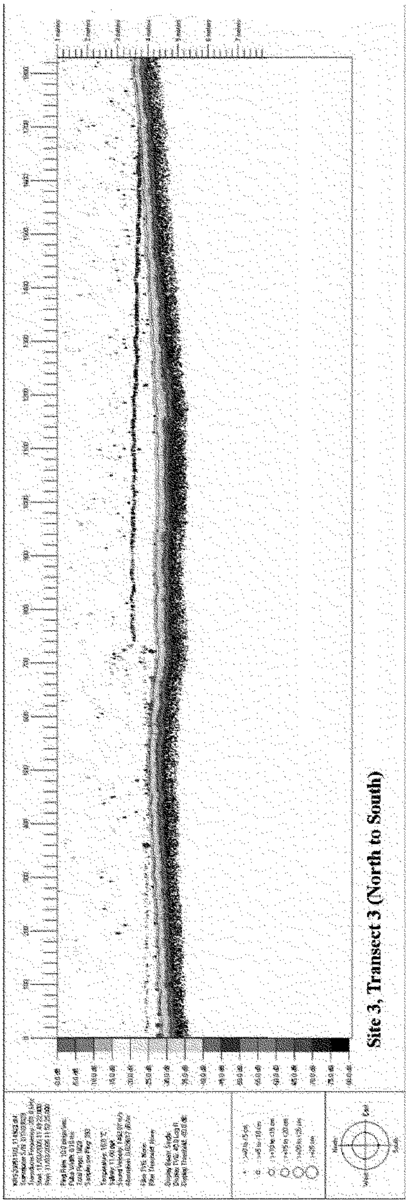

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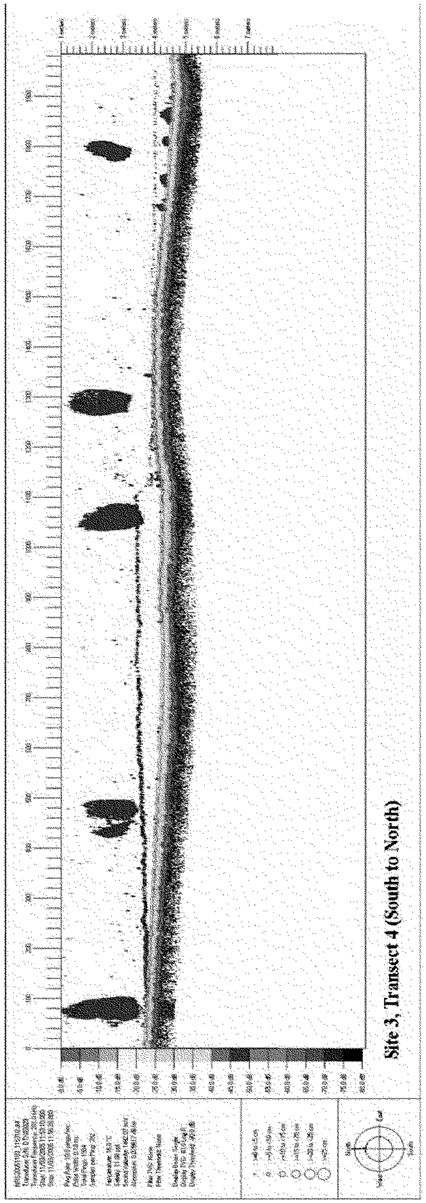

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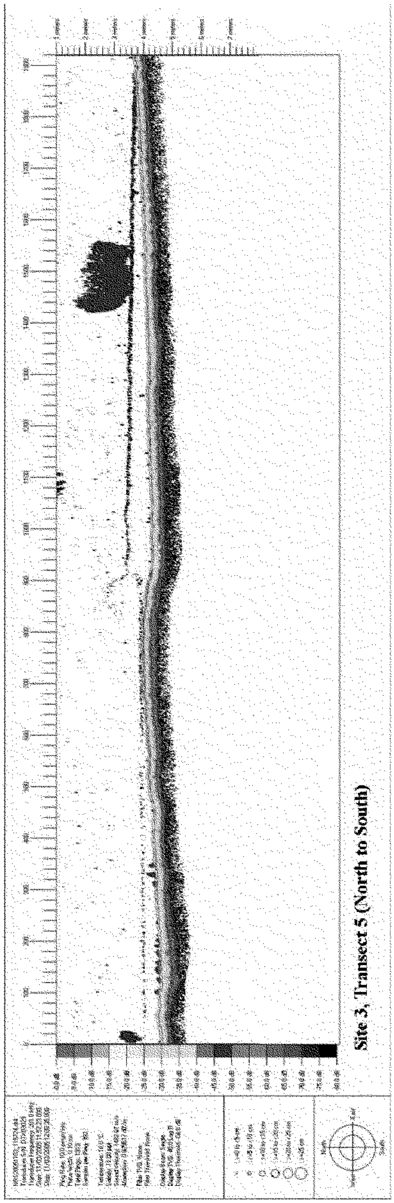

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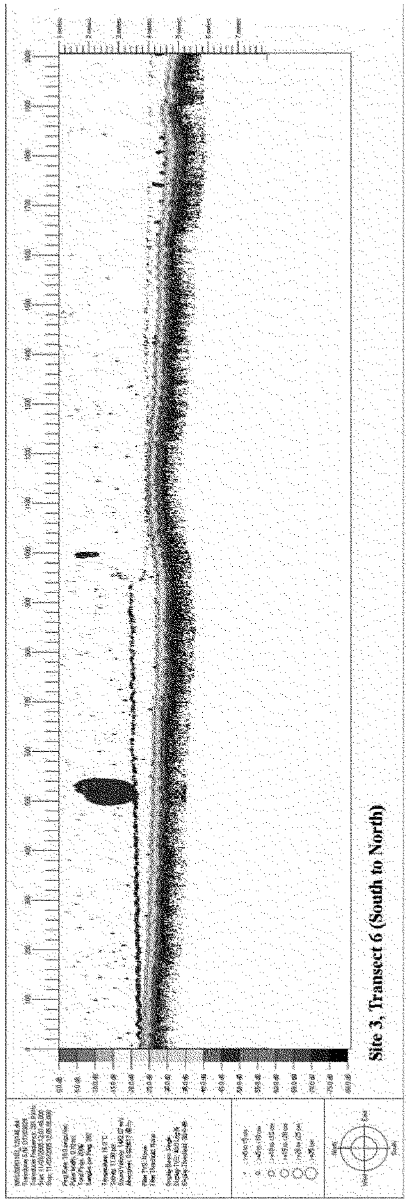

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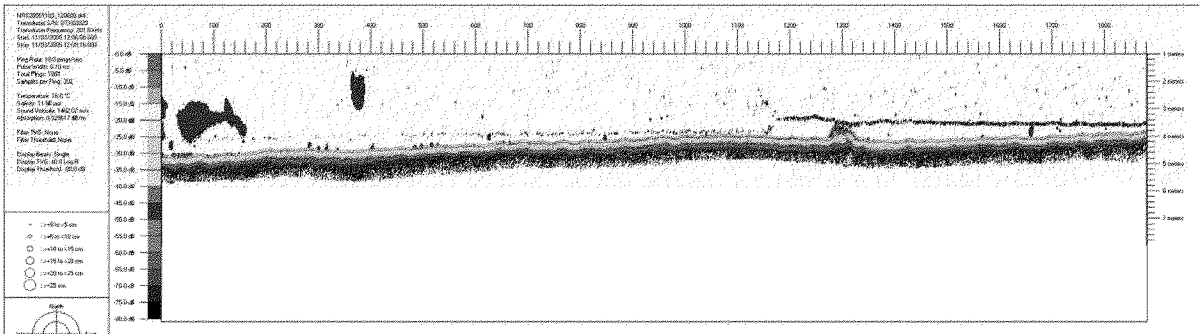

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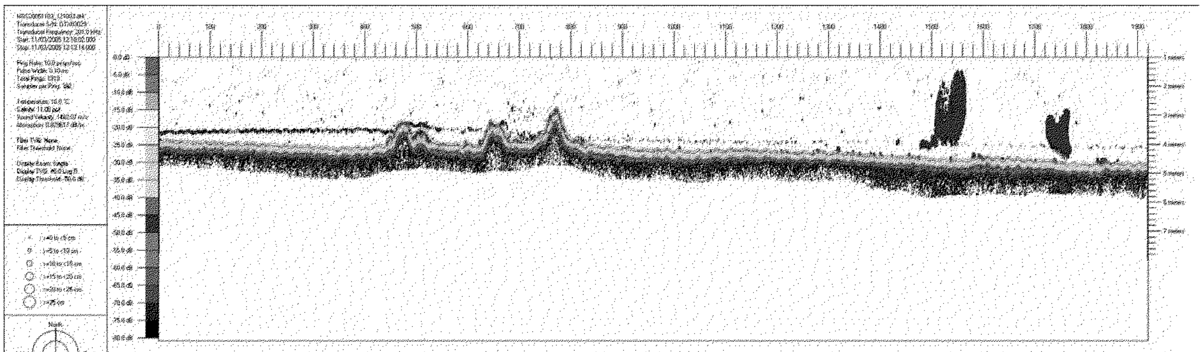

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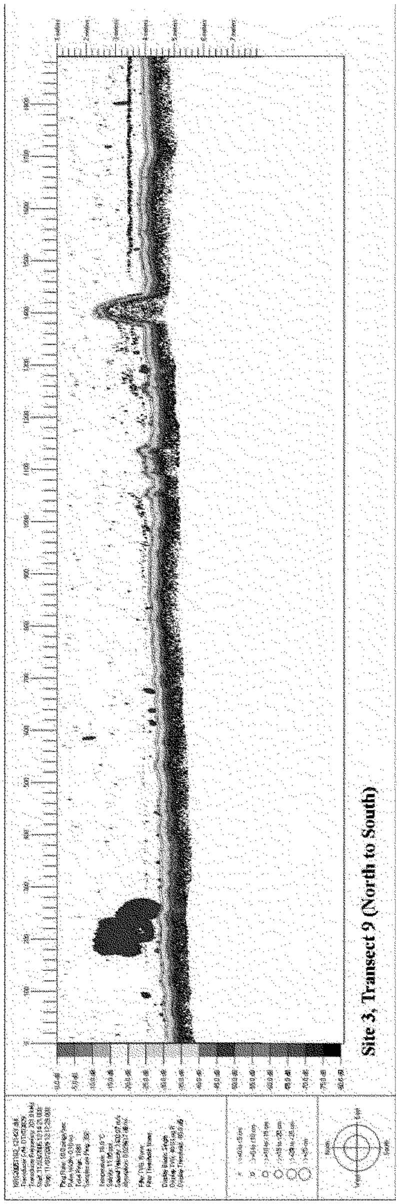

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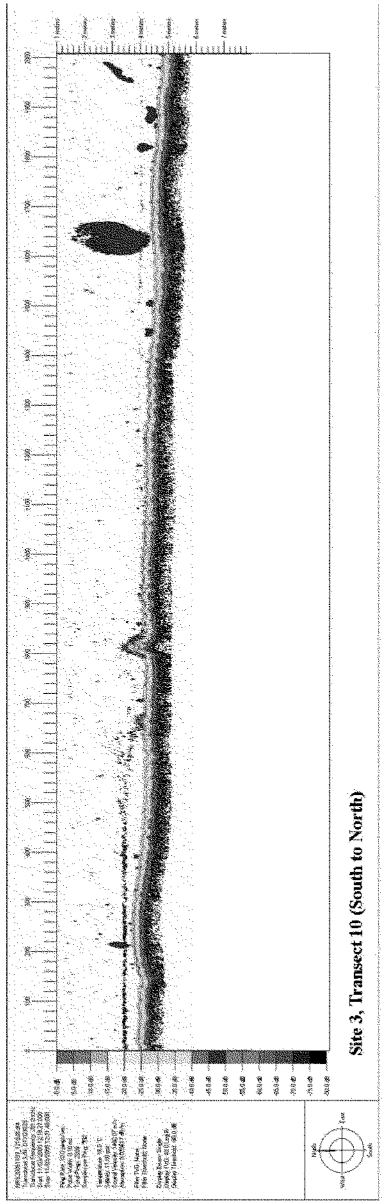

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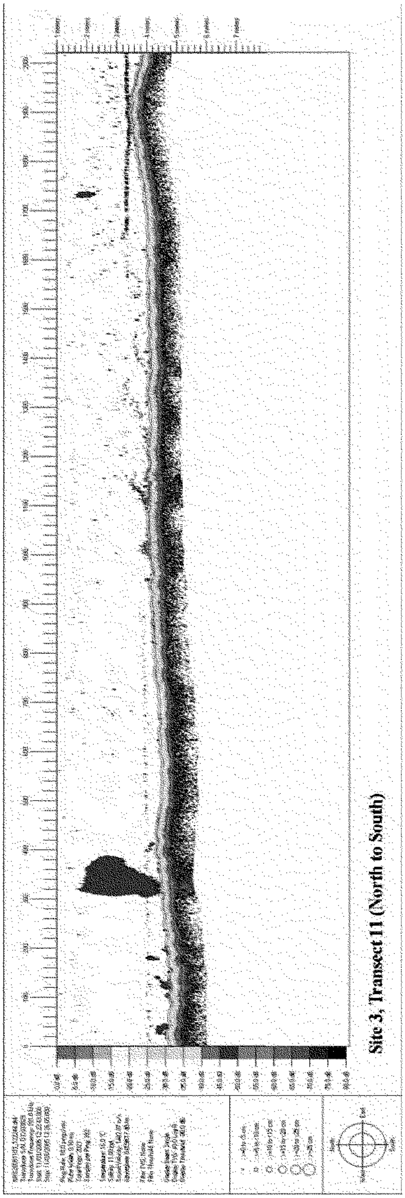

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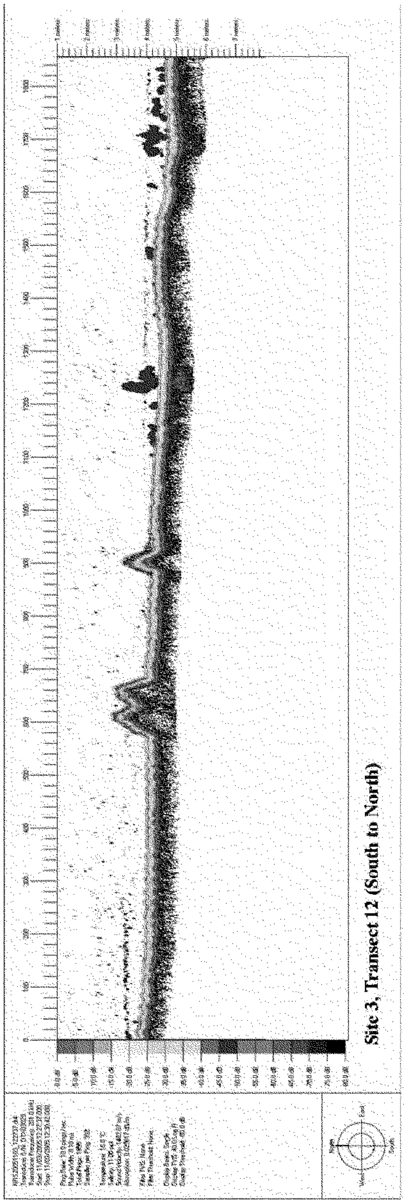

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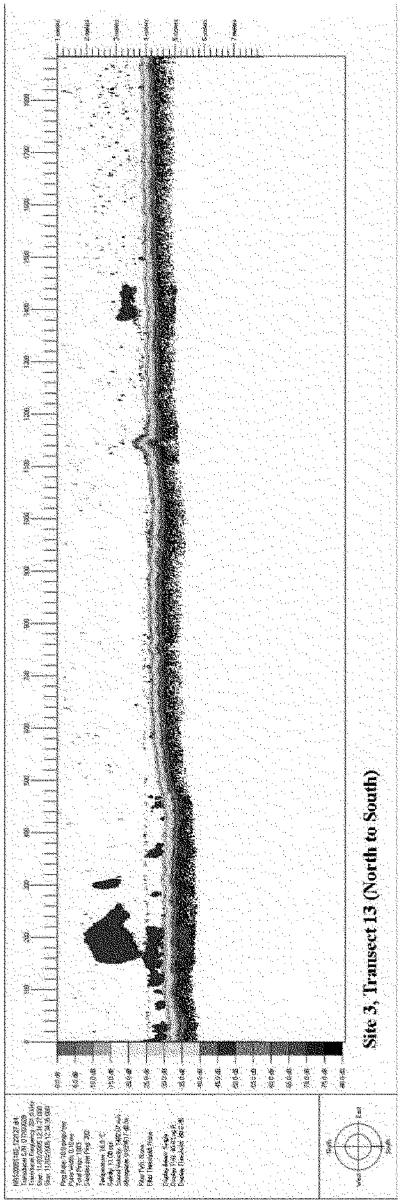

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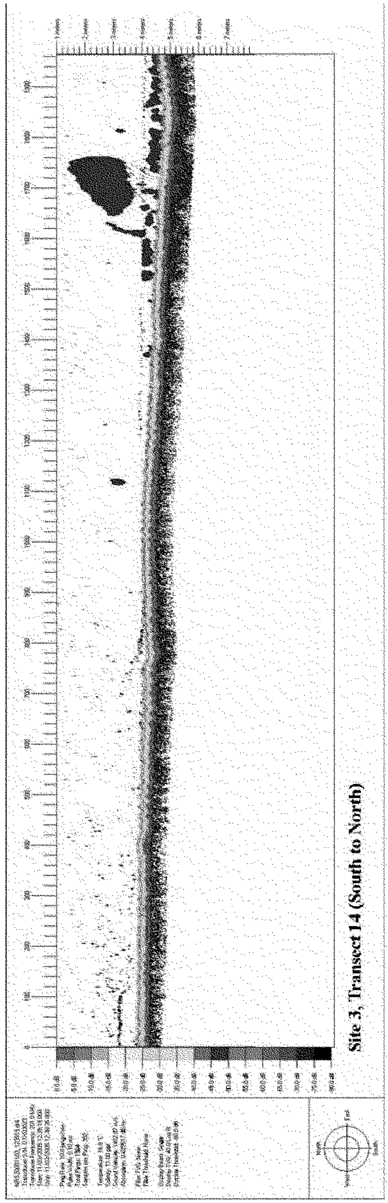

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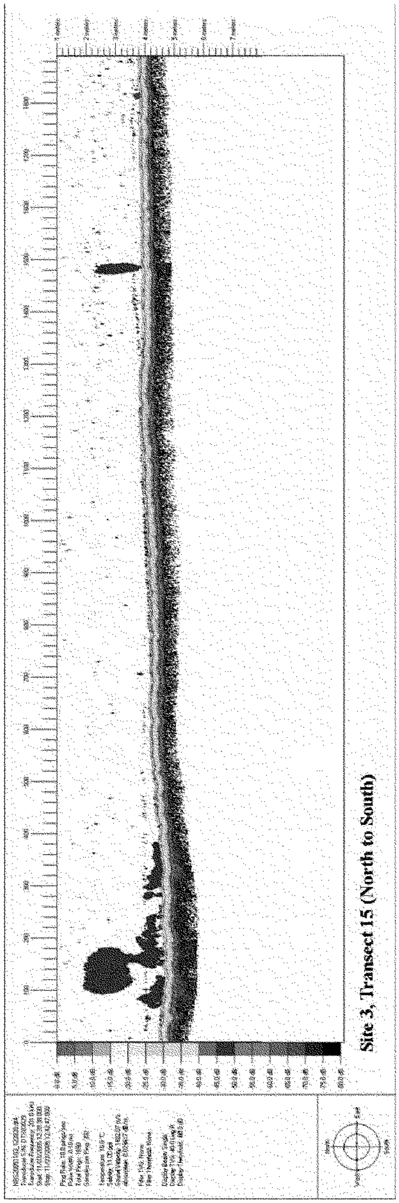
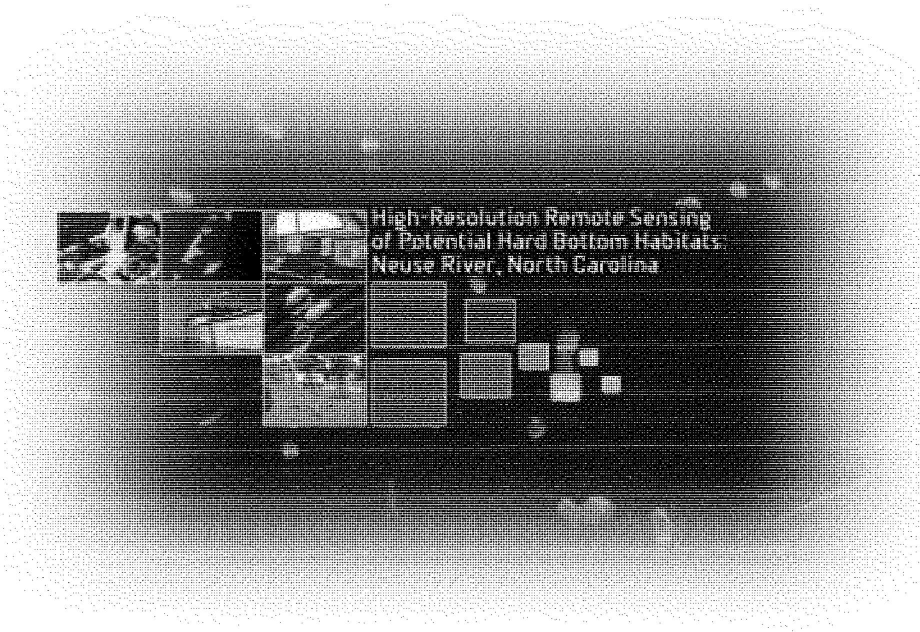


Site 3, Transect 15 (North to South)

High-Resolution Remote Sensing of Potential Oyster Reef & Riverbed Classification: Neuse River Estuary, North Carolina August 2006



Survey Report

Project No. DACW54-02-D-0006, Delivery Order 0037, Side-Scan Potential Oyster Beds and Riverbed Classification, Neuse River, NC
G&O Project Number 146046.T37.6480.GEO

Submitted by:

GREENHORNE & O'MARA
CONSULTING ENGINEERS

With Subconsultant:

geodynamics
COMPLEX COASTAL CHANGE MADE CLEAR

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Executive Summary

Geodynamics LLC was contracted on July 26th by the USACE Wilmington District through Greenhorne & O'Mara Inc. to perform a detailed side-scan and multibeam sonar survey within 13 areas designated by the District (Figure 1). This high-resolution survey is phase one of a two phase effort to locate and quantify potential oyster reefs in the Neuse River Estuary by the US Army Corps of Engineers Wilmington District for future oyster rehabilitation efforts in the region. To better assess oyster reef locations the sides-can data was used to generate a series of unsupervised classifications of the seafloor. The classification polygons will be used to assess the locations that require further investigation with both remotely sensed data and ground truth information.

The August 12-16th side-scan and multibeam surveys of the Neuse River Estuary employed a Klein 3000 digital side-scan sonar and a Simrad EM3002 shallow water multibeam sonar system to collect spatially dense seafloor imagery and bathymetric data for the assessment oyster reef habitats as described in the official Scope of Work (Appendix A). The dual frequency side-scan system runs at both 100 and 500 kHz nominal. In order to maximize coverage while maintaining the resolution of the system we expanded the swath widths to 300m (range of 150m) and a pixel resolution of 4096. The multibeam system runs at 300 kHz and is compensated for motion and heading with an Applanix POS MV 320 v4 inertial navigation system. The EM3002 produces a swath of sonar approximately 4 times the water depth and collects approximately 400 soundings per square meter. Sound velocity was calculated using an Odom Digibar Pro sound velocity meter and an applied Microsystems MiniSV for real-time calculations at the sonar transducer.

Positioning information was acquired using a Trimble 5700 Real-Time Kinematic GPS (RTK-GPS) receiver integrated with a Trimble DGPS beacon and the POS MV 320. To calculate "tidal" elevations we used a surveying method called Post-Processed Kinematic. A base station was established on NGS mark *PAM 43* and collected an elevation point every 6 seconds. The GPS rover on the survey vessel also collected position and elevation data every 6 seconds and the data were then post-processed in Trimble Geomatics Office to calculate a "tide" file for hydrographic data.

Survey Preparation

Survey Area

The Neuse River survey was comprised of 64 planned survey lines spaced 820' (250m) in depths ranging from ~5' MLLW to ~25' MLLW. The distance between survey lines was calculated to maximize side-scan coverage in separate zones of relatively equal depths using a swath width of 984' (300m) for side-scan as indicated on the NOAA digital nautical chart 1152_1.kap and 11548_1.kap. Swath widths of multibeam sonar are approximately 4 times water depth. The total survey area was ~ 25 square miles or ~ 180 line miles.

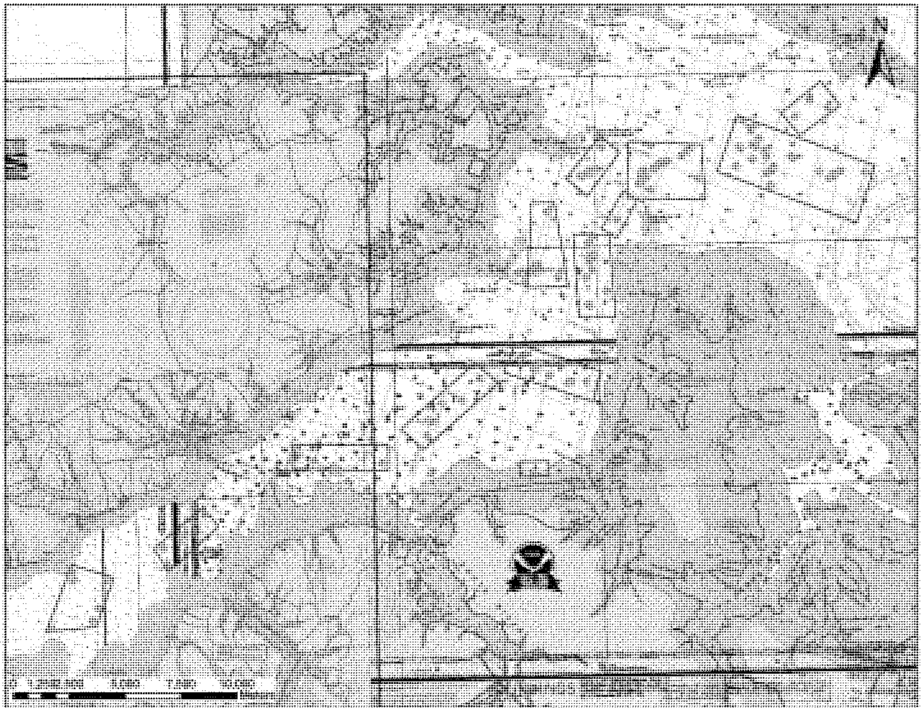


Figure 1. Neuse River side-scan & multibeam survey planning map illustrating the proposed survey extents.

Multibeam Calibration

Introduction & Purpose

Multibeam swath sonar systems combine a complex array of instruments, consisting of the transducer, motion sensor, gyrocompass, and geodetic GPS system. Standards developed by the International Hydrographic Organization (IHO), USACE Standards for Hydrographic Surveys, and the NOS Hydrographic Surveys Specifications and Deliverables for shallow water (<30 m) hydrography (IHO 1987; USACE 2003; NOS 2003) are used as the protocol for calibration. Proper alignment of these instruments with one another and with the vessel's reference frame is critical to achieve the high-accuracy required in the SOW. Calculation of the horizontal and vertical offsets between each of the instruments is followed by a series of sea-based measurements known as the patch test.

The patch test is performed to calculate several residual biases influenced by the dynamics of the survey vessel and the alignment of the instruments. Results of the patch test, documented in the following sections, are used to calculate a pitch, roll and heading offset and positioning time delay or navigation latency. Additional calibration measures are performed in the field including comparison of nadir depths with a lead line and frequent sound velocity profiles. The results of these daily field checks can be found in the html metadata file accompanying the final soundings.

Post-Processes Kinematic GPS

There are many environmental and operator-based influences that can affect the accuracy of RTK-GPS and the resultant baseline solutions (Bilker 2001; Trimble Navigation Limited 1998; Magellan Corporation 2001). Although RTK-GPS is an emerging tool among hydrographers, little attention has been given to an accuracy standard for this methodology—especially in the field of coastal mapping and monitoring (Morton et al., 1993). In an effort to limit operator error and to quantify daily environmental error, we have developed an internal standards protocol for RTK error estimation based on thresholds developed by the California Department of Transportation and the US Army Corps of Engineers (USACE) Topographic Accuracy Standards (CALTRANS 2002; USACE 1994).

Although our group uses RTK-GPS somewhat exclusively for hydrographic surveying the lack of survey control and distance between survey zones precluded its use for this reconnaissance phase of the project. In order to correct multibeam soundings for sea-surface elevation change we used a technique called Post Process Kinematic (PPK). This technique allows for the calculation of long baseline solutions without real-time corrections supplied via UHF radio.

Two independent GPS receivers collect observed sets of carrier phase data during the same time period (epoch) and are processed together to create baselines between their relative positions. In this case we set a land-based station on NGS benchmark *PAM 43* a 2^{nd} order vertical mark with scaled horizontal positioning (Figure 2). The vessel rover is set to the same configuration and logs simultaneously. The Known Point Initialization method allows Trimble Geomatics Office to use both the collected data and the WGS-84

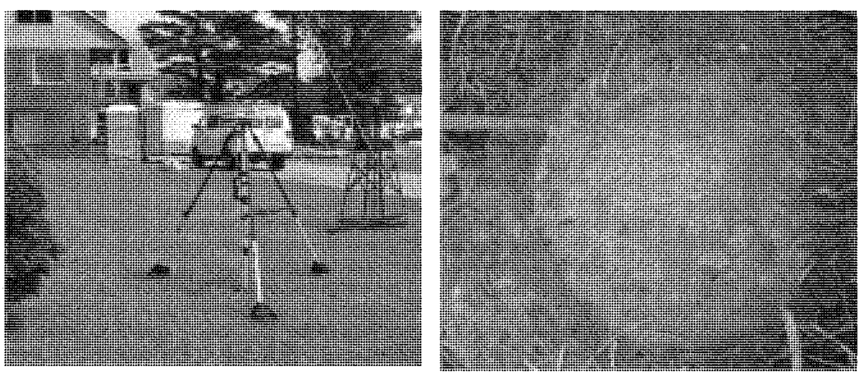


Figure 2. Neuse River side-scan & multibeam survey planning map illustrating the proposed survey extents.

baseline solution to determine the integer ambiguities which is then applied to all subsequent occupations. Base and rover GPS observations are downloaded into Trimble Geomatics Office. Once the files logged at each location are imported, baselines are processed using an automated procedure. Baseline solutions are then checked for errors and accuracy and the final PPK points are exported. The data is then formatted and averaged with a running time average in order to remove wave driven elevation changed and provide the overall water level change. Results of the PPK survey show that elevation data used as a "tide" file for multibeam data processing are within +/- 0.49" (+/- 15 cm) RMS accuracy.

Although horizontal positioning from *PAM 43* was not needed for a PPK elevation survey we did run a static survey each night on the mark. Data from 3 ~10hr static surveys were run through the NGS Online Positioning User Service (OPUS) to derive horizontal positioning and verify the elevation. This exercise was completed in the event that we occupy the mark in RTK for phase 2.

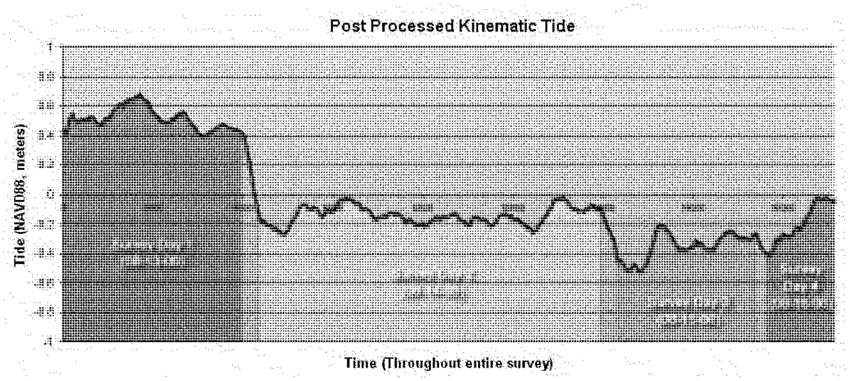


Figure 3. Graph showing the final PPK Tide plot using in multibeam data processing.

Multibeam Echosounder Calibration Report

Calibration Date:	June 24, 2006
Ship	
Vessel	RV 4-Points
Echosounder System	EM3002
Positioning System	POS MV (tightly coupled)-RTK GPS
Attitude System	POS MV
Sound Velocity Probe	Odem Digibar Pro (profiler) / Valeport Mini SVS (at head)

Calibration type: Multibeam Sonar

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. This report has been adopted and modified from NOAA. Calibration must be conducted A) prior to CY survey data acquisition B) after installation of echosounder, position and vessel attitude equipment C) after changes to equipment installation or acquisition systems D) whenever the Hydrographer suspects incorrect calibration results. The Hydrographer shall periodically demonstrate that calibration correctors are valid for appropriate vessels and that data quality meets survey requirements. In the event the Hydrographer determines these correctors are no longer valid, or any part of the echosounder system configuration is changed or damaged, the Hydrographer must conduct new system calibrations.

Annual		
Installation	x	
System change	x	
Periodic/QC		
Other		

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch. Standard calibration patch test procedures are described in *Field Procedures for the Calibration of Multibeam Echo-sounding Systems*, by André Godin (Documented in Chapter 17 of the Caris HIPS/SIPS 6.0 User Manual, 2006). Additional information is provided in *POS/MV Model 320 Ver 4 System Manual* (10/2003), Appendix F, Patch Test, and the NOAA Field Procedures Manual (FPM, 2003). The patch test method only corrects very basic alignment biases. These procedures are used to measure static navigation timing error, transducer pitch offset, transducer roll offset, and transducer azimuth offset (yaw). Dynamic and reference frame biases can be investigated using a reference surface.

Pre-calibration Survey Information

Reference Frame Survey

RV 4-Points was surveyed by the National Geodetic Survey on February 15, 2006 for precise centerline and instrument locations. Steve Breidenbach performed the survey with a Trimble 5603 total Station.

(IMU, Ref Pt., and XY of CG are all co-aligned and attitude and position is valid at the sensor. The values below are entered in POSview software.)

Reference to IMU Lever Arm

X(m)	Y (m)	Z (m)
0	0	0

Reference to Pri. GPS

X(m)	Y (m)	Z (m)
1.849	-1.061	-1.724

IMU frame w.r.t. Reference frame

X(deg)	Y (deg)	Z (deg)
0	0	0

Reference to Sensor Lever Arm

X(m)	Y (m)	Z (m)
-0.097	-2.130	0.849

Reference to CG

X(m)	Y (m)	Z (m)
0	0	0.313

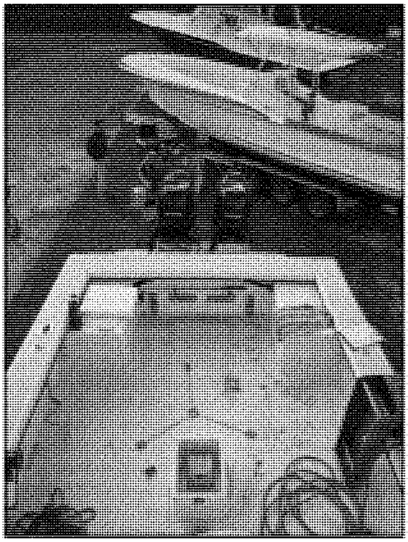


Figure 4. Photo of the centerline and instrument survey by NGS.

Reference to Vessel (Pt of validation for attitude and nav)

X(m)	Y (m)	Z (m)
-0.097	-2.130	0.849

__X__ Measurements verified for this calibration.
_____ Drawing and table attached.
_____ Drawing and table included with project report

POS MV Configuration File: 4_points_022806. *________________

Notes: NGS vessel survey results were put in POSview and GAMS calibration was done on February 28, 2006.

Calibration Area

Site Description

This patch survey was conducted in the Port of Morehead City's turning basin near Beaufort Inlet, North Carolina (N34 41 39.16 W076 40 07.53). This site was selected for its particular bottom features, such small scale ripple fields, sand waves (wavelength: ±5m, amplitude: ±0.15m), deep flat areas, and high slopes.

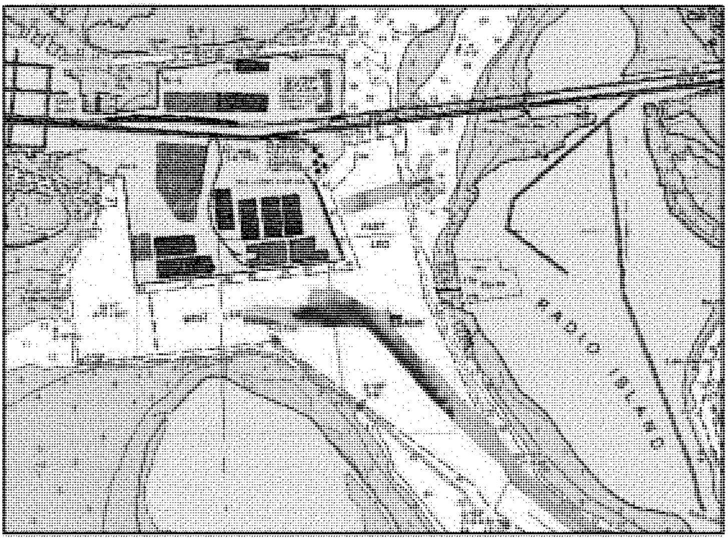


Figure 5. Map of the patch survey area within the Morehead City Turning Basin.

Survey Procedure

Vessel biases were determined through a patch test survey procedure. Data was acquired and analyzed in Kongsberg SIS package. The latency test was performed first by surveying the same survey line in the same direction at 2 different vessel speeds. The latency test was done twice to verify initial results. The pitch test was done second by surveying the same survey line in opposite directions at the same speed and evaluating the sloped portion of the survey line. The roll test was performed next by surveying the same survey line in opposite directions at the same speed and evaluating the deep flat portion of the survey line. The roll test was done twice to verify initial results. The yaw test was performed next by surveying 2 adjacent survey lines in the same direction, with similar speeds, with enough overlapping coverage such that the outer beams from each swath overlap (±40%).

Calibration Lines

Hypack Line	**Line File**	**Az.**	**Spd**	**Correction**			
				Pitch	Roll	Yaw	Latency
1	0000_20060301_163731_4points.all	57°	3.3kts				X
1	0001_20060301_164249_4points.all	57°	7.1kts				X

1	0002_20060301_165502_4points.all	237°	3.2kts				X
1	0003_20060301_165938_4points.all	237°	7.0kts				X
1	0002_20060301_155849_4points.all	237°	7.0kts	X			
1	0003_20060301_160222_4points.all	57°	7.0kts	X			
1	0000_20060301_172142_4points.all	57°	7.0kts		X		
1	0001_20060301_172427_4points.all	237°	7.0kts		X		
1	0000_20060301_183521_4points.all	237°	7.0kts		X		
1	0001_20060301_183741_4points.all	57°	7.0kts		X		
8	0001_20060301_191059_4points.all	280°	7.0kts			X	
7	0002_20060301_191957_4points.all	100°	7.0kts			X	

Sound Velocity Correction

Measure water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site. Conduct SV observations as often as necessary to monitor changing conditions and acquire a SV observation at the conclusion of calibration proceedings. If SV measurements are measured at the transducer face, monitor surface SV for changes and record surface SV with profile measurements.

Sound Velocity Measurements

Time	Max Depth	Surface SV	Change Observed	Position	
				Latitude	Longitude
14:52:00	15.5m	1490.2		34 42.9705	76 41.6239
Continuous SV at head			<4 m/s throughout entire calibration		

Data Acquisition and Processing Guidelines

Initially, calibration measurement offsets should be set to zero in vessel configuration files. Static and dynamic draft offsets, inertial measurement unit (IMU) lever arm offsets, and vessel reference frame offsets must be entered in appropriate software applications prior to bias analysis. Perform minimal cleaning to eliminate gross flyers from sounding data.

Navigation Timing Error (NTE)

Measure NTE correction through examination of a profile of the center beams from lines run in the same direction at maximum and minimum vessel speeds. NTE is best observed in shallow water.

Transducer Pitch Offset (TPO)

Apply NTE correction. Measure TPO correction through examination of a profile of the center beams from lines run up and down a bounded slope or across a conspicuous feature. Acquire data on lines oriented in opposite directions, at the same vessel speed. TPO is best observed in deep water.

Transducer Roll Offset (TRO)

Apply NTE and TPO corrections. Measure the TRO correction through examination of roll on the outer beams across parallel overlapping lines. TRO is best observed over flat terrain in deep water. An additional check for TRO adjustment can be performed by running two lines parallel to a sloped surface.

Transducer Azimuth Offset (TAO or yaw)

Apply NTE, TPO and TRO corrections. Measure TAO correction through examination of a conspicuous topographic feature observed on the outer beams of lines run in opposite directions.

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Bernstein/Hohing	0.00	0.00	0.00	-0.65
Final Values	0.00	0.00	0.00	-0.65

Corrections Calculated in:	
Caris	
ISIS (BathyPro)	
Other	SIS

NOTE: TRO bias of -0.65 was put in SIS software.

Evaluator: Dave Bernstein
Reviewed by: Dave Bernstein
Accepted by: Dave Bernstein
Date accepted: June 25, 2006

Graphical Examples of Calibration Acceptance

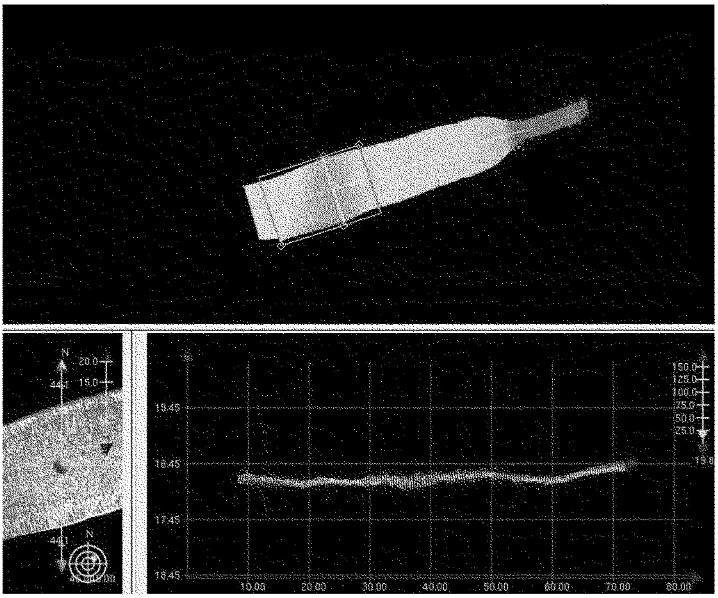


Figure 6. Caris screen grab illustrating acceptance of roll calibration.

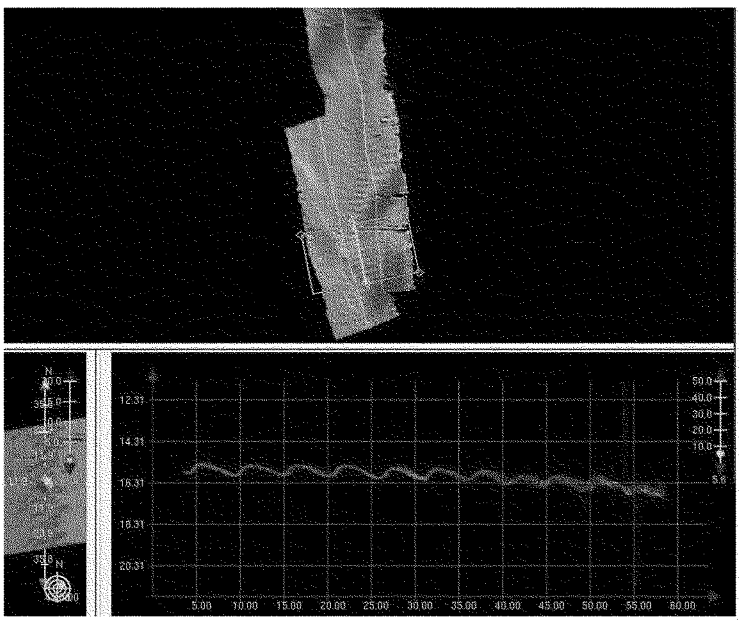


Figure 7. Caris screen grab illustrating acceptance of yaw calibration.

Data Processing Routines & QA/QC Information

Introduction

Processing high-density multibeam bathymetry and backscatter data requires a multitude of processing routines and data quality analyses. The following section will detail all aspects of data post-processing for the Neuse River surveys. Also presented in this section is detailed QA/QC information and analysis generated throughout the various processing procedures.

Bathymetry Processing

The multibeam collects swath widths approximately 4 times the water depth. The portions of swath, mainly in the outer beams, that exhibit areas of inconsistent data are clipped and not included in the final digital file. Sounding track lines are generally parallel to each other and parallel to the seafloor contour. Sinuous lines and data acquired during turns are often not included in the final processed data. To meet the accuracy and resolution standards for measured depths specified in the USACE Hydrographic Surveying Manual and the NOS Hydrographic Surveys, Specifications and Deliverables Manual, measured echosounder depths were corrected for all departures from true depths attributable to the method of sounding or to faults in the measuring apparatus. These corrections are subdivided into four categories, and are listed below in the sequence in which they were applied to the data.

1. Instrument error corrections: included to account for the sources of error related to the sounding equipment itself.

2. Vessel offsets: added to the observed soundings to account for the depth of the echosounder below the water surface, positioning of the motion reference unit, and GPS antenna.

3. Velocity of sound correctors: applied to the soundings to compensate for the fact that echosounders may only display depths based on an assumed sound velocity profile while the true velocity may vary in time and space.

4. Heave, pitch, roll, heading and navigation latency corrections: applied to the multibeam soundings to correct for the effect of vessel motion caused by waves and swells, the error in the vessel's heading, and the time delay from the moment the position is measured until the data is received by the GPS receiver.

Multibeam Data Processing Steps in CARIS HIPS software:

The EM3002 sonar system has a unique arrangement of data flow. Most settings that influence the data are put in before and during a survey and therefore are not a factor in data processing (these include vessel offsets, lever arms, vessel biases, timing biases, and survey sound velocity). Vessel attitude is also processed real-time during a survey.

Post-processing of multibeam data consist of attitude and navigation editing, merging, swath editing, area-based editing, and exporting of final data.

1. Attitude & Navigation Editing: Errors or gaps in attitude and navigation information causing errors in soundings are edited.

2. Merging: Computing and integrating the GPS tide in the sounding data. Additional sound velocity corrections are made if needed in this phase. Draft changes for datum conversions are made here as well.

3. Total Propagated Error (TPE) is calculated

4. Swath- and beam-based filters and TPE (IHO standards) filters are applied.

5. Swath Editing: Swaths are edited for erroneous data if needed

6. Base or CUBE Surface is created for area- and CUBE-based editing.

7. Area-based editing using the subset editor to edit/check erroneous data only within the desired subset.

8. CUBE filtering (if needed)

9. Recompute TPE

10. Recompute CUBE and/or base surface

11. Final export of base surface to XYZ decimated soundings (1m, NC State Plane NAD83, Meters).

Side-Scan Processing

1. Side scan is replayed (ISIS) and slant range corrected. Areas that have lost bottom track data are manually digitized to replace lost altitude data.

2. Appropriate image corrections are determine in ISIS and defined for the mosaic procedure.

- A threshold of 4 was used for all files incorporated in the mosaic. This means the 8 bit or 16 bit data is shifted by 4 bits to correct the histogram when the data is played for mosaic.

- A "STANDARD: TVG correction with no Balance correction was applied to all files in the mosaic. This correction provided the best mosaics given the raw data.

3. The data is then mosaiced using ISIS to play back the data and Delphmap Mosaic to create the mosaic file.

All of the mosaic setting and corrections are applied in Delph Mosaic.
- layback = 4.5m
- X shift = 4.3m
- set data resolution 50 cm for channels 1-2
- cover up for overlapping lines
- fill gaps between pings
- use course made good for heading (heading not as useful due to unknown declinations to the klein mag compass)

During this stage, the depth, delay, and duration settings are altered for each file played back in order to provide adjacent lines with specific coverage (overlap) in ISIS.

4. The mosaic in Triton DDS_VIF format is then exported to Geo-Tiff file format with associated .world file.

Typical Side-Scan Artifacts

Feature Accuracy Information: Side-scan sonar artifact information has been synthesized from the Handbook of Seafloor Sonar Imagery, Blondel & Murton, Geoff Shipton at Triton Imaging, and from out past experience with these data.

The Klein 3000 is a digital side-scan sonar system capable of producing digital image maps of the seafloor from reflected sound waves or acoustic backscatter from the seafloor. These images are created by transmitting a series of sound pulses and recording their echoes from the seafloor as the survey vessel moves across a set course. The sound source and receivers are built into a "tow fish" that moves through the water at varying depths and distances from the survey vessel dependent on the water depth. The returned signal is then recorded by shipboard computers with an amplitude range of 0-255 with strong returns recorded as higher values and weak returns recorded as lower values. The darkness or brightness of a side-scan mosaic is a function of the gradient or slope of the seafloor, surface roughness, and the sediment characteristics such as texture which can all be interpreted by a marine geologist.

The main advantage of side-scan sonar over the backscatter product generated from multibeam sonar is the greater coverage that can be achieved (ex. in 10m of water = 40m for multibeam and up to 300m (although this dataset uses a swath width of 120m for higher detail) with side-scan) and a more detailed image of the seafloor. However, side-scan data tends to be much noisier and contains far more artifacts than multibeam. Below are some of the major artifacts to be expected in any side-scan mosaic.

Heave & Motion Artifacts: In a perfect scenario side-scan would be collected in flat calm conditions with zero boat motion that would translate into the towed vehicle. In addition, towing a side-scan into shallow water creates additional heave artifacts due to the short tow. Flat calm conditions rarely happen in an oceanic environment and really never happen when approaching the nearshore environments where waves begin to propagate. Heave artifacts are caused by changes in pitch due to tugging on the vehicle line. At the point where the fish moves through the horizontal (Pitch = 0) the sonar beam strikes the bottom at a right angle and the return path is directly along the axis, which gives a good return. Either side of the zero pitch point the returns become weaker. The effect on the record is banding in the across track direction. Aside from slight pitch corrections made in the processing software (ISIS in this case) there is nothing that can be done to correct for the fact that the point where the return comes from moves fore and aft as the pitch changes. Roll, Pitch, Yaw can all be taken into account in post processing to some reasonable level; however, the towfish based altimeter and flux gate compass are not to the standard of those used for compensating bathymetric data.

Running Parallel to a Slope Artifacts: Depending on how steep the slope is you will see a stronger return on the uphill slope and a weaker return on the downhill slope. How much this affects the image will depend on two things; how steep the slope and how reflective the seafloor. The slope could, in some cases, decrease the grazing angle sufficiently that the sound simply bounces off completely and hardly anything gets back. This angle varies with different bottom types. The artifact that can be generated in this scenario, provided there is a highly reflective bottom (which we see in several areas at Topsail) is a two toned effect on the area of interest. There are a few independent gain settings for each sonar channel that can help; however, applying different gain settings for each opposing line becomes a bit black magic and hence we don't typically tweak these settings beyond a certain point.

Sea Surface Reflection Artifacts: In shallow water applications such as the Topsail Island project side-scan sonar imagery can be corrupted by multiple reflections from the sea surface. The first reflection is formed when the sonar beam reflects once from the seafloor and once from the sea surface. This artifact can manifest itself as bright lines parallel to the sonar track, at a distance from the sonar track roughly equivalent to the water depth. If the swath is wide enough subsequent multiples will also be present as equidistant bright lines parallel to the first reflections. They primarily occur in areas with flat and smooth sedimentary features or from white capping of waves on the surface. A few of these artifacts can be seen in the inshore side-scan line at Topsail.

Water Column Artifacts: Artifacts related to the propagation of the acoustic pulse in the water column from the sensor to the seafloor and back can be attributed to two sources. The first are variations in the structure of water column due to density variations, salinity variations and temperature variations. Depending on the depth, a certain amount of thermocline layers will modulate the depth and angle at which the acoustic rays propagate. These artifacts are generally at the far range of the swath and look similar to linear bedforms. The second artifact that can be produced from speed of sound variations are derived from the presence of bubbles in the water. This may come from the wake of the survey vessel or from cavitation caused by the ships propellers. High-frequency systems such as the Klein 3000 are sensitive to bubbles and cause the sonar beams to become partially dispersed and partially reflected before they reach the seafloor. The artifact that can be created in this case is random data gaps at all ranges. In the Topsail data there is no indication that thermoclines are playing a role in artifact generation (sound velocity measurements for multibeam do not indicate any presence of thermoclines); however, prop wash may be the cause for some random gaps in across track data.

Radiometric Artifacts: The most frequent cause of systematic radiometric artifacts reside in the acquisition system itself. Connections between the cable and topside computers, broken points in cable, faulty grounds, etc. Another cause is interference between other acoustical systems. Although we turn off our shipboard singlebeam sonar since this is a known point of origin for artifact we are running the Simrad EM3002 multibeam sonar simultaneously which might create a small level of cross-talk. We have never seen this in the data per say but there are some slight noise artifacts on the edges of some swaths that might be attributed to cross-talk between the two systems. Another possible radiometric artifact is the rapid attenuation of the backscattered signal when the sonar platform goes up or down too rapidly or an abrupt change in seafloor depth. This change is usually too localized and rapid to be corrected with the normal time-varying gain (TVG).

Geometric Artifacts: Side-scan data can become distorted by the variations in the horizontal and vertical movement of the towfish such as those created by motion; however, variations in the survey vessel speed, if not taken into account properly, can cause distortion in the along-track direction. If the platform speed assumed during processing is higher than the actual value the swath lines will be positioned too far away from each other, and the image will be stretched along-track. Conversely, if the platform speed is lower, the swath lines will be positioned too close to each other, and the image will be compressed along-track. Discrepancies between matching seafloor morphology will be the result. Since we collected multibeam sonar simultaneously we were able to use the cm-scale positioning from the RTK-GPS to align each successive swath.

Examples of Known Artifacts in Neuse River Side-Scan Data

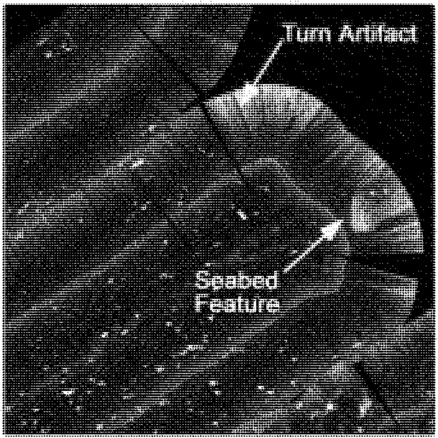


Figure 8a. Turn artifact in side-scan record.

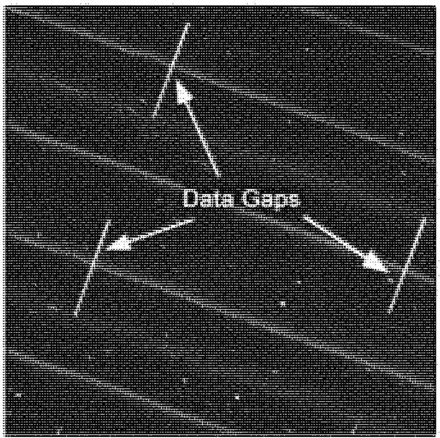


Figure 8b. Data gap due to file switching in ISIS.

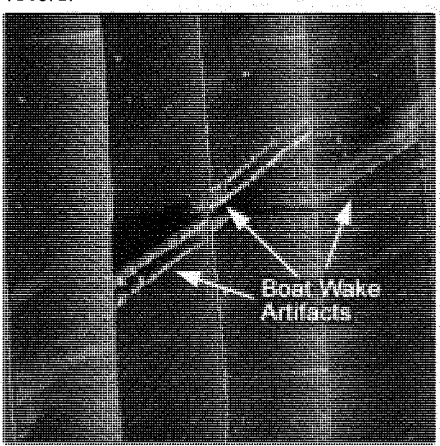


Figure 8c. Artifacts produced surface reflection of boat wakes.

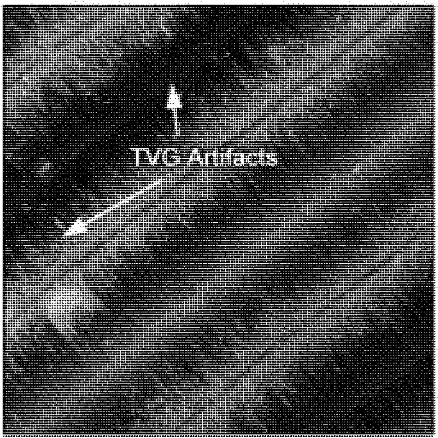


Figure 8d. Time varied gain artifacts between port and starboard transducer.

Potential Oyster Reef Identification

Auto-classification of side-scan and multibeam data is an emerging tool to identify areas of like seafloor texture for a variety of benthic habitat and coastal engineering applications. Geodynamics has performed extensive testing on two of the industries standard software packages that perform classification on side-scan sonar data and customized image statistical routines using ArcGIS. The follow section outlines pertinent information on the results of this work and recommendations for future seafloor classification projects.

Quester Tangent Approach: SideView
Assessment of the QTC (Quester Tangent Corporation) auto-classification routines began on USACE project no. DACW54-02-D-0006 entitled *High Resolution Remote Sensing of Potential Hard Bottom Habitats: Topsail Island, NC July 2006*. Although not in the Phase 1 scope or budget for this project Geodynamics felt it was important to have Quester Tangent perform an auto-classification of side-scan data to 1) determine the accuracy of classification output with our system and our particular setup and 2) determine the feasibility of using this product for Phase 1 of the Neuse River project. In mid July 2006 Geodynamics entered into a contract with the QTC to process an unsupervised classification of the Topsail Island side-scan data.

Results of the QTC analysis for Topsail Island are detailed in appendix D of this report; however, on the whole the results were "less than satisfactory". The auto-classification using SideView picked up an inordinate amount of false classifications on areas of known data artifacts (figure 9). Most of these artifacts are commonly found in side-scan data (prior section and figure 8) due to this type of remote sensing method (i.e. towed transducer array, no motion compensation, etc). Some of the artifacts producing false classifications are a result of shallow water and short vehicle tows which is simply the nature of both the Topsail Island and Neuse River projects. For more detailed information on the subject please contact Chris Freeman at Geodynamics.

On August 25, 2006 a Neuse River meeting was held at Geodynamics headquarters and concerns over using QT SideView for the Neuse River project were expressed. It was decided at this time to abandon using the QT and start researching the feasibility of using Triton Imaging's SeaClass software. However, in a last effort to assess the software we made contact with Dr. Doug Levin and Mr. Jay Lazar from the NOAA Chesapeake Bay Office's Habitat Mapping Group whose main task is to map oyster reef areas within the Chesapeake Bay using remote sensing techniques. This group has also been experimenting with the QTC SideView product and we felt it critical to compare our observations as a final assessment. Although a full assessment from this group is forthcoming an opening correspondence stated that "an initial round of success has been met with one problem after another". At this time we have abandoned using QTC SideView for analysis on any Corps projects; however, we will continue our research on how to best classify these type of data.

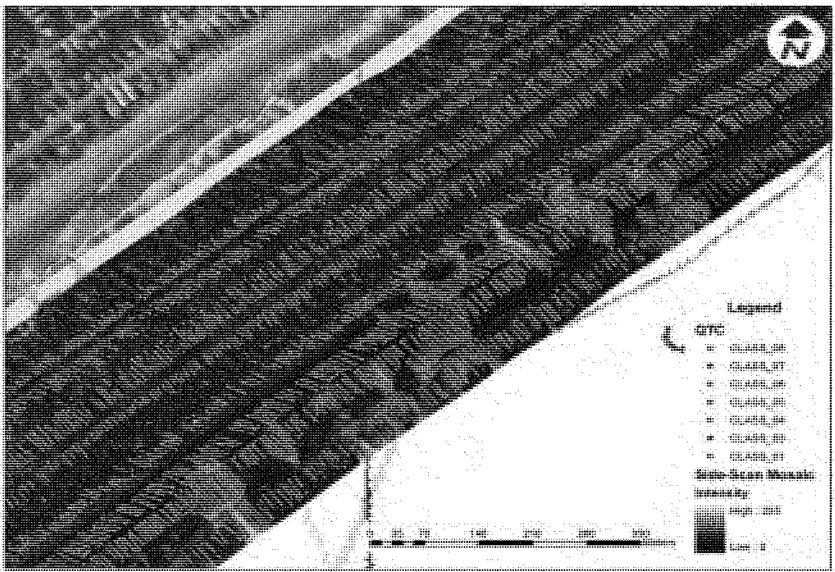


Figure 9. Map illustrating QTC seabed classification results.

Triton Imaging Approach: SeaClass
SeaClass uses a different approach to classifying the seafloor whereby a neural network is built around a user specified area within the side-scan mosaic. The result is a polyline (vector layer) that is generated around pixel intensities (0-255) that correspond to the user's selection. It is important to note that Triton Imaging engineers consider this program to be a "Beta version" and very little R&D has gone into the software since it was first launched. Appendix E is a QTC document quantitatively describing the differences between the two packages.

Although an auto-classifier which uses the pixel values rather than the raw amplitude data should provide a cleaner output there were several problems with this software package as well. The main problems we faced with the software were:
1). The classification procedure fails when classifying three or more areas on a side-scan mosaic. Several variations of the SeaClass settings were used to try and get 3 to 4 output classes. Classification runs were also performed overnight, however, after several days of trying we could only get 2 classes. This is critical since at least three classes can be visually discerned from the mosaics.

2). Like with QTC SideView the classification algorithms detect common side-scan artifacts including the edges of the swath and nadir region (figure 10).

3). The neural network only uses 30 representative samples to build the vector output of classification.

4). The output is an open polyline that can not be transformed into a polygon. A closed polygon is preferable to isolate areas of similar seafloor composition.

These issues were presented to the District on September 7th and subsequent test data was sent for review. After inspection of the SeaClass data it was decided that no further effort should be put forth on exploring a SeaClass analysis and to complete a "heads up" digitization on the main areas of interest.

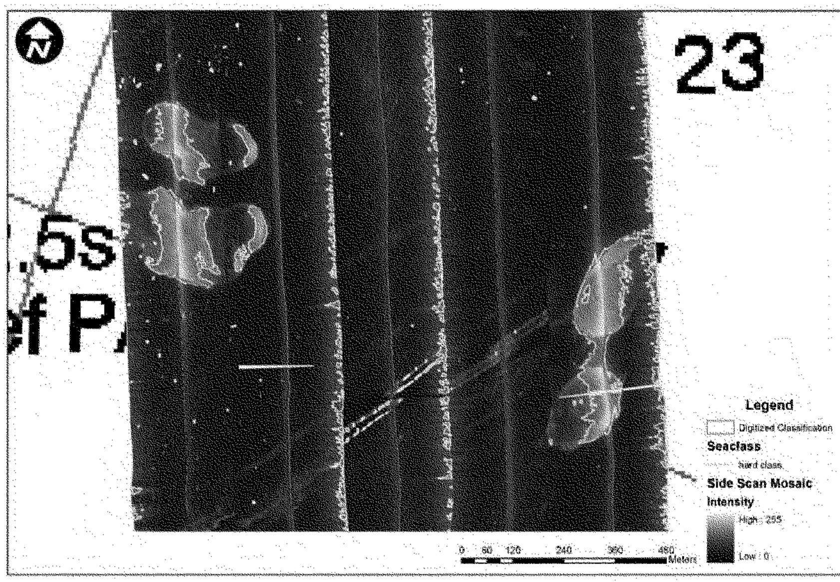


Figure 10. Map illustrating SeaClass seabed classification results overlaid with manually digitized seabed classification from a visual interpretation of a side-scan mosaic.

ArcGIS Approach: Principal Component Analysis

Another approach we have completed through our ongoing research into seafloor classification is to use a Principal Component Analysis (PCA) in the ArcGIS platform. Figure 11 shows the results of work completed on multibeam backscatter imagery for Ocean City, Maryland. Although there are a few subtle artifacts, including the nadir region, overall the results are fairly good. This can be attributed to the fact that the multibeam bathymetry and backscatter are beamformed, have cm-scale XYZ positioning and are compensated for 4D motion of the vessel. Our recommendation, provided benthic habitat classifications become critical for phase 2 of the Neuse River project, is that we attempt to run QTC Multiview on the multibeam backscatter to assess the accuracy of this product.

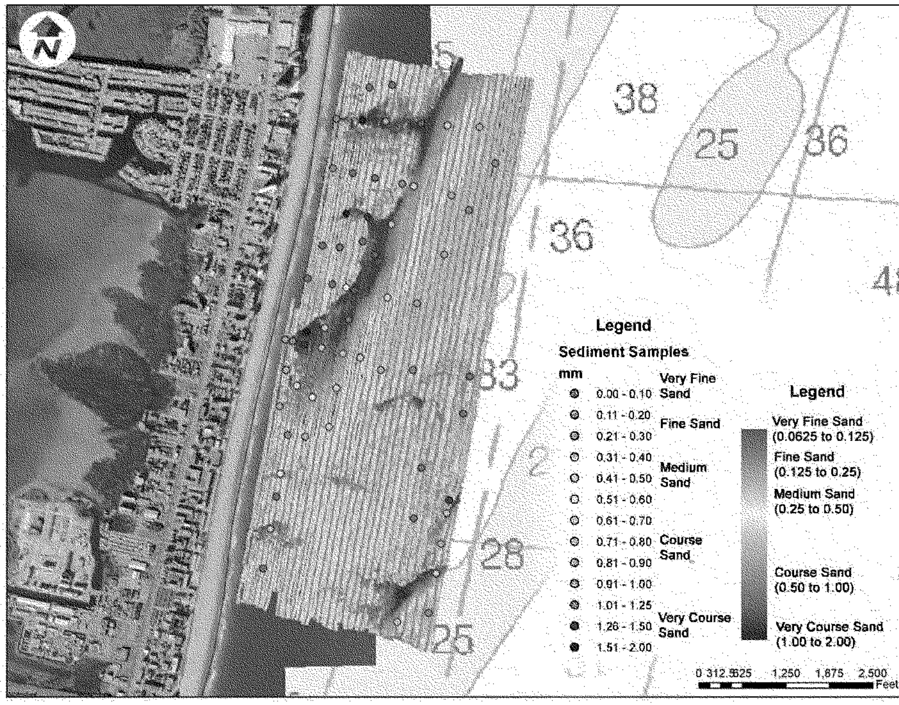


Figure 11. Map illustrating a PCA analysis in Arc on multibeam backscatter imagery.

Digitizing Approach: "Heads Up" Digitizing in ArcView
Our final approach was to visually classify the data to identify major features which were likely candidates for possible exploration in phase 2. The main feature common to each of the mosaics were both isolated and clustered reefs with a circular to oblong footprint. Conversations describing these features to our NOAA collogues along with Chuck Wilson at the USACE Wilmington District suggest that these are in fact a signature of an oyster reef. Figure 10 shows the results of digitization of these features.

Although there are likely 2-3 more benthic classes observable at most sites, some of which have a high intensity acoustic return, more information is needed from the District on whether these areas merit further investigation in phase 2.

Neuse River Remote Sensing Workflow Diagram

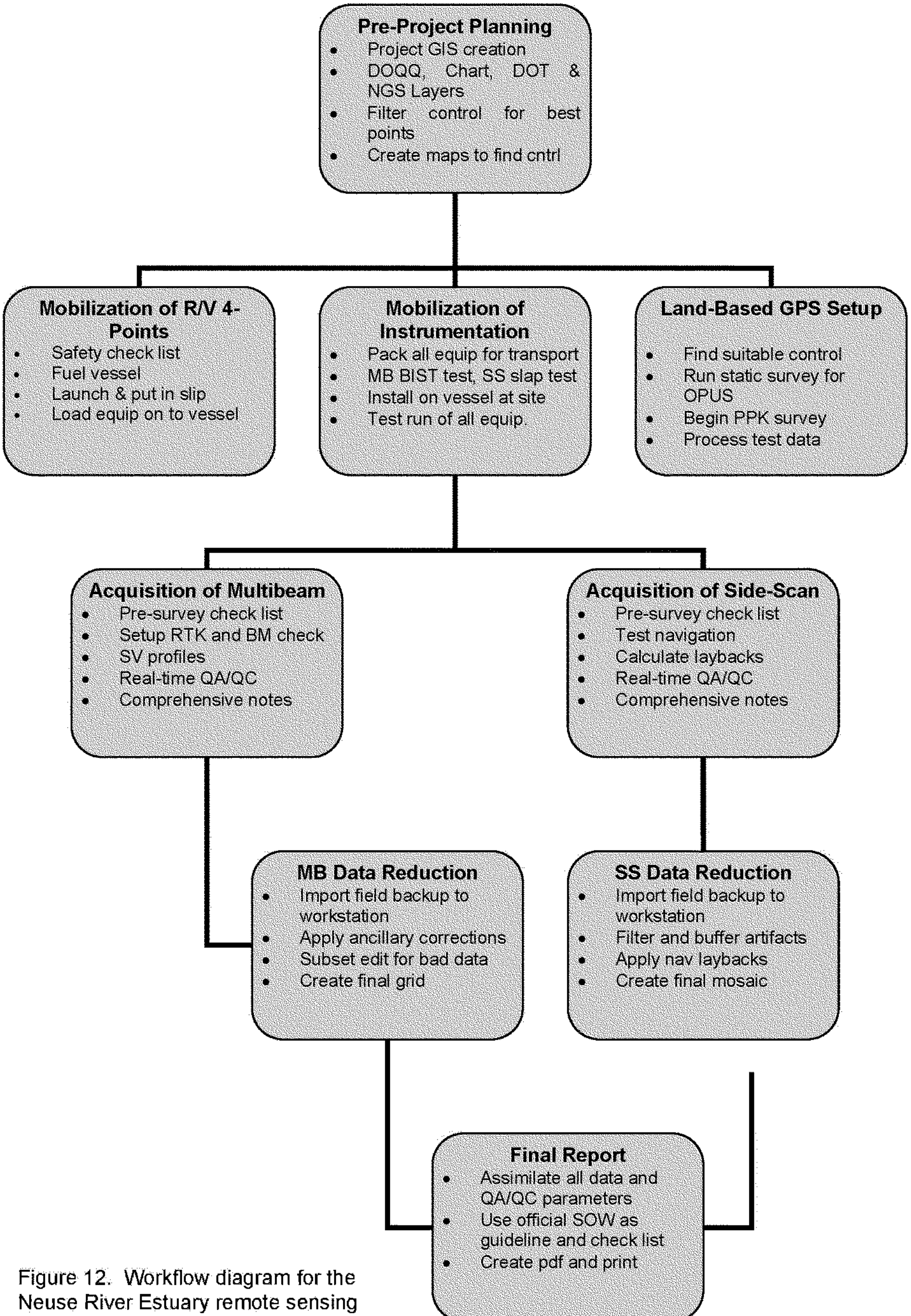


Figure 12. Workflow diagram for the Neuse River Estuary remote sensing project.

Neuse River Remote Sensing QA/QC Workflow Diagram

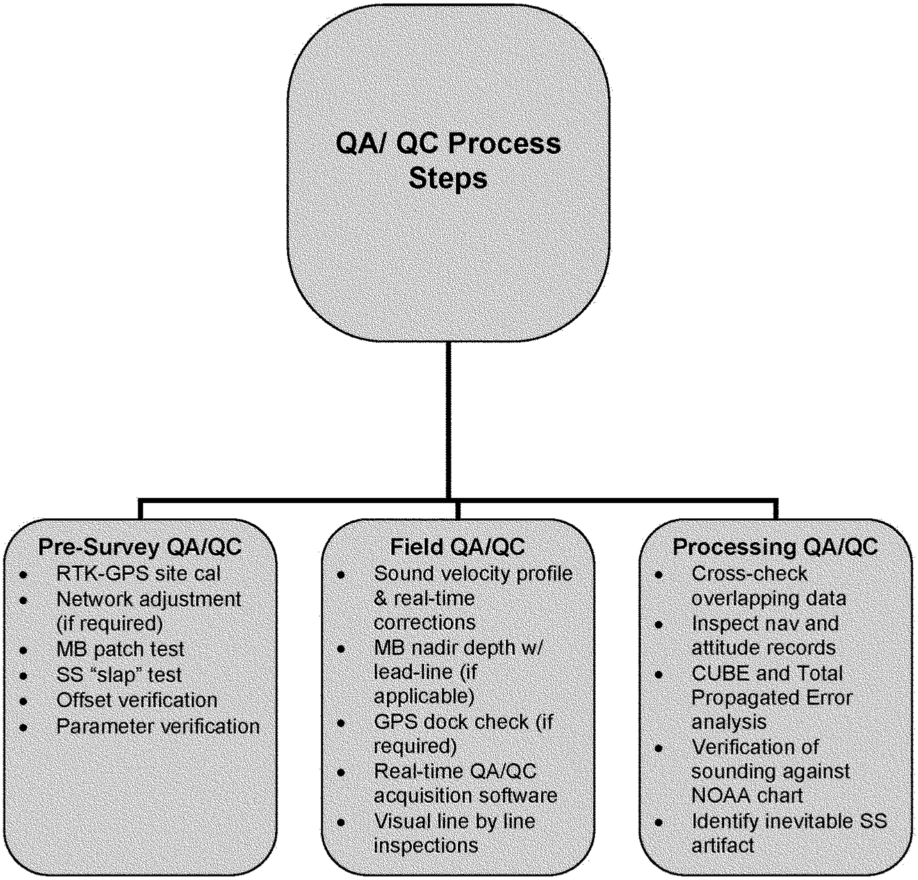


Figure 13. QA/QA Workflow diagram for the Neuse River Estuary remote sensing project.

Graphical Summary of Deliverables

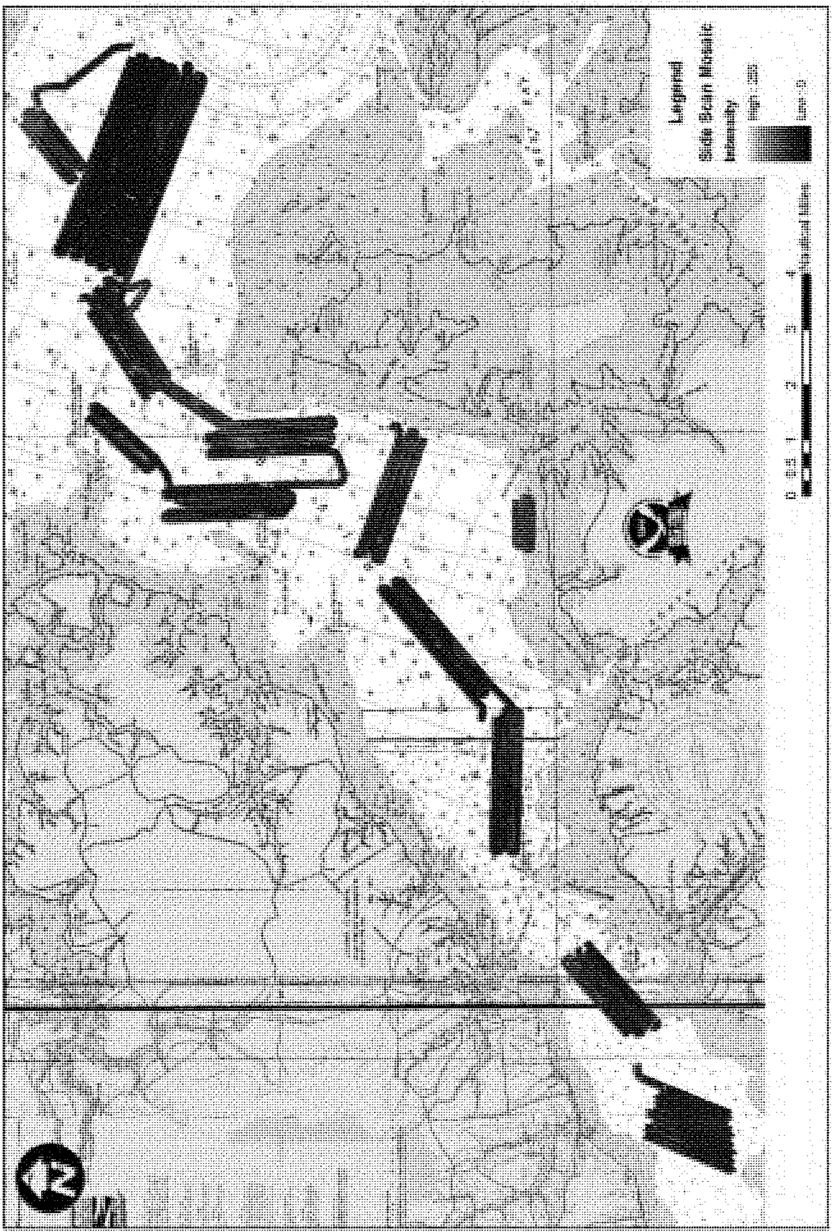


Figure 14. Final side-scan coverage map.

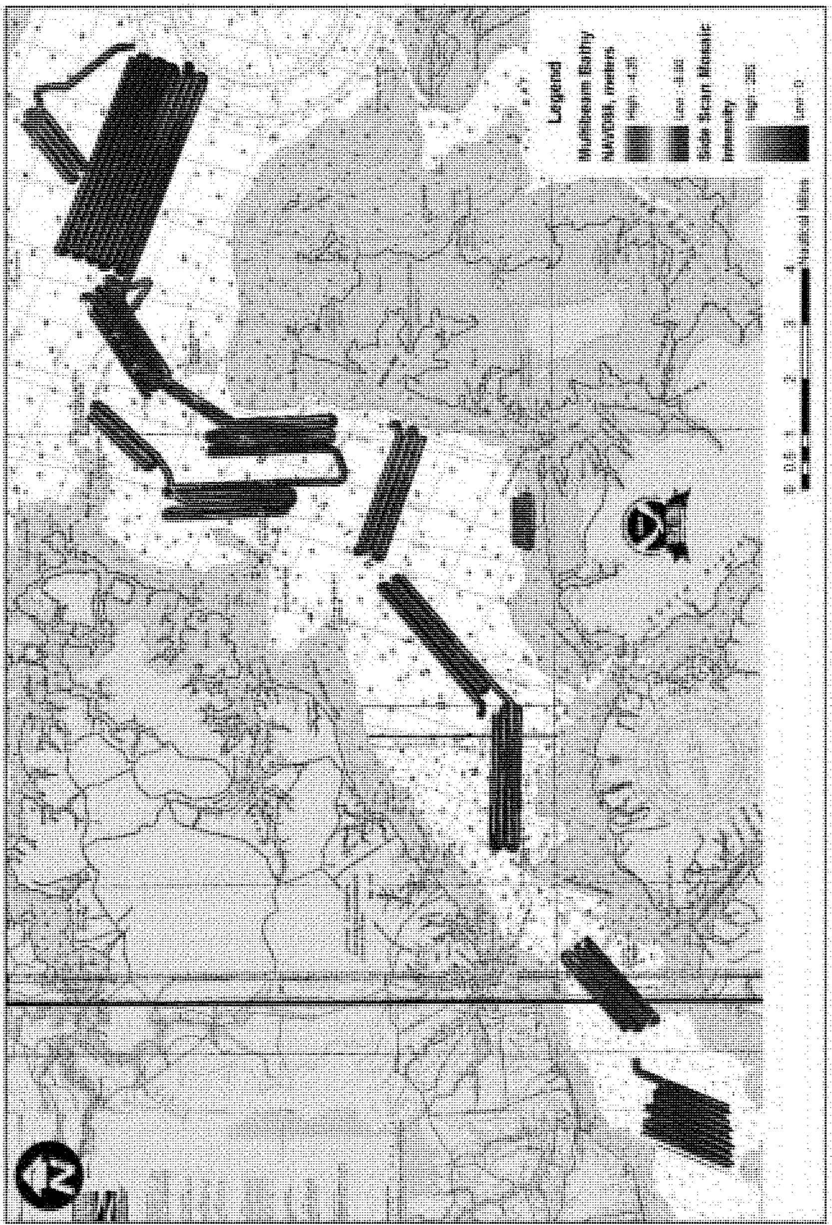


Figure 15. Map showing side-scan mosaics and processed multibeam bathymetry overlaid.

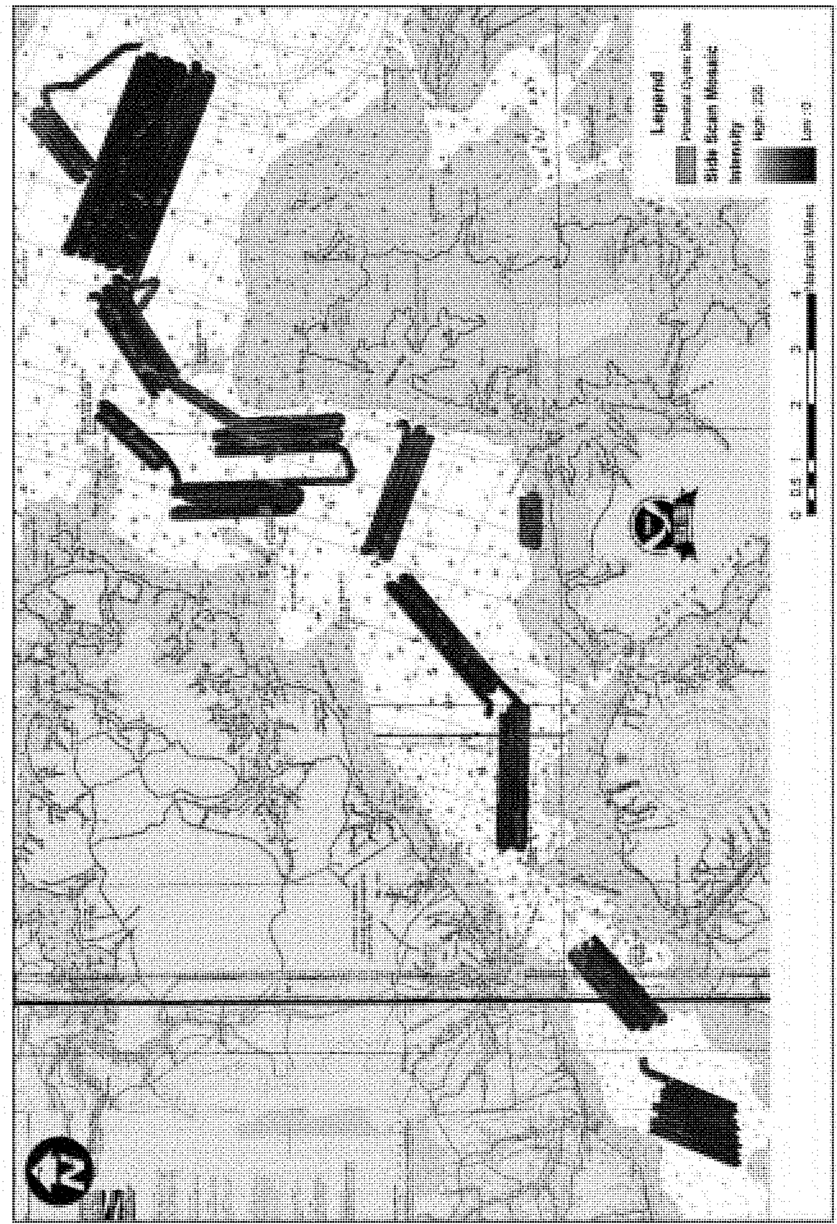


Figure 16. Map illustrating potential oyster beds determined from visual inspection and digitization of the side scan mosaics.

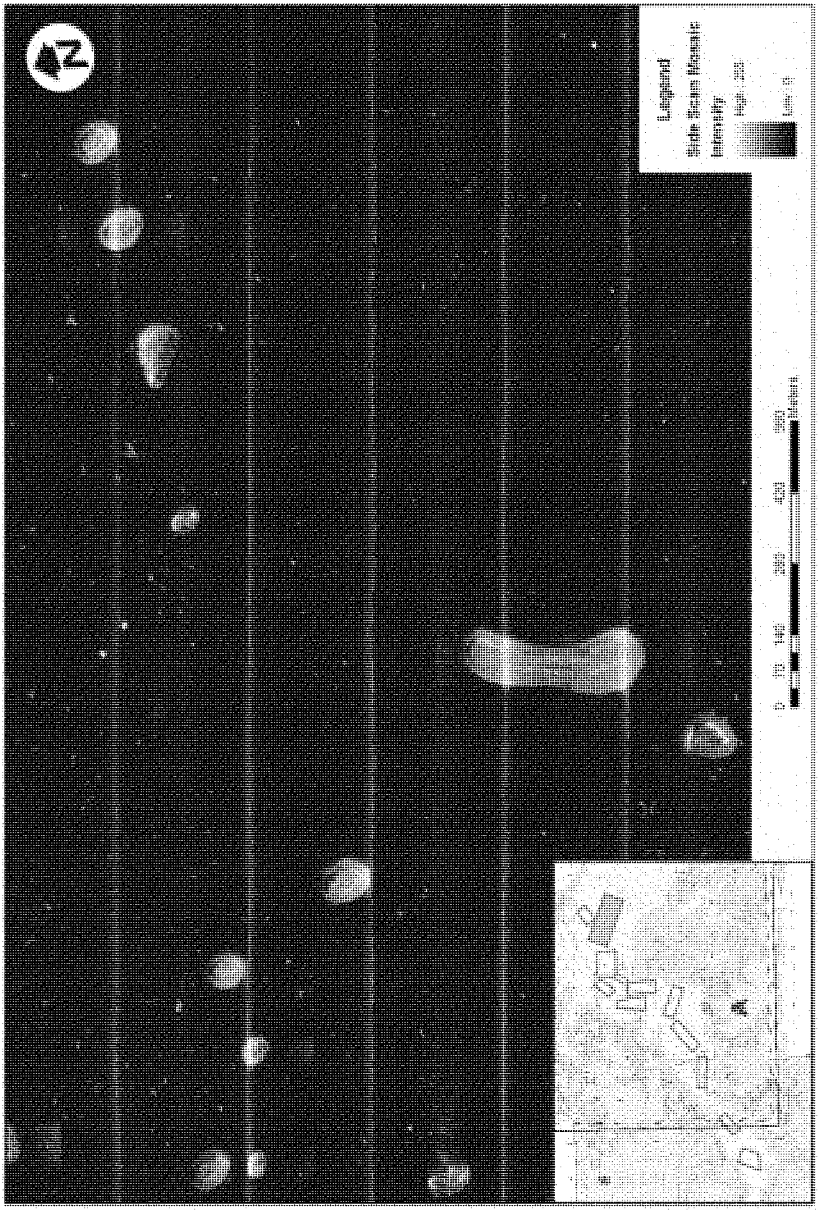


Figure 17. Map showing potential oyster beds in a close-up view of Site 12 in the mouth of the Neuse River.

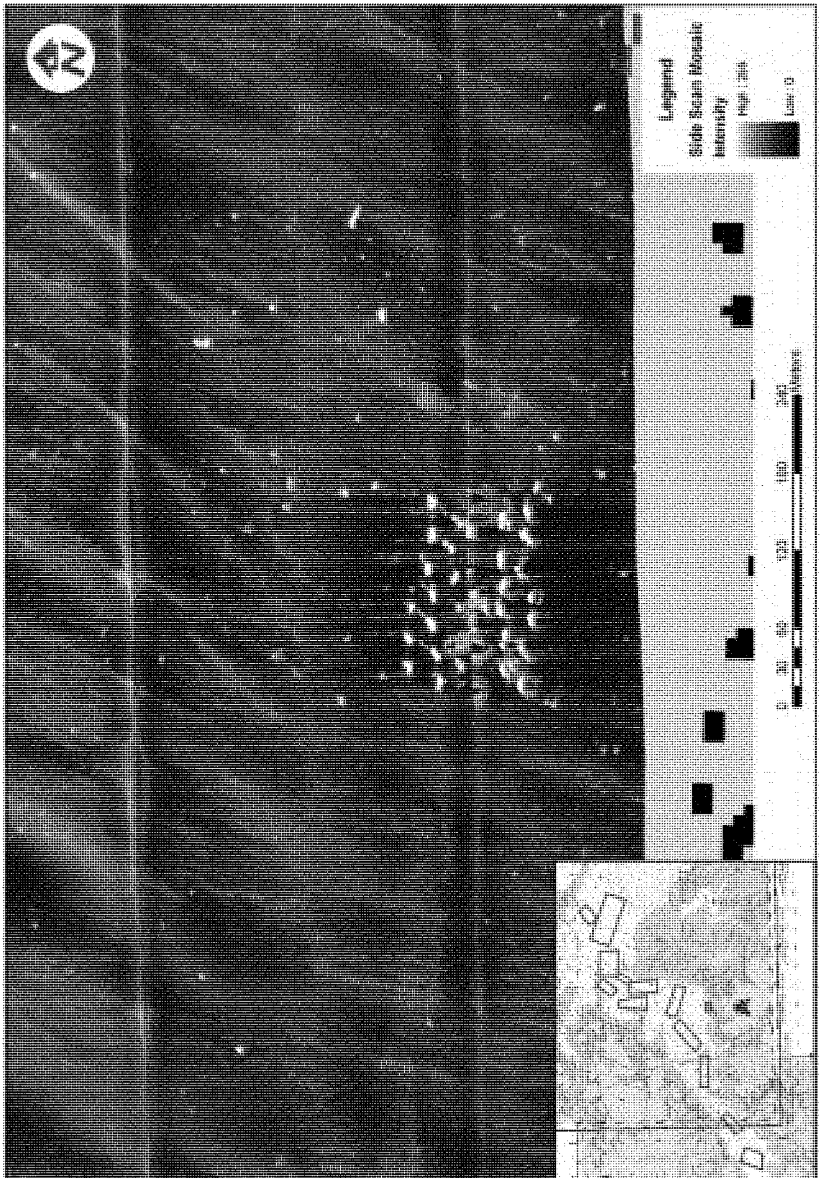


Figure 18. Side-scan mosaic of Site 5 which shows experimental oyster beds.

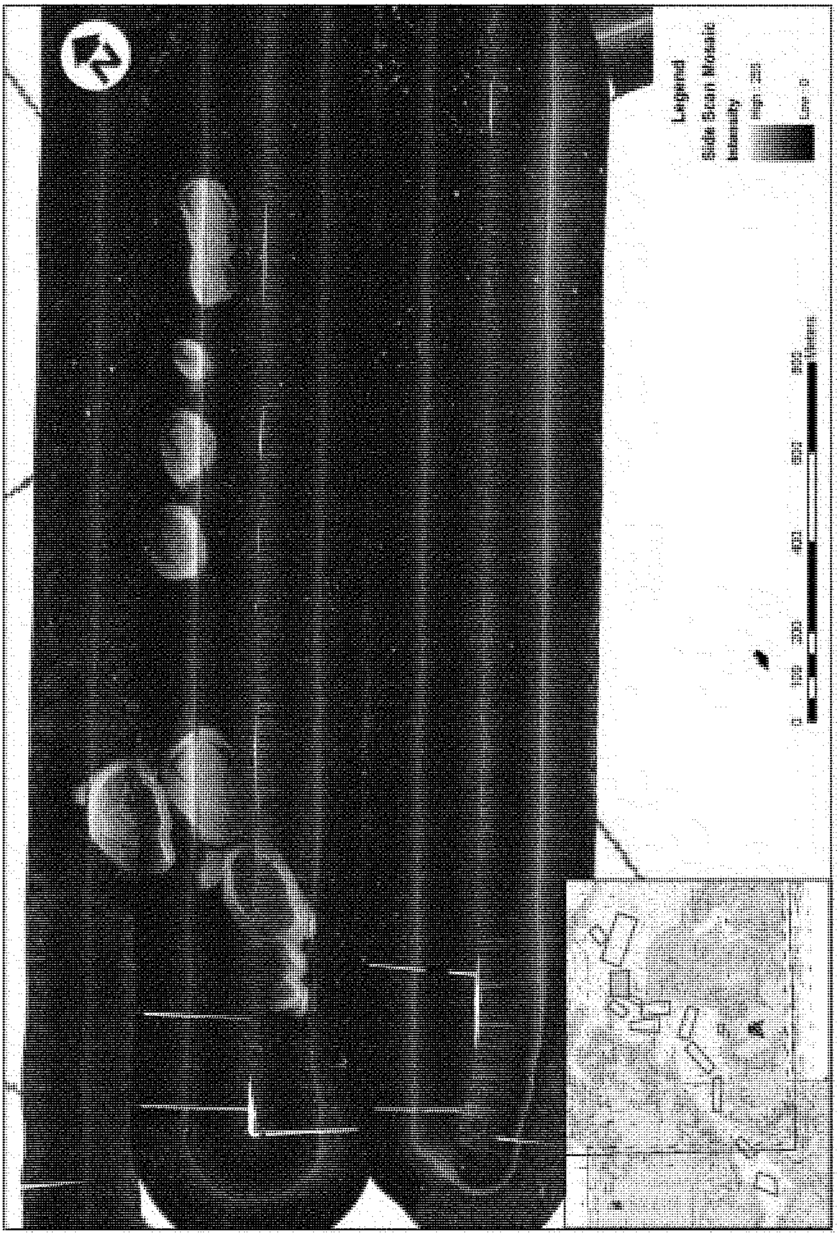


Figure 19. Map showing potential oyster beds in a close-up view of Site 11 in the mouth of the Neuse River. .

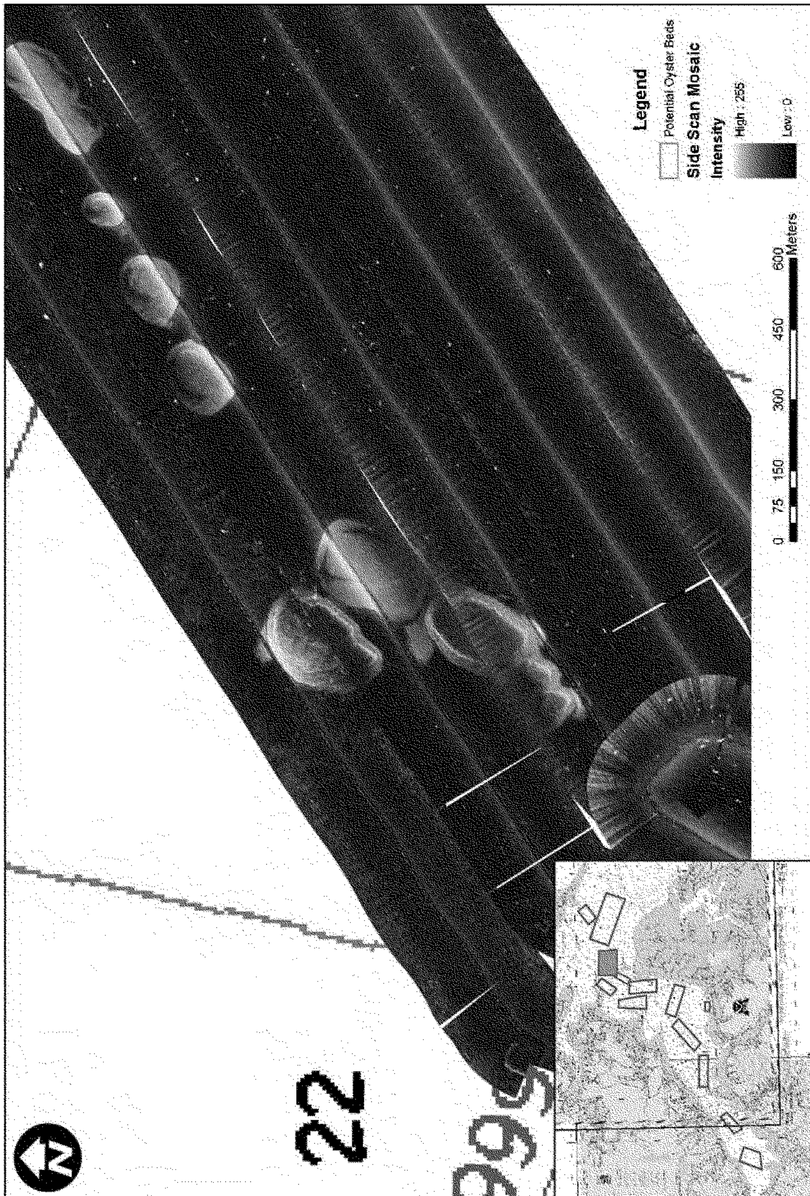


Figure 20. Map showing potential oyster beds in a close-up view of Site 11 and the identification of these features as potential oyster beds.

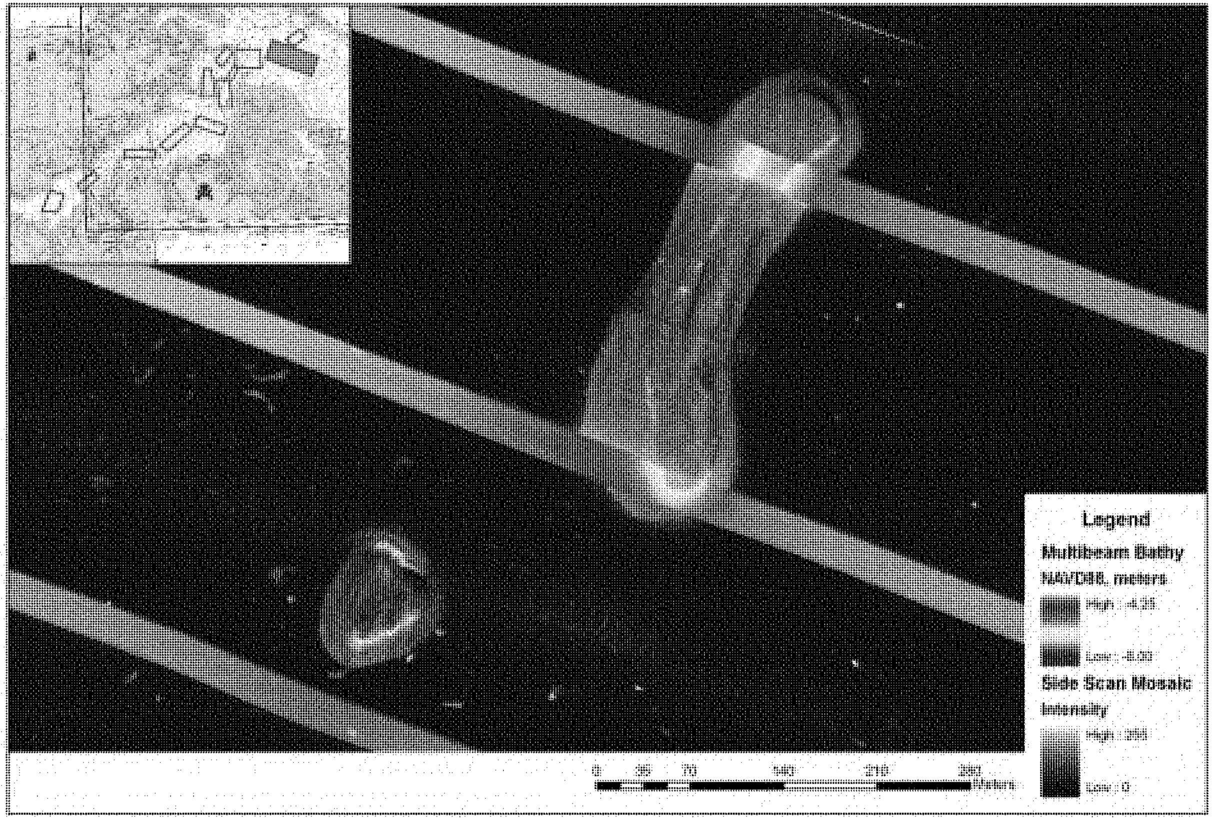


Figure 21. Multibeam coverage over an “amoeba” reef.

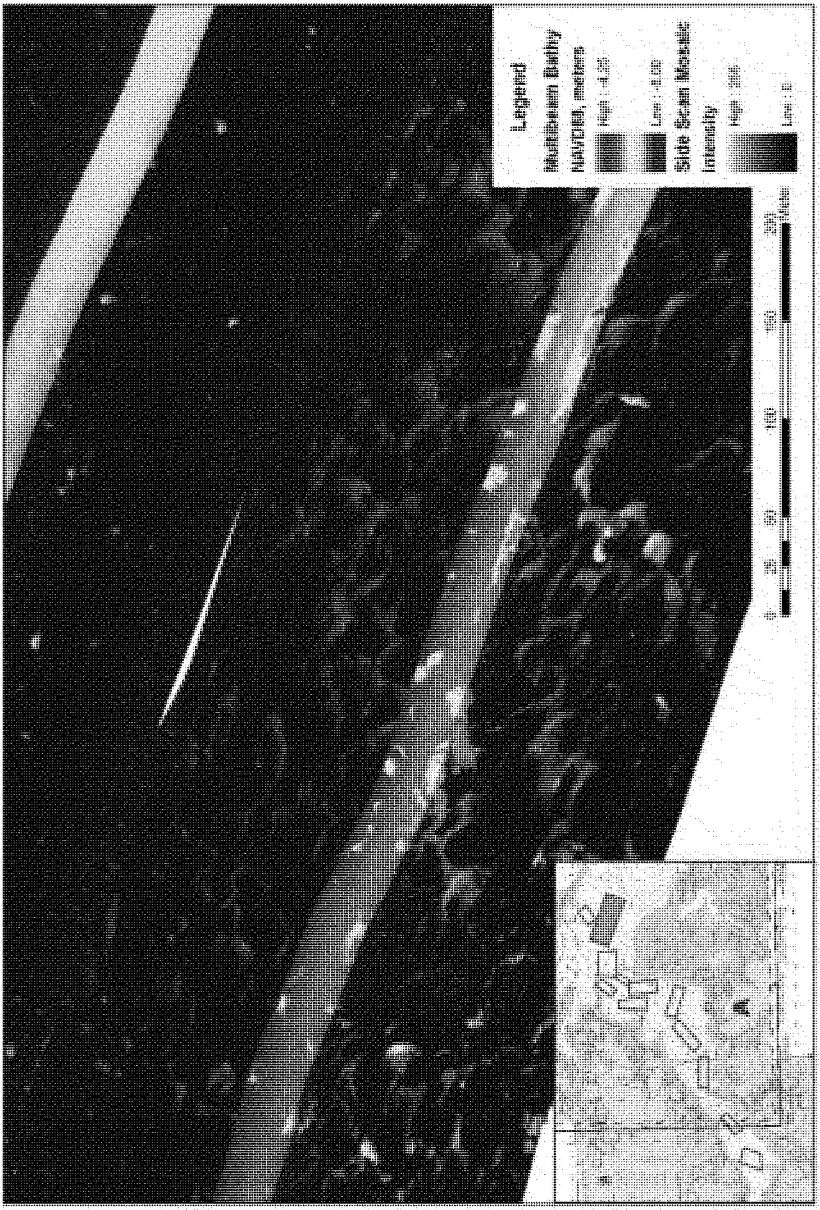


Figure 22. Multibeam data coverage over a non "amoeba" reef.

Appendix A – Official USACE Scope of Work

SCOPE OF WORK
FOR
SIDE-SCAN POTENTIAL OYSTER BEDS
AND
RIVERBED CLASSIFICATION
NEUSE RIVER, NORTH CAROLINA

1. General. The Contractor shall acquire Side-Scan Data completely over and within a 300 meter radius of designated points in the Estuary of the Neuse River in North Carolina for the purposes of classifying and mapping the existing riverbed. The Contractor shall survey, classify, and map the riverbed over all points in the ESRI Shapefile provided by the Government.

2. Survey Control. All horizontal and vertical control used for this survey shall be from the North Carolina or a Federal Agency Network and be of third order accuracy or better. All control loops must be tied to at least two or more control points. The Contractor shall furnish a list of all points used to the Government. **All work shall be relative to WGS 1984 in the horizontal plane and NAVD 1988 in the vertical plane.**

3. Clearances. The Contractor shall acquire all Clearances necessary to obtain the required data. All discussions for access to private or public property or restricted waters or airspace must be included in the required weekly status report with name of person, address, and telephone number.

4. Required Deliverables. The Contractor is required to deliver Shapefiles, Raster Data Sets, TINs, Metadata Records, a Weekly Status Reports, and a Final Written Report. All data shall be delivered on a newly purchased portable Maxtor USB Hard Drive with sufficient capacity for all deliverables. The newly purchased Hard Drive will become property of the Government upon delivery.

4.1 Shapefiles. The Contractor shall deliver Georeferenced Shapefiles from the Multibeam Survey. The Shapefiles shall be in a format compatible with ESRI ArcView/ArcInfo Version 9.0.

4.1.1 Point Shapefiles. The Contractor shall deliver Point Shapefiles from the Multibeam Survey. The Point Shapefiles shall represent the final appropriate correction applied points of the Bathymetric Survey.

4.1.2 Polygon Shapefiles. The Contractor shall deliver Polygon Shapefiles from the Side-Scan Survey and Riverbed Classification. The Riverbed Classification shall be derived using Quester Tangent Algorithms.

4.2 Side-Scan Raster Data Sets. The Contractor shall deliver Georeferenced Raster Data sets from the Side-Scan Survey. The Raster Data sets shall represent the final appropriate correction applied image of the Side-Scan Survey. The

Raster Data Sets shall be in a format compatible with ESRI ArcView/ArcInfo Version 9.0.

4.4 Metadata Record. An FGDC compliant metadata record for each spatial data deliverable shall be created using ESRI ArcView/ArcInfo ArcCatalog version 9.0. Appropriate information shall be entered in all required fields. The Contractor shall attach the appropriate metadata record to each spatial data file using ArcCatalog so that no importing or formatting of the metadata record is required by the Government.

5. Weekly Status Report. **The Contractor is required to submit a Weekly Status Report each week, beginning on the Task Order Award Date, until all deliverables are received and accepted by the Government**. The Weekly Status Report shall be delivered via e-mail no later than 8:00 AM each Monday and shall document the Contractor's progress from the previous Monday through the previous Sunday. The status report shall itemize each scope item with percent of work complete and an estimated date of completion. The report shall also include the number and type of field crews working, a description of any problems and/or delays encountered, and any photographs of the site and/or significant site features (such as outlet structures, retaining walls, escarpments, etc.) and/or specialized data collection activities.

6. Final Written Report. A written report summarizing all data collection activities shall be submitted as a Portable Document File (PDF) and in bound hardcopy. The following items shall be included in the survey report:

- Written description of workflow to complete task order (start to finish) including flowchart diagram and detailed description of QA/QC process
- Dates and times of each data collection activity
- Atmospheric Conditions for each day of data collection activity
- All Horizontal and Vertical Control used including monument name, establishing agency, date established, description, and published horizontal and vertical values
- TBM descriptions with vertical values
- Copy of all field notes
- Complete and detailed list of all survey equipment used including copy of last factory calibration report
- Metadata Records as described in 4.4 above
- Photographs of the site and any significant features or data collection techniques used

7. Quality Control. If work is found to be in error, incomplete, illegible or unsatisfactory after assignment is completed, the Contractor shall be liable for all cost in connection with correcting such errors. Corrective work may be performed by Government personnel or Contractor personnel at the discretion of the Contracting Officer. In any event, the Contractor shall be responsible for all costs incurred for correction of such errors, including salaries, automotive expenses, equipment rental, supervision, and any other costs in connection therewith. All data and deliverables shall be reviewed for the following:

- Required coverage of the project limits
- Capture of all required features
- Required accuracies
- Required horizontal and vertical datum
- Adherence to the delivery order requirements

8. Technical POC. All technical questions concerning work under this task order shall be directed to Jim Jacaruso at (910) 251-4064.

9. Completion Date. All work required under this task order shall be **completed and delivered no later than 21 calendar days from the Task Order Award Date.**

This schedule is subject to adjustment by the Contracting Officer in writing.

10. Deliver To. All work shall be delivered to:

U. S. Army Corps of Engineers
Wilmington District
Attn: Jim Jacaruso, TS-EE
69 Darlington Avenue
PO Box 1890
Wilmington, NC 28402-1890

Appendix B - Benchmark Descriptions

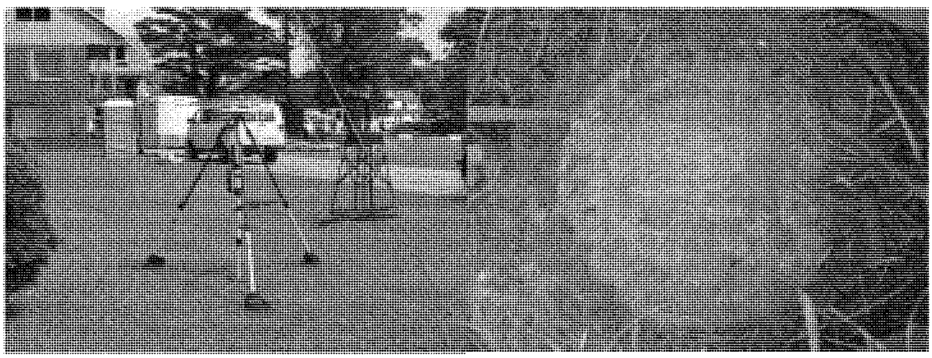
NGS Mark Designated PAM 43

DESIGNATION: PAM 43 (used for Post Process Kinematic basestation)
PID: AEA6107
STATE/COUNTY: NC/PAMLICO
USGS QUAD: Oriental (1987)

Current Survey Control:
NAD 83(1986): 35 01 30 (N) 076 41 30 (W) Scaled
NAVD 88: 1.687 (meters) 5.53 (feet) Adjusted

OPUS results:
NAD 83 (CORS96): 35 01 30.07360 (N) 076 41 28.84146 (W)
NAVD 88: 1.682 (meters) 5.52 (feet)

LAPLACE CORR: N/A DEFLEC99
GEOID HEIGHT: -37.48(meters) GEOID03
DYNAMIC HT: 1.686 (meters) 5.53 (feet) COMP
MODELED GRAV: 979,728.1 (mgal) NAVD 88
HORZ ORDER: N/A
VERT ORDER: SECOND CLASS II



Appendix C– Field Notes, Daily GPS Quality & Copy of Field Book

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Multibeam Daily Operation Proceedures & Checklist

Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X			
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X	34 58 17.9324	76 44 50.6443	1518.3
SV Cast #1	X	34 58 17.9324	76 44 50.6443	1518.3
SV Cast #2	X	34 59 31.1662	76 41 28.8204	1521.3
SV Cast #3				
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes	
Project	USACE Neuse SS1
Survey Area	Western-most survey areas in Neuse mapping project (1,2)
Sea State	1-2' E swell/chop
Wind	E 10-15 kts and increasing (am), by 3pm ENE 5-10kts
Air Temperature	71 F(am), 82 F (pm)
Sea Temperature	81.0 F (am)
Tides	N/A (but around 11:30am high at ocracoke inlet)
Survey Features & Navigational Aids	N/A
Comments	Left dock at 6:30am. Survey Box 1 - Klein at +/- 3.5m altitude. Determined that the EM3002 is a noise source in the side-scan data. Break after Box 1 due to wind/seas at 11:00 AM EST. (3 hrs docked) Resume in calmer conditions at 4:00 PM EST. Survey box 2 klein altitude +/- 4m (more layback out than box 1). Winds calming by 4 PM. At Docks at 6:30 PM EST. TOTAL TIME = 10.0 Hrs)

Line Name	MS/CL	Direction	Notes
0	MS	200	HP 9 - start 7:00am EST (box 1)
1	MS	200	HP 9- end 7:30am
2	MS	20	HP 8
3	MS	200	HP 7
4	MS	20	HP 6
5	MS	200	HP 5
6	MS	20	HP 4
7	MS	200	HP 3
8	MS	20	HP 2
9	MS	20	HP 1
10	MS	200	HP 1
End Survey Box 1 - Seas up to 2-3' and data is deteriorating			
Start survey box 2 at 4pm			
13	MS	227	HP 6
14	MS	47	HP 5
15	MS	227	HP 4
16	MS	47	HP 3 - features at N end extend NE
17	MS	227	HP 2 - turn
18	MS	227	HP 2
End Survey Box 2 to hit the fuel docks and prep for Monday AM			

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Multibeam Daily Operation Proceedures & Checklist

Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X			
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime		35 07.7823	75 27.1433	1521.7
SV Cast #1		35 07.7823	75 27.1433	1521.7
SV Cast #2		35 07.0855	75 21.9463	1523.9
SV Cast #3				
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes	
Project	USACE Neuse SS1
Survey Area	Eastern-most survey areas in Neuse mapping project (12,13,6)
Sea State	<1' SE swell/chop (am), 1-2' chop by PM
Wind	ESE 5-8 kts (am), SW10 kts (pm)
Air Temperature	72 F(am), 87 F (pm)
Sea Temperature	83.0 F
Tides	N/A (but around 12:20 pm high at ocracoke inlet)
Survey Features & Navigational Aids	N/A
Comments	Left Dock at 6:15 AM EST Run from Oriental to Box 12 at 14kts, then 24 kts, took approx 40 min.. Survey Box 12 - Klein at +/- 4.5-5.0m altitude. Survey Box 13 - Klein at +/- 3m. Wind really coming up SW at 10-15...giving a lotof surface chop=deteriorating side-scan. Survey Box 6 - Klein at +/- 3-3.5m. Transit back in took 40min (rougher conditions) - 8:30 PM in slip. TOTAL=14.25hrs

USACE Neuse SS1 08-14-06 Page 1

Line Name	MS/CL	Direction	Notes
0	MS	110	HP 11 - start 7:20am EST (box 12)
1	MS	110	HP 11
2	MS	290	HP 10
3	MS	290	HP 10
4	MS	110	HP 9
5	MS	110	HP 9
6	MS	290	HP 8
7	MS	290	HP 8
8	MS	110	HP 7
9	MS	110	HP 7
10	MS	290	HP 6
11	MS	290	HP 6
12	MS	110	HP 5
13	MS	110	HP 5
14	MS	290	HP 4
15	MS	290	HP 4
16	MS	110	HP 3
17	MS	110	HP 3
18	MS	290	HP 2
19	MS	290	HP 2
20	MS	110	HP 1
21	MS	110	HP 1
End Survey Box 12 - 3:15 PM EST			
Transit to Survey Box 13 - testing HD mode (nadir)			
22	TR	160/160	Equidistant Mode
23	TR	254/254	High Desity Mode
24	TR	160/160	Equidistant Mode
Start Survey Box 13 - 3:40 PM EST			
25	MS	231	HP 5
26	MS	51	HP 4
27	MS	251	HP 1
28	MS	51	HP 2
End Survey Box 13 - Data turning bad due to seas and no hardbottom in SS			
Transit into Box 6 (more sheltered)			
Start Survey Box 6 - 5:35 PM EST			
29	MS	288	HP 1
30	MS	108	HP 2
31	MS	288	HP 3
32	MS	108	HP 4
33	MS	108	HP 4
End Survey Box 6 - 7:30pm EST			

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Multibeam Daily Operation Proceedures & Checklist

Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X			
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime		35 07.3977	076 29.2337	1521.8
SV Cast #1		35 07.3977	076 29.2337	1521.8
SV Cast #2		35 00.6938	076 31.9477	1524.3
SV Cast #3				
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes

Project	USACE Neuse SS1
Survey Area	Eastern-most survey areas in Neuse mapping project (11,10,7,8,9,5)
Sea State	1' SW swell/chop
Wind	SW 5-10 kts (am), SW 5-10 kts (pm)
Air Temperature	74 F(am), 90 F (pm)
Sea Temperature	82.2 F
Tides	N/A (but around 1:10 pm high at ocracoke inlet)
Survey Features & Navigational Aids	N/A
Comments	Left dock at 6:00am. Run from Oriental to Box 11 at 27kts took approx 30 min. Survey Box 11 - Klein at +/- 3.5-4 m altitude. Klein has remained at same layback length for boxes 11,10,7,8,9. Survey Box 5 - Klein at +/- 2.5-3.0 m altitude. In slip at 6:00 PM. TOTAL TIME: 12:00 Hrs

USACE Neuse SS1 08-15-06 Page 1

Line Name	MS/CL	Direction	Notes
0	MS	56	HP 5 - start 6:36am EST (box 11)
1	MS	236	HP 4
2	MS	56	HP 3
3	MS	256	HP 2
4	MS	56	HP 1
5	TR	n/a	HP 8
6	CL	306	HP 8
Ens Survey Box 11 - 9:15 EST - Transit to Survey Box 10			
7	TR	n/a	HP 2
8	MS	221	HP 2 - start box 10
9	MS	41	HP 3
10	MS	221	HP 4
End Box 10 - 10:20am EST - Transit to Box 7			
11	TR	n/a	HP 4
Start Box 7 - 10:30 AM EST - line down center to validate whole box or modified version			
12	MS	176	HP 4
13	MS	176	HP 4
14	MS	356	HP 2
15	MS	176	HP3
16	MS	356	HP 5
17	MS	176	HP 6
End Box 7 - Transit to Box 8			
18	TR	n/a	HP 2
Start Box 8 - 12:45 PM EST			
19	MS	356	HP 2
20	MS	176	HP 3
21	MS	356	HP 4
22	MS	176	HP 5
23	MS	176	HP 5
24	MS	356	HP 6
End Survey Box 8 - 3:00pm EST - Start Survey Box 9 Immeadiately			
25	MS	31	HP 2
26	MS	211	HP 3
End Survey Box 8 - 3:40pm EST - Pull Gear and Transit to Survey Box 5 to asses depths			
27	MS	87	HP 1 - Survey Box 5 Start at 4:05 PM
28	MS	267	HP 2
29	MS	87	HP 3
End Survey Box 5 at 5:00 PM EST and transit to docks			

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Multibeam Daily Operation Proceedures & Checklist

Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X			
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime		35 02.0767	076 35.0065	1521.2
SV Cast #1		35 02.0767	076 35.0065	1521.2
SV Cast #2				
SV Cast #3				
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes	
Project	USACE Neuse SS1
Survey Area	Middle survey areas in Neuse mapping project (4,3)
Sea State	Pretty darn flat
Wind	variable to E 5kts (am)
Air Temperature	72 F(am), 90 F (pm)
Sea Temperature	80.7 F (am)
Tides	N/A (but around 2:00 pm high at ocracoke inlet)
Survey Features & Navigational Aids	N/A
Comments	Left dock at 5:45am. Run from Oriental to Box 11 at 27 kts took approx 17 min. Survey Box 4 - Klein at +/- 4.0 m altitude. Survey Box 3 - Klein at +/- 2.0 m altitude and had to raise to +/-3.5 m.

Line Name	MS/CL	Direction	Notes
0	MS	48	HP 1 - start 6:18am EST (box 4)
1	MS	228	HP 2
2	MS	48	HP 3
3	MS	228	HP 4
End Survey Box 4 - Transit to Survey Box 3			
4	TR	n/a	HP 3
Start Survey Box 3			
5	MS	270	HP 3
6	MS	90	HP 4
7	MS	270	HP 2
8	MS	90	HP 1
End of Entire Survey			

USACE NEUSE 8-12-06

- Logo gear ?
- Transit to site 3:00pm leave dock in PKS
- Arrive Oriental at 5:00pm
- Setup Klein 3K
- Searched for BM's → found PAM 43

PAM 43 8-13-06

PID = AE6107

35 01 30. / 143,890.

76 41 30. / 820,220. (± 180 m acc)

1.687 m NAVD 88 (2nd order)

HERE POINT =

143,884.385 m N

820,245.499 W

PPK Survey Started and run through day 1

Surveyed Box 1 & 2

high winds mid day → ducked into ADAMS CREEK

USACE NEUSE SS 1 8-14-06

Set up PPK RTK Base & checked logged data

Leave dock at 6:15am

arrive at Box 12 at 7:05 am

* See daily MB log for conditions

START Box 12 @ 7:20 AM

Surveyed Box 12, 13, 6

411 = MEM CAFE = 252-249-2600

Set up PPK Base & started logging 8-15-06

left dock ... see Survey Log!

↳ detailed notes!

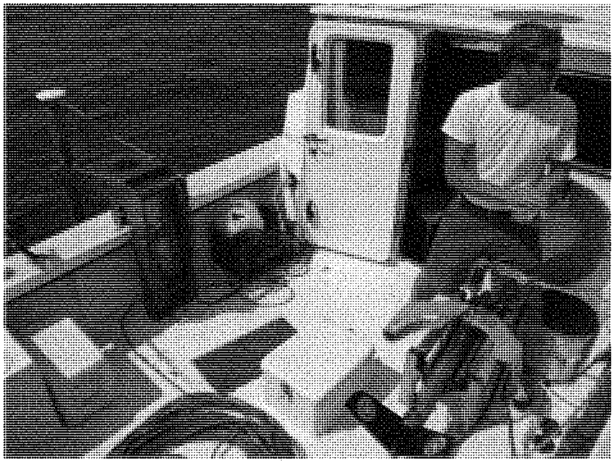
Set PPK Base to log 8-16-06

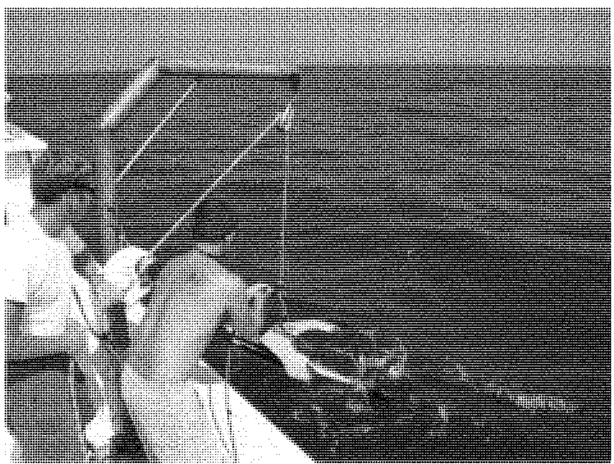
- See Detailed survey log for field notes

Appendix D - *R/V 4-Points* Setup & Instrument Accuracies

Multibeam Deployment

Side-Scan Deployment





Survey Instruments & Published Accuracies

Survey Vessel

The research vessel *4-Points* is a custom fiberglass survey boat designed specifically for shallow water sonar and acoustical operations. The vessel is 25' long with a 10' beam; the bottom tapers from a deep "Carolina" style Vee to a relatively flat-bottomed stern that provides a shallow draft of approximately 1.2'. Twin 140 four-stroke engines, hung on a stainless steel bracket, power the vessel. All electronics and generators are grounded to the sea via a bottom mounted bonding plate to eliminate all electrical noise. The transducer mount was engineered and designed at the University of North Carolina at Chapel Hill's Institute of Marine Science specifically for multibeam and ADCP surveys (Hench, et. al, 2000 "A portable retractable ADCP boom-mount for small boats". *Estuaries*, 23 (3): 392-399.). The mount was designed to keep the transducer below any potential bow wave and to also house the motion sensor directly over the transducer. Side-scan instrumentation is deployed, towed and retrieved from custom davit on starboard side.

Side-Scan Sonar Equipment

- **Klein 3000 side-scan sonar towfish**
  - Frequency: 132 kHz and 445 kHz
  - Transmission pulse: tone burst selectable from 25-400 usec. Independent pulse for each frequency
  - Beams: horz-100 kHz 7 degrees, horz-500 kHz 21 degrees, vertical-40 degrees
  - Range: 100 kHz to 450m, 500 kHz to 150m
  - Multiplexer: T1, 1.5 MB/sec
  - Note: There are no calibration reports associated with side-scan

Multibeam Equipment

- **Simrad EM 3002 multibeam sonar transducer**
  - Multi-Frequency: in 300 kHz band
  - Max ping rate: 40 Hz
  - No. of beams/ping: 254 Roll and Pitch stabilized
  - Beam width: $1.5^{\circ} \times 1.5^{\circ}$
  - Beam spacing: 0.9°
  - Depth range from sonar head: 1 to 150 m
  - Depth resolution: 1 cm
  - Depth accuracy: 5 cm RMS
  - Range sampling rate: 15 kHz
  - Bottom detection by phase or amplitude. Seabed imaging & classification with backscatter (sidescan-like) output.
  - Full swath width accuracy to the latest IHO standard

- **POS MV 320 v4 Main Specifications (with RTK Corrections)**

- Roll, Pitch accuracy: 0.02° (1 sigma with GPS or DGPS) 0.01° (1 sigma with RTK)
- Heave Accuracy: 5 cm or 5% (whichever is greater) for periods of 20 seconds or less
- Heading Accuracy: 0.02° (1 sigma) with 2 m antenna baseline, 0.01 (1sigma) with 4 m baseline
- Position Accuracy: 0.5 - 2 m (1 sigma) depending on quality of differential corrections 0.02 - 0.10 m (RTK) with input
- Velocity Accuracy: 0.03 m/s horizontal

- **Trimble 5700 dual frequency GPS system & RTK-Basestation**
  - Instrument used for positioning and tidal corrections
  - High precision L1 and L2 measurements
  - 24 channels L1 C/A code, L1/L2 full cycle carrier
  - Extremely low latency (20 milliseconds)
  - RTK-GPS accuracy depends on conditions such as multipath, obstructions, satellite geometry, atmospheric parameters and basestation control quality.
    - Published horizontal accuracy: 10 mm + 1ppm RMS
    - Published vertical accuracy: 20 mm + 1ppm RMS

- **Odom Hydrographics Digibar Pro sound velocity probe**
  - Sampling rate: 10 Hz
  - Depth accuracy: > 31 cm
  - Velocity accuracy: +/- 0.3 m/sec

Computers & Software

- Rack mounted multibeam acquisition PC
  - 3.0 GHz Intel Pentium 4 processors with 800 MHz system bus
  - 1 GB of RAM
  - Triton Elics International (TEI) Isis version 6.2 acquisition software
  - CARIS HIPS/SIPS processing software

- Rack mounted Simrad multibeam power unit
  - EM3002 controller and power modulator

- (3) Fujitsu pentop navigation PC
  - Hypack Max.

- (4) Dell high-end GIS processing workstations
  - Arcview 3.3, ArcGIS 9.1, Surfer 8.0, Trimble Geomatics Office, Matlab 12, TEI Bathypro and DelphMap, CARIS

Backup field & processing computers and instrumentation

- (2) Dell laptops

- (3) Fujitsu pentop
- (5) Maxtor 250 – 300 gigabyte external backup drive

Appendix E – QTC Topsail Island Processing Report

SIDESCAN SEABED CLASSIFICATION

Processing of Klein 3000 data

Prepared for Geodynamics LLC

SC75-840C

Issue Date: July 28, 2006

QUESTER TANGENT

Making Data Intelligent™

DATE	REVISION	DESCRIPTION
06.07.28	R00	Original Issue

Quester Tangent
Marine Technology Centre
201-9865 West Saanich Road
Sidney, B.C., Canada V8L 5Y8
Tel: 1-250-656-6677
Fax: 1-250-655-4696
www.questertangent.com

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EXECUTIVE SUMMARY

Quester Tangent received approximately 5 GB of Klein 3000 XTF data acquired on July 18, 2006 by Geodynamics LLC from the Topsail, NC area. The data are from the first survey of a 2-phase project. The data were processed in QTC SIDEVIEW, automated seabed classification for sidescan sonar imagery. Although the overall results were less than satisfactory due to the challenges of acquiring sidescan data in a shallow water, very dynamic environment, some specific classes such as reef areas were well demarcated. Specific issues relating to original data quality and recommendations for improvement are outlined in the report.

INTRODUCTION

The following report describes the classification of a set of sidescan data using QTC SIDEVIEW. The original data were acquired using a Klein 3000 sidescan and provided to Quester Tangent on 2 DVDs in XTF format.

It is well known that the statistical characteristics of a sonar backscatter image depend on the bottom type. Even to a novice user, the texture differences between images of rocks, sand, and mud are readily apparent. Differences between silt and clay are less obvious. Statistical processing can capture many of the pertinent details of the interaction between the sound and the bottom and of its vertical relief. Multivariate statistics can then isolate those details that are rich in information about the bottom, producing features that contain the information necessary for accurate and reliable bottom classifications.

Image-based seabed classification is the segmentation of seabeds into discrete classes based on the characteristics of acoustic backscatter throughout a region. Segmentation is a valid and useful survey tool, even though it does not independently identify geophysical types. Dividing the seabed into classes is useful because seabed characteristics are relatively constant throughout a class and distinct from the characteristics of other classes. Therefore, the amount of ground truth that needs to be collected, visually or mechanically, is dramatically reduced. The strategy of identifying classes with a few samples and confidently extrapolating those characteristics throughout the acoustic classes is both scientifically valid and very cost effective.

The Quester Tangent approach to automated classification involves the data first being transformed into a format readable by QTC SIDEVIEW software. Both automatic and manual data quality assessment is performed throughout the process including the reformatting stage. Image patches or rectangles are placed on only the most suitable data. Features capturing the subtleties of image intensity and texture are generated. A statistical analysis helps to further refine the information to the point where classification can occur. Classification of the bottom that gave rise to these features is done by an automated clustering method that adapts to the characteristics of the multibeam or sidescan data set. Each cluster represents a bottom type, which can be identified based on ground truth; for example, photographs, grain-size analysis, or other local data. If the bottom type is known before classification, data from the areas of known sediment type can be used to build a catalogue, which would then be used to classify subsequent or archived data. This is called supervised classification. The alternative, unsupervised classification, forms the data into logical clusters that can then be identified based on ground truth. The effectiveness of unsupervised classification in uncovering practical and valuable information from the acoustic data has been demonstrated in many projects. This clustering technology, with its ability to easily perform supervised and unsupervised classification, forms part of QTC SIDEVIEW.

PROCESSING THE DATA

Loading Data

Backscatter images from a wide variety of sidescan systems can be loaded with position and ancillary data. Validation and quality control are important considerations. Backscatter data points can be flawed for various reasons, including tow fish and vessel motion, and interference from another sonar source. The data are cleaned to ensure the highest quality data available are presented to the classification. Data designated as not usable are captured in a mask. The mask is used to exclude regions of poor quality from further processing. QTC SIDEVIEW gives the user several cleaning options (Table 1).

Name	Function
Preserve Bottom Edits	The altitude line in the sidescan images may be edited. This function saves those edits.
Water Column Offset (m)	The water column must always be masked. This tool allows a specified distance from the altitude pick into the image to be masked.
Angle	The image can be masked using the sonar depression angle. The angle values are as follows: zero degrees is in the horizontal plane with the sonar and ninety degrees is directly below the sonar
Range (m)	Parts of the image can be excluded using absolute or percent range. All data greater than the specified range value will be masked.
Surface Echo (m)	The sidescan image may display some along track banding which does not represent the seafloor. This may be a result of surface echo. This tool allows for masking of this banding.
Preserve Border Edits	A tool is provided to edit the border in the sidescan images. This function saves those edits.
Despeckle	The program facilitates removal of speckle during feature generation. Despeckle level allows the user to choose the size of the median filter kernel (low, medium or high) used in the despeckle algorithm during feature generation.

Table 1: Cleaning tools.

Placing Rectangles

The seabed in the image is divided into rectangular patches. Patch placement depends on data quality through use of the mask. The mask and the user-selected patch sizing determine the number of patches per side (to port and to starboard). A class assignment will be generated for each patch.

Generate Features

A large number of features are extracted from the backscatter amplitudes in each rectangular patch of each image. QTC SIDEVIEW is able to use many features because Principal Components Analysis (PCA), in the next processing step, will select those combinations of features best suited to each data set.

For bottom classification, features are extracted from both backscatter image data and depth data using the following algorithms:

Basic Statistics: Mean, standard deviation, and higher-order moments are indicative of acoustic impedance changes and interface roughness

Quantile and Histogram: These measure the distribution of backscattered information intensities at low resolution.

Power Spectra: Fast Fourier Transforms (FFTs) are used to find power spectra, which describe statistical characteristics on many resolution scales.

Ratios based on Power Spectra (Pace): Ratios of log-normalised power in various frequency bands provide good discrimination for classifying images.

Grey-Level Co-occurrence Matrices: Grey-Level Co-occurrence Matrices (GLCMs) describe the amplitude changes over selected distances and directions in the image patch, and are widely used to assess texture.

Fractal Dimension: Fractal dimension is a sensitive measure of the distribution and structure of both backscatter and depth variations.

These features have been selected to capture as many useful aspects of the data as possible. As QTC SIDEVIEW was developed, the selection of features was frequently examined to determine which features were providing useful discrimination and to determine if any algorithm consistently produced redundant features. One interesting result from these studies was that mean intensity was rarely the sole determining feature in the overall classification process. It is combinations of intensity and texture that seem to drive classifications.

Multivariate Statistical Analysis

A major strength of QTC SIDEVIEW processing is the incorporation of multivariate statistical techniques as they permit the use of many features. Experience has shown that some features are important in what might be called the standard classifications: mud, sand, gravel, and so on. Others are important for more specialised classifications such as discriminating among sand/mud mixtures. For any particular data set, PCA selects the features that are most useful for the discrimination task at hand. Features that are close to constant are largely disregarded. Redundancies, that is, correlated features, are also acceptable, but only one remains significant. What is left is a reduced feature set that compactly describes the diversity of the data set. While some features may have little diversity or be tightly correlated when used to describe one set of seabed sediments such as open continental shelf sand and gravel, they may be found to give useful discrimination in other cases, such as on deltaic sediments. Thus, the connection between features and classification adapts to the character of the data set.

For each patch of each image, the features are calculated and then arranged as a row vector containing 132 elements. The name we give to these rows of features is Full Feature Vectors (FFVs). This information must be optimised or reduced without losing any details of the sediment. The dimension of the FFVs is reduced by multivariate statistical processing to isolate the combinations of features that are responsible for most of the diversity in the data set. In general, the top three combinations capture a very high percentage of the variance, so the rest of the combinations can be disregarded. These top three combinations are called Q-values.

The result of this reduction process is contained in the reduction matrix. Any FFV can be reduced to three Q-values by matrix multiplication. The reduction matrix is part of the catalogue used for supervised classification. New FFVs, derived from any subsequent acoustic survey, can be reduced to Q-values in this way as part of the supervised classification process. Alternatively, the multivariate statistical processing can be run on any partial or complete data set to find new information.

Cluster Analysis

The acoustic response - represented by Q1, Q2, and Q3 - from like seabeds will be similar. When plotted on a three-axis plot, called Q-space, points with similar values, for example from a single seabed type, form a cluster. Thus, data from three different seabeds form three clusters and new data points are classified based on their locations relative to the clusters in Q-space.

Each catalogue is specific to the sonar system used for data collection and may also be specific to particular operating conditions of that sonar.

Catalogues can be based on a set of sample sonar images or by sampling the whole data set. Over time, a library of classes could be produced from which various catalogues can be created, depending on the application. With the catalogue selected, the complete data file can be classified.

Classification of Seabed

Classify Seabed is the process of applying a catalogue to a data set. If the entire data set is used in an unsupervised classification process, the result is both a catalogue and a classified data set. Confidence and probability values are also calculated during Classify Seabed. If less than the entire data set was clustered, this step is used to classify all the data. Both these processes are unsupervised classification.

Catalogues can also be useful for supervised classification. In this process, each new patch is assigned to one of the clusters, or sediment types, based on a pre-existing catalogue.

Presentation

The final product is an ASCII comma-delimited file that can be imported into mapping software for the production of plots and 3D models. GIS systems are often used to demonstrate correlations between acoustic classes and other GIS layers. Another popular presentation is of the classifications draped over a bathymetric model of the surveyed area.

SIDESCAN DATA QUALITY

Data Challenges

The Klein 3000 data provided by Geodynamics presented significant quality challenges. The survey vessel was a small boat, operating in open seas with a substantial swell from the southeast. The maximum water depth was about 10 m. The sidescan was towed from a sheave supported overboard on the starboard side, on enough cable that it was about 6 m aft of the sheave (which was 4.3 m to starboard of the ship reference point). Other acoustic equipment that affected the sidescan images were an EM3002 on a pole on the vessel's port side and a sounder on the towfish.

Preparing the images for classification in QTC SIDEVIEW required an atypical amount of effort. Also, towfish instability introduced some artefacts into the images that could not be removed by pre-processing. These issues included:

Towfish yaw

Figure 1 shows towfish heading and yaw rate on a line from this survey. A heading is plotted for each ping time, and pings were 0.1 s apart. Because the horizontal beam width on the Klein 3000 is very small, yaw rates exceeding a few degrees per second can give non-recoverable gaps in images. The explanation goes like this: In plan view, sound is transmitted into a narrow fan. It takes a few milliseconds for sound to reach the seabed at typical ranges and for the echo to return to the towfish. The transmit and receive beams are identical, so as the towfish yaws they both sweep around. If they have swept more than some angle, the echo arrives at the towfish outside the receive beamwidth and is not recorded. The Klein 3000 has transmit and receive beamwidths of 0.3° (taken together, they give the advertised system beamwidth of 0.21°). It takes 67 ms for the round-trip to 50 m range. Thus echoes from 50 m are lost if the yaw rate exceeds 0.3°/0.067 s = 4.5 °/s. Much of the time, the yaw rates in Figure 1 are much larger than this. 31% of the time, they are less than 4.5 °/s. This is the primary explanation for bright and dark streaks in the outer parts of the images.

Towfish pitch

Erratic towfish motion is caused by vessel heave being transmitted down the towcable. This causes heave, which drives pitch unless the connection is precisely at the hydrodynamic centre of effort (which moves about, so this is impossible). Pitch and heave lead to yaw, roll, sway, and surge. Yaw has the most serious effect on the sonar image, with pitch second. In this survey, towfish pitch (Figure 2) had some effects, but it would be difficult to isolate these from those caused by yaw.

Towfish roll

Towfish roll does not lead to parts of the image going missing but can affect the image in other ways. The vertical beam pattern is very broad (about 40° for the Klein 3000), far exceeding any occurring towfish roll. However details of the beam pattern move across the image with roll. There is less backscatter amplitude near nadir to port, suggesting that this towfish tows slightly port up.

Low altitude

The towfish altitude, that is, its height above the seabed, ranged from 0 to 6.5 m during this survey, and was often only 2 m or so. At the ranges used, 50 or 75 m, the angle between the sound ray and the bottom, the grazing angle, is very small, less than 1° through most of the range. Very small grazing angles give very large shadows for even small bottom irregularities, and indeed big parts of these images are shadow. This is not ideal for acoustic seabed classification since the amplitude and texture of seabed backscatter from these areas have been lost.

Bottom Picking

There is a sounder on the towfish to record towfish altitude. This is often done on sidescan towfish because the sidescan transducers send very little power vertically down, meaning that the start of the sidescan seabed echo is often not a reliable measure of altitude. Altitude is needed for slant-range correction and for image compensation. (QTC SIDEVIEW does slant-range correction of classified positions, not of the image). During this survey, though, only an erratic small fraction of these altitudes was logged. This meant several hours of work manually tracing a bottom pick for each line.

Interference from a multibeam echosounder

Crosstalk between different acoustic systems operated simultaneously is often found, even if their primary frequencies are quite different. If one is an imaging sonar, interference is often called walkover, because the extraneous echoes appear atop the image. If the systems are unsynchronised, as they often are, the interference appears in regular patterns, loosely suggesting footprints. In this survey, the EM3002 on the port side walked over the port sidescan image. Typically, it can be seen only at ranges greater than about 40 m, because the sidescan gain increases with range. In some lines the walkover is a major interference; in others it can barely be seen. One reason may be that the towfish was astern of the multibeam, and thus receives the multibeam echoes only when yawed appropriately. Walkover can have a major effect on classification because it adds a major artificial texture. Either it has to be filtered away, or these regions must be excluded from the classification process. In QTC SIDEVIEW, the despeckle filter is effective at averaging away the walkover, but also smoothes the entire image. While this may have been effective in this survey, the approach that was taken was to mark a border on the images, the inner boundary at which the walkover appears. In 14 lines, borders were drawn on the port side at ranges near 40 m. On half of these, multipath reverberation caused some walkover to starboard at long ranges (where the gain is high), so border s were drawn near 60 m, typically, to exclude ranges beyond that from classification.

Wake

With the towfish 6 m aft of the sheave, the vessel wake was above it and to port. It could be seen clearly on six lines, at a range of 4 m. Eddies from the wake sometimes extended to almost 6 m. QTC SIDEVIEW contains a filter for this situation, called the surface-return filter. It was used to mask the image from 3.7 to 5.5 m on these lines. This filter operates on both sides, so the same mask had to be applied to the starboard image, even though it was not needed there.

Artificial samples at end of each ping

A common artefact in Klein imagery is that the last 40 or so samples of each ping are artificially large, often at or close to the maximum possible digital value. QTC SIDEVIEW has a filter for this. It was used to remove the last 3% of each ping from the region to be classified.

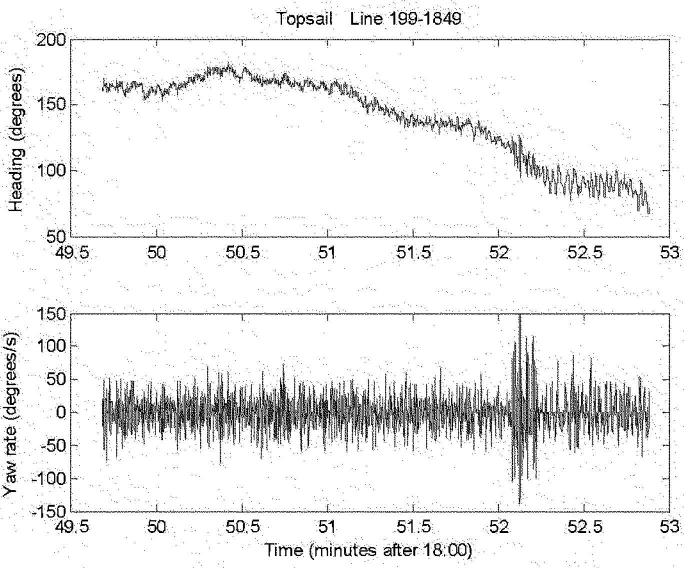

Figure 1: Towfish heading and yaw rate in a line of Topsail data set

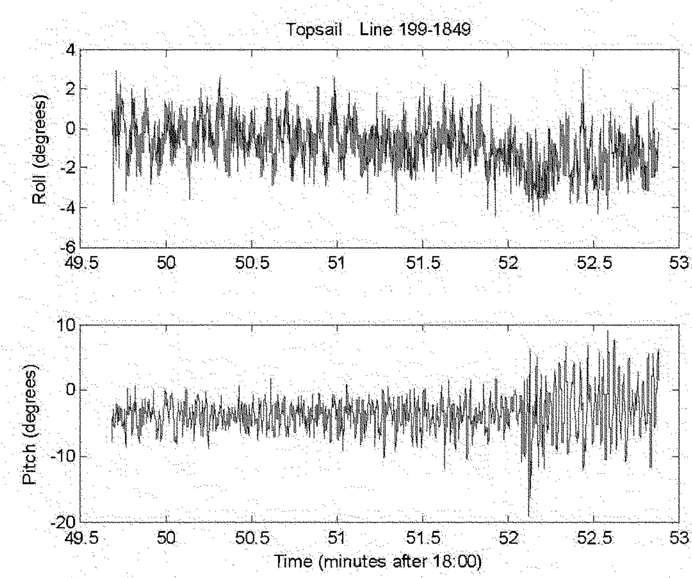

Figure 2: Towfish pitch and roll in a line of the Topsail data set

Individual Line Cleaning

Table 2 shows an assessment of each line and the cleaning process used for it. In addition, bottom picking was done for each line.

Line number	Sonar range (m)	Typical altitude (m)	EM3002 walkover on port image	Border cleaning applied	Wake cleaning applied
199-1104	50	0 – 4	> 40 m, important	Yes	Yes
199-1122	50	1.4 – 4	Not evident		
199-1139	50	0.8 – 2	Not evident		
199-1157	50	3 – 4	Not evident		
199-1214	50	2.5 – 4	Not evident		
199-1232	50	3	Not evident		
199-1312	75	4	> 50 m, important	Yes	
199-1317	75	3.5 – 5	Negligible		
199-1335	75	4	Negligible		
199-1353	75	4	Negligible		
199-1410	75	4	Negligible		
199-1428	75	4	Negligible		
199-1446	75	0 – 4	> 55 m, important	Yes	
199-1507	75	1.5	> 35 m, important	Yes	
199-1508	75		Issues with altitude	Ignore line	Ignore line
199-1509	75	2 – 4	> 45 m, important	Yes	
199-1527	75	4 – 5	> 60 m, important		
199-1545	75	5	> 60 m, important		
199-1603	75	5	Negligible		
199-1620	75	5.5 – 6.3	> 650 m, important		
199-1638	75	5.5 – 6.5	Negligible		
199-1656	75	6	Negligible		
199-1658	75	1 – 5	Negligible		
199-1701	75		Often on bottom	Ignore line	Ignore line
199-1703	75	1 – 2.5	> 40 m, important	Yes	
199-1720	75	1.4 – 4	> 40 m, important	Yes	
199-1738	75	1	> 40 m, important	Yes	Yes
199-1756	75	1 – 2	> 40 m, important	Yes	Yes
199-1814	75	1.5 – 3.4	> 40 m, important	Yes	Yes
199-1831	75	0.5 – 2.2	> 40 m, important	Yes	Yes
199-1849	75	1.3 – 4	> 40 m, important	Yes	Yes
199-1853	75	5	> 40 m, important	Yes	
199-1911	75	5	> 50 m, important	Yes	
199-1919	75	5	Negligible		
199-1920	75	4 – 5.5	Negligible		
199-1938	75	4	Negligible		

Table 2. Survey lines in Topsail data set

Processing Parameters

In addition to the line by line cleaning detailed in Table 2, Table 3 outlines additional cleaning parameters used. Rectangle size was 17 pixels along track by 129 pixels across track, which generated 388017 records. This represents an approximate seafloor footprint of 4.0 metres by 4.0 metres.

Name	Value
Preserve Bottom Edits	Yes
Magnetic Variation	24^0
Angle	As specified in Table 2
Range (m)	As specified in Table 2
Surface Echo (m)	Yes, where applicable
Preserve Border Edits	Yes
Despeckle	No

Table 3: Cleaning parameters.

Additional Filtering

Additional filtering of the FFV data was done as follows:

Time

From 18:49:40 to 18:54:10, to remove the 180° turn in the southwest corner. Filtered 3082 records.
From 19:19:13 to 19:22:22, to remove the 180° turn part ways up the east edge. Filtered 686 records.

Slant range

Slant range > 50 m. Filtered 70873 records. This aids somewhat in reducing range dependence, in that it hides the longest-range rectangles.

CLASSIFICATION RESULTS

Prior to the presentation of the classification results it helps to understand the nature of the backscatter from the entire survey area. This is important when analyzing the relationship between the geology, its backscatter response and the results of the automated classification. This is accomplished by the generation of a backscatter mosaic as shown in Figure 3.

Unsupervised classification was applied on a line by line basis and 8 classes were identified. The results are presented in Figure 4 as a series of data points, where individual points are assigned a class. Additionally, the data can be interpolated to provide a gridded plot suitable for overlay on bathymetry. QTC CLAMS was used to generate such a plot (figure 5). The class colours used in Figure 5 are termed "similarity colours". Acoustically similar seabeds are displayed using similar colours. It is important to understand that the plot is a map of acoustic diversity. It is incumbent on the interpreter to assign labels such as "reef" to the classes based on an interpretation of the original backscatter data or ground truth data.

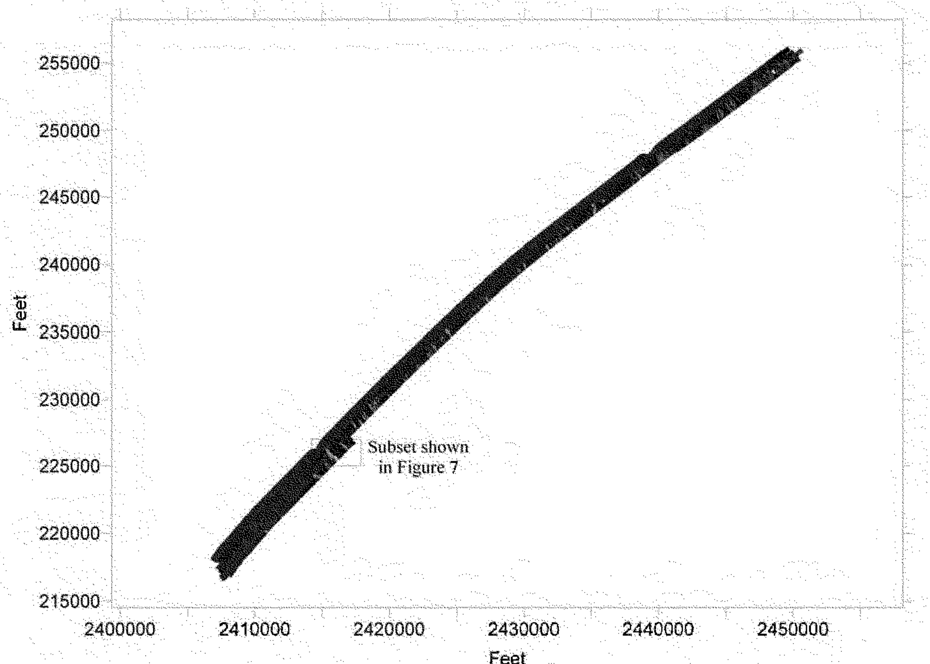

Figure 3. : Backscatter Mosaic of "Topsail" survey area. (source: Geodynamics Group)

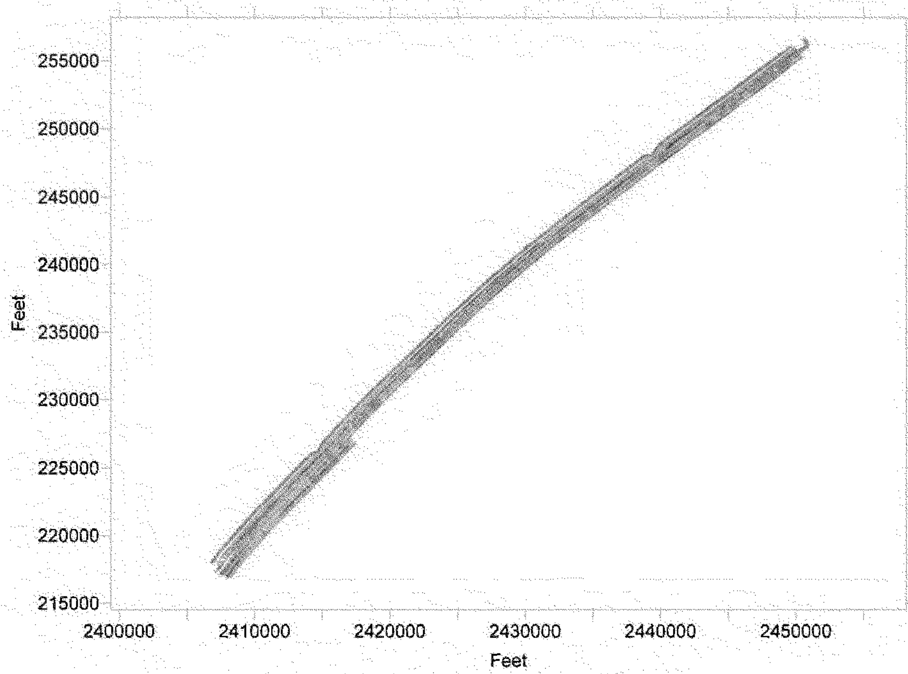

Figure 4: Acoustic Classes Overlaid on Bathymetry

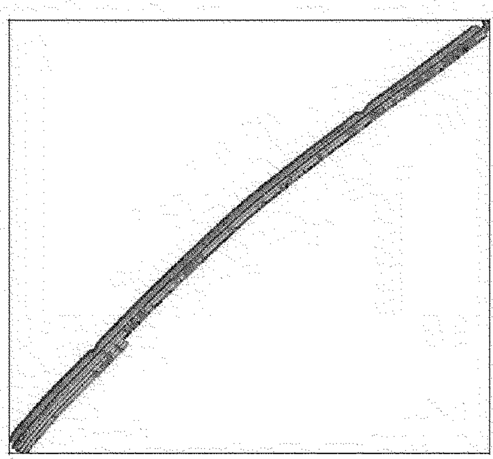

Figure 5 Interpolated classified point data set.

The results were not of the high quality normally achieved when processing data in QTC SIDEVIEW. Several examples of Klein 3000 data in XTF format have been processed previously with excellent results. The striping in the classification particularly evident on Figure 5 is a result of the original data quality. The classification has nevertheless identified the reef areas as a unique class, as shown in Figure 6.

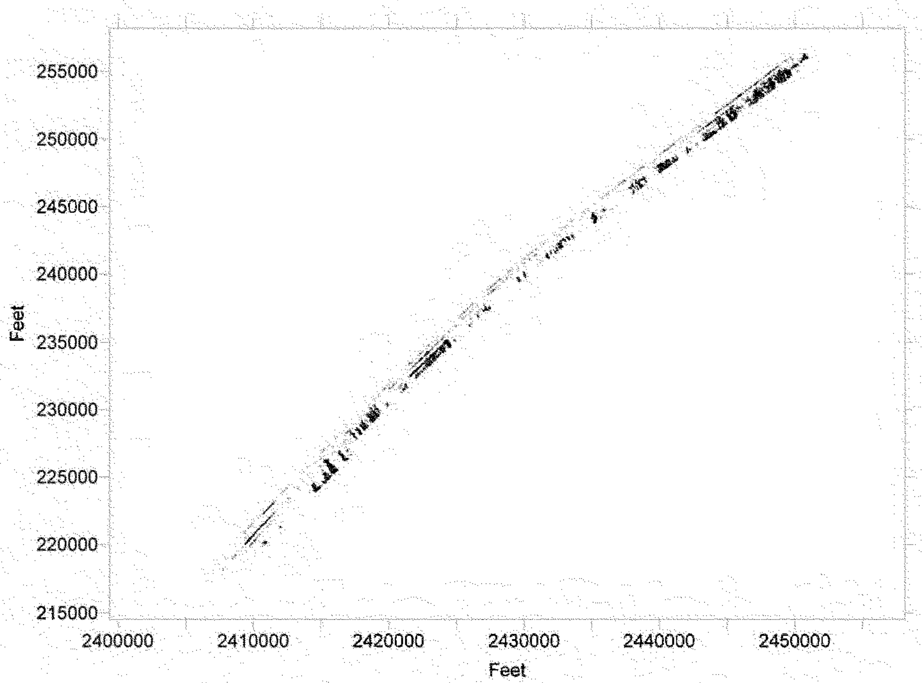

Figure 6: The results of automatic classification showing only Class 5 which is interpreted as reef.

A subset of the imagery is shown in Figure 7. The individual records associated with each original rectangular patch on the image are plotted on the backscatter mosaic. There is a clear correlation between the high intensity backscatter interpreted as reef and the purple class. The other note is the apparent offset in the heading causing the records associated with each ping to be somewhat oblique to vessel track.

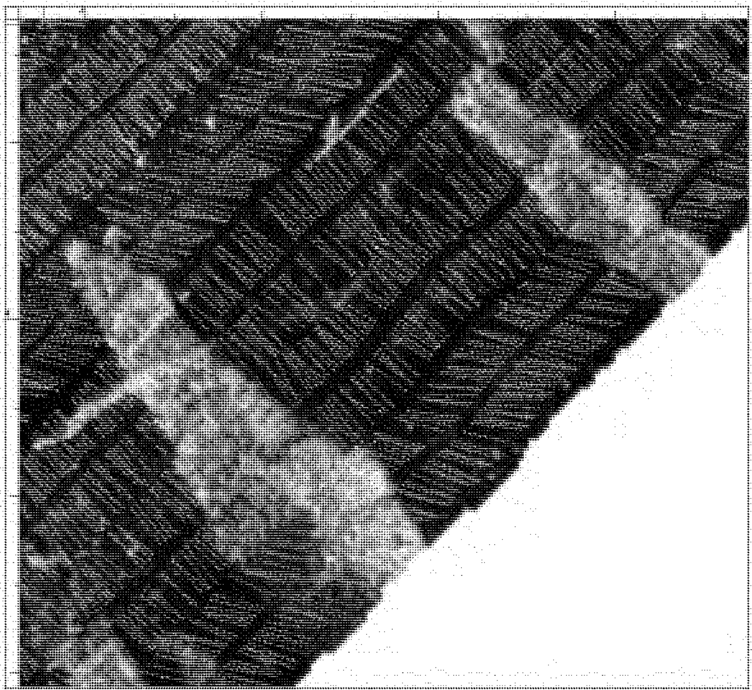

Figure 7: Class 5 interpreted as reef only. The purple class (Class 5) correlates with the reef class seen on the sidescan sonar mosaic. Please see Figure 3 for location of this area.

DISCUSSION AND RECOMMENDATIONS

While there are numerous challenges relating to the acquisition of sidescan sonar, data perhaps the two that stand out are the stability of the towfish and the towfish altitude. Given the environment in which the data were collected this is not surprising. Indeed, the results as shown in the sidescan sonar mosaic are quite acceptable for manual interpretation of the geology. The combination of these acquisition challenges however, diminish the ability automatic classification of all except for the most broad features (e.g. reefs) and perhaps even the subtleties of the geology as interpreted by a marine geologist or geophysicist.

Based in information passed on by the client there exist a veneer of sand over top of some of the reefs. This is evident from the existence of sandwaves. Typically sandwaves exhibit a regular pattern in texture that can be identified in QTC SIDEVIEW. Only the "reef class" could, for example, be submitted to the statistical analysis and clustering to identify "subclasses" of reef with a veneer of sand. Given the data quality previously mentioned this advanced processing was not considered.

Recommendations

1. Given the environment it might be advisable to experiment with a fixed hull or pole-mounted towfish to maximize altitude (rule-of-thumb is altitude 10% to 15% of max. range). This should have the added advantage of reducing fish yaw.
2. If possible, refrain from having an echosounder at similar frequency running at the same time as the sidescan sonar data are being collected.
3. Having access to good quality bottom picks would have decreased the amount of time taken for automatic classification. We recommend an analysis of the reasons for the poor quality bottom picks in the data.

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Appendix F: QTC Report on Triton SeaClass

A Comparison between Triton Elics SeaClass™ and Quester Tangent Corporation QTC MULTIVIEW™ and QTC SIDEVIEW™

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December 2003

Informal Document

QUESTER TANGENT

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INTRODUCTION

This document describes a comparison between QTC MULTIVIEW™ and QTC SIDEVIEW™, on the one hand, and TEI SeaClass™, developed and marketed by Quester Tangent Corporation and Triton Elics International, respectively. Both software packages use backscatter images from multibeam sonars to classify seabed sediments. The two packages, developed independently, use similar methods in some processing steps and distinctly different methods in others, so a comparison is clearly of interest. This comparison is not a competition, however – the differences between the two are too far-reaching. A prime example is that only MULTIVIEW does unsupervised classification, in which the survey data control the number of classes and the assignments of points to classes, while SeaClass always requires the user to designate areas of the images as examples of each class. These two approaches usually give quite different results.

Another reason why this comparison cannot be competitive is that classification maps can hardly ever be ranked quantitatively. To do so would require a map of actual sediment types for comparison. To some extent, maps like this are available from expert interpretation of the same images, but experts can be confident only about the clearest distinctions: bedrock vs. sand waves vs. soft sediments, and one hopes to classify to more classes than this. Ground truth, from grab samples and the like, never has the spatial resolution and coverage needed for image comparisons. In practice, classification maps are assessed for consistency and absence of artifacts and, to a limited extent, compared against a mixture of expert interpretation and the always-inadequate ground truth.

The data sets used for comparison were recorded by a Reson 8101 multibeam sonar, equipped with Option 033 to record the backscatter, and by a Klein 5500 sidescan sonar. The location is the approaches to the harbour in Portsmouth, NH. The data are available from the Common Data Set compiled for the Shallow Survey Conferences (http://www.ccom.unh.edu/ shallow/shallow_commo.htm). The area contains rock outcroppings, coarse and fine sand, and a large area of sand waves.

The next part of this document describes the steps in SeaClass that lead to classification maps. SeaClass is a module of DelphMap™, and the preparatory steps are done in DeplhMap. The SeaClass process is then described and results presented. Some MULTIVIEW and SIDEVIEW results from the same area are presented, followed by a concluding section. The QTC processes are not described here. Descriptions are available in the manuals and in a paper in the IEEE Oceans '03 conference.

SEACLASS PROCESS AND RESULTS

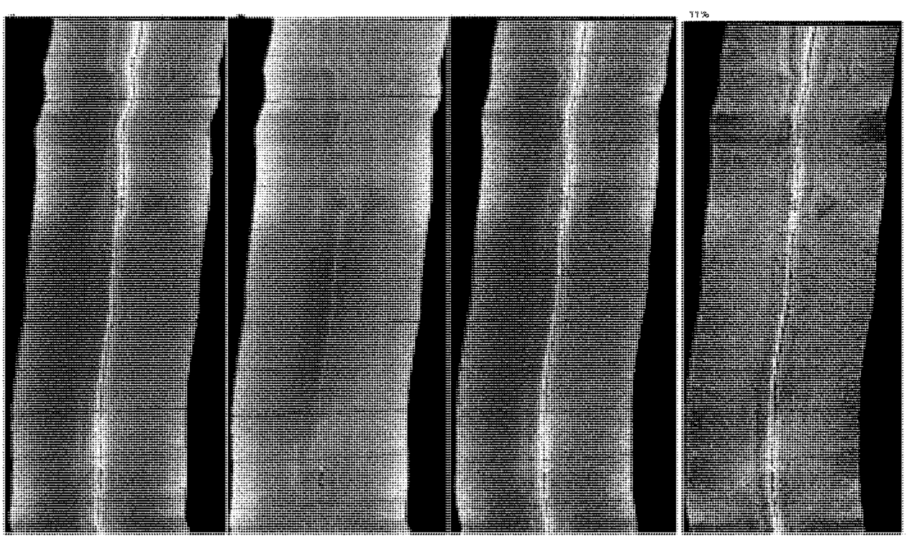
Using ISIS to Compensate and Mosaic Images

ISIS records data in XTF format, which are then loaded into DelphMap for display and making mosaics. SeaClass operates only on mosaiced data. The mosaics can contain one or several survey lines.

Mosaicking plays an important role in the seabed classification process. To get the best result, the user is required to choose a method for smoothing navigation, bottom-tracking method, manual and automatic time-varied gain (TVG), and beam pattern and grazing angle compensation. In preparing a mosaic for classification, the most important are those methods that control the uniformity of the image amplitudes. After the image has been corrected for slant-range distortion and the water column has been removed, prominent across-track variations in signal intensity generally remain. These variations result in track-parallel stripes of high and low intensity. Using the beam pattern and grazing angle compensation, the user can eliminate, to a degree, these unwanted patterns. Different combinations of the above will have different impact on the mosaic imagery. Figure 1 shows some different mosaics of the same line, demonstrating that selecting different methods can give quite different images.

Figure 1 is a series of mosaics of the same line of imagery from a Reson 8101 multibeam. Position and heading for Figure 1.A was from the traditional method with Course-Made-Good headings. Its amplitudes were not compensated. Figure 1.B relied on the same positioning method and was compensated using beam angle compensation. Position and heading for Figure 1.C are from the Kalman method, and it also was beam angle compensated. These three mosaics were applied without any TVG corrections. Figure 1.D was mosaicked using the Kalman method, but with TVG set to *Auto*, with *darkness* tuned to 3%, *strength* tuned to 50%, and *contrast* tuned to 11%.

These four examples show that sometimes it is not easy to decide which methods to use for making the



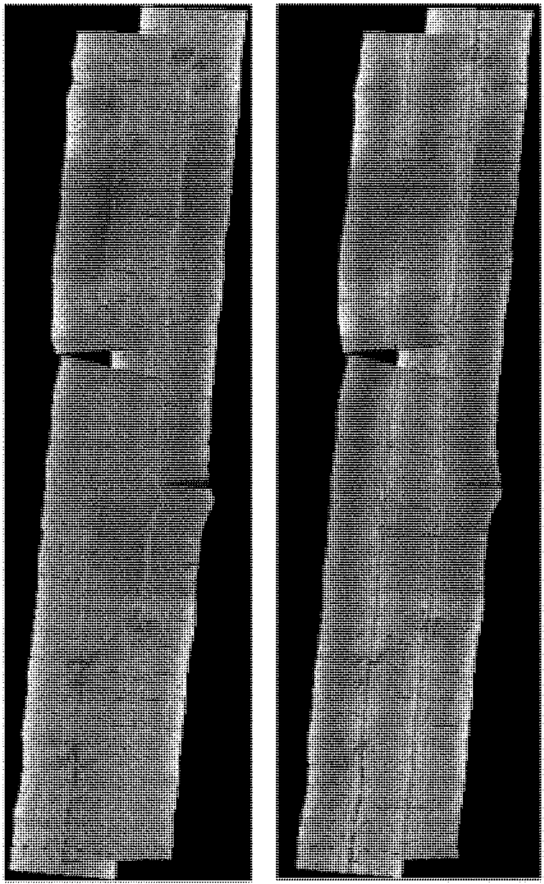
A B C D

Figure 1. The same sonar image recorded by a Reson 8101 in Portsmouth Harbour with various choices of mosaicking, compensation, and TVG correction methods, as explained in the text. The regular black across-track lines indicate distance travelled.

mosaic. Both distributions of amplitude and texture look different, even though these are images of the same line. In the SeaClass classification process, both amplitude and texture play central roles, in both picking training samples manually, and in the classification itself.

Multi-Line Mosaic from Reson Survey

The importance of the mosaicking method is even more obvious in mosaics of several lines together.



A B

Figure 2. Merged Reson 8101 mosaicked images from Portsmouth Harbour. Mosaic A was made with each line compensated with its own beam-angle compensation (BAC) and with non-Kalman positioning; B with a single BAC and Kalman positioning. The overlap method was shine through. Size is about 300 m by 1700 m.

Figure 2 presents two mosaics of the same three lines. Because no calibration data for the multibeam was available, we followed the TEI manual by using Isis to derive an empirical beam-angle compensation (BAC) from the amplitudes of at least several hundred pings from featureless regions. Each line in Figure 2A was compensated with its own BAC, while in Figure 2B compensation was with a single BAC obtained from one of the lines. (The positioning methods also differ; only 2B was done with the Kalman method.) In both mosaics the seam between survey lines is evident, particularly in 2B. Consequences of the choice of compensation method can also be seen. In the southeast corner, for example, near the seam between the east-most and the central line, Figure 2B is noticeably brighter.

Multi-Line Mosaic from Klein Survey

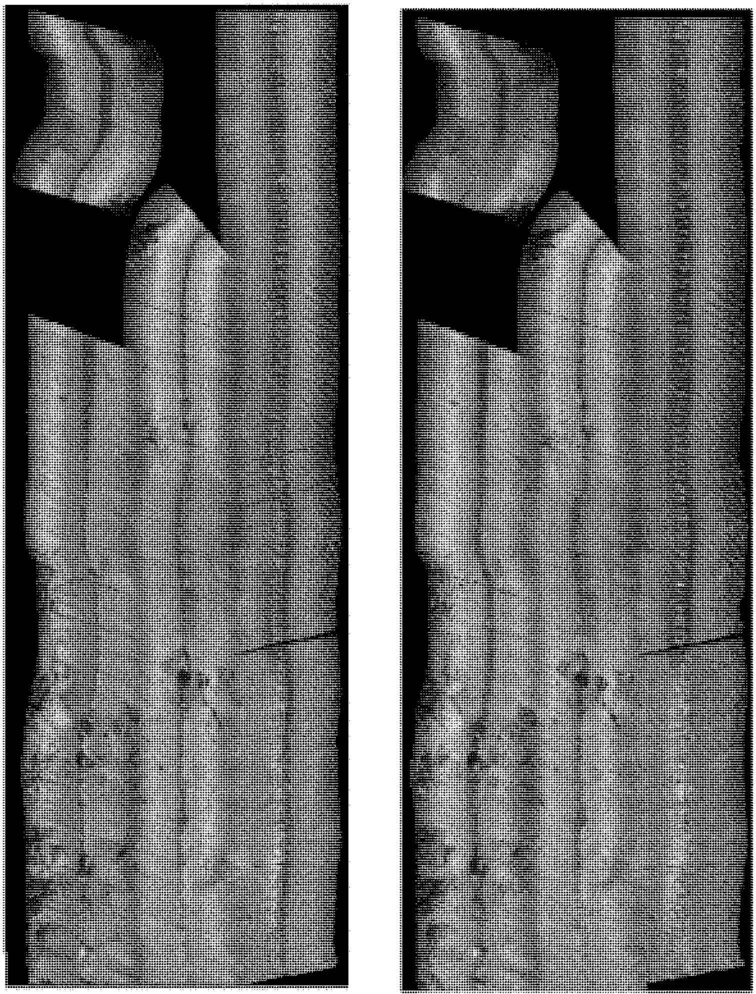
With side scan data as the source, it is still easy to generate mosaics of different amplitudes and textures. The lines in Figure 3A were compensated using a single BAC, while the ones in Figure 3B were each compensated with their own BAC. As with the Reson imagery, the ship tracks are evident and regions that differ in character because of the mosaicking method can be found. (All these side-scan lines were mosaicked using the Kalman method.)

Not included here are examples of the different methods of handling overlaps between survey lines. A popular method is shine-through, in which the largest of the overlapping amplitudes is retained. Shine-through was used for all the mosaics in this work. Another option is Z-order, which follows the sequence in which lines were imported into the mosaic. Z-order is the Delph-Map default ("Using DephMap", p 82.)

Mosaicking Methods and Classification

To form mosaics, the image data are resampled for several reasons. Mosaics are geographically correct, and the geocoding process requires selecting and merging pixels from the waterfall images. The image sample rate, which was constant in the waterfall plot, is not retained when images are resampled to remove the water column. Usually, the final mosaic has fewer pixels than the original images had.

These mosaics are the raw material for classification in SeaClass. Since the amplitude and texture of the mosaics depend on the mosaicking methods, so will the classification results. Any dependence on user choices poses risks of introducing artifacts into the classifications. In particular, the ship tracks and seams between mosaics are usually evident in mosaics and are thus very likely to lead to classification artifacts.



A B

Figure 3. Merged Klein 5500 mosaicked images from Portsmouth Harbour. Mosaic A was made with each line compensated with its own beam-angle compensation (BAC); B with a single BAC. The overlap method was shine through. Size is about 400 m by 1400 m.

SeaClass Training Samples and Resolution

SeaClass can be called from TEI's DelphMap or can be run as a stand-alone program. The main steps in classifying are listed below. Figure 4 illustrates the various lengths that relate to resolution.

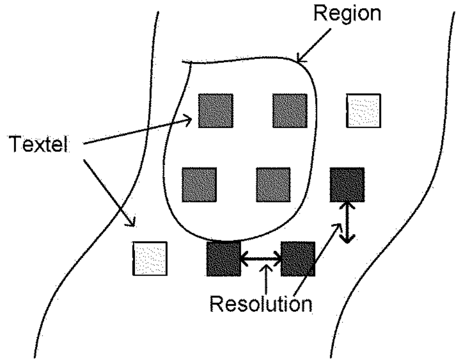


Figure 4. An illustration of the lengths involved in SeaClass classification. Each colour represents a different acoustic class. The squares are the textels whose sizes are always twice of the learning sample size.

1. Select a mosaic image generated in ISIS.
2. For each class the user selects samples representative of the desired class. *Sample size* is the length of a side of a training sample, which must be square. *Sample size* is defined when the first sample is selected. After that, it is not available for change. Statistics are computed for each selected sample, and these data are the input for training the neural network.
3. As the mosaic is classified, it is divided into textels, whose sides are twice as long as the *sample size*. *Resolution* is the step size between two textels (regions that are classified). If the *resolution* is less than the *sample size*, there is overlap between textels. The mosaic image is then divided into textels with the defined *sample size*. Amplitudes from each textel are submitted to the neural network and assigned to the class to which they are most similar statistically. It a textel does not fit into any of the user-defined classes, it is assigned to the unclassified class.
4. After all the textels have been classified, they are grouped into regions. *Minimum Class Area* is the minimum area that must be assigned a single class. Any region with an area less than the specified

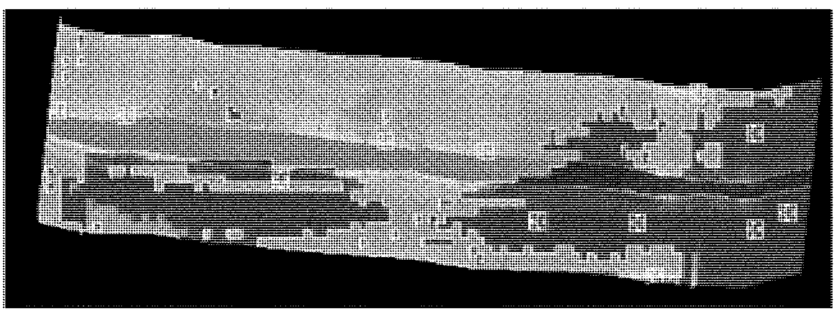


Figure 5: SeaClass classifications of a Reson 8101 mosaic image from Portsmouth Harbour with sample size of 8 m (meaning each textel is 16 x 16 m^2), resolution of 14 m, and minimum class area 10 m^2. Nadir width is 10 m. Yellow and blue regions are the two distinct classes. The yellow squares are the locations of the training samples.

value is suppressed and replaced with the most probable class for the neighbourhood. Any region greater or equal to the minimum class area value will be assigned to a user-defined class or the unclassified class. The user is also asked to input a value for *nadir width*. If the mosaic contains only one line the nadir is not classified directly but rather assigned to the most probable surrounding classification. (Using SeaClass, p. 59).

5. Finally, a DXF file is generated depicting the classified regions.

Figure 5 illustrates the lengths and sizes involved in the process.

SeaClass Classes as Publicized by TEI

Before classifying imagery from Portsmouth harbor, let us look at one of the SeaClass classification examples provided in the DemoFile folder, which comes with the TEI package. One would expect this set of classes, since they are publicized by TEI, to be of high quality and free of artifacts.

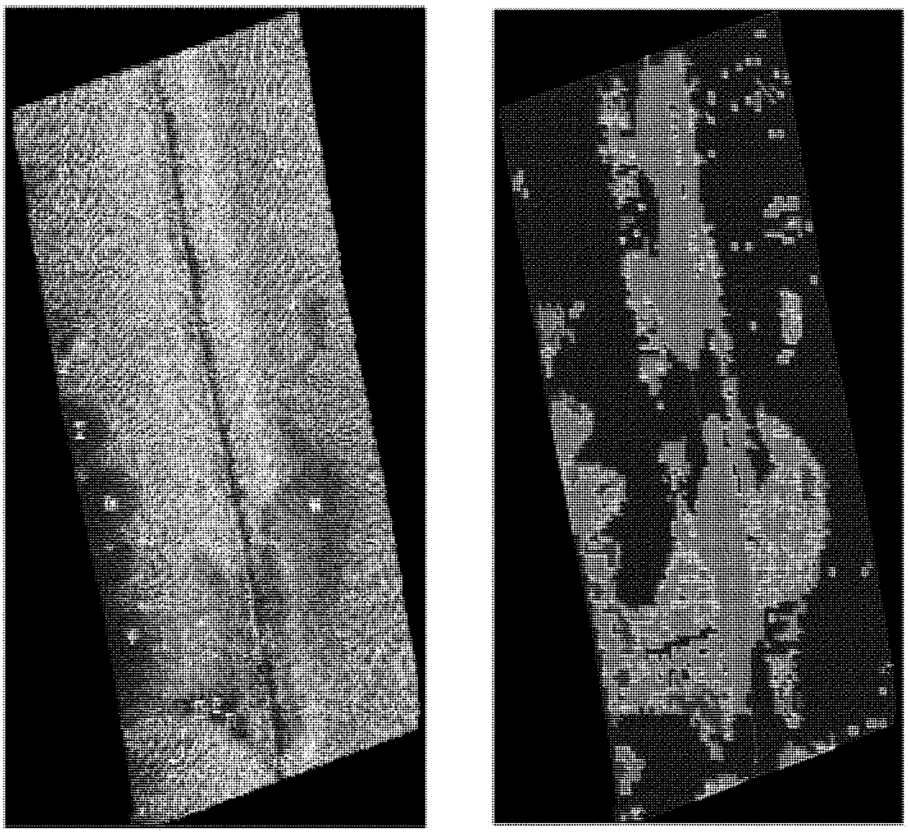
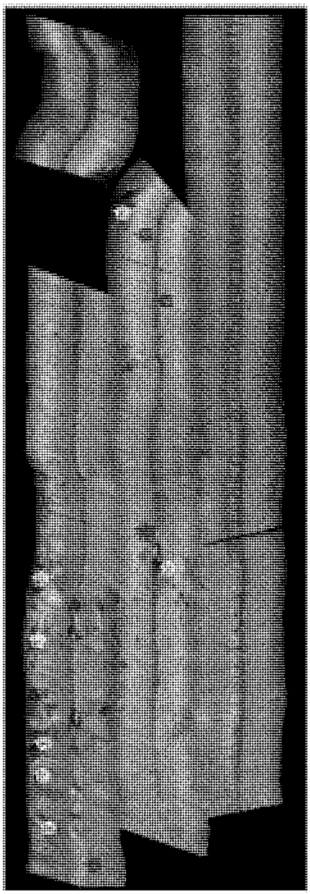


Figure 6. An example processed by TEI. On the left is the mosaiced image, with SeaClass classes on the right. The size is about 200 m by 360 m., Sample size is 32 m, nadir width is 10 m, resolution is 3 2m. and minimum class area is 10 m^2.

As shown in Figure 6, there are three classes. According to TEI literature, blue represents the sand class, purple rock, and khaki mud, while the unclassified region is shown green. In the image, the only area in which borders between sediment types are even close to parallel to the ship track is the dark semicircles to port at large ranges. The mud-sand border all through the northern half, parallel to the ship track, is clearly artifact from inadequate image compensation. The regions classified as mud in those dark semi-circles seem unrealistic and may have the same general cause. This does not serve as a good example of useful or realistic classification.

SeaClass Classes with Individual or Shared Beam-Angle Classifications

We have already seen examples of how the mosaics are affected by compensating each line with its own BAC, or using one BAC for all the lines in the mosaic. Here we explore the effects of that choice on SeaClass classes.



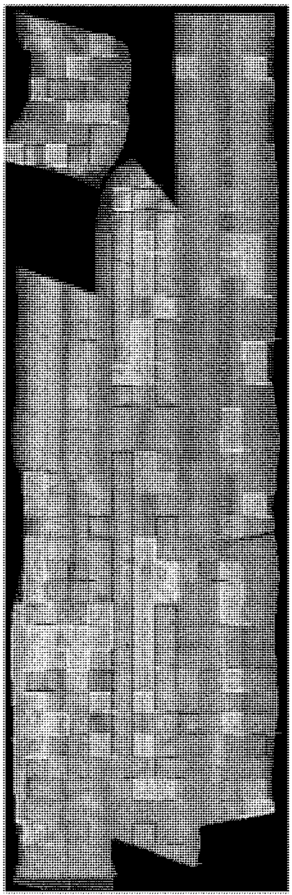


Figure 7. A Klein 5500 mosaic from Portsmouth Harbour, on the left, overlaid with the training samples for the four classes. Compensation was with a single BAC. Yellow samples are from rocky areas, magenta sand waves, blue sandy/gravel areas with higher reflectivity, and red sand area with lower reflectivity. The size is about 400 m by 1400 m.

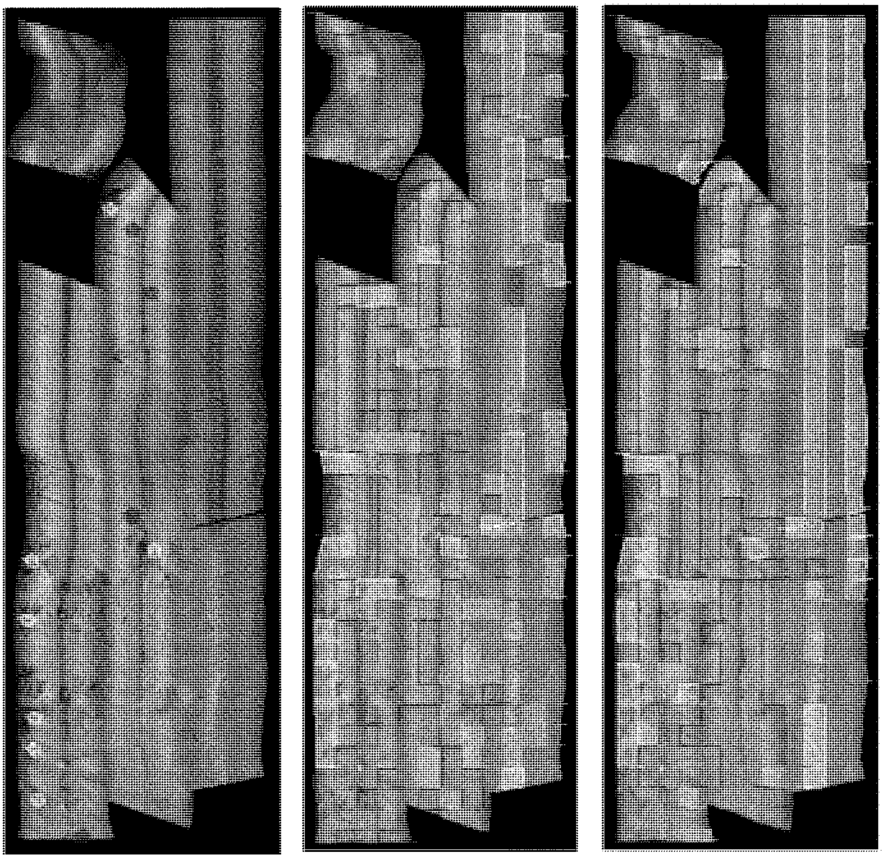


Figure 8. A Klein 5500 mosaic from Portsmouth Harbour, on the left, overlaid with the training samples for the four classes. Each survey line was compensated with its own BAC. Colours are as in Figure 7. The size is about 400 m by 1400 m.

The lines in Figure 7 were compensated with the one BAC file, while in Figure 8 each line was compensated with its own BAC. To the right of the images are SeaClass classifications using the same training samples. While some trends are common to these two classification maps, such as rock to the west and sandy gravel in the south centre, the maps are very different. In both maps there are far too many class borders that are parallel to the ship tracks, due to inadequate compensation and artifacts where survey lines abut. In multi-line mosaics the nadir regions are treated the same as any other region giving, in both maps, many misclassified areas due to the image artifacts at nadir. On the right of Figure 8 is a classification map based on a new set of training samples, optimized for the mosaic in that figure. All the same criticisms apply, perhaps even more so. (In all these examples the learning sample size was 8 m, resolution was 32 m, and the minimum class area was 10 m^2.)

Effects of Selection of Learning Samples

In SeaClass, selecting the training samples is an important step, since it defines the classes. Here we report an experiment in which one more training sample is added to the 21 samples in the example shown in Figure 7. The 22nd sample, a sand-wave sample, was put in the southern part of the sand wave field. The class boundaries change a lot with this one additional sample, and the flaws and artifacts are not reduced. Another striking difference is the resolution. Even though it looks like the minimum class area has been lowered for Figure 9, the smallest class area in that figure is still bigger than 10 m^2, meaning that the resolution as displayed in both figures was determined by SeaClass, not by the user.

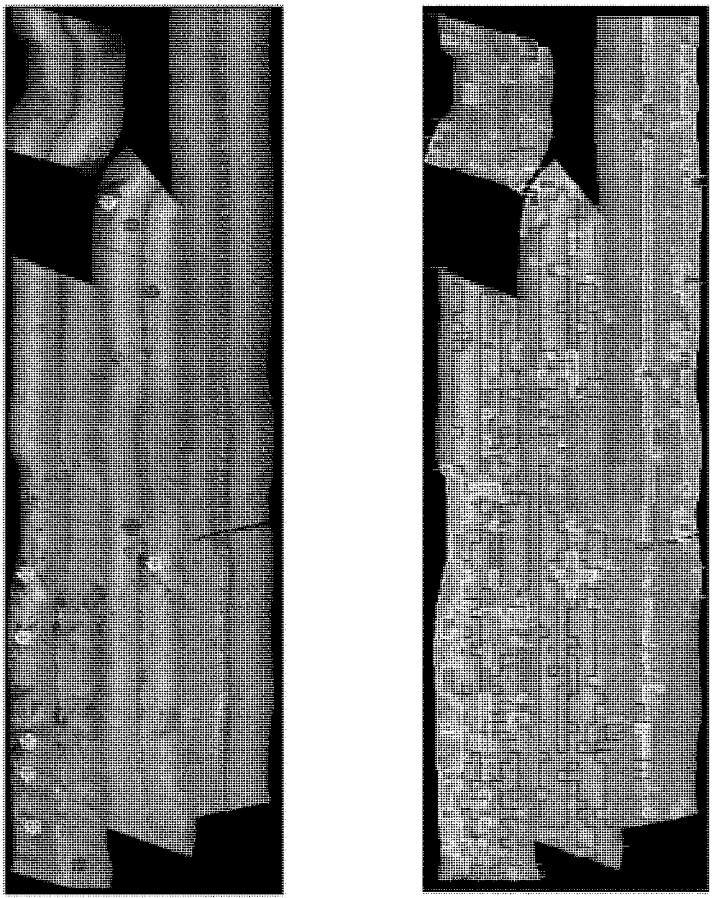


Figure 9. To the left is the same mosaic as in Figure 7 with the same training samples plus one additional magenta training sample. The resulting classification from SeaClass, on the right, can be compared with the right-hand side of Figure 7.

Effects of Textel Size, Resolution, and Minimum Class Areas

In SeaClass, textel size, resolution, and minimum class area also affect the classification results markedly. For the same sonar line, even though the same set of learning samples is used, combinations of different lengths and areas lead to many interesting classifications. The learning sample size used here was 8 m. The yellow hollow squares represent the learning samples (all the training samples are shown yellow, even though three were designated as being in the first class and four in the second class).

The SeaClass manual does not discuss overlap classes; nevertheless most of the top figure appears to

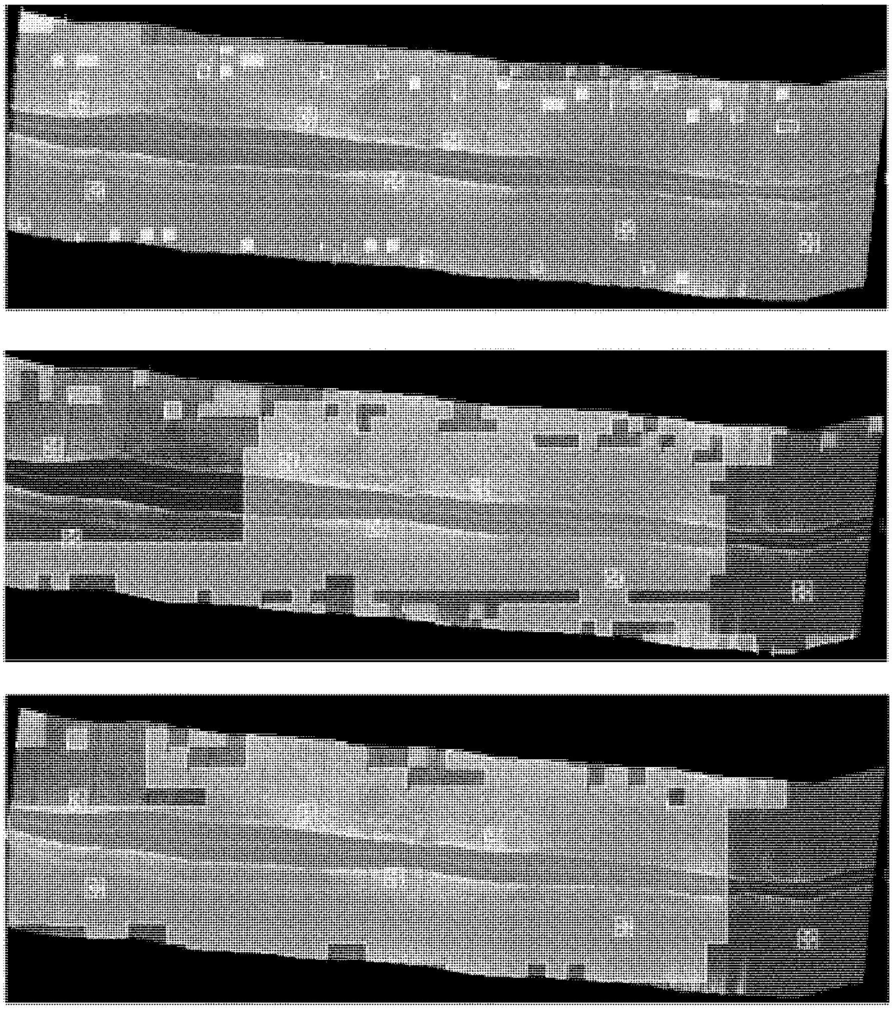


Figure 10. SeaClass classes with resolution, from top to bottom, of 10 m, 14 m, and 18 m. Nadir width was 10 m and minimum class area 10 m^2. Blue and yellow represent classes 1 and 2. In the top map green appears to be the overlap of the blue and yellow classes. The sites of the seven training samples appear as open squares.

have been classified as overlap. Unclassified areas would have been cyan. Comparing the lower two maps, we see that the designation of many areas has been changed, as well as the resolution.

Comparing SeaClass Results with High-Resolution Bathymetry

Detailed bathymetry plays little, if any, role in SeaClass processes. Because detailed bathymetry is often easy to interpret, overlaying classes on sun-illuminated bathymetry can show how well the classes correspond to ground truth. This section describes two such comparisons. Both used the Reson mosaic shown in Figure 2A, with training samples in four classes. With the help of the detailed bathymetry, these could be selected and positioned with confidence. The resulting classes do not correlate well with sediment types. The yellow class, for example, is present in most rocky areas as one would expect, but occurs often elsewhere. The magenta class, which should be sand waves, occurs almost everywhere except on the sand waves. The two sand classes are intermingled unrealistically and occur on the rocks as well as on sand.

Class	**Colour**	**Figure**
Yellow	Rock	11C, 12C
Blue	Sand, less reflectivity	11D, 12D
Magenta	Sand waves	11E, 12E
Red	Sand/gravel	11F, 12F

Table 1. SeaClass Classes in the Approaches to Portsmouth Harbor

In an attempt to improve these results, we used a different training set. These class maps are in Figure 12[1], which is organized the same way as Figure 11. While the classes are more contiguous in the second example, the correlation with sediment type was not improved.

[1] In Figure 11, the training samples were coloured manually to indicate the class of which they were samples. This was not done in preparing Figure 12. Those class assignments can be inferred from the sediment distribution in the high-resolution bathymetry. In both figures the learning sample size was 8 m, resolution was 14 m, and minimum class area was 10 m^2.

Figures 11-15 follow the text of this report.

MULTIVIEW AND SIDEVIEW PROCESSES AND RESULTS

At this point we switch from classifications by TEI SeaClass to classifications by QTC MULTIVIEW and QTC SIDEVIEW. After some introductory material, we go directly to class maps. There is no need to examine effects of various user selections of mosaicking methods or compensation methods or training samples. With the QTC process, compensation is done in the background, with no user intervention, following a procedure for which a patent application has been filed. QTC classifies individual survey lines, merging the classification results, rather than mosaicking images. As to training sets, QTC uses a completely different approach in which the data set is divided into its natural classes, depending on the nature of the observations. This unsupervised classification does not use a training set.

QTC MULTIVIEW provides automated classification of multibeam sonar data, and QTC SIDEVIEW classifies sidescan images. They generate statistical features for patches of sea floor from the backscatter amplitudes, using a suite of algorithms that includes the GLCM features used by SeaClass and many others. The user does not select learning samples, thus does not require previous knowledge of the area. Instead, multivariate statistical processing and k-means clustering isolates the best features to capture the data sets diversity and allows the data itself to segment the area into its natural classes. Each class is reasonably homogeneous in its acoustic character, and thus represents a homogeneous seabed type.

These packages include extensive quality control. MULTIVIEW, for example, uses the depth data that was collected at the same time as the backscatter to mask beams with unrealistic depths, because the backscatter from those beams is probably from the fish, bubbles, or whatever caused the anomalous depth. Beams may also be masked based on depression angle or range. Pixels corresponding to the masked beams also become masked. In SIDEVIEW, pixels may be masked for various reasons including being affected by a surface return and being at a range that places them on land. Just as with QTC's single-beam classification products, it has been shown repeatedly that careful quality control is a prerequisite to reliable classification.

Compensation in MULTIVIEW and SIDEVIEW uses a patented approach in which statistics on backscatter amplitudes over most of the dataset are collected, and all amplitudes are then compensated using the resulting tables. In Multiview, where co-located depth data are available, true grazing angles are computed for each beam footprint. Grazing angle is used as an independent variable in the statistical tables because backscatter depends so heavily on it. The compensation process in the QTC products is in the background and requires no user action. Compensation in DelphMap is also based on correcting for range and angle, but uses depression angle, not grazing angle. Perhaps DelphMap does permit it, but we were not able to collect data from more than one line before compensation nor were we able to get sensible results with depression angle-based compensation.

MULTIVIEW and SIDEVIEW classify line by line, not using mosaics. This avoids the sub-sampling that is inherent to any mosaicking process, avoids the artifacts that arise at the borders between lines, and allows the sonar geometry that was used to collect each pixel (range and angles) to be used for compensation and for quality control.

MULTIVIEW Classifications of Reson Multibeam Data

The MULTIVIEW classification process is not described here; instead the reader is referred to the manual and to recent QTC publications, particularly the paper from the IEEE Oceans '03 conference. Figure 13 shows MULTIVIEW classes for the same area used for the SeaClass classifications. The MULTIVIEW user chooses the rectangle size (129x17 pixels in this case), and the number of clusters to split to in the unsupervised classification process. This Figure 13 shows the classes after five splits (six classes). Each dot represents a single classification result, not interpolated or smoothed, and they are overlaid on the same shaded relief. Class descriptions come not from the acoustics, but rather from interpreting the detailed bathymetry and from grab samples. Magenta represents sand waves; red represents rocks and blue represents gravelly sand. Yellow and cyan are other combinations of sand and gravel, acoustically distinct from each other and from the blue class. The green class appears to be a small distinct rock class.

The map of all six classes, in Figure 13, shows clear range dependence over the sand waves, between the magenta and yellow classes. While this could be an artifact of the MULTIVIEW process, there is another explanation. In sonar images, sand waves seen from above look very different from those seen at small grazing angles, that is, at long sidescan ranges, because shadows are formed only at small grazing angles. The yellow class appears to be sand without shadows, sand fine enough that sand waves will form in the currents typical of this area.

Interpolating Classes

QTC CLAMS™ is a new QTC product for processing feature and class data that are distributed geographically. One of the tools in CLAMS is categorical interpolation, which is a smoothing and interpolating method for class data. Another assigns colours to classes based on their positions in feature space, which is helpful in that clusters that are neighbours in Q space and take on similar colours are acoustically similar as well.

Figures 14 and 15 show MULTIVIEW, SIDEVIEW, and QTC IMPACT classes from the approaches to Portsmouth Harbor. The actual area was about twice the size of that in Figures 11-13, and includes the area in the southwest part. Figure 14 shows six classes in similarity colours, not interpolated, and Figure 15 shows interpolated classes. Both are overlaid on sun-illuminated bathymetry, which gives strong guidance to class interpretations, as before. The grain-size data that were used in assigning geophysical labels to classes is shown in Figure 14. Table 2 summarizes these assignments and gives the area of each class.

The MULTIVIEW classes in Figure 15 pass every quality test. There is no evidence of range artifacts. The red class, rock, covers all the rocky areas, and only the rocky areas. The olive area is sandy gravel, prevalent in the current-dominated areas except in the sand waves. The blue classes are various sand classes, perhaps with the deeper blue colours indicating larger grain sizes. Smaller grains are found to the east, where the water is shallower and, because of the row of rocks, there is less current.

The SIDEVIEW classes, from data recorded by a Klein 5500, have much the same character as the MULTIVIEW classes. The sand waves are not as well resolved, as discussed above. Different grain sizes to the east can be seen in these classes also.

The IMPACT classes, from echoes generated by a Suzuki sounder at 200 kHz also have some of the same characteristics. Detailed discussion of these classes is beyond the scope of this report.

	Area (km^2)			Description		
Class Colour	Reson	Klein	Suzuki	Reson	Klein	Suzuki
Olive	1.34	1.39	1.64	gS, gmS	gS, sG	gS, sG
Deep azure	0.28	0.13	0.19	S	S	sG, S, R
Red brown	0.21	0.16	0.14	R	R	R
Light blue green	0.18	0.13	0.30	S	S, mS	S, sG, gS
Baby blue	0.12	0.03	0.08	mS, gS	S	gS
Desert Blue	0.05	0.08	0.07	R	S, R	R

Notes: Survey areas were not identical; m = mud, s = sand, g = gravel, r = rock, upper case denotes primary constituent.

Table 2. Descriptions and areas of six QTC classes. The Reson images were processed and classified in QTC Multiview, the Klein images in QTC Sideview, and the Suzuki echoes in QTC Impact.

DISCUSSION

Supervised and Unsupervised Classification

Although SeaClass and the QTC products, MULTIVIEW and SIDEVIEW, all classify the seabed, the fundamental classification methods differ.

SeaClass does only supervised classification. The user supervises with knowledge of the seabed in the survey area, knowing how many classes of sediment there are, what they are, and where good samples of each are. Examples of each type are presented to SeaClass as the training data set. SeaClass then maps the survey area by deciding which class each patch of the area is closest to, and assigning the patch to that class. Another allowed result is no assignment.

MULTIVIEW and SIDEVIEW do unsupervised classification, primarily. The survey area is segmented into regions that are acoustically homogeneous within some bounds, and acoustically distinct from the other regions. This process is also called provincing. Labels are attached to the regions later based, as with supervised classification, on non-acoustic data from photographs, divers, grab samples or the like. This ground truth can be gathered efficiently after unsupervised classification by selecting sites that are representative of the acoustic classes, away from their borders. Unsupervised classification is more complex, and the resulting classes may require more interpretation. However it is better suited to complex seabeds, particularly those involving mixtures of the types of classes one would use for supervised classification.

MULTIVIEW and SIDEVIEW have the ability to extend the process to new areas. Each unsupervised classification process yields a catalogue, which defines the algorithms that control the segmentation. Applying the catalogue to the data used for unsupervised classification reproduces that segmentation. Applying it to new data segments those new regions consistently. SeaClass operates similarly, provided the user selects consistent compensation and mosaicking methods and the images were recorded without changing any sonar settings.

Direct sediment identification is not possible based on acoustics alone. Non-acoustic data are required if one needs to attach physical labels, such as rock or silt, to acoustic classes. This type of knowledge of the sediments in the area is required for supervised classification. With unsupervised classification it is required only if physical labels are required. There are applications, such as some studies of habitat, in which correlations between acoustic class and biological data will be the final result, with no need to describe grain size or other characteristics of the bottom.

Using Mosaics Handicaps Classification

The image presented to SeaClass is a geo-referenced mosaic of one or more survey lines. A mosaic is a resampled, and usually down-sampled, version of the image recorded at sea. Resampling changes the image statistics. Filling the region under the ship in a geographically correct way usually makes that region appear different from its neighbours. In multi-line mosaics, borders where lines meet are also usually evident. Treating these overlap regions with shine-through (showing the largest amplitude from any line) distorts the image statistics. The purpose of SeaClass is to classify the sediments based on the statistics of their backscatter – clearly it could be more successful if it did not have to contend with these distortions and artifacts.

MULTIVIEW and SIDEVIEW operate on the image as recorded at sea, without resampling or introduced artifacts. Their processes exploit the extra information available at this stage, particularly the range to each pixel, the associated grazing and depression angles, and (in MULTIVIEW) the quality of the parent beam that gave rise to that pixel.

Number of features

Both products derive statistical features from rectangular image patches, and then use these features, rather than the image amplitudes themselves, for classification. SeaClass uses 44 features derived from

Gray-level Co-occurrence Matrices (GLCM). This can be broken down as 11 features with two step sizes taken both along and across-track. MULTIVIEW and SIDEVIEW use 132 features, of which 63 are the same or similar GLCM features. The other 64 are based on histogram and quantile analysis, on features proposed by Pace, on the power spectrum, and on fractal dimension (fractal dimension features were not active in the work described here). The wider range of features captures more image details.

Artifacts due to Range Dependence

Any border between classes that is parallel to the ship's track is suspect. Class borders are occasionally oriented this way, of course, but should this happen often one should suspect that the images are inadequately compensated and the class assignments are being controlled by artifacts. Most of the SeaClass images in this report have far too many class borders parallel to the ship track. A prime example is Fig. 5, which is a Triton Elics publicity file, thus presumably one of their best results. This image has low amplitude under the ship, rising to a maximum at about 25% of maximum range, then gradually declining. These variations dominate the class map. For example, none of the yellow class is at less than 12% of maximum range and in the upper half of the image hardly any khaki class is at more than 30% of maximum range. The fact that Triton Elics selected this example for publicity implies that they are unaware that artifacts are prominent in SeaClass maps.

MULTIVIEW and SIDEVIEW classes are not free of range dependence, but it has only a modest influence on class assignments. Achieving this requires careful quality control and sophisticated image compensation, and both are present in the QTC products.

Nadir region

The nadir region in sonar images usually has far higher reflectivity than elsewhere. No sidescan sonar gives useful nadir images because sidescan transmit little power in that direction. With multibeam images, SeaClass does not attempt to classify the nadir region to within a width set by the user. MULTIVIEW can usually classify through the nadir region.

User choices

The SeaClass user is required to choose regions whose sediments are the classes sought, as described above. Back in DelphMap, there is detailed user control of the compensation process, requiring choices of method, of which line(s) to base the compensation function on, and of whether to compensate individual lines or across the data set. In SeaClass, he or she has to choose the number of samples for training, the sample size, the resolution, and the minimum class area. Some of the results in this illustrate that the resulting class maps can be quite sensitive to some of these choices.

In MULTIVIEW and SIDEVIEW, the user has to choose the rectangle size and has to control the cluster process. Provided the rectangle sizes are reasonable, the classes are not very sensitive to that choice. Several statistical indicators are provided to guide the user through the cluster process.

Direct and Interpolated Classes

The only result available from SeaClass is after averaging to the minimum class area. MULTIVIEW and SIDEVIEW provide the classification result for every patch. These can be averaged or interpolated by various means, including categorical interpolation and Caris tiling. The direct classification results are useful in several ways, of which the most important is assessing the quality of the classes. Class consistency in overlap regions, for example, can be studied only before interpolation or smoothing.

CONCLUSIONS

This paper is not a comparative study of SeaClass against MULTIVIEW and SIDEVIEW. The classification processes are quite different and the results are presented in different ways. No rankings are presented here. In any case, given the affiliation of the authors, there would be no credibility to our rankings. Instead it is left to the reader to compare the classification results presented here and draw conclusions.

Consistency between SeaClass results and ground truth is very dependent on the selection of the training samples. It is appropriate, therefore, to mention the qualifications of the operator (B.O.) who selected the samples. She was a senior undergraduate in a Mathematics and Physics degree program. She had no formal training in sonar, but had worked with sidescan imagery and high-resolution bathymetry at Quester Tangent for two months, during which time she had demonstrated a good grasp of sonar principles and image interpretation. Her instructions were to use her knowledge to select the best possible samples. In other words, we could have guaranteed poor SeaClass results by bad selection of training samples, but instead attempted to do a fair assessment by assigning the selection to a short-term employee (little conflict of interest) who had a typical amount of sonar experience.

Artifacts due to range dependence are key indicators of the quality of classification results. Occasionally borders between classes are parallel to the ship track, but only occasionally. Inadequate compensation of image amplitudes for beam pattern, grazing angle, and related effects very often lead to artifact class borders at near-constant ranges. In our opinion, the first test that should be applied in assessing the quality of multibeam acoustic classifications is to examine the classification map for borders parallel to the ship track – finding more than an occasional parallel border indicates unrealistic classes.

A summary of the salient differences between QTC classification processes and those of SeaClass is given in Table 3.

Topic	QTC MULTIVIEW	QTC SIDEVIEW	TEI SeaClass
Range artifacts	Rare	Rare unless sharp relief	Frequent
Source of compensation data	Entire data set or multiple lines	Entire data set or multiple lines	Single survey line
Use grazing angle in compensation?	Yes. Bathymetry data and beam angles are used to find grazing angle for each beam footprint.	No. Always use angle at sonar.	No. Optional to use angle at sonar.
Classify mosaics or lines?	Single lines (batch processing is available)	Single lines (batch processing is available)	Mosaics. User choices in overlap regions affect classes. Artifacts from mosaicking process usually affect classes.
Constrain area to be classified	By quality of bathymetry data, by sonar range, by beam angle, by grazing angle, by depth, by ping number, by time of day	By excluding regions, by sonar range, by angle at the sonar, by depth, by ping number, by time of day	By width of nadir region
Able to mask surface return?	Not applicable	Yes	No
Supervised classification?	Yes	Yes	Yes. User must select many learning samples, and classes depend heavily on these selections.
Unsupervised classification?	Yes	Yes	No
Sizes user must choose	Height and width of sub-image	Height and width of sub-image	Size of learning samples, resolution, minimum class area, nadir width. (First three must be square.)
Sensitivity of class assignments to user choices of sizes	Modest	Modest	High
Classify different pulse lengths together*?	No	No	Yes
Interpolates near nadir?	Classifies entire image within constraints	Classifies entire image within constraints	Interpolates with mosaic of single line. Classifies entire area of multi-line mosaics, often giving artifacts.
Resamples amplitudes before classification?	Only if needed to put all pings on common sampling rate. If this occurs, entire ping is resampled to constant rate.	Only if needed to put all pings on common sampling rate. If this occurs, entire ping is resampled to constant rate.	Always, and to a sampling rate that varies with range, thus introducing further range dependence into the amplitude statistics.
User decisions for compensation	None – fully automatic	None – fully automatic	TVG darkness, TVG strength, TVG contrast, use beam angle or not,
Allow no assignment?	No, but confidence and probability statistics are provided.	No, but confidence and probability statistics are provided	Yes, some regions are sometimes not classified.
Number of features	132	132	44
Number of types of features	5. Basic, Pace, GLCM, power spectrum, fractal.	5. Basic, Pace, GLCM, power spectrum, fractal.	1. GLCM
Full set of classes output?	Yes	Yes	No. Final result has been averaged to minimum class area.

* Changing the pulse length changes the insonified area and thus the statistical nature of the backscatter. This can result in images from the same sediment at different pulse lengths being artificially split among several classes.

Table 3. Comparing some salient features of QTC MULTIVIEW, QTC SIDEVIEW, and TEI SeaClass.

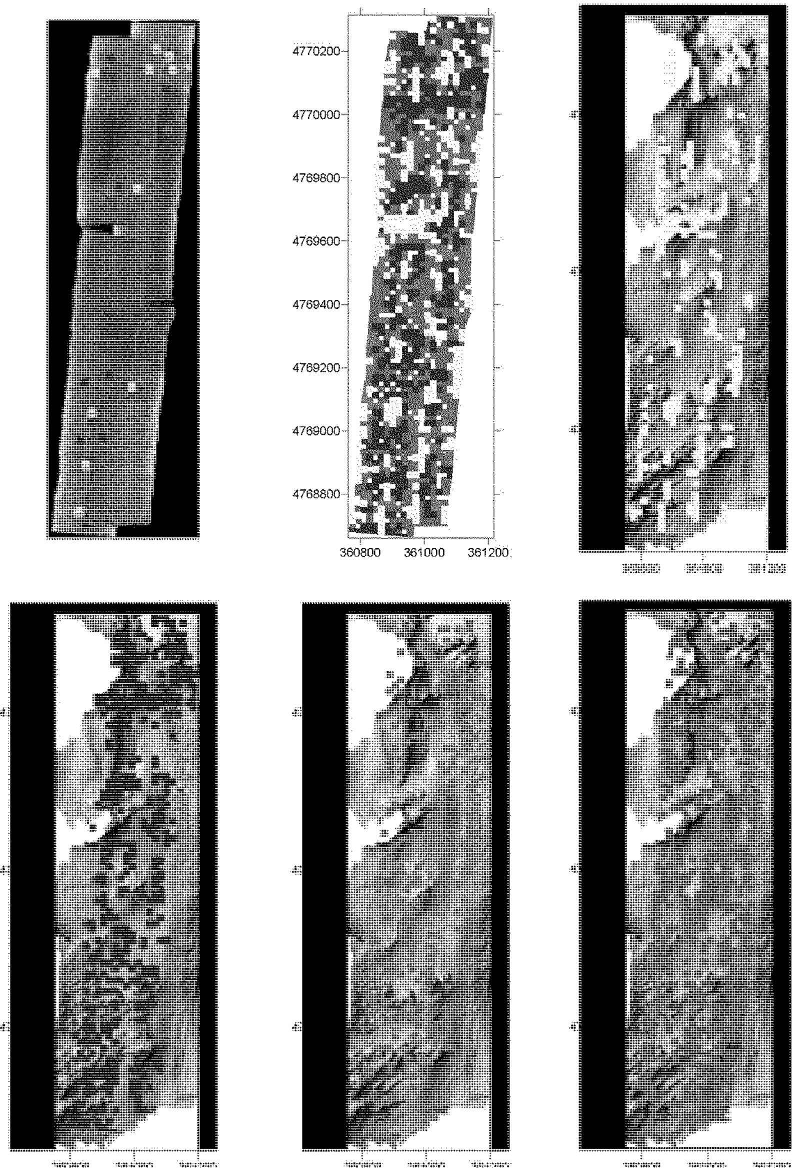


Figure 11. Training samples for four classes on a Reson mosaic of Portsmouth Harbor, the SeaClass class map, and a map of each of the four classes overlaid on high-resolution bathymetry.

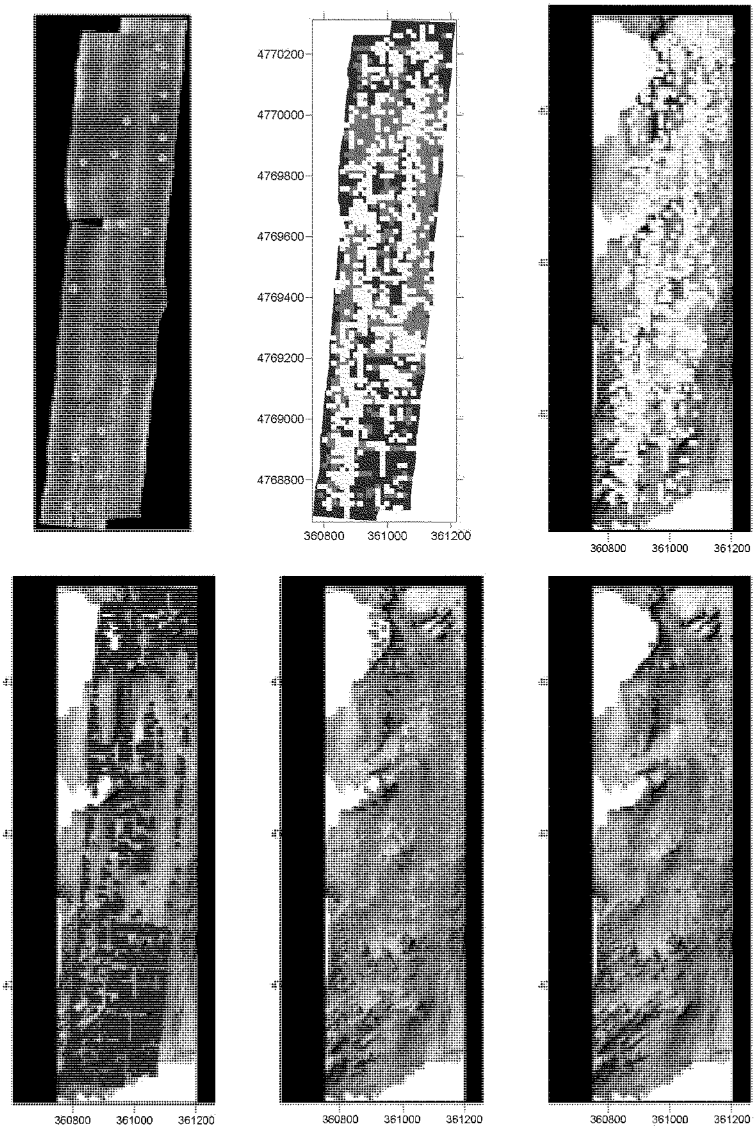


Figure 12. Training samples for four classes on a Reson mosaic of Portsmouth Harbor, the SeaClass class map, and a map of each of the four classes overlaid on high-resolution bathymetry. To make Figures 11 and 12, two different training sets were used.

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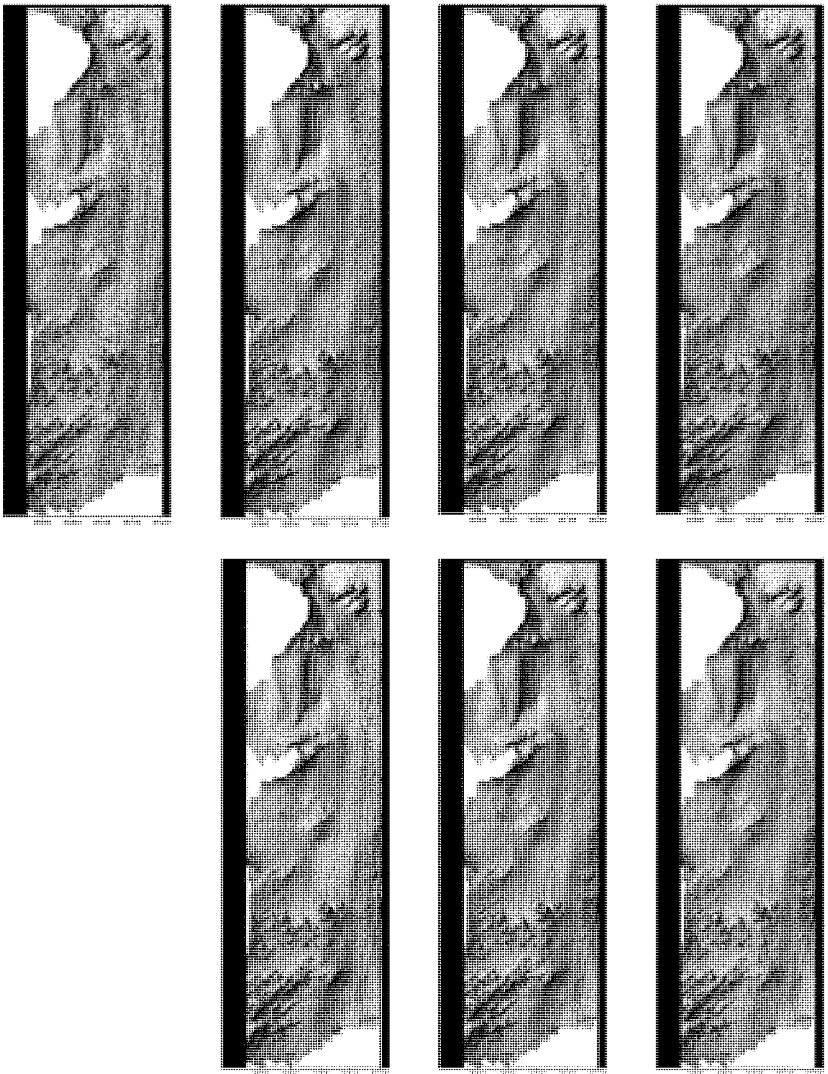


Figure 14. QTC MULTIVIEW classes for the same area shown in Figures 12 and 13. Unsupervised classification through clustering gave six classes, shown overlaid on overlaid on high-resolution bathymetry. These classes are not interpolated or smoothed.

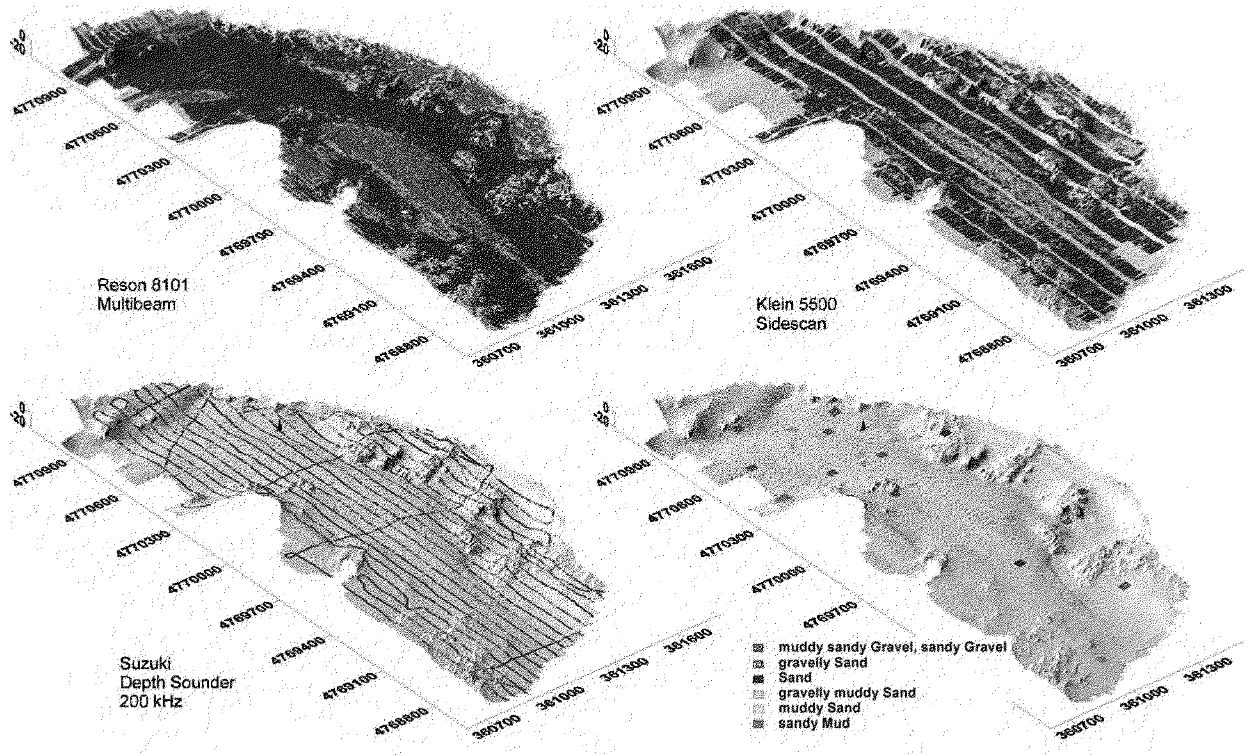


Figure 14. 2 Classes from QTC MULTIVIEW, SIDEVIEW and IMPACT; each based on data from the multibeam, sidescan, and single-beam sounder named. The classes are shown as overlays on artificially illuminated bathymetry derived from the Reson depths. Each data set was classified unsupervised, splitting to six classes. The Reson colours are the arbitrary assignments given by the cluster process. For the Klein and Suzuki maps the colours were interchanged to emphasise the consistency with the Reson classes. Bottom right are grain sizes as given in the Common Data Set. Vertical exaggeration is 3 times.

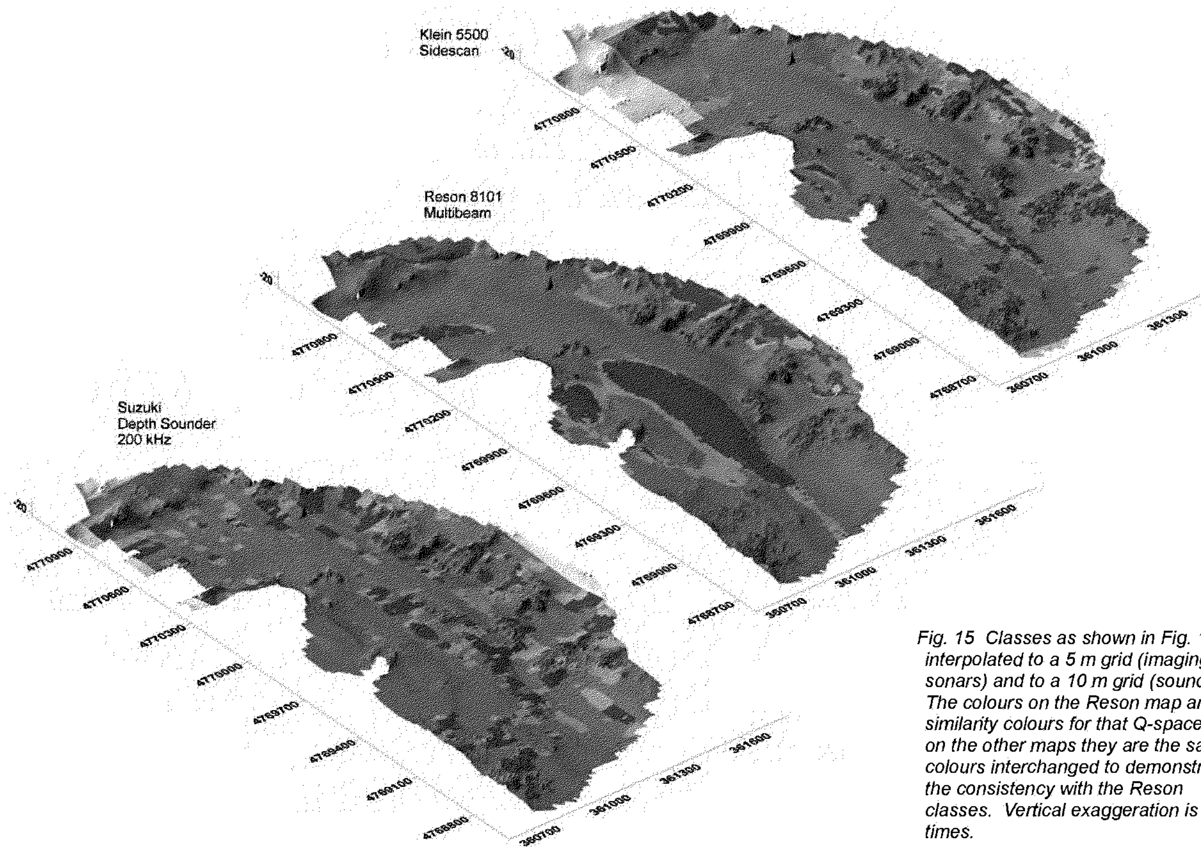
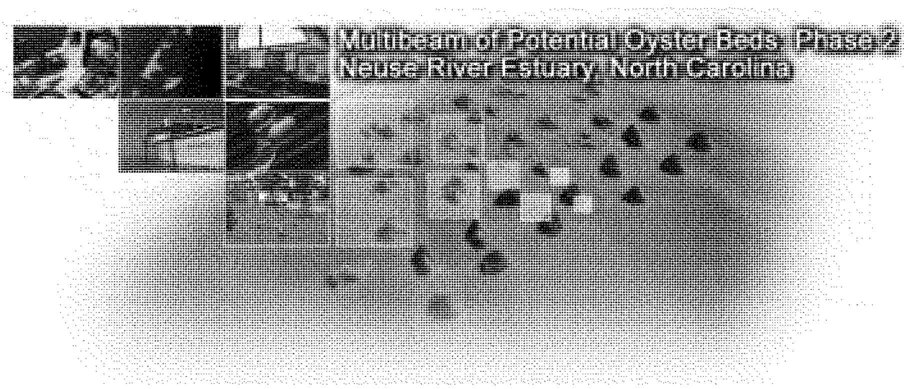


Fig. 15 Classes as shown in Fig. 14 interpolated to a 5 m grid (imaging sonars) and to a 10 m grid (sounder). The colours on the Reson map are similarity colours for that Q-space, and on the other maps they are the same colours interchanged to demonstrate the consistency with the Reson classes. Vertical exaggeration is 3 times.

Multibeam of Potential Oyster Beds: Phase 2, Neuse River Estuary, North Carolina



Survey Report

Project No. 140484.000.6480. GEO
Contract No. 140484 NC DENR

Submitted by:

GREENHORNE & O'MARA
CONSULTING ENGINEERS

With Subconsultant:

geodynamics
COMPLEX COASTAL CHANGE MADE CLEAR

TABLE OF CONTENTS

Executive Summary

Geodynamics LLC was contracted by the USACE Wilmington District through Greenhorne & O'Mara Inc. on April 12, 2007 to perform a detailed bathymetric survey (phase 2) of all the zones identified as potential oyster reefs from the August 2006 side-scan sonar surveys performed by Geodynamics (phase 1). The June 4-9 and July 22-25, 2007 multibeam surveys employed a Simrad EM3002 shallow water multibeam sonar system to collect spatially dense bathymetric data across all areas of the seafloor identified as potential oyster reefs in Phase 1 for the development of an accurate surface model as described in the official Scope of Work (Appendix A). The system runs at 300 kHz and is compensated for motion and heading with an Applanix POS MV 320 v4 inertial navigation system. Sensor offsets have been surveyed to close within 1 millimeter by the National Geodetic Survey. The EM3002 produces a swath of sonar approximately 4 times the water depth and collects approximately 400 soundings per square meter. Sound velocity was calculated in real-time at the transducer head with an Applied Microsystems miniSV and profile data was collected with an Applied Microsystems SV Barcheck profiler. Published accuracies on each of the systems can be found in Appendix C.

Section 4 of the final USACE SOW stipulated that Post Process Kinematic (PPK) elevations be used for "tidal" offsets and that Differential GPS (DGPS) be used for horizontal positioning due to lack of complete Real-Time Kinematic GPS (RTK-GPS) range. Multibeam data positioning and water elevation data made use of a Trimble DGPS beacon integrated with the Applanix POS MV 320 inertial navigation system. RTCM corrections where received from the US Coast Guard DGPS broadcast station 771 located in New Bern. Water surface elevations were calculated using a Trimble 5700 GPS receiver mounted directly over the transducer collecting Post Process Kinematic (PPK) data every 5 seconds. Post processed elevation data was generated from the National Geodetic Survey Continuing Operating Station (CORS) NBR 6.

Rigorous calibration tests, including a detailed patch test, were performed on the multibeam instrumentation prior to the start of data acquisition. A sensor offset survey was performed by the National Geodetic Survey and all elevation and orientation loops closed at 1 millimeter. Multibeam swath bathymetry data was processed in Caris and QA/QC measures calculated.

Survey Preparation

Survey Area

The Neuse River multibeam survey was comprised of 572 planned survey lines spaced 75' apart to obtain 100% seafloor coverage (Figure 1). The total area of the survey encompassed 3.42 square miles with a total of 240 line miles.

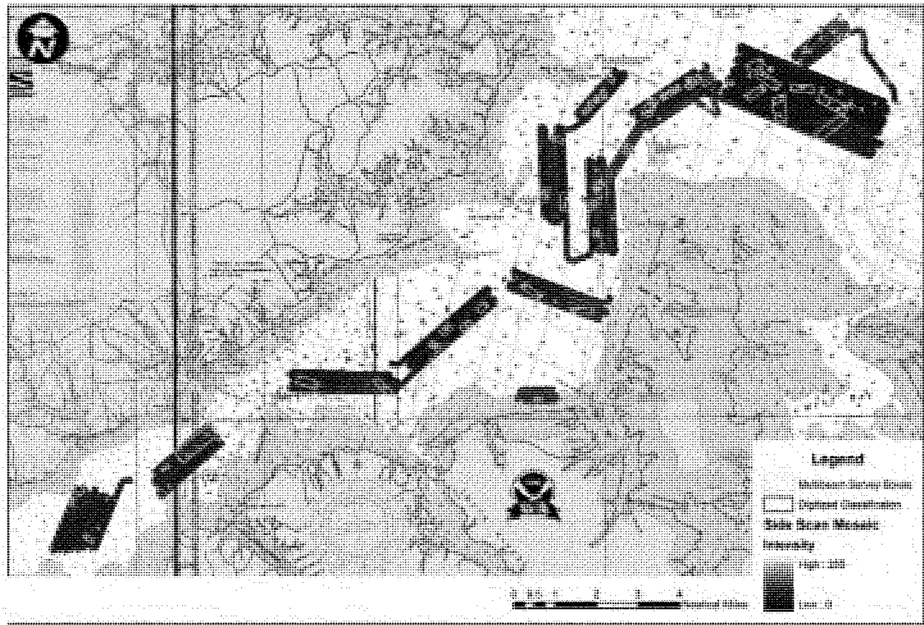


Figure 1. Map of the Phase 1 sidescan sonar data and Phase 2 multibeam survey areas.

Survey Positioning & Elevation

DGPS Positioning

Differential GPS was chosen as the positioning source by the USACE Wilmington District due to the large survey extents and lack of control within the survey area and logistics / cost of using real-time solutions from RTK-GPS. DGPS corrections were used from US Coast Guard DGPS broadcast station no. 771 (Table 1). Corrections were supplied to the Applanix POS MV 320 inertial navigation system through a Trimble DGPS beacon located on the starboard side of the R/V 4-Points. Published real-time accuracies by the USCG are 1-10 meters XY.

New Bern, NC Coast Guard Differential Global Positioning Corrections Broadcast Station 771

RBn Antenna Location:	35 10.50N, 077 02.92W
REFSTA Ant Location (A):	35 10.50874N, 077 03.00149W
REFSTA Ant Location (B):	35 10.49830N, 077 02.98893W
REFSTA Ant Location (B):	35 10.49830N, 077 02.98893W
REFSTA RTCM SC-104 ID (A):	196
REFSTA RTCM SC-104 ID (B):	197
Broadcast Site ID:	771
Transmission Frequency:	294 KHZ

Transmission Rate:	100 BPS
Signal Strength:	75uV at 259KM

Table 1. Detailed information on USCG DGPS broadcast station 771.

PPK Elevations

Although our group uses RTK-GPS somewhat exclusively for hydrographic surveying the lack of survey control and distance between survey zones precluded its use for the Neuse River multibeam surveys. In order to correct multibeam soundings for sea-surface elevation change we used a technique called Post Process Kinematic (PPK). This technique allows for the calculation of long baseline solutions without real-time corrections supplied via UHF radio.

Two independent GPS receivers collect observed sets of carrier phase data during the same time period (epoch) and are processed together to create baselines between their relative positions. In this case we set a land-based station on NGS benchmark *PAM 43* a 2nd order vertical mark with scaled horizontal positioning (Figure 2). The vessel rover is set to the same configuration and logs simultaneously. The Known Point Initialization method allows Trimble Geomatics Office to use both the collected data and the WGS-84

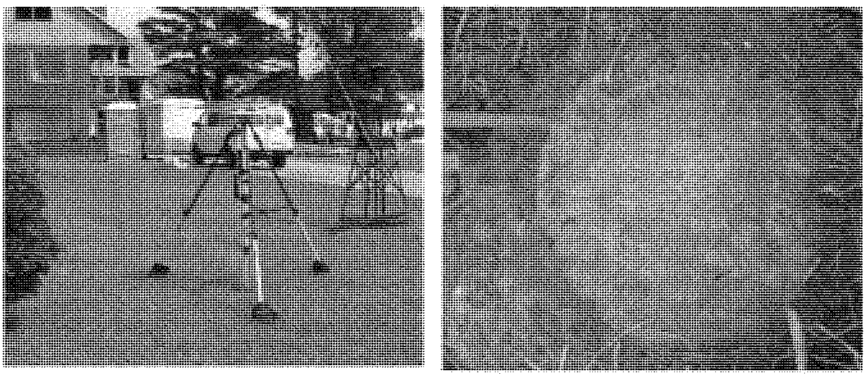


Figure 2. Neuse River PPK setup on NGS mark Pam 43.

baseline solution to determine the integer ambiguities which is then applied to all subsequent occupations. Base and rover GPS observations are downloaded into Trimble Geomatics Office. Once the files logged at each location are imported, baselines are processed using an automated procedure. As a double check this same procedure was completed using the National Geodetic Survey Continuing Operating Station (CORS) NBR 6 located in New Bern which was ultimately used for the corrections.

Baseline solutions are then checked for errors and accuracy and the final PPK points are exported. The data is then formatted and averaged with a running time average in order to remove wave driven elevation changed and provide the overall water level change. Results of the PPK survey show that elevation data used as a "tide" file for multibeam data processing are within +/- 0.07' average accuracy. It is important to note that heave calculations from the POS can be slightly degraded with this method since the POS MV is not "tightly coupled" with real-time kinematic solutions. There are a few areas that we observed small motion artifacts in the less than 10cm range. See metadata for further info.

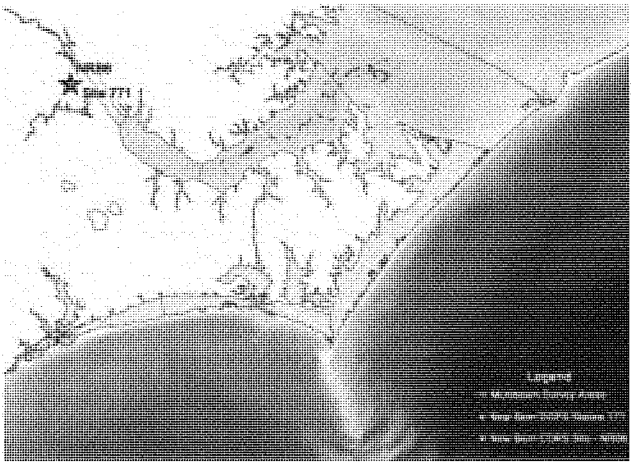


Figure 3. Neuse River PPK and DGPS correction stations located in New Bern, NC.

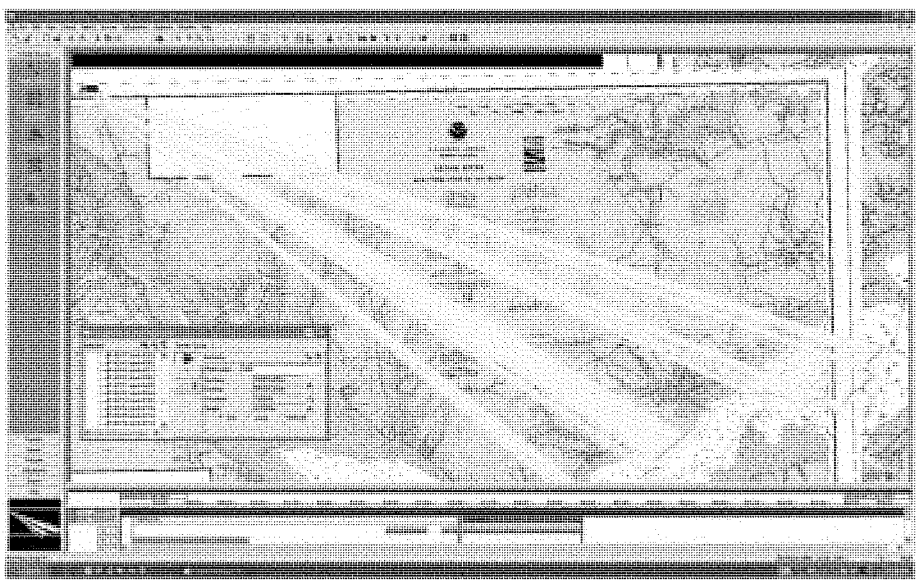


Figure 4. TGO screen grab showing processed baseline vectors.

Modification of the Original Survey Design

A couple of field modifications to the original survey design had to be made in order to stay within the budgeted survey time of 64 hours. Also, the project was originally designed and estimated around the fall / winter when much longer weather windows are observed so only a single mob / demob was budgeted. In an attempt to acquire the data within the fastest possible time Geodynamics took advantage of two separate weather windows whose extra costs have been directly absorbed by Geodynamics.

Three types of modifications where made. 1). Toward the end of the survey when the time shortage became apparent we modified the line plans in some areas to only include the main features with the required boundary around them (Figure 5). 2). Quick investigation of areas that were likely candidates for false returns in the Phase 1 sidescan data (Figure 6). When nothing was apparent in these boxes we quickly abandoned the site and moved on and 3) survey boxes 28 and 46 were not collected at all since box 46 had the tell tail signature of fish or another type of false target that was digitized was measured in previous projects and verified through investigation of boxes 1, 12, 40, 43, 44, 45. Survey box # 28 was not collected since there was no "amoeba" type signature recorded in Phase 1 and was only indented in planning for exploratory verification purposes. Surveying this entire box would have put us over in time about 12-15 hours (Figure 7). For further information please contact Geodynamics directly.

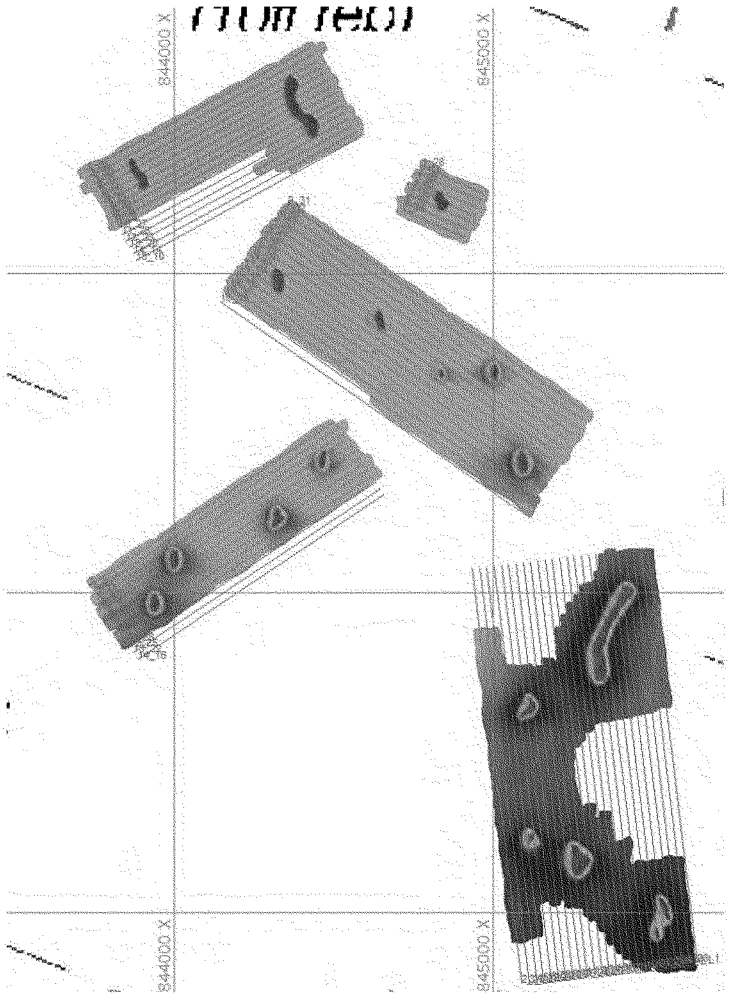


Figure 5. Example of line plans modified to stay within schedule. Note that all modifications were on seafloor areas that did not have any identifiable signatures in the sidescan data.

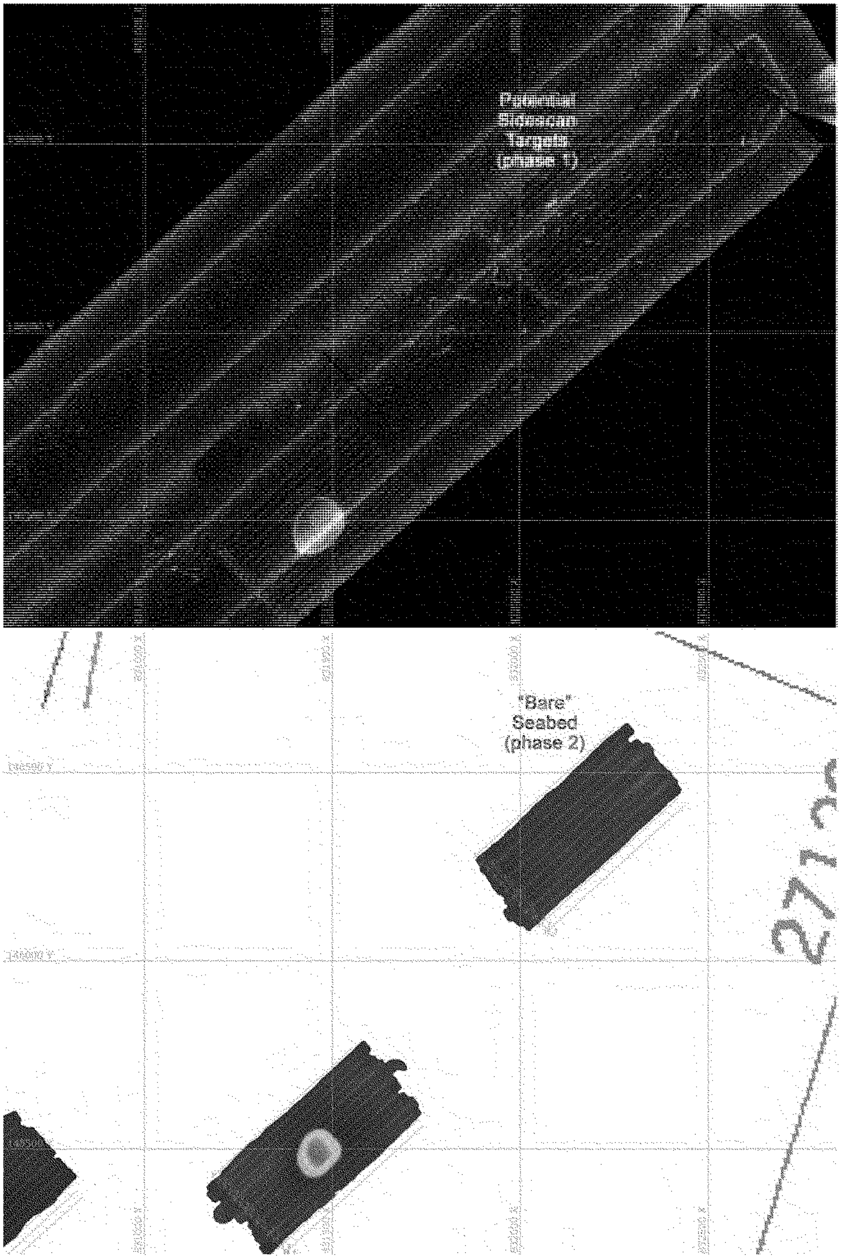


Figure 6. Example of an area surveyed with no identifiable seafloor feature with significant elevation.

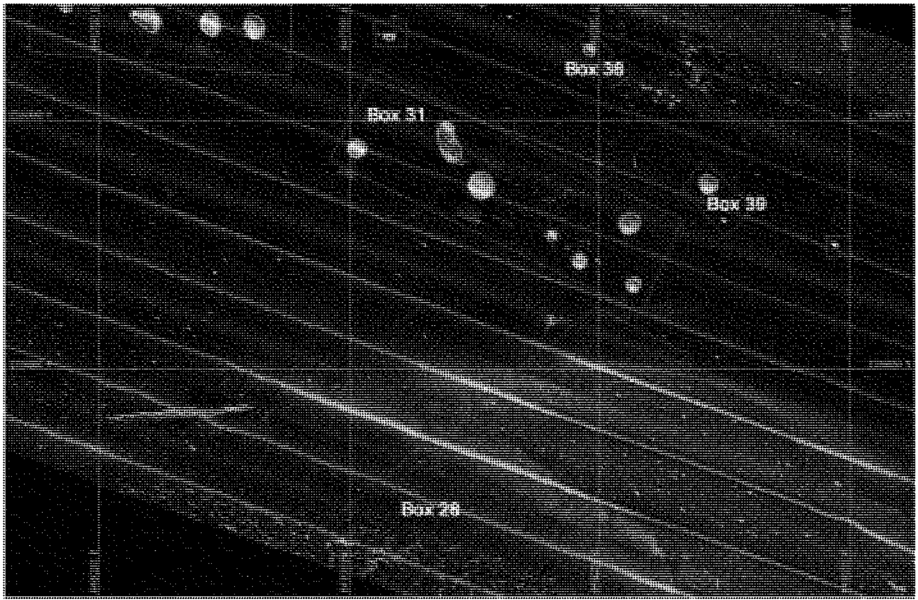


Figure 7. Image showing box 28 with no "amoeba" type feature.

Multibeam Calibration

Multibeam swath sonar systems combine a complex array of instruments, consisting of the transducer, motion sensor, inertial navigation, in-line sound velocity probe, sound velocity profiler and geodetic GPS systems using high-speed data modems. Standards developed by the International Hydrographic Organization (IHO), USACE Standards for Hydrographic Surveys, and the NOS Hydrographic Surveys Specifications and Deliverables for shallow water (<30 m) hydrography (IHO 1987; USACE 2003; NOS 2006) are used as the protocol for calibration. Proper alignment of these instruments with one another and with the vessel's reference frame is critical to achieve the high-accuracy required in the SOW. Calculation of the horizontal and vertical offsets between each of the instruments completed by the National Geodetic Survey is followed by a series of sea-based measurements known as the patch test.

The patch test is performed to calculate several residual biases influenced by the dynamics of the survey vessel and the alignment of the instruments. Results of the patch test, documented in the following sections, are used to calculate a pitch, roll and heading offset and positioning time delay or navigation latency. Additional calibration measures are performed in the field including comparison of nadir depths with a lead line and frequent sound velocity profiles. The results of these daily field checks can be found in the html metadata file accompanying the final soundings.

Multibeam Echosounder Calibration Report

Calibration Date:	April 19, 2006
Ship	
Vessel	RV 4-Points
Echosounder System	EM3002
Positioning System	POS MV (tightly coupled)-RTK GPS
Attitude System	POS MV
Sound Velocity Probe	Odem Digibar Pro (profiler) / Valeport Mini SVS (at head)

Annual		
Installation	x	
System change	x	
Periodic/QC		
Other		

Calibration type: Multibeam Sonar

The following calibration report documents procedures used to measure and adjust sensor biases and offsets for multibeam echosounder systems. This report has been adopted and modified from NOAA. Calibration must be conducted A) prior to CY survey data acquisition B) after installation of echosounder, position and vessel attitude equipment C) after changes to equipment installation or acquisition systems D) whenever the Hydrographer suspects incorrect calibration results. The Hydrographer shall periodically demonstrate that calibration correctors are valid for appropriate vessels and that data quality meets survey requirements. In the event the Hydrographer determines these correctors are no longer valid, or any part of the echosounder system configuration is changed or damaged, the Hydrographer must conduct new system calibrations.

Multibeam echosounder calibrations must be designed carefully and individually in consideration of systems, vessel, location, environmental conditions and survey requirements. The calibration procedure should determine or verify system offsets and calibration correctors (residual system biases) for draft (static and dynamic), horizontal position control (DGPS), navigation timing error, heading, roll, and pitch. Standard calibration patch test procedures are described in *Field Procedures for the Calibration of Multibeam Echo-sounding Systems*, by André Godin (Documented in Chapter 17 of the Caris HIPS/SIPS 6.0 User Manual, 2006). Additional information is provided in *POS/MV Model 320 Ver 4 System Manual* (10/2003), Appendix F, Patch Test, and the NOAA Field Procedures Manual (FPM, 2003). The patch test method only corrects very basic alignment biases. These procedures are used to measure static navigation timing error, transducer pitch offset, transducer roll offset, and transducer azimuth offset (yaw). Dynamic and reference frame biases can be investigated using a reference surface.

Pre-calibration Survey Information

Reference Frame Survey

RV 4-Points was surveyed by the National Geodetic Survey on February 15, 2006 for precise centerline and instrument locations. Steve Breidenbach performed the survey with a Trimble 5603 total Station.

(IMU, Ref Pt., and XY of CG are all co-aligned and attitude and position is valid at the sensor. The values below are entered in POSview software.)

Reference to IMU Lever Arm

X(m)	Y (m)	Z (m)
0	0	0

Reference to Pri. GPS

X(m)	Y (m)	Z (m)
1.849	-1.061	-1.724

IMU frame w.r.t. Reference frame

X(deg)	Y (deg)	Z (deg)
0	0	0

Reference to Sensor Lever Arm

X(m)	Y (m)	Z (m)
-0.097	-2.130	0.849

Reference to CG

X(m)	Y (m)	Z (m)
0	0	0.313

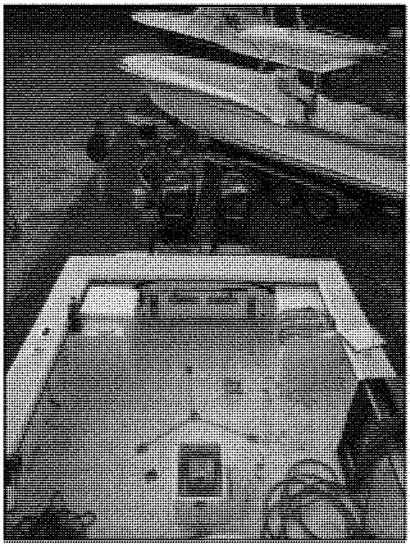


Figure 8. Photo of the centerline and instrument survey by NGS.

Reference to Vessel (Pt of validation for attitude and nav)

X(m)	Y (m)	Z (m)
-0.097	-2.130	0.849

__X__Measurements verified for this calibration.
___ __Drawing and table attached.
_____Drawing and table included with project report

POS MV Configuration File: 4_points_022806._*________________

Notes: NGS vessel survey results were put in POSview and GAMS calibration was done on February 28, 2006.

Calibration Area

Site Description

This patch survey was conducted in the Port of Morehead City's turning basin near Beaufort Inlet, North Carolina (N34 41 39.16 W076 40 07.53). This site was selected for its particular bottom features, such as small scale ripple fields, sand waves (wavelength: ±5m, amplitude: ±0.15m), deep flat areas, and high slopes.

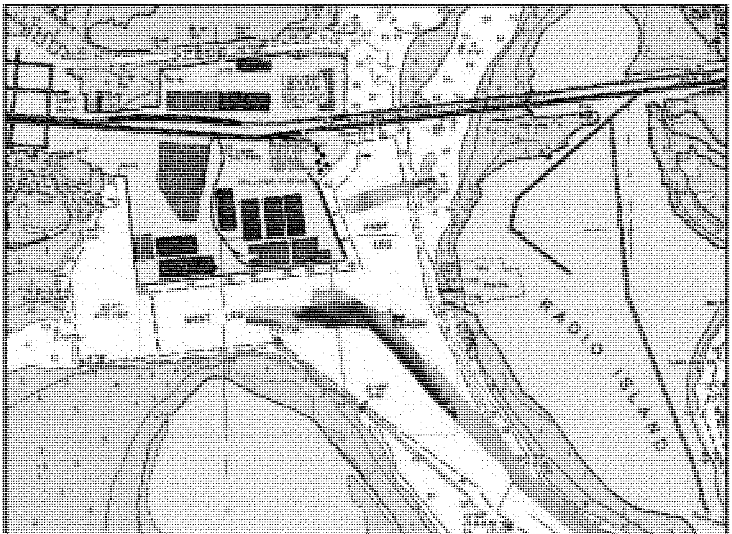


Figure 9. Map of the patch survey area within the Morehead City Turning Basin.

Survey Procedure

Vessel biases were determined through a patch test survey procedure. Data was acquired and analyzed in Kongsberg SIS package. The latency test was performed first by surveying the same survey line in the same direction at 2 different vessel speeds. The latency test was done twice to verify initial results. The pitch test was done second by surveying the same survey line in opposite directions at the same speed and evaluating the sloped portion of the survey line. The roll test was performed next by surveying the same survey line in opposite directions at the same speed and evaluating the deep flat portion of the survey line. The roll test was done twice to verify initial results. The yaw test was performed next by surveying 2 adjacent survey lines in the same direction, with similar speeds, with enough overlapping coverage such that the outer beams from each swath overlap (±40%).

Calibration Lines

Hypack Line	Line File	Az.	Spd	Correction			
				Pitch	Roll	Yaw	Latency
1	0000_20060301_163731_4points.all	57°	3.3kts				X
1	0001_20060301_164249_4points.all	57°	7.1kts				X
1	0002_20060301_165502_4points.all	237°	3.2kts				X
1	0003_20060301_165938_4points.all	237°	7.0kts				X
1	0002_20060301_155849_4points.all	237°	7.0kts	X			
1	0003_20060301_160222_4points.all	57°	7.0kts	X			
1	0000_20060301_172142_4points.all	57°	7.0kts		X		
1	0001_20060301_172427_4points.all	237°	7.0kts		X		
1	0000_20060301_183521_4points.all	237°	7.0kts		X		
1	0001_20060301_183741_4points.all	57°	7.0kts		X		
8	0001_20060301_191059_4points.all	280°	7.0kts			X	
7	0002_20060301_191957_4points.all	100°	7.0kts			X	

Sound Velocity Correction

Measure water sound velocity (SV) prior to survey operations in the immediate vicinity of the calibration site. Conduct SV observations as often as necessary to monitor changing conditions and acquire a SV observation at the conclusion of calibration proceedings. If SV measurements are measured at the transducer face, monitor surface SV for changes and record surface SV with profile measurements.

Sound Velocity Measurements

Time	Max Depth	Surface SV	Change Observed	Position	
				Latitude	Longitude
14:52:00	15.5m	1490.2		34 42.9705	76 41.6239
Continuous SV at head			<4 m/s throughout entire calibration		

Data Acquisition and Processing Guidelines

Initially, calibration measurement offsets should be set to zero in vessel configuration files. Static and dynamic draft offsets, inertial measurement unit (IMU) lever arm offsets, and vessel reference frame offsets must be entered in appropriate software applications prior to bias analysis. Perform minimal cleaning to eliminate gross flyers from sounding data.

Navigation Timing Error (NTE)
Measure NTE correction through examination of a profile of the center beams from lines run in the same direction at maximum and minimum vessel speeds. NTE is best observed in shallow water.

Transducer Pitch Offset (TPO)
Apply NTE correction. Measure TPO correction through examination of a profile of the center beams from lines run up and down a bounded slope or across a conspicuous feature. Acquire data on lines oriented in opposite directions, at the same vessel speed. TPO is best observed in deep water.

Transducer Roll Offset (TRO)
Apply NTE and TPO corrections. Measure the TRO correction through examination of roll on the outer beams across parallel overlapping lines. TRO is best observed over flat terrain in deep water. An additional check for TRO adjustment can be performed by running two lines parallel to a sloped surface.

Transducer Azimuth Offset (TAO or yaw)
Apply NTE, TPO and TRO corrections. Measure TAO correction through examination of a conspicuous topographic feature observed on the outer beams of lines run in opposite directions.

Patch Test Results and Correctors

Evaluator	NTE (sec)	TPO (deg)	TAO (deg)	TRO (deg)
Bernstein/Hohing	0.00	0.00	0.00	-0.65
Final Values	0.00	0.00	0.00	-0.65

Corrections Calculated in:	
Caris	
ISIS (BathyPro)	
Other	SIS

NOTE: TRO bias of -0.65 was put in SIS software.

Evaluator: Dave Bernstein
Reviewed by: Chris Freeman
Accepted by: Dave Bernstein
Date accepted: April 21, 2006

Graphical Examples of Calibration Acceptance

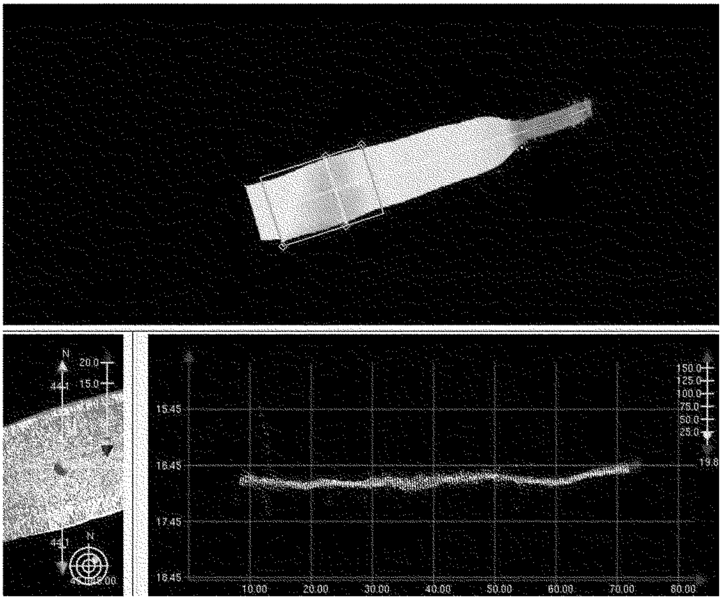


Figure 10. Caris screen grab illustrating acceptance of roll calibration.

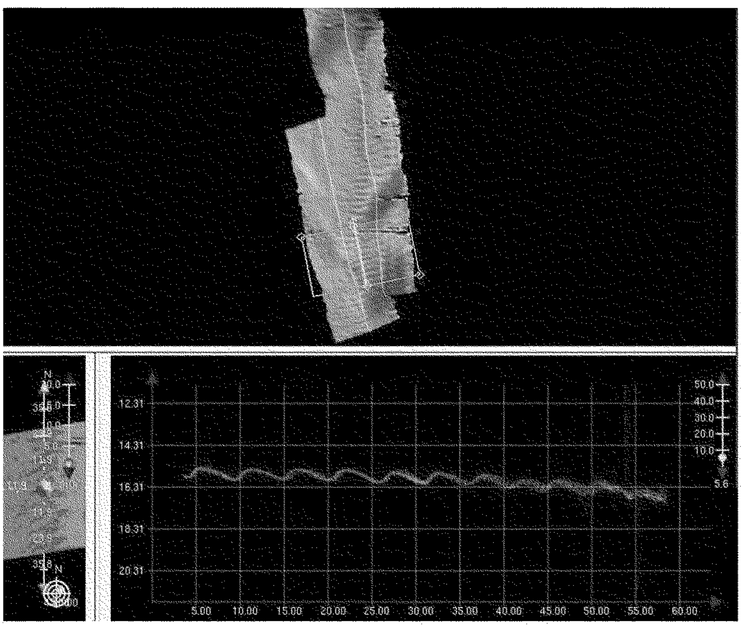


Figure 11. Caris screen grab illustrating acceptance of yaw calibration.

Data Processing Routines & QA/QC Information

Introduction

Processing high-density multibeam bathymetry and backscatter data requires a multitude of processing routines and data quality analyses. The following section will detail all aspects of data post-processing for the Neuse River multibeam surveys. Also presented in this section is detailed QA/QC information and analysis generated throughout the various processing procedures.

Bathymetry Processing

The multibeam collects swath widths approximately 4 times the water depth. The portions of swath, mainly in the outer beams, that exhibit areas of inconsistent data are clipped and not included in the final digital file. Sounding track lines are generally parallel to each other and parallel to the seafloor contour. Sinuous lines and data acquired during turns are not included in the final processed data. To meet the accuracy and resolution standards for measured depths specified in the USACE Hydrographic Surveying Manual and the NOS Hydrographic Surveys, Specifications and Deliverables Manual, measured echosounder depths were corrected for all departures from true depths attributable to the method of sounding or to faults in the measuring apparatus. These corrections are subdivided into four categories, and are listed below in the sequence in which they were applied to the data.

1. Instrument error corrections: included to account for the sources of error related to the sounding equipment itself.

2. Vessel offsets: added to the observed soundings to account for the depth of the echosounder below the water surface, positioning of the motion reference unit, and GPS antenna.

3. Velocity of sound correctors: applied to the soundings to compensate for the fact that echosounders may only display depths based on an assumed sound velocity profile while the true velocity may vary in time and space.

4. Heave, pitch, roll, heading and navigation latency corrections: applied to the multibeam soundings to correct for the effect of vessel motion caused by waves and swells, the error in the vessel's heading, and the time delay from the moment the position is measured until the data is received by the GPS receiver.

Multibeam Data Processing Steps in CARIS HIPS software:

The EM3002 sonar system has a unique arrangement of data flow. Most settings that influence the data are put in before and during a survey and therefore are not a factor in data processing (these include vessel offsets, lever arms, vessel biases, timing biases, and survey sound velocity). Vessel attitude is also processed real-time during a survey.

Post-processing of multibeam data consist of attitude and navigation editing, merging, swath editing, area-based editing, and exporting of final data.

1. Attitude & Navigation Editing: Errors or gaps in attitude and navigation information causing errors in soundings are edited.

2. Merging: Computing and integrating the tide in the sounding data. Additional sound velocity corrections are made if needed in this phase.

3. Total Propagated Error (TPE) is calculated (N/A without RTK-GPS).

4. Swath- and beam-based filters and TPE (IHO standards) filters are applied (N/A without RTK-GPS).

5. Swath Editing: Swaths are edited for erroneous data if needed

6. Base or CUBE Surface is created for area- and CUBE-based editing.

7. Area-based editing using the subset editor to edit/check erroneous data only within the desired subset.

8. CUBE filtering and editing

9. Recompute TPE (N/A without RTK-GPS)

10. Recompute CUBE and/or base surfaces

11. Final export of base surface to XYZ decimated soundings.

Written Description of Workflow

Contracting History

- Request to prepare cost estimate for all boxes identified to contain potential oyster reefs on 10/10/06
- Initial estimate and survey design provided to G&O on 10/11/06
- Request for a new estimate for specified boxes w/in the Tetra Tech grid area ~ 11/13/06
- Submittal of new estimate on 11/15/06
- Final contract for initial cost estimate to survey all boxes was received by Geodynamics on 4/12/07

Project Planning

- Build of project GIS and line plans 10/10/06
- Initial survey design was submitted to the USACE Wilmington District on 10/11/06. A reduced effort was designed and submitted between 11/3/06 and 11/15/06.
- We heavily researched using the USCG Continuing Operating Reference station for our tidal elevation offset calculations. Spoke with Clay Pate at Duncan Parnell about the use of these data to calculate water surface elevations for the project on 4/30/07. It was decided to use this data as either a backup to using PAM 43 or for the actual corrections which ever was better for the final data.

Data Acquisition

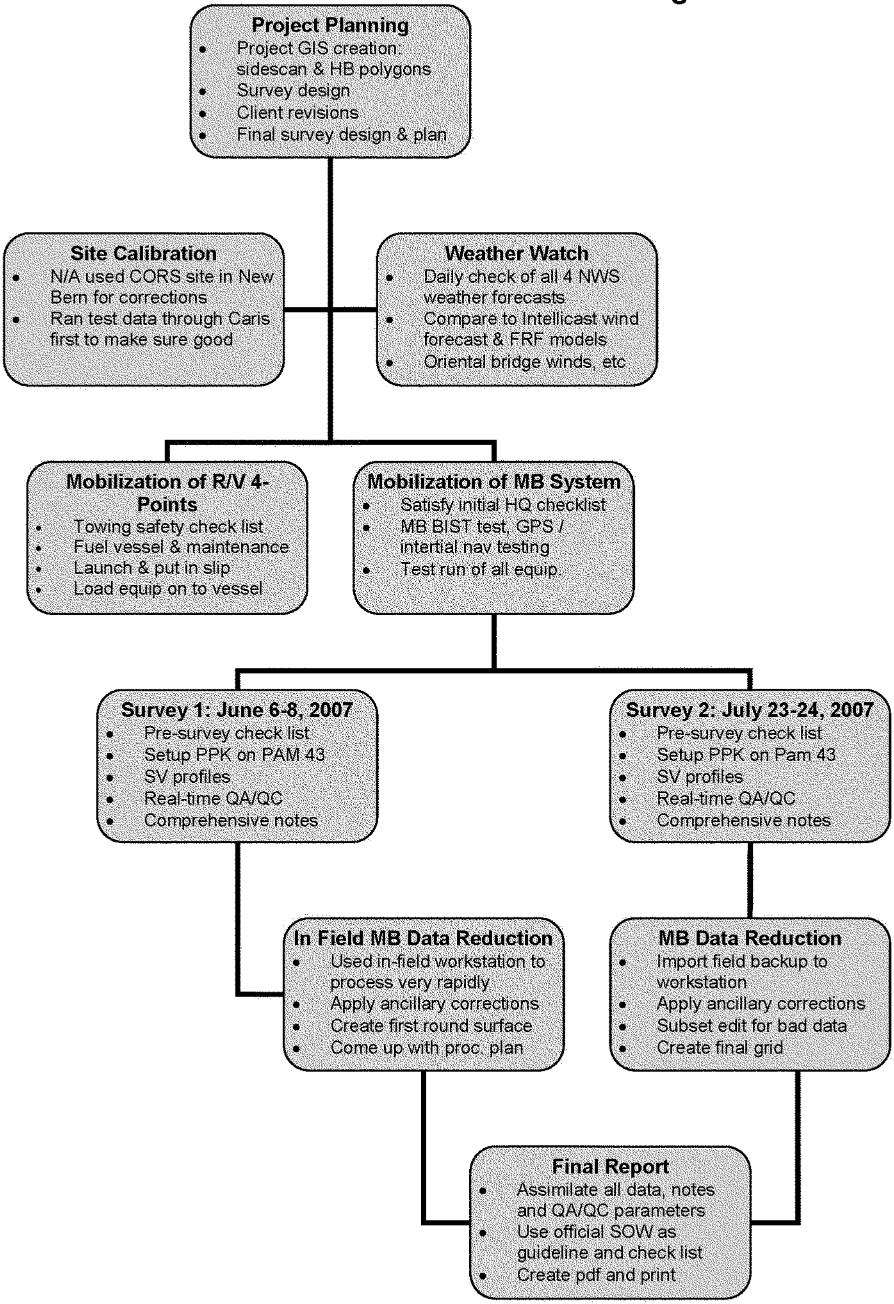
- The weather watch for the Neuse multibeam project began ~ late May 07 after completion of several other previously contracted projects.
- A window became available the first week in June 2007 and mob / data acquisition commenced between June 4th and June 9th, 2007. Strong southeasterly winds on the 9th precluded the field crew from finishing the project so demobilization commenced.
- A three day weather window precluded the field crew from data acquisition following the 9th.
- A rare cold front approached the area on the 20th. Strong winds out of the North precluded acquisition for the Neuse so it was decided to acquire data at Bogue Banks where these strong offshore winds created favorable conditions. Immediately after this project was completed the field crew rapidly demobed and mobed for the Neuse. Strong am winds on the 23rd laid down to nearly calm. Several 16 hour plus days where put in to finish the project late on the 24th.

Data Processing & Reporting

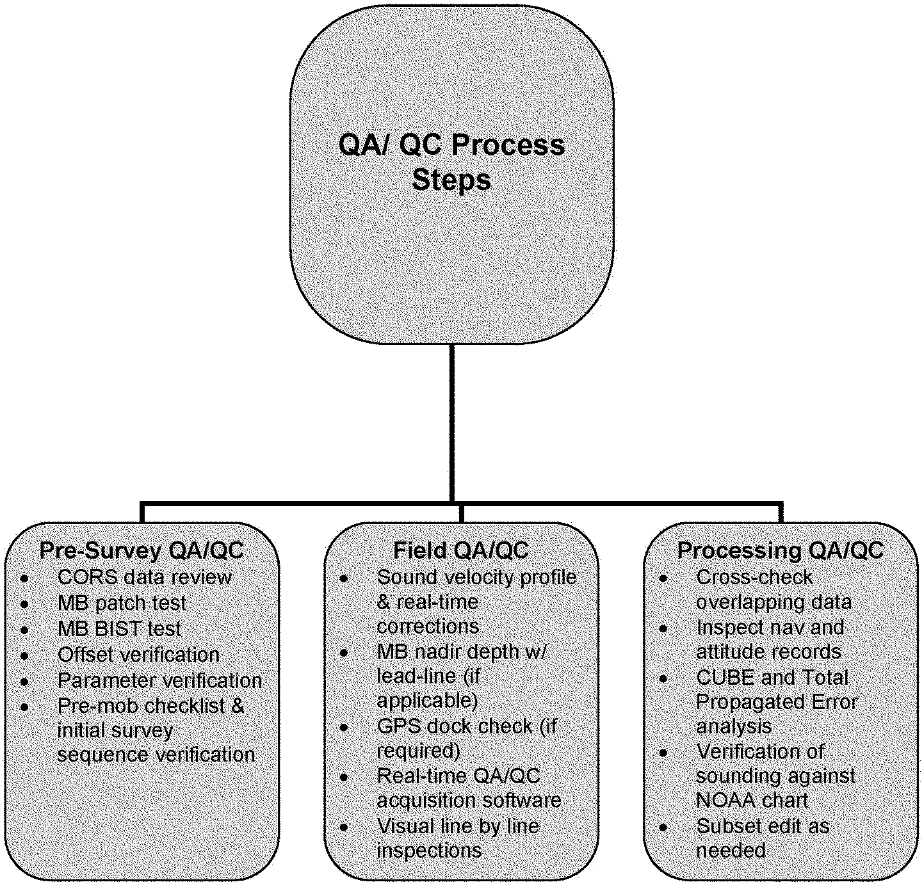
- Data processing for the Neuse project began after the first round of data acquisition; however, these data could not be finalized until all the data was collected.

- Final CORS data downloaded and "tide" file generated on July 25.
- Data required subset editing in 90% of the boxes
- Reporting began after the first round of data acquisition to gain a head start on this phase of the project.
- Final data processing and reporting began shortly after July 24th.
- Data finalized and final maps made for report on Aug 15-16th.
- Report finalized and data sent to both the USACE and G&O on Aug 17th.

Neuse River Multibeam Workflow Diagram



Neuse River Multibeam QA/QC Workflow Diagram



Graphical Summary of Deliverables

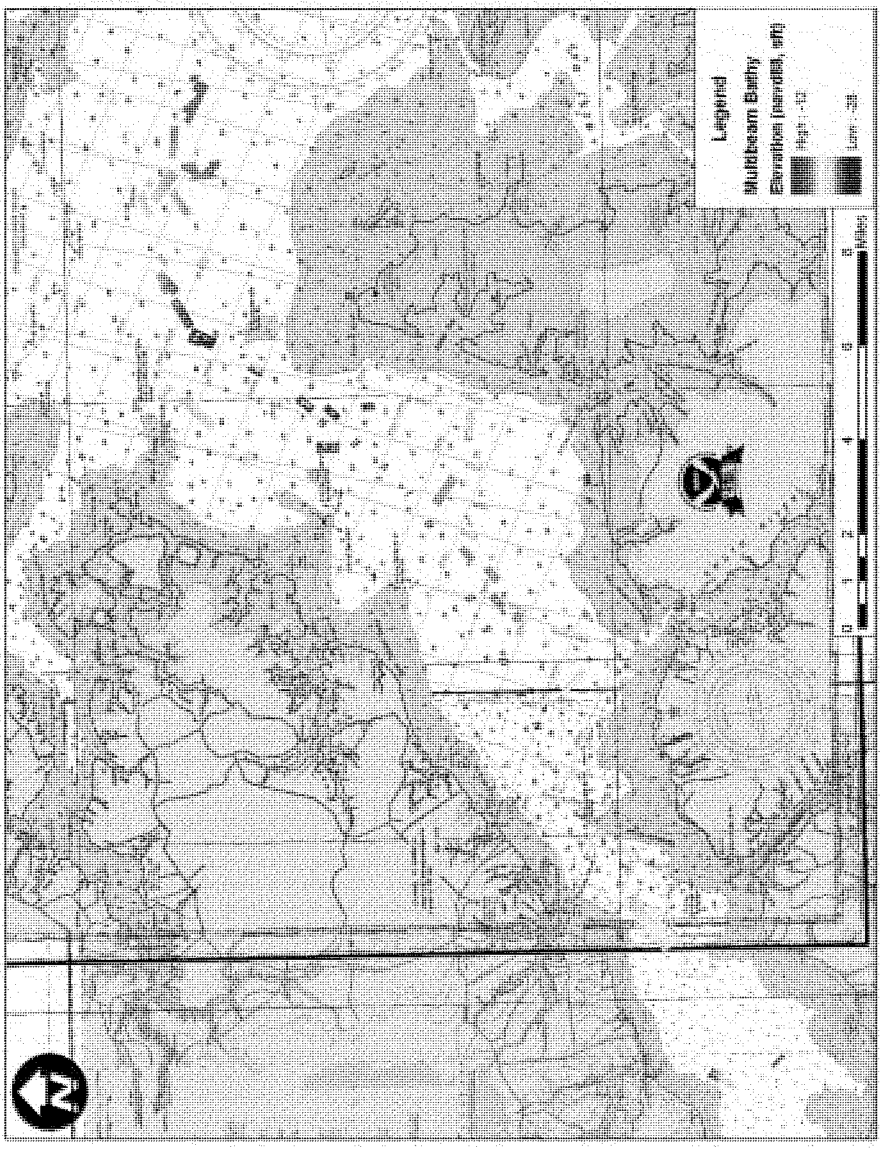


Figure 12. Plan view bathymetric map showing total survey coverage.

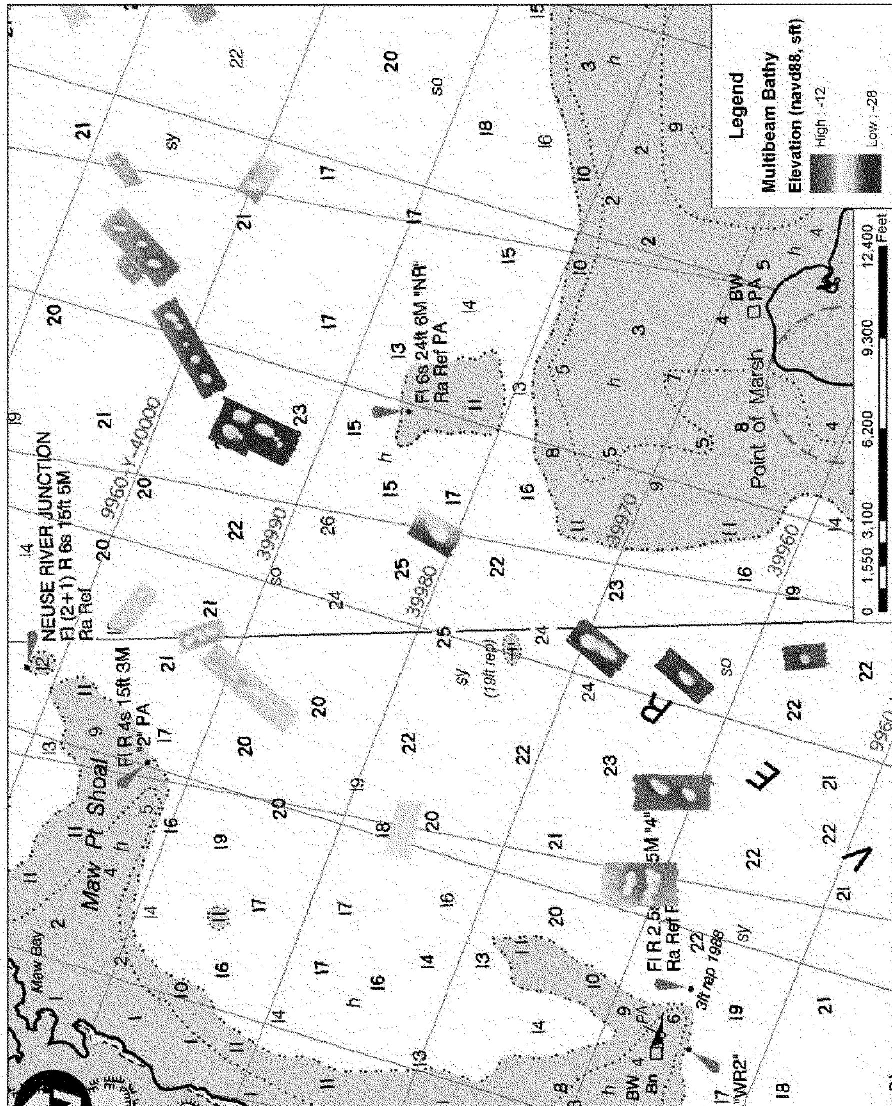


Figure 13. Plan view map showing outer Neuse survey coverage.

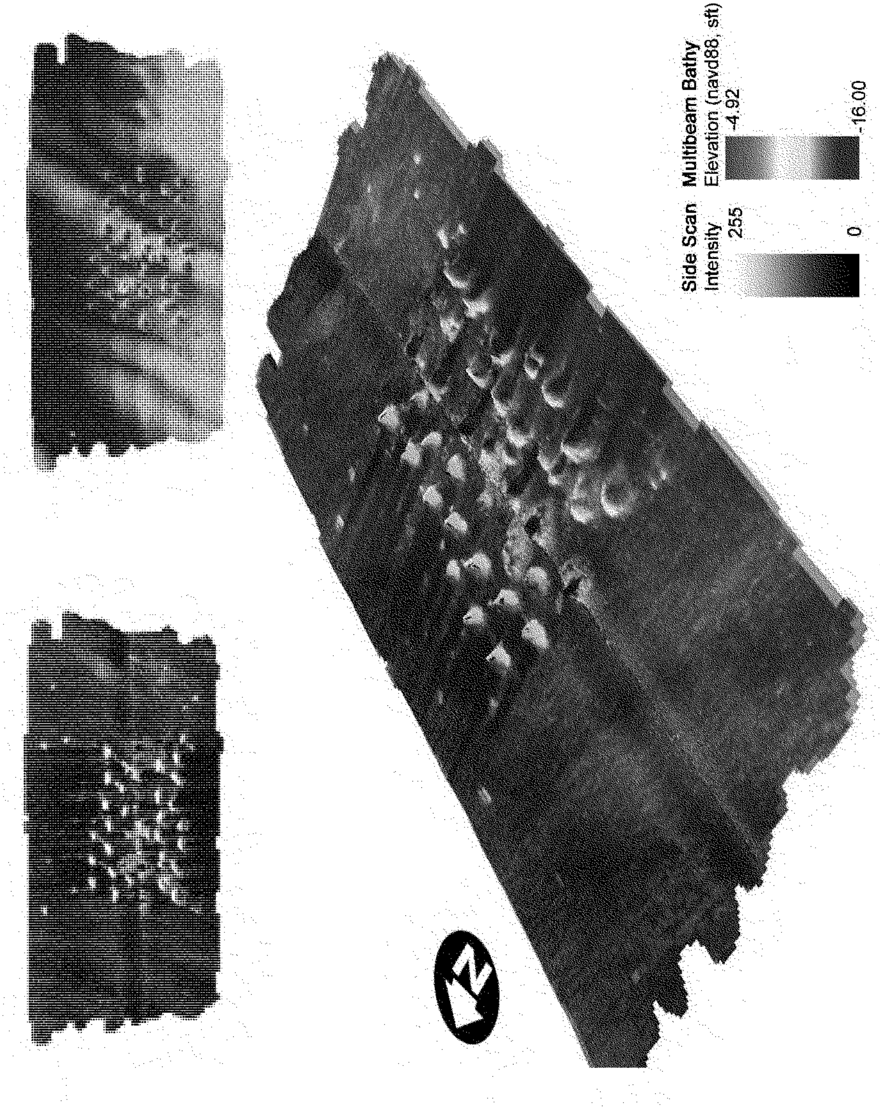


Figure 14. 3D perspective image of Neuse site #11 with sidescan draped over top.

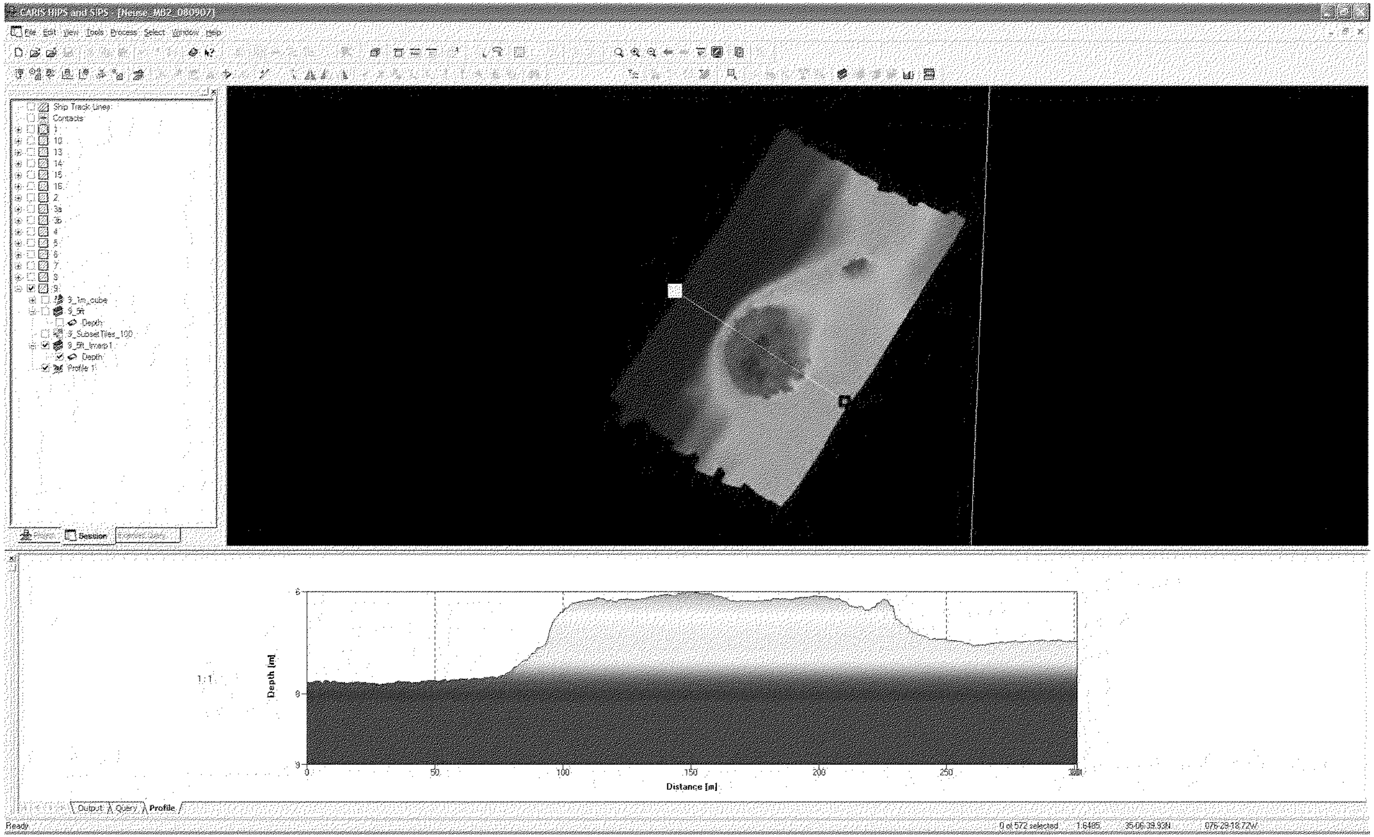


Figure 15. Site # 21 with profile struck through the center of the main feature.

Appendix A – Official USACE Scope of Work

SCOPE OF WORK:
MULTIBEAM OF POTENTIAL OYSTER BEDS: PHASE 2
NEUSE RIVER, NORTH CAROLINA

1. Location of Work. The tasks to be performed under this scope of work pertain to the geographic area of Topsail Island, North Carolina from New Topsail Inlet to the Surf City boarder. (Note: mistake in Government provided scope)

2. General Requirements. The Contractor shall supply all necessary labor, materials, equipment, rentals, and travel expense to conduct and document the work as described herein.

3. Detailed Requirements. The Contractor shall acquire full coverage multibeam sonar data completely over and within a 50m -100m radius of potential oyster reefs within the designated survey limits as indicated on figure 1. These areas correspond to the potential oyster reefs identified in Phase 1 of the project.

The A-E shall provide all necessary services, equipment, labor, and materials to perform a multibeam survey within the survey limits as indicated on figure 1, and the post processing of the collected field data into the required formats and deliverables as indicated. The following survey datums are required:

Horizontal – North Carolina State Plan, NAD83, US Survey, Feet
Vertical – North American Vertical Datum of 1988, Feet

USACE EM 1110-2-1003 Hydrographic Surveying

Note: USACE documents can be downloaded from the following web site:
http://www.usace.army.mil/inet/usace-docs/eng-manuals/em.htm

A. Hydrographic Data. Hydrographic survey coverage for the area depicted on the attached map shall be provided. The contractor shall conduct the multibeam surveys as to ensure 100% coverage to the extent practical of the survey area shown on the attached map. Survey lines should be taken at sufficient intervals to ensure this coverage. Coordinates shown on the attached map are in feet and reference the North Carolina State Plane Coordinate System, NAD83. All data shall meet the recommended minimum performance standards established in EM 1110-2-1003 (Table 3-1) for the "Other General Surveys and Studies" project classification.

B. System Calibration and Check. The contractor shall calibrate and check the multibeam system in accordance with the procedures outlined in EM 1110-2-1003. A log (either written or digital) containing the results of all calibrations and checks shall be kept by the contractor.

C. Data Editing. All hydrographic survey data shall be fully edited and corrected. The data shall undergo a gridded depth reduction using 5-foot cells or less, where the depth saved shall be the depth closest to the center of the cell.

4. Survey Control. Phase 2 multibeam surveys will make use of NGS Mark *Pam 43* in Oriental, NC to calculate Post Processed Kinematic (PPK) tidal elevations in the NAVD 88 vertical reference plane. Differential GPS will be used to aid the onboard inertial navigation system to provide horizontal positioning.

5. Clearances. The Contractor shall acquire all Clearances necessary to obtain the required data. All discussions for access to private or public property or restricted waters or airspace must be included in the required weekly status report with name of person, address, and telephone number.

6. Required Deliverables. The Contractor is required to deliver Shapefiles, Raster Data Sets, Metadata Records, a Weekly Status Reports, and a Final Written Report. All data shall be delivered on the project dedicated Maxtor USB Hard Drive with sufficient capacity for all deliverables. The drive is property of the Government. (Note: drive was not sent back prior to delivery. Data to be delivered on DVD or directly to G&O via FTP.

6.1 GIS-Compatible Data The Contractor shall deliver data in a format compatible with ESRI ArcView/ArcInfo Version 9.x.

6.1.1 Multibeam Data. The Contractor shall deliver an ArcGrid of each Multibeam Survey area specified in the attached project design map. The ArcGrid shall represent the final data with all appropriate corrections (motion, tides, CUBE, TPE, etc) applied.

6.1.2 Point Shapefiles. The Contractor shall deliver any ancillary data that could possibly be imported into a geodatabase in shape file format.

6.2 Metadata Record. An FGDC compliant metadata record for each spatial data deliverable shall be created using ESRI ArcView/ArcInfo ArcCatalog version 9.0. Appropriate information shall be entered in all required fields. The Contractor shall attach the appropriate metadata record to each spatial data file using ArcCatalog so that no importing or formatting of the metadata record is required by the Government.

7. Weekly Status Report. **The Contractor is required to submit a Weekly Status Report each week, beginning on the Task Order Award Date, until all deliverables are received and accepted by the Government**. The Weekly Status Report shall be delivered via e-mail no later than 8:00 AM each Monday and shall document the Contractor's progress from the previous Monday through

the previous Sunday. The status report shall itemize each scope item with percent of work complete and an estimated date of completion. The report shall also include the number and type of field crews working, a description of any problems and/or delays encountered, and any photographs of the site and/or significant site features (such as outlet structures, retaining walls, escarpments, etc.) and/or specialized data collection activities.

8. Final Written Report. A written report summarizing all data collection activities shall be submitted as a Portable Document File (PDF) and in bound hardcopy. The following items shall be included in the survey report:

- Written description of workflow to complete task order (start to finish) including flowchart diagram and detailed description of QA/QC process
- Dates and times of each data collection activity
- Atmospheric Conditions for each day of data collection activity
- All Horizontal and Vertical Control used including monument name, establishing agency, date established, description, and published horizontal and vertical values
- TBM descriptions with vertical values
- Copy of all field notes
- Complete and detailed list of all survey equipment used including copy of last factory calibration report
- Metadata Records as described in 4.4 above
- Photographs of the site and any significant features or data collection techniques used

9. Quality Control. If work is found to be in error, incomplete, illegible or unsatisfactory after assignment is completed, the Contractor shall be liable for all cost in connection with correcting such errors. Corrective work may be performed by Government personnel or Contractor personnel at the discretion of the Contracting Officer. In any event, the Contractor shall be responsible for all costs incurred for correction of such errors, including salaries, automotive expenses, equipment rental, supervision, and any other costs in connection therewith. All data and deliverables shall be reviewed for the following:

- Required coverage of the project limits
- Capture of all required features
- ***Required accuracies***
- Required horizontal and vertical datum
- Adherence to the delivery order requirements

10. Technical POC. All technical questions concerning work under this task order shall be directed to Jim Jacaruso at (910) 251-4064.

11. Schedule & Completion Date. Upon commencement of work and weather permitting, fieldwork for the Neuse River multibeam survey should proceed such that it is completed no later than mid- April (Note: this date was from the original estimate that was sent to the Prime on 10/11/06. Contract ultimately went through on 4/12/07). Safety of field crew is the priority, followed by timeliness of schedule. The contractor is to use judgment on the exact days of data collection for both safety and data quality concerns. Scheduling of surveys should be coordinated with the POC in advance and weekly updates of progress to obtain field data will be provided. Data analysis, documentation, and computer files should be delivered by late November pending the ultimate schedule for data acquisition (Note: this date was from the original estimate that was sent to the Prime on 10/11/06. Contract ultimately went through on 4/12/07). This schedule is subject to adjustment by the contracting officer for conditions beyond the control of the parties hereto.

12. Deliver To. All work shall be delivered to:

U. S. Army Corps of Engineers
Wilmington District
Attn: Jim Jacaruso, TS-EE
69 Darlington Avenue
PO Box 1890
Wilmington, NC 28402-1890

Appendix B – Field Notes

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Multibeam Daily Operation Proceedures & Checklist

6/6/2007				
Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X	n/a	n/a	n/a
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X	34 59 56.3994	076 41 35.6445	1509.8
SV Cast #1	X	34 59 56.3994	076 41 35.6445	1509.8
SV Cast #2	X	34 58 53.9546	076 42 45.1309	1511.3
SV Cast #3	X	35 0146.3970	076 35 12.7419	1513.5
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes

Project	USACE MB 2
Survey Area	Survey boxes 0-8
Sea State	1-2 w/chop early, 1' late
Wind	10-15kts W, lighten to 10kts around 10am, NW 5-10kts pm
Air Temperature	78 F(am), 90 F (pm)
Sea Temperature	75.7 F (am)
Tides	N/A
Survey Features & Navigational Aids	N/A
Comments	Lett dock at 5:30am. Back to dock at 8:30pm = 15hrs on water

Line Name	MS/CL	Direction	Notes
0	MS	230	HP 1 Box 3 - 6:26am Start
1	MS	50	HP 2
2	MS	230	HP 3
3	MS	50	HP 4
4	MS	230	HP 5
5	MS	50	HP 6
6	MS	230	HP 7
7	MS	50	HP 8
8	MS	230	HP 9
9	MS	50	HP 10
10	MS	230	HP 11
11	MS	50	HP 12
12	MS	230	HP 13
13	MS	50	HP 14
14	MS	230	HP 15
15	MS	50	HP 16
16	MS	230	HP 17
17	MS	50	HP 18
18	MS	230	HP 19
19	MS	50	HP 20
20	MS	230	HP 21
21	MS	50	HP 22
22	MS	230	HP 23
23	MS	50	HP 24
24	MS	230	HP 25
25	MS	50	HP 26
26	MS	230	fill in
27	MS	230	HP 27
28	MS	50	HP 28
29	MS	230	HP 29
30	MS	50	HP 30
31	MS	230	HP 31
32	MS	50	HP 32
33	MS	230	HP 33
34	n/a	n/a	transit to Box 4
35	MS	230	HP 2 - Box 4
36	MS	50	HP 3
37	MS	230	HP 4
38		50	
39		230	
Transit to Box 2			
40	MS	135	HP 10-Box 2
41	MS	315	HP 9
42	MS	135	HP 8
43	MS	315	HP 7
44	MS	135	HP 6
45	MS	315	HP 5
46	MS	n/a	transit to Box 0
47	MS	21	HP 8

48	MS	201	HP 7
49	MS	21	HP 6
50	MS	201	HP 5
51	MS	21	HP 4
52	MS	201	HP 3
53	MS	21	HP 2
54	MS	201	HP 1
55	N/A	21	fill in
56	MS	25	HP 2 - Box 1
57	MS	205	HP 3
58	MS	25	HP 4
59	MS	205	HP 5
60	MS	25	HP 6
61	MS	205	HP 7
62	MS	25	HP 8
63	MS	205	HP 14
64	MS	25	HP 15
65	MS	205	HP 16
66	MS	25	HP 17
67	MS	205	HP 18
68	MS	25	HP 19
69	MS	205	HP 20
70	MS	25	HP 21
71	n/a	n/a	fill-in
72	n/a	n/a	fill-in
73	MS	290	HP 3 - Box 5
74	MS		HP 4
75	MS		HP 5
76	MS		
77	MS	290	HP 6
78	MS	110	HP 7-delete
79	MS	290	HP 8
80	MS	110	HP 9
81	MS	290	HP 10
82	MS	110	HP 11
83	MS	290	HP 13
84	MS	110	HP 14
85	MS	290	HP 15
86	MS	110	HP 16
87	MS	290	HP 17
88	MS	290	HP 18- end box 5 large portion
89	MS	290	HP 18 - box 5 small section
90	MS	110	HP 17
91	MS	290	HP 16
92	MS	110	HP 15
93	MS	290	HP 14
94	MS	110	HP 13
95	MS	290	HP 12 - end box 5
96	n/a	94	transit to box 6
97	MS	133	HP 3

98	MS	313	HP 4
99	MS	133	HP 5
100	MS	313	HP 6
101	MS	133	HP 7
102	MS	313	HP 8
103	MS	133	HP 9
104	MS	313	HP 10
105	MS	133	HP 11
106	MS	313	HP 12
107	MS	133	HP 13 - End Box 6
108	MS	305	HP 1 - Start Box 7
109	MS	125	HP 2
110	MS	305	HP 3
111	MS	125	HP 4
112	MS	305	HP 5
113	MS	125	HP 6
114	MS	305	HP 7
115	MS	125	HP 8
116	MS	305	HP 9
117	MS	125	HP 10
118	MS	305	HP 11
119	MS	47	HP 1 - Box 8
120	MS	227	HP 2
121	MS	47	HP 3
122	MS	227	HP 4
123	MS	47	HP 5
124	MS	227	HP 6
125	MS	47	HP 7
126	MS	227	HP 8
127	MS	47	HP 9
128	MS	227	HP 10
129	MS	47	HP 11-end box 8
End Survey Day = 8:05pm			

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Multibeam Daily Operation Proceedures & Checklist

6/7/2007				
Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X	n/a	n/a	n/a
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X			
SV Cast #1	X			
SV Cast #2	X			
SV Cast #3	X			
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes

Project	USACE MB 2
Survey Area	Survey boxes 9-
Sea State	1' or less early AM
Wind	S at 5kts early AM
Air Temperature	79 F(am), 90 F (pm)
Sea Temperature	76.5 F (am)
Tides	N/A
Survey Features & Navigational Aids	N/A
Comments	Left dock at 5:00am. Back to dock at 8:30pm = 15.5 hrs on water

Line Name	MS/CL	Direction	Notes
0	MS	47	HP 2 Box 9 - 5:54am Start
1	MS	227	HP 3
2	MS	47	HP 4
3	MS	227	HP 5
4	MS	47	HP 6
6	MS	47	HP 8
7	MS	227	HP 9
8	MS	47	HP 10
9	MS	227	HP 11
10	MS	47	HP 12 - End of box 9
11	MS	47	HP 10 - Box 10
12	MS	227	HP 9
13	MS	47	HP 8
14	MS	227	HP 7
15	MS	47	HP 6
16	MS	47	HP 6
17	MS	227	HP 5
18	MS	47	HP 4
19	MS	227	HP 3
20	MS	47	HP 2 - End of box 10
21	MS	124	HP 6 - Box 13
22	MS	304	HP 7
23	MS	124	HP 8
24	MS	304	HP 9
25	MS	124	HP 10
26	MS	304	HP 11
27	MS	124	HP 12
28	MS	304	Hp 13
29	MS	124	HP 14
30	MS	304	HP 15
31	MS	124	HP 16
32	MS	304	HP 17
33	MS	124	HP 18- End Box 13
34	MS	94	HP 3 - Box 14
35	MS	274	HP 4
36	MS	94	HP 5
37	MS	274	HP 6
38	MS	94	HP 7
39	MS	274	HP 8
40	MS	94	HP 9
41	MS	274	HP 10
42	MS	94	HP 11
43	MS	274	HP 12
44	MS	94	HP 00-- end box 14
45	MS	355	HP 2 - Box 18
46	MS	175	HP 3
47	MS	355	HP 4
48	MS	175	HP 5

49	MS	355	HP 6
50	MS	175	HP 7
51	MS	355	HP 8
52	MS	175	HP 9
53	MS	175	HP 10
54	MS	355	HP 11
55	MS	175	HP 12 End of box 18
56	MS	41	HP 12 - Box 19
57	MS	221	HP 11
58	MS	41	HP 10
59	MS	221	HP 9
60	MS	41	HP 8
61	MS	221	HP 7
62	MS	41	HP 6
63	MS	221	HP 5
64	MS	41	HP 4
65	MS	221	HP 3
66	MS	41	HP 2 - End of box 19
67	MS	40	HP 13 - Box 20
68	MS	220	HP 12
69	MS	40	HP 11
70	MS	220	HP 10
71	MS	40	HP 9
72	MS	220	HP 8
73	MS	40	HP 7
74	MS	220	HP 6
75	MS	40	HP 5
76	MS	220	HP 4
77	MS	40	HP 3
78	MS	220	HP 2
79	MS	40	HP 1
80	MS	220	HP 11 fill-in - End of box 20
81	MS	180	HP 18 - Box 17
82	MS	180	HP 17
83	MS	0	HP 16
84	MS	180	HP 15
85	MS	0	HP 14
86	MS	180	HP 13
87	MS	0	HP 12
88	MS	180	HP 11
89	MS	0	HP 10
90	MS	180	HP 9
91	MS	0	HP 8
92	MS	180	HP 7
93	MS	0	HP 6
94	MS	180	HP 5
95	MS	0	HP 4
96	MS	180	HP 3 - End of box 17
97	MS	360	HP 19 - Box 16
98	MS	180	HP 18
99	MS	360	HP 17

100	MS	180	HP 16
101	MS	360	HP 15
102	MS	180	HP 14
103	MS	360	HP 13
104	MS	180	HP 12
105	MS	360	HP 11
106	MS	180	HP 10
107	MS	360	HP 9
108	MS	180	HP 8
109	MS	360	HP 7
110	MS	180	HP 6
111	MS	360	HP 5
112	MS	180	HP 4
113	MS	360	HP 3
114	MS	180	HP 2
115	MS	360	HP 1
116	MS	180	HP 00-- end box 16
117	MS	90	HP 13 - Start Box 11
118	MS	270	HP 12
119	MS	90	HP 11
120	MS	270	HP 10
121	MS	90	HP 9
122	MS	270	HP 8
123	MS	90	HP 7
124	MS	270	HP 6
125	MS	90	HP 5
126	MS	270	HP 4
127	MS	90	HP 3
128	MS	270	HP 2
129	MS	90	HP 1
130	MS	n/a	Fill - in
131	MS	n/a	Fill - in
132	CL	180	HP 3 11b.lnw
133	CL	0	HP 4
134	CL	180	HP 5
135	CL	0	HP 6
136	CL	180	HP 7
137	CL	0	HP 8
138	CL	180	HP 9
139	CL	0	HP 10
140	CL	180	HP 11
141	CL	0	HP 12
142	CL	180	HP 13
143			Fill - in
144			Fill - in
145			Fill - in - End Box 11
146	MS	270	HP 1 - Box 12
147	MS	90	HP 2
148	MS	270	HP 3
149	MS	90	HP 4
150	MS	270	HP 5
151	MS	90	HP 6
152	MS	270	Fill-in
153	MS	90	Fill-in
154	MS	270	Fill-in
End Survey Day - 5:15pm			

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Multibeam Daily Operation Proceedures & Checklist

6/8/2007				
Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X	n/a	n/a	n/a
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X			
SV Cast #1	X			
SV Cast #2	X			
SV Cast #3	X			
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes	
Project	USACE MB 2
Survey Area	Survey boxes 9-
Sea State	1' or less early AM, 2-3 by 9am
Wind	SW at 10 - 15, am, up to 15+kts
Air Temperature	79 F(am), 90 F (pm)
Sea Temperature	76.5 F (am)
Tides	N/A
Survey Features & Navigational Aids	N/A
Comments	Lett dock at 5:30am. End survey due to weather at 12:30am EST back to dock at 1:30 am EST = 8 hrs on water. Will likely redo these two boxes since the motion isn't being factored very well due to no RTK corrections. Will have to process the data first to see

Line Name	MS/CL	Direction	Notes
0	MS	283	HP 9 - Box 15 on Site at 6:07am
1	MS	103	HP 8
2	MS	283	HP 7 - GPS outage
3	MS	283	HP 7 cont.
4	MS	103	HP 6
5	MS	283	HP 5
6	MS	103	HP 4 - weather deteriorating
0	MS	283	HP 9 - Box 16
1	MS	103	HP 8
2	MS	283	HP 7
3	MS	283	HP 6
4	MS	103	HP 5
5	MS	283	HP 4
6	MS	103	End survey: weather causing motion

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Multibeam Daily Operation Proceedures & Checklist

7/23/2007				
Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X	n/a	n/a	n/a
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X	35 06 28.1604	076 31 07.4219	1521.5
SV Cast #1	X	35 06 28.1604	076 31 07.4219	1521.5
SV Cast #2	X			
SV Cast #3	X			
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes	
Project	USACE MB 2
Survey Area	Survey boxes 15-26, 47-49
Sea State	1-2' waves, choppy, white-caps, layed out flat by 1:00pm EST, light chop from 5-8pm EST
Wind	NE 10-15
Air Temperature	80 F(am), 90 F (pm)
Sea Temperature	78.5 F (am)
Tides	N/A
Survey Features & Navigational Aids	N/A
Comments	Lett dock at 10:00 EST, Box 15 swell side-to. 1st line at 11:53 EST. End survey lines at 7:55pm EST at dock at 8:40 pm EST. = 11 hrs on water, 30 min PPK setup. Clipped a couple of lines that did not have any features in them.

Line Name	MS/CL	Direction	Notes
0	MS	283	HP 11-Box 15 Start at 1533
1	MS	103	HP 10
2	MS	283	Hp 9
3	MS	103	HP 8
4	MS	283	HP 7
5	MS	103	HP 6
6	MS	283	HP 5
7	MS	103	HP 4
8	MS	283	HP 3
9	MS	103	HP 2
10	MS	283	HP 1- End Box 15
11	MS	40	HP 1- Start Box 47
12	MS	220	HP 2
13	MS	40	HP 3 - GPS break in data
14	MS	40	HP 3
15	MS	220	HP 4
16	MS	40	HP 5
17	MS	220	HP 6
18	MS	40	HP 7
19	MS	220	HP 8
20	MS	40	HP 9
21	MS	220	HP 10
22	MS	40	HP 11-End box 47
23	MS	342	HP 1 - Start box 48
24	MS	162	HP 2
25	MS	342	HP 3
26	MS	162	HP 4
27	MS	342	HP 5
28	MS	162	HP 6
29	MS	342	HP 7
30	MS	162	HP 8
31	MS	342	HP 9 - End box 48
32	MS	310	HP 1 - Start box 49
33	MS	130	HP 2
34	MS	310	HP 3
35	MS	130	HP 4
36	MS	310	HP 5
37	MS	130	HP 6
38	MS	310	HP7
39	MS	130	HP 8
40	MS	310	HP 9 - End of box 49
41	MS	30	HP 13 - Start of box 21
42	MS	210	HP 12
43	MS	30	HP 11
44	MS	210	HP 10
45	MS	30	HP 9
46	MS	210	HP 8
47	MS	30	HP 7

48	MS	210	HP 6
49	MS	30	HP 5
50	MS	210	HP 4
51	MS	30	HP 3
52	MS	210	HP 2
53	MS	30	HP 1- End of box 21
54	MS		Transit to box 22
55	MS	25	HP 18 - Start box 22
56	MS	205	HP 17
57	MS	25	HP 16
58	MS	205	HP 15
59	MS	25	HP 14
60	MS	205	HP 13
61	MS	25	HP 12
62	MS	205	HP 11
63	MS	25	HP 10
64	MS	205	HP 9
65	MS	25	HP 8
66	MS	205	HP 7
67	MS	25	HP 6
68	MS	205	HP 5
69	MS	25	HP 4
70	MS	205	HP 3
71	MS	25	HP 2
72	MS	205	HP 1 - End of box 22
73	MS	59	HP 1 - Start of box 23
74	MS	239	HP 2
75	MS	59	HP 3
76	MS	239	HP 4
77	MS	59	HP 5
78	MS	239	HP 6
79	MS	59	HP 7
80	MS	239	HP 8
81	MS	59	HP 9
82	MS	239	HP 10
83	MS	59	HP 11- End of box23
84	MS	46	HP 12 - Start of box 24
85	MS	226	HP 11
86	MS	46	HP 10
87	MS	226	HP 9
88	MS	46	HP 8
89	MS	226	HP 7
90	MS	46	HP 6
91	MS	226	HP 5
92	MS	46	HP 4
93	MS	226	HP 3
94	MS	46	HP 2
95	MS	226	HP 1- End of box24
96	MS	46	HP 6 - Start of box26
97	MS	226	HP 5
98	MS	46	HP 4

99	MS	226	HP 3
100	MS	46	HP 2
101	MS	226	HP 1- End of box 26
102	MS		Hiccup
103	MS		HIccup
104	MS	55	HP 1 - Start of box 25
105	MS	235	HP 2
106	MS	55	HP 3
107	MS	235	HP 4
108	MS	55	HP 5
109	MS	235	HP 6
110	MS	55	Fill in line HP 6
End of Survey Day 7:55pm EST			

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Multibeam Daily Operation Proceedures & Checklist

7/24/2007				
Pre-Survey Operations	**Complete**	**Notes**		
		Latitude (Northing)	**Longitude (Easting)**	**Elev.**
Perform Dock-side GPS Check	X	n/a	n/a	n/a
Power up POS MV	X			
Power up UPS	X			
Power up EM3002 PU	X			
Power up Acquisition PC	X			
Power up Navigation PC	X			
Power up Trimble GPS	X			
Perform BIST (head in water)	X			
Survey Operations		**Latitude (Northing)**	**Longitude (Easting)**	**Value**
Input Initial SV cast in SIS Runtime	X			
SV Cast #1	X			
SV Cast #2	X			
SV Cast #3	X			
SV Cast #4				
SV Cast #5				
SV Cast #6				
SV Cast #7				
SV Cast #8				
Vessel Draft Check (waterline to ducer)				0.53m

General Survey Notes

Project	USACE MB 2
Survey Area	Survey boxes 27-
Sea State	Calm, lt.surface chop, <1'
Wind	E 5-10kts
Air Temperature	75 F(am), 84 F (pm)
Sea Temperature	78.5 F (am), 79.2 F (noon)
Tides	N/A
Survey Features & Navigational Aids	N/A
Comments	Left dock at 5:00 EST. Return to dock at 8:30pm EST = 15.5 hrs on water. By days end we reached our proposed time limit on the project. Not wanting to go over in time we did not collect data in one box that did not have an "ameoba" and one box that was an obvious fish school. Several other boxes we trimmed to just get data surrounding the features to stay on time and also take advantage of the weather window. We will make a detailed list of this information in the final report.

Line Name	MS/CL	Direction	Notes
0	MS	304	Start survey 6:20am EST, HP 1 Start box 27
1	MS	124	HP 2
2	MS	304	HP 3
3	MS	124	HP 4
4	MS	304	HP 5
5	MS	124	HP 6
6	MS	304	HP 7
7	MS	124	HP 8
8	MS	304	HP 9
9	MS	124	HP 10
10	MS	304	HP 11 - End box 27
11	MS	116	HP 7 - Start box 35
12	MS	296	HP 6
13	MS	116	HP 5
14	MS	296	HP 4
15	MS	116	HP 3
16	MS	296	HP 2
17	MS	116	HP 1- End box 35
18	MS	61	HP 1 Start box 32
19	MS	241	HP 2
20	MS	61	HP 3
21	MS	241	HP 4
22	MS	61	HP 5
23	MS	241	HP 6
24	MS	61	HP 7
25	MS	241	HP 8
26	MS	61	HP 9 - GPS error
27	MS	61	HP 9
28	MS	241	HP 10
29	MS	61	HP 11
30	MS	241	HP 12
31	MS	61	HP 13
32	MS	241	HP 14 - End box 32
33	MS	113	HP 1 - Start box 36
34	MS	293	HP 2
35	MS	113	HP 3
36	MS	293	HP 4
37	MS	113	HP 5
38	MS	293	HP 6
39	MS	113	HP 7 - End box 36
40	MS	124	HP 2 - Start box 33
41	MS	304	HP 3
42	MS	124	HP 4
43	MS	304	HP 5
44	MS	124	HP 6
45	MS	304	HP 7
46	MS	124	HP 8

47	MS	304	HP 9
48	MS	124	HP 10
49	MS	304	HP 11
50	MS	124	HP 12
51	MS	304	HP 13
52	MS	124	HP 14
53	MS	304	HP 15 - End box 33
54	MS	236	HP 2 - Start box 34
55	MS	56	HP 3
56	MS	236	HP 4
57	MS	56	HP 5
58	MS	236	HP 6
59	MS	56	HP 7
60	MS	236	HP 8
61	MS	56	HP 9
62	MS	236	HP 10
63	MS	56	HP 11- End Box 34
64	MS	173	HP 2 - start Box 29
65	MS	353	HP 3
66	MS	173	HP 4
67	MS	353	HP 5
68	MS	173	HP 6
69	MS	353	HP 7
70	MS	173	HP 8
71	MS	353	HP 9
72	MS	173	HP 10
73	MS	353	HP 11
74	MS	173	HP 12
75	MS	353	HP 13
76	MS	173	HP 14
77	MS	353	HP 15
78	MS	173	HP 16
79	MS	353	HP 17
80	MS	173	HP 18
81	MS	353	HP 19
82	MS	173	HP 20
83	MS	353	HP 21
84	MS	173	HP 22
85	MS	353	HP 23
86	MS	173	HP 24
87	MS	353	HP 25
88	MS	353	HP 26
89	MS	173	HP 25
90	MS	353	HP 24
91	MS	173	HP 23
92	MS	353	HP 22
93	MS	173	HP 21
94	MS	353	HP 20
95	MS	173	HP 19
96	MS	353	HP 18
97	MS	173	HP 17

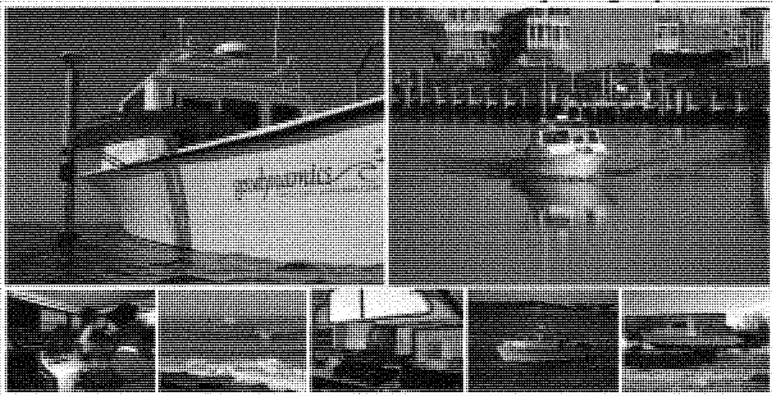
98	MS	353	HP 16
99	MS	173	HP 15
100	MS	353	HP 14
101	MS	173	HP 13 - End Box 29
102	MS	95	HP 11 - Start box 30
103	MS	275	HP 10
104	MS	95	HP 9
105	MS	275	HP 8
106	MS	95	HP 7
107	MS	275	HP 6
108	MS	95	HP 5
109	MS	275	HP 4
110	MS	95	HP 3 - End box 30
111	MS	116	HP 17 - Start box 31
112	MS	296	HP 16
113	MS	116	HP 15
114	MS	296	HP 14
115	MS	116	HP 13
116	MS	296	HP 12
117	MS	116	HP 11
118	MS	296	HP 10
119	MS	116	Fill in
120	MS	116	HP 9
121	MS	296	HP 8
122	MS	116	HP 7
123	MS	296	HP 6
124	MS	116	HP 5
125	MS	296	HP 4
126	MS	116	HP 3
127	MS	296	HP 2
128	MS	116	HP 1
129	MS	116	HP 9
130	MS	296	HP 8
131	MS	116	HP 7
132	MS	296	HP 6
133	MS	116	HP 5
134	MS	296	HP 4
135	MS	116	HP 3
136	MS	296	HP 2
137	MS	116	HP 1 - End box 31
138	MS	89	HP 2 - Start box 40
139	MS	269	HP 3
140	MS	89	HP 4 - End box 40
141	MS	317	HP 7 - Start box 39
142	MS	137	HP 6
143	MS	317	HP 5
144	MS	137	HP 4
145	MS	317	HP 3
146	MS	137	HP 2
147	MS	317	HP 1
148	MS	137	Fill in

149	MS	15	Fill in - End box 39
150	MS	315	HP 2 - Start Box 38
151	MS	135	HP 3
152	MS	315	HP 4
153	MS	135	HP 5
154	MS	315	HP 6 - End Box 38
155	MS	270	HP 6 - Start Box 37
156	MS	90	HP 5
157	MS	270	HP 4
158	MS	90	HP 3 - End Box 37
159	MS	270	HP 6 - Start Box 42
160	MS	90	HP 5
161	MS	270	HP 4
162	MS	90	HP 3
163	MS	270	HP 2
164	MS	90	HP 1 - End Box 42
165	MS	52	HP 1 - Start Box 41
166	MS	232	HP 2
167	MS	52	HP 3
168	MS	232	HP 4
169	MS	52	HP 5
170	MS	232	HP 6
171	MS	52	HP 7
172	MS	232	HP 8
173	MS	52	HP 9
174	MS	232	HP 10
175	MS	52	HP 11 - End Box 41
176	MS	68	HP 4 - Start Box 45
177	MS	248	HP 3 - End Box 45 (a false SS return)
178	MS	221	HP 5 - Start Box 44
179	MS	41	HP 4 (a false SS return)
180	MS	221	HP 3 - End Box 44
181	MS	228	HP 4 - Start Box 43
182	MS	48	HP 3 - nothing, false return
End of survey 7:40 pm EST			

Appendix C – Equipment & Instrument Accuracies

R/V 4-POINTS

Hydrographic Survey

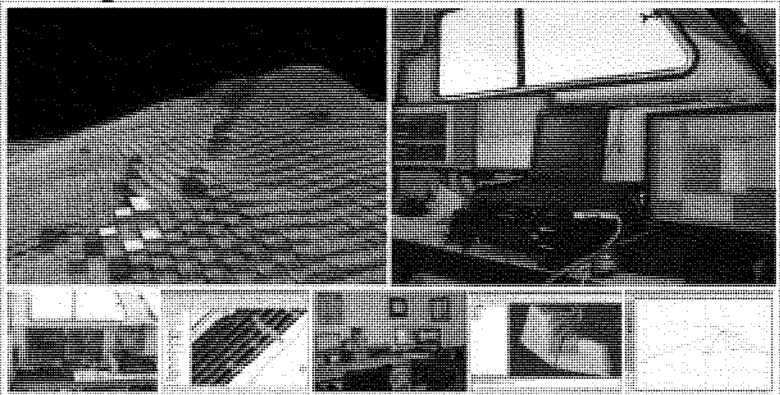


The research vessel 4-Points is a custom fiberglass survey boat designed specifically for shallow-water sonar and acoustical operations. The vessel is 25' long with a 10' beam; the bottom tapers from a deep "Carolina" style Vee to a relatively flat-bottomed stern that provides a shallow draft of approximately 1.2'. Twin 140 four-stroke engines, hung on a stainless steel bracket, power the vessel. All electronics and generators are grounded to the sea via a bottom mounted bonding plate to eliminate all electrical noise. Side-scan instrumentation is deployed, towed and retrieved from custom davit on starboard side.

Instrumentation:

- **Simrad EM 3002 multibeam sonar**
  - Multi-Frequency: in 300 kHz band
  - Max ping rate: 40 Hz
  - No. of beams/ping: 254 Roll and Pitch stabilized
  - Beam width: 1.5° x 1.5°
  - Beam spacing: 0.6°
  - Depth range from sonar head 1 to 150 m
  - Depth resolution: 1 cm
  - Depth accuracy: 5 cm RMS
  - Range sampling rate: 15 kHz
  - Bottom detection by phase or amplitude. Seabed imaging & classification with backscatter (sidescan-like) output.
  - Full swath width accuracy to the latest IHO standard
- **POS MV 320 v4 (with RTK Corrections)**
  - Roll, Pitch accuracy: 0.02° (1 sigma with GPS or DGPS)
  - 0.01° (1 sigma with RTK)
  - Heave Accuracy: 5 cm or 5% (whichever is greater)
  - Heading Accuracy: 0.02° (1 sigma) with 2 m antenna baseline
  - Position Accuracy: 0.02 - 0.10 m (RTK) with input
- **Trimble 5700 dual frequency GPS system & RTK-Basestation**
  - Instrument used for topo/bathy positioning and tidal corrections
  - High precision L1 and L2 measurements
  - 24 channels L1 C/A code, L1/L2 full cycle carrier
  - Extremely low latency (20 milliseconds)
  - Published horizontal accuracy: 10 mm + 1ppm RMS
  - Published vertical accuracy: 20 mm + 1ppm RMS
- **Odom Hydrographics Digibar Pro sound velocity probe**
  - Sampling rate: 10 Hz
  - Depth accuracy: ± 31 cm
  - Velocity accuracy: +/- 0.3 m/sec
- **Applied Microsystems MicroSV sound velocity sensor**
  - SV: time of flight
  - Sampling rate: 10 Hz or continuous programmable
  - Velocity accuracy: 0.05 m/sec
  - Sampling rate: 10 Hz
  - AC or DC power

Processing



Geodynamics maintains a cluster of high-end computer workstations and file/backup servers for the most demanding geospatial data acquisition, processing and analysis. At geodynamics we specialize in high-end spatial data processing and analysis through geographic information science and 3D visualization.

Instrumentation:

Hardware:

- **Field**
  - Custom rack mounted multibeam acquisition PC
  - 3.6 GHz Intel Pentium 4 processors with 800 MHz system bus
  - 2 GB of RAM
  - 512 Dual DVI graphics card
  - (2) 500 GB SATA hard drives
  - Simrad SIS & Applanix POS View acquisition software
  - CARIS HIPS/SIPS
  - (3) Fujitsu pentop navigation PC
  - (3) Maxtor external backup hard drives ~ 850 GB of storage
- **Office**
  - (4) high-end Dell GIS processing workstations
  - (2) Dell workstation laptops
  - (2) 1 TB RAID network attached storage devices
  - (4) Maxtor / Seagate external backup drives ~ 1.2 TB of storage

Software:

- **Multibeam / Side Scan**
  - Caris HIPS / SIPS 6 sp2
  - Triton Imaging ISIS
  - Triton Imaging BathyPro & DelphMap
- **Singlebeam**
  - Hypack Max v. 4.3 sp1
  - Caris HIPS / SIPS 6 sp2
- **Topographic**
  - Trimble Geomatics Office
  - Caris HIPS / SIPS 6 sp2 (Lidar)
- **GIS**
  - ArcView 3.3a (Spatial, 3D & Image Analyst)
  - ArcGIS 9.1 (Spatial, ArcScene, 3D, Survey & Geostatistical Analyst)
  - Surfer 8.0
  - [illegible]

US Army Corps
of Engineers

WILMINGTON DISTRICT

DRAFT
CONDITION INDEX AND DESEASE ASSESSMENT OF SUBTIDAL OYSTER SPECIMENS FROM 39 NEUSE RIVER ESTUARY REEFS COLLECTED IN JULY 2008

For the

NEUSE RIVER BASIN FEASIBILITY STUDY
NORTH CAROLINA

February 2009

CONDITION AND DESEASE INDEXES FROM OYSTER SPECIMENS COLLECTED FROM DEEP WATER SUBTIDAL REEFS IN JULY 2008

1.0 List of Acronyms

COR	Contracting Officer's Representative
COC	Chain of Custody
NCDMF	North Carolina Division of Marine Fisheries
NCDWR	North Carolina Division of Water Resources
LD	Laboratory Data
OGA	Oyster Growing Area
PT	Process Tracking
TBD	To Be Determined
UNC-W CMS	University of North Carolina at Wilmington, Center for Marine Science
USACE	U.S. Army Corps of Engineers

2.0 Project Delivery Team

Corps COR	Phil Payonk
Corps Technical Lead	Chuck Wilson
UNCW Principal Investigator	Troy Alphin
UNCW Lead Tech, Condition	Melissa Mitchell
UNCW Lead Tech, PCR	Ann Markwith

3.0 PROBLEM DEFINITION/BACKGROUND

Problem Identification The Wilmington District and State of NC are currently conducting the Neuse River Basin Study that includes potential restoration of subtidal oyster reefs in the Neuse River estuary. The NCDMF consider Eastern oyster (*Crassostrea virginica*) a keystone estuarine species and healthy oyster reefs as vital to the estuarine ecosystem. Current scientific literature describes oysters as providing important services including; water filtration, and habitat for benthos, fish and shrimp. Oyster populations are on the decline having been impacted by historic fishing practices, pollution and disease. The protozoan *Perkinsus marinus* causes DERMO disease in infected oysters. It lives in the oyster's immune cells and is thought to suppress their function. Up to 50% of oysters infected during their first year will die during the second summer with 80-90% succumbing in year 3 and very few surviving four years (EOBRT 2007). In the Neuse River Estuary oyster degradation is particularly apparent. Prior to the 1950s the Neuse estuary supported a productive oyster fishery with oyster supplies adequate to support a now defunct, local soup cannery. However, oyster harvest from the Neuse has declined dramatically with existing harvest primarily from shallow subtidal reefs and only limited harvest from the few deepwater reefs that remain viable. While these reefs continue to provide an important habitat for fish and invertebrates, occasionally, deep waters of the Neuse River estuary become hypoxic, and during extreme cases, anoxic for prolonged periods due to combined effects of stratification from a lack of wind mixing and eutrophication. These events can result in mass oyster mortality and can kill other reef fauna. Some studies suggest that the extent and frequency of hypoxia has increased in the Neuse estuary in recent decades due to increased anthropogenic nutrients, and that a reduced reef height from destructive harvest practices, increase their vulnerability to impacts of hypoxia. Limited qualitative sampling by NCDMF the USACE in 2006 and an ongoing Sea Grant Study identified a range of reef conditions in the Neuse Estuary from dead shell to good oyster growth including sites of apparently sufficient height and location to support sustainable oysters. This provides evidence that viable deep water oyster reef, can exist in portions of the Neuse River estuary.

Previous and Ongoing Data Collection Efforts. Remote sensing of subtidal oyster reefs in the Neuse River estuary was completed in 2007. Side-scan sonar was used to located potential reefs. Full coverage multibeam hydrographic survey was used to confirm reef status and collect detailed information on physical characteristics of each reef. One hundred and thirty one (131) reef targets ranging in size from less than 0.1 acre to about 16 acres, and totaling about 245 acres, have been identified.

Water quality within the Neuse Estuary is continually monitored as part of extensive ongoing Neuse Estuary monitoring programs at cooperating NC universities and a 3-Dimensional water quality model is available for the Lower Neuse estuary. Combined, these efforts are known as the Neuse River Mod-Mon Project. The Corps has updated the model for the period of 1998-2006 for the purpose of the Neuse River Basin Study. Water quality output is available for each of 4 water layers including; the bottom, surface and two intermediate layers (25% and 75% of depth) and include the elevation of each layer and associated salinity, dissolved oxygen, temperature, current velocity and direction, and chlorophyll.

Model output will be interpreted by the Corps to evaluate water quality and flow as components of oyster habitat suitability within existing model grids cells, covering a variable water surface area of about 0.75 square miles, and representing existing or potential oyster reef locations. An Oyster Habitat Suitability Index (OHSI) will be assigned to each layer with in each grid based on a modified Habitat Evaluation Procedure (HEP). A water quality based planning model will be developed to predict oyster habitat suitability throughout the oyster growing area under existing and predicted future conditions.

Use of Data Collected or Facilitated By this effort. The USACE will use this biological data to field validate the planning model or appropriately weight model parameters as needed based on statistical analysis. In addition the USACE and UNCW will use this biological data, WQ model output and survey data to determine the actual correlation of physical parameters with biological attributes of Neuse River reefs. The USACE will develop a statistical model as appropriate and recommendations will be developed for reef design criteria that incorporate any physical parameters such as size, height, or other pertinent factors identified as attributes for reef sustainability.

Collection sites were selected to include a representative sample of known reefs with the following attributes.

1. Located within the Neuse River Estuary Oyster Growing Area (OGA). Potential to support oyster growth.
2. Within the Corps Multibeam Survey Area. (Physical Data Available)
3. Located within the 3D Model Grid. (WQ output and Habitat Suitability Index Available)
4. Minimum continuous top area of 0.1 hectare (0.24 acres) to minimize field time in target acquisition.

Reef Sample Locations. Oyster specimens were provided from 39 Reefs (Table 1) combined from three dredge tows for each reef top sample area (1 /reef Table 1). Although some reefs had more that one reef top sample area available, collection were made from only the largest sample area on each reef. Sample areas were selected by the USACE to represent an expected consistent site condition to reduce sample variance.

Table 1. PROPSED REEFS AND SAMPLE APEAS				
Task #	Reef ID	Foot Print (Acres)	Sample Area ID	Sample Area (Acres)
1	ERHA-00046	2.04	FHSA-00168	0.5
2	ERHA-00048	2	FHSA-00064	0.68
3	ERHA-00049	2.76	FHSA-00066	0.39
4	ERHA-00050	2.4	FHSA-00068	0.43
5	ERHA-00054	3.52	FHSA-00075	0.63
6	ERHA-00056	2.7	FHSA-00076	0.64
7	ERHA-00057	3.3	FHSA-00077	0.98
8	ERHA-00058	3.41	FHSA-00078	0.82
9	ERHA-00059	4.26	FHSA-00079	1.29
10	ERHA-00060	3.48	FHSA-00080	0.9
11	ERHA-00061	7.33	FHSA-00081	2.82
12	ERHA-00063	2.84	FHSA-00090	0.59
13	ERHA-00064	6.59	FHSA-00086	2.91
Option	ERHA-00065	10.74	FHSA-00083	0.55
Option	ERHA-00065	10.74	FHSA-00084	1.12
14	ERHA-00065	10.74	FHSA-00085	2.48
15	ERHA-00066	6.61	FHSA-00088	2.44
16	ERHA-00067	4.71	FHSA-00087	1.58
17	ERHA-00068	5.18	FHSA-00089	1.73
18	ERHA-00069	2.12	FHSA-00166	0.96
19	ERHA-00070	6.85	FHSA-00094	2.54
20	ERHA-00071	1	FHSA-00095	0.36
21	ERHA-00072	8.83	FHSA-00096	4.9
22	ERHA-00074	2.11	FHSA-00098	0.94
23	ERHA-00076	2.37	FHSA-00101	1.04
24	ERHA-00077	2.55	FHSA-00102	1.02
25	ERHA-00078	2.7	FHSA-00103	1.32
26	ERHA-00079	0.73	FHSA-00104	0.25
27	ERHA-00080	1.96	FHSA-00105	0.91
28	ERHA-00081	1.43	FHSA-00106	0.57
Option	ERHA-00082	11.3	FHSA-00107	0.34
29	ERHA-00082	11.3	FHSA-00109	3.72
30	ERHA-00083	8.52	FHSA-00110	4.24
31	ERHA-00084	8.43	FHSA-00111	3.24
32	ERHA-00085	3.53	FHSA-00112	1.35
33	ERHA-00086	2.82	FHSA-00113	0.96
Option	ERHA-00088	6.01	FHSA-00115	0.37
34	ERHA-00088	6.01	FHSA-00116	1.4
35	ERHA-00089	3.74	FHSA-00117	1.47
36	ERHA-00091	2.22	FHSA-00119	0.65
37	ERHA-00092	2.52	FHSA-00120	0.68
38	ERHA-00130	3.04	FHSA-00122	0.6
Option	ERHA-00131	15.83	FHSA-00091	1.2
Option	ERHA-00131	15.83	FHSA-00092	0.35
39	ERHA-00131	15.83	FHSA-00093	3.05

4.0 TASK DESCRIPTION

Description and Scope . The Wilmington District contractor Versar (USACE 2008) conducted sampling on 39 Neuse River estuary deep water reefs in July 2008. The UNCW CMS benthic lab was contracted to (A) Receive and safely store live oyster specimens collected by Versar, Inc. via a concurrent USACE field sampling contract until processed by the UNCW CMS benthic lab, providing technician support to (B) assess the condition of oyster specimens from sampled reefs, and (C) assess the degree of *P marinis* infection for oyster specimens from sampled reefs. The findings of the UNCW efforts are included in this report.

Field sheets were completed by Versar Inc. for each sample and total of 40 live oysters were collected from each reef and delivered live and in good condition to the UNC-Wilmington CMS Benthic Lab.

Laboratory Analysis. Oyster specimens from each reef were inspected and 30 specimens representing the best condition and size distribution were processed in the UNC-W benthic Lab to (1) determine a Hopkins Index of Condition for each reef sampled by the Field Contractor and (2) the degree of *Perkinsus marinus* infection to be assessed using Quantitative Polymerase Chain Reaction (PCR) assay. All measurements were recorded on a individual Lab Data forms (provided by the USACE). Process Tracking forms were be annotated with Date, Time, and Location as the samples wee moved from storage, Benthic Lab, air drying areas, PCR Lab, oven, freezer etc.

Hopkins Index of Condition. Methods to determine condition Index followed those developed by Lawrence and Scott (Lawrence and Scott, 1982) using weight to determine cavity volume to be used to calculate Hopkins' Index (dry meat weight in grams)(100)/(internal volume in $Cm^{3)}$.

Protocol. The protocol used for this analysis is a follows:

1- Cull any gaping or broken oysters upon receipt. At this time any unacceptable samples will be reported to the USACE..
2- Clean remaining oysters, removing any attached organisms and separating any clumps. Wipe clean oysters and let air dry under fan until visibly dry. Record drying time.
3- Chose 30 oysters from the sample (or all if sample is less than 30) making sure they have tightly closed shells. When choosing oysters take into account sizes, trying to represent the size distribution within the sample.
4- Label each oyster with the reef # and its individual # (i.e. top valve should read R1 1). Bottom valve will be labeled once oyster is shucked. Label weigh boats at this time as well (once again indicating reef # and oyster #)
5- Weigh each oyster.
6- Weigh each weigh boat for initial weight. Weights for both this step and step 5 should be to 0.01g.

At this point if processing is not being continued oysters should be returned to cold room and time and date should be recorded on the data sheet. Oysters will be stored by reefs in individual bins.

7- Measure length (from umbo) and width using digital calipers. Measurements should be to the nearest 0.01 mm.
8- Shuck each oyster making sure to keep all pieces of shell together.
(When oysters are being processed they will be laid out on Styrofoam boards used in Tidal Creeks. Once shucked and tissue removed the shell pieces are placed on board in number order to initially dry so that 2nd valve can be marked with ID info).
9- Once open a section of mantle from above the labial palps will be removed from the first 20 oysters of each sample. Tissue samples will be placed in .5ml microcentrifuge tube labeled with project name, reef and oyster numbers, and collection date.

Mantel samples will be stored in -80C freezer in DNA lab. At this point location, date and time for samples will be recorded.

10- The tissue and any shell fragments will be placed in corresponding weigh boat and weighed. Once all weights are recorded samples will be placed in drying oven at 70C for 24-48hr (or until dry). When dry the tissue dry weights will be taken (make sure to allow weigh boats to cool 5-10 minutes before weighing).

Once again location, date and time for samples will be recorded.

11- Once valves have been sufficiently marked with ID info, they will be placed in an appropriate area for air drying 24-30hr.

Location, date and time for samples will be recorded.
If shell weights cannot be taken at this time then shells will be bagged to process at a later date. If they are able to be processed then repeat step 5 with empty shells.

Results will be averaged for each reef and used as a biological indicator of reef condition for a particular reef.

Diagnosis of *Perkinsus marinus* Infection. The protozoan *Perkinsus marinus* causes DERMO disease in infected oysters. It lives in the oyster's immune cells and is thought to suppress their function. *P. marinus* infection will be assessed using Quantitative Polymerase Chain Reaction (PCR) assay that targets the protozan's rRNA gene. Total DNA will be extracted from the oyster tissue and the IGS region amplified using a LightCycler PCR machine. Results for the 20 samples for each reef will be averaged and a Disease Index calculated to be used as a biological indicator of biological condition for a given reef.

4.0 Schedule for the Work Performed

Schedule for Sampling/Testing/Reporting Schedule	Approximate Date
Kick-off Meeting	July 2008
First Live Oysters Provided to UNC-W CMS for Biological Analysis	July 2008
Submit Compiled Libratory Data Sheets for	February 2008

Condition Index and PCR and Transmittal Log.	

5.0 Attachments

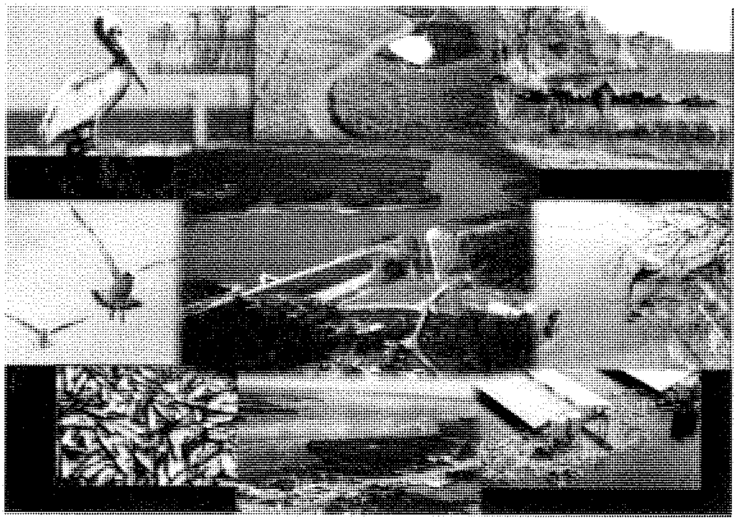
1. Condition Index Data Forms for all reef samples
2. PCR Counts and Quantities

References

Lawrence, D. R. & Scott, G. I. (1982) The Determination and Use of Condition Index of Oysters. *Estuaries*, **5**, 23-27.

Neuse River Basin
Integrated Feasibility Report and Environmental Assessment

Appendices G-T



IN COOPERATION WITH

NCDENR

PREPARED BY:

US Army Corps of Engineers
Wilmington District

November 2012

Appendix G: Economic and Incremental Cost Analysis

TABLE OF CONTENTS

1.0 ECONOMIC AND SOCIAL CONSIDERATIONS

This appendix presents the socio-economic issues related to the Neuse River Basin project implementation.

The primary effects of the project are the costs of implementation (National Economic Development [NED] cost), and the environmental benefits (i.e. ecosystem restoration and improvements). These costs and benefits are incorporated into a Cost Effectiveness/Incremental Cost Analysis (CE/ICA) which is a main tool used in the socio-economic evaluation of an environmental restoration project.

The primary effects of the project include the costs of implementation as well as the ecosystem restoration and improvement benefits. Project implementation costs are monetarily expressed in terms of the net national project cost (NED costs). Project costs have regional impacts as expenditures on the project within the regional economy that could cause changes in local and regional earnings, sales, and employment. While the costs of implementation are expressed in traditional monetary terms, ecosystem improvement, the most significant beneficial effect of the project is not expressed in monetary terms. Ecosystem improvement is expressed in terms of National Ecosystem Restoration benefits in accordance with U.S. Army Corps of Engineers (USACE) policy. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the federal objective shall be selected.

The potential economic impacts of the alternative restoration plans are secondary consequences of the environmental improvements and hydrologic changes that are expected to result from the proposed structural and operational modifications to the project study area. These projected impacts are contingent upon the successful implementation and operation of restoration plans and subsequent outputs and therefore, subject to the uncertainties inherent in ecosystem restoration activities. Due to the challenges inherent in quantifying National Ecosystem Restoration (NER) effects or benefits, quantifying the resulting NED impact is also a challenge.

Nonetheless, there are methods for evaluating the economic efficiencies of producing these alternative restoration plans.

In order to evaluate the economic efficiencies of the span of project alternatives, an analysis of the NED costs and NER benefits of each alternative is undertaken. Specifically, a CE/ICA is utilized to determine the alternatives that provided the least unit cost per unit of benefits.

This appendix is responsible for considering a variety of social conditions relevant to the project. These social conditions are intricately interconnected with the economics of the project. They include elements such as population, water demand, recreation, environmental justice, and a variety of other considerations.

1.1 Elements of the Socio-economic Investigation

This investigation assesses the economic effects of the alternative ecosystem restoration plans formulated in the feasibility phase of the Neuse River Basin project. The economic evaluation of the alternative restoration plans includes the elements discussed in the following sub-sections.

1.1.1 Evaluation of Project Costs

Project costs include all expenditures required to implement the alternative plans. The federal government and the State of North Carolina would share these costs. Neuse River Basin project costs include those for initial construction; lands; relocations; rights of way; rehabilitation, replacement, and repair; and operations and maintenance (O&M) (including the costs of post-construction monitoring and adaptive management).

1.1.2 Regional Economic Development Effects

The potential Regional Economic Development (RED) effects of the Selected Alternative Plan (SAP) include changes in income, employment, or economic output of the region.

1.1.3 Other Social Effects

The potential social effects of the SAP include effects on minority, elderly, and disadvantaged groups, population displacement, and effects on community cohesion. The economic analysis for the Neuse Basin watershed study was conducted in a manner consistent with Federal Statutes and U.S. Army Corps of Engineers (USACE) policy. Procedures for estimating NED and RED effects are specified in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (U.S. Water Resources Council, 10 May1983), Engineering Regulation (ER) 1105-2-100 (22 April 2000), and other USACE guidance.

The potential economic impacts of the alternative restoration plans are secondary consequences of the environmental improvements and hydrologic changes that are expected to result from the proposed structural and operational modifications to the Neuse River Basin project study area. These projected impacts are contingent upon the successful implementation and operation of restoration plans and subsequent outputs and therefore, subject to the uncertainties inherent in those ecosystem restoration activities. Due to the challenges inherent in quantifying NER benefits, quantifying the resulting NED benefit is also a challenge. Nonetheless, there are methods or evaluating the economic efficiencies of alternative restoration plans.

1.2 Methodology

A number of factors were considered prior to developing the methodologies used to evaluate the economic effects of the alternative restoration plans. These factors include: available analytical tools, economic theory, federal policy, obtainable data, and time and budgetary constraints. These factors are discussed in the sections to follow.

1.2.1 Without-Plan and With-Plan Conditions

Proper definition of the without-plan and with-plan conditions is critical to the planning process. The without-plan condition is the most likely condition expected to exist in the future in the absence of a proposed project. The future without plan condition is the benchmark against which alternative future with-plans are evaluated. National and regional socio-economic parameters considered include income, employment, population and other aggregate projections such as land use trends, water supply and water demand. Comparisons of conditions with the implementation of alternative plans to future without-plan conditions were performed to identify the beneficial and adverse effects of the proposed plans. Depending on the alternative and the type of economic impact changes resulting from implementation of a restoration plan, it may be desirable or undesirable when compared to the future without-plan condition. For example, alternatives that include modifications to the current system to provide additional water storage areas may result in fewer economic losses associated with agricultural (irrigation) water shortages. This would be a desirable ancillary benefit of restoration.

1.2.2 Economic Analysis Methodology

Consistent with USACE guidance, neither a traditional benefit-cost ratio nor a net NED analysis is required for NER plans. For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the federal objective shall be selected. The methodologies used to conduct economic analysis studies for the project were based on a combination of factors, including: economic theory, USACE's ecosystem restoration and economic evaluation policies, and the characteristics of methodologies used by economists to value ecosystem benefits. For this study, the alternative restoration plans were compared using information in monetary and non-monetary units. The economic analysis of the Neuse River Basin alternative restoration plans include: (1) the NED costs (in monetary terms), (2) the anticipated environmental benefits resulting from restoration measures (in non-monetary terms), (3) the NED benefits and impacts attributable to the following: agricultural water supply, municipal and industrial (M&I) water supply, commercial navigation, recreation, and commercial fishing (in monetary and non-monetary terms) and (4) the positive and adverse regional economic effects (RED) and social effects resulting from project implementation.

This section of the report addresses the above items. The economic basis for making policy decisions about whether to invest public funds in ecosystem restoration for the Neuse River Basin project is comparing monetary costs and non-monetary benefits in order to determine whether the expenditure is justified and to select the plan which minimizes the cost of obtaining ecosystem benefits. The costs of ecosystem restoration projects include: initial construction costs; major rehabilitation and repair costs; O&M costs; post construction monitoring costs; and adverse NED effects. Typically, these costs can be expressed in monetary (i.e., dollar) terms.

The principal challenge of ecosystem restoration economics is estimating the value of restoration benefits. The primary purpose of each alternative plan is ecosystem restoration. The benefits of ecosystem restoration are usually expressed by ecologists in non-monetary units, such as acres of specific habitat created, indices of biological productivity associated with habitat improvement, or increased abundance and/or diversity of particular species of plants or animals. For decision-making purposes, it would be desirable to express ecosystem restoration benefits in monetary terms, in order to compare them with project costs.

Expressing the costs and benefits of alternatives in a common, monetary metric would facilitate selection of the best restoration plan for a given site. However, calculating the monetary value of environmental amenities is both difficult and controversial. Environmental amenities are public goods that are generally not exchanged in the marketplace. For marketable commodities (i.e., items that people buy and sell), the demand and prices paid for these goods can be used as "proxies" for determining their value to consumers. In the absence of data on consumers' expenditures for environmental amenities, resource economists have attempted to develop techniques that can be used to estimate their value using indirect indicators of consumers' "willingness to pay" for ecosystem restoration. For goods and services that are not purchased in the marketplace, non-market valuation approaches must be used to infer their value to the public. There are direct and indirect use values for these goods and services. Use values refer to the value consumers obtain from using a good that is related to an environmental amenity.

Non-consumptive use values refer to the value obtained by a user in cases for which the good remains to be used by others in the future, such as catch-and-release fishing or bird watching. It is reasonable to expect that the alternative restoration plans will generate additional use values to the public. Non-market activities that would benefit from restoration plans include recreational fishing, subsistence activities, and a variety of eco-tourism related activities (e.g., bird watching, hiking and canoeing).

Non-use values include the values the public obtains from simply knowing that the good or resource is available, even if they have not used it previously. Individuals may value a good simply from knowing it exists (existence value) or because they may want to have the opportunity to use it at some future time (option value).

Again, it is reasonable to expect that the alternative restoration plans will generate additional non-use values to the public. The tremendous interest in and support for ecosystem restoration, not just in North Carolina but throughout the country (and the world), is an indication that a broad segment of society values the ecosystem, even though most have never experienced the area first hand.

Theoretically, it is possible to determine the value of restoring the Neuse River Basin ecosystem by asking people what they would be willing to pay for different levels and types of restoration projects, or by observing what they spend on ancillary costs (e.g., travel, subsistence, equipment) when they engage in these nonmarket experiences. Economists have developed a variety of techniques to estimate society's willingness to pay for these types of non-marketable environmental amenities. These economic valuation techniques include market-based, surrogate market, and no -market methodologies (Freeman, 1993). Market-based approaches estimate the value of environmental resources using information generated in the marketplace. These approaches include changes in factors of production, valuation of complimentary goods and services, defensive expenditures, and market valuation of the next best alternative. Surrogate-market techniques estimate value based on preferences revealed in surrogate markets. These techniques include the travel cost method and hedonic valuation. The contingent valuation method (CVM) is the most widely accepted non-market valuation methodology. CVM is perceived as the most effective technique to determine society's willingness to pay for environmental protection and/or restoration and is the only technique able to estimate non-use (i.e., option and existence) values. This method is based on carefully designed surveys that solicit respondent's willingness to pay for a specific environmental resource in a given condition. The survey is intended to reveal both users' and non-users' willingness to pay for the resource.

Unfortunately, these surrogate-market techniques, including CVM, have significant shortcomings that lead to concerns about their reliability and validity. They are especially problematic in cases for which respondents are unfamiliar with the environmental amenity, when the issue is controversial, or where it generates strong reactions, based on ethical, rather than economic motivations. Most importantly for the Neuse River Basin effort, the reliability and validity of these techniques are especially questionable in situations in which the actual changes that would result from the restoration efforts are difficult to precisely describe or visualize. Finally, stated preference methods, such as CVM, can be expensive to implement, especially when multiple alternatives are being evaluated.

As specified in USACE's ecosystem restoration policy (EC 1105-2-210: Ecosystem Restoration in the Civil Works Program), ecosystem restoration projects are not subject to traditional benefit-cost analyses. An ecosystem restoration proposal must still be justified by comparing the monetary costs and non-monetary benefits of restoring degraded ecosystems. USACE ecosystem restoration evaluation procedures focus on the non-monetary benefits of restoration, comparing these benefits to monetary costs using CE/ICA procedures.

2.0 POPULATION AND ECONOMY

The sections that follow evaluate the economic impacts of the alternative restoration plans.

The people who live in the study area, and the economic activity, in which they are engaged, comprise important components of the area's total environment. In addition to the direct use of this data for the water use projections and OSE mentioned above, residents of the study area represent the socio-economic environment for the other impact topics of flooding, water use shortages, fishing, recreation, and navigation.

Any course of action forthcoming from this study will have effects throughout an economic system as well as the natural ecosystem(s), the health and sustenance of which are the impetus for this investigation. The economic system is connected with the natural ecosystem and in general is ultimately dependent upon it for survival. This connection is especially strong in the study area.

Adverse changes in the health and condition of the natural system can cause severe negative impacts on the economic system, particularly in the study area for this feasibility study. Conversely, in this study area, beneficial changes to the natural system are expected to have a strong positive effect on the economic system. It is significant, therefore, to describe and understand the general economic and social environment within which such changes could take place. Although the main focus of economic impact evaluation efforts undertaken for this study has been to describe the economic impacts and benefits of alternatives being considered for implementation, describing the broader context for these evaluation efforts is also necessary and important.

Competition for regional water resources has intensified with the increase in population and agriculture industry growth. This places a strain on existing resources, which will eventually surpass the readily available sources. When the needs of the natural system are then factored in, demands become greater and conflicts among competing water users would become even more severe. While most people recognize the need for a healthy ecosystem to support the region's economy and jobs, many people are concerned that restoration projects would displace farms and other businesses, limit development, reduce available water supply and reduce job opportunities. By contrast, continued degradation of the central and eastern North Carolina ecosystem would adversely affect lifestyles in and around the study area.

2.1 Project Area

The existing land use within the study boundaries varies from preserve lands to agriculture and industrial urban uses. A large portion of eastern and central North Carolina remains natural, although much of it is disturbed land.

Acreage of the impacted counties, in the Neuse River Basin, is defined in Table 2.1-1. Figure 2.1-1 illustrates the location of counties in the basin and Figure 2.1-2 illustrates land cover in the basin.

Table 2.1-1: Areas of Potentially Impacted Counties

County	Area	% of Area in Basin	% of area in State
North Carolina	48,710.88	NA	NA
Neuse Basin Counties	62,34.00	NA	12.80
Beaufort	827.97	13.28	1.70
Carteret	519.80	8.34	1.07
Craven	708.30	11.36	1.45
Duplin	817.73	13.12	1.68
Durham	290.32	4.66	0.60
Edgecombe	505.30	8.11	1.04
Franklin	492.02	7.89	1.01
Granville	531.12	8.52	1.09
Greene	265.40	4.26	0.54
Harnett	595.01	9.54	1.22
Johnston	791.85	12.70	1.63
Jones	471.88	7.57	0.97
Lenoir	399.85	6.41	0.82
Nash	540.27	8.67	1.11
Onslow	766.82	12.30	1.57
Orange	399.84	6.41	0.82
Pamlico	336.94	5.40	0.69
Person	392.31	6.29	0.81
Pitt	651.58	10.45	1.34
Sampson	945.45	15.17	1.94
Wake	831.92	13.34	1.71
Wayne	552.57	8.86	1.13
Wilson	371.09	5.95	0.76

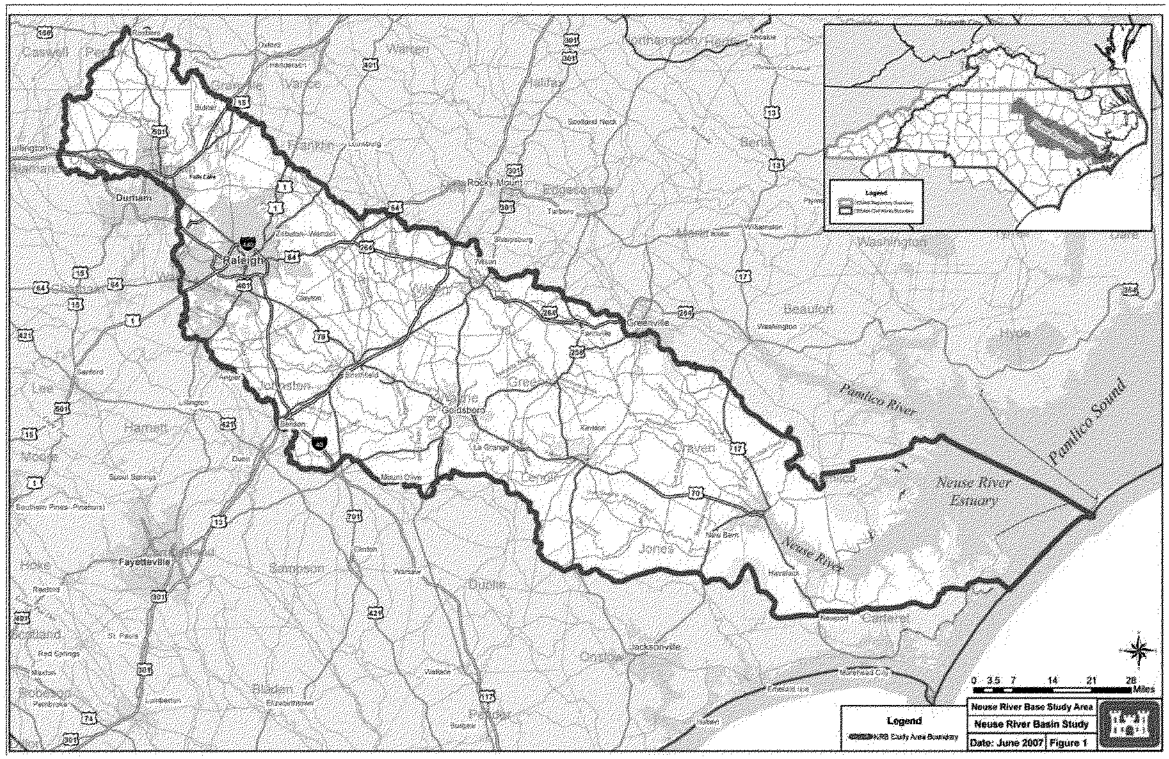


FIGURE 2.1-1: MAP OF NEUSE RIVER BASIN STUDY AREA

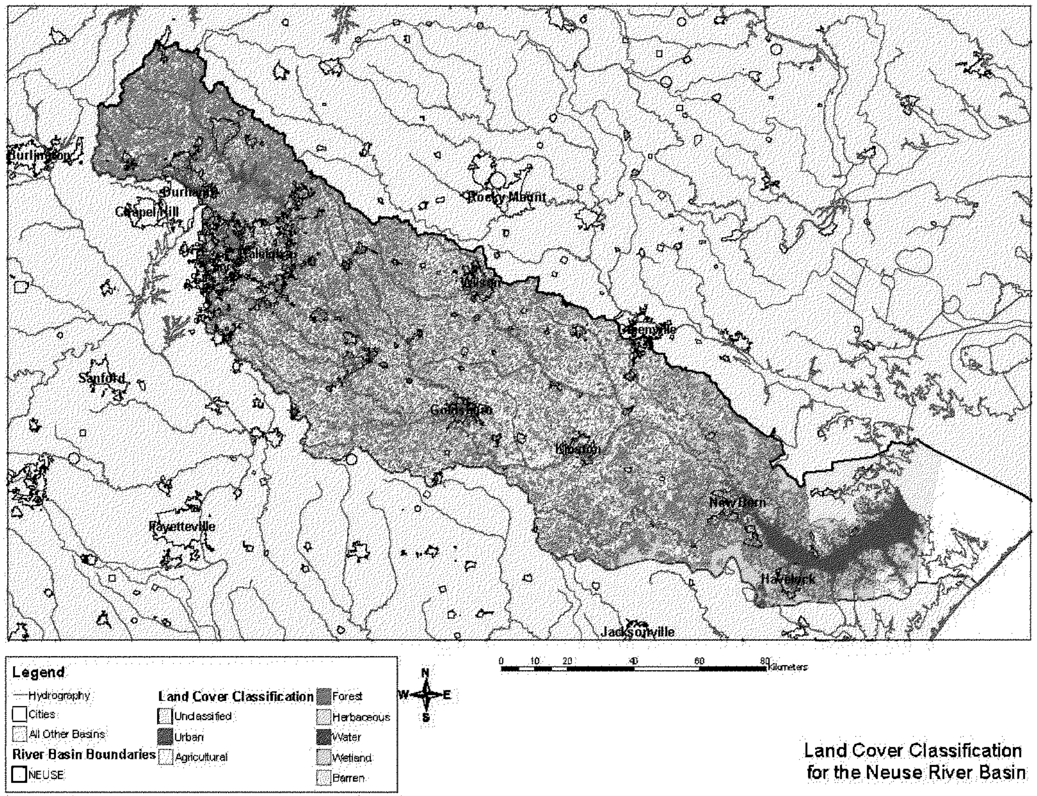


FIGURE 2.1-2: MAP OF LAND COVER IN THE NEUSE RIVER BASIN STUDY AREA

2.2 General

Typical socio-economic and demographic data for the twenty three-county Neuse Basin study area indicate lower than average income when compared to the rest of the state. North Carolina's economy is generally characterized by strong wholesale and retail trade, government and technology sectors. North Carolina's temperate climate attracts vacationers and other visitors and helps to make the State a significant destination for people from all over the country. Easily developed land, accessible water supply, abundant natural resources, and the aesthetic beauty of the region are the fundamental building blocks of the local economy. Relative to the national economy, the manufacturing sector has played less of a role in North Carolina, including the study area. However, high technology manufacturing has begun to emerge as a significant sector in the State over the two decades.

2.3 Population

This section includes a description of the local economy and demographics of the study area. This descriptive information provides insight into the study area's socio-economic characteristics, and provides part of the basis for different facets of the economic impact evaluation work in the rest of this document.

The following Tables 2.3-1 through 2.3-3 represent the existing and trending population, gender, ethnic, and age profiles of the Neuse Basin study area.

Table 2.3-1: Neuse River Basin County Population Profile, 2010

Area	2010 Population	2000 Population	% Change, 2000-2010
State of North Carolina	9,535,483	8,049,313	18.5
Beaufort	47,759	44,958	6.2
Carteret	66,469	59,383	11.9
Craven	103,505	91,436	13.2
Duplin	58,505	49,063	19.2
Durham	267,587	223,314	19.8
Edgecombe	56,552	55,606	1.7
Franklin	60,619	47,260	28.3
Granville	559,916	48,498	23.5
Greene	21,362	18,974	12.6
Harnett	114,678	91,025	26.0
Johnston	168,878	121,965	38.5
Jones	10,153	10,381	-2.2
Lenoir	59,495	59,648	-3
Nash	95,840	87,420	9.6
Onslow	177,772	150,355	18.2
Orange	133,081	118,227	13.2
Pamlico	13,144	12,934	1.6
Person	39,464	35,623	10.8
Pitt	168,148	133,798	25.7
Sampson	63,431	60,161	5.4
Wake	900,993	627,846	43.5
Wayne	122,623	113,329	8.2
Wilson	81,234	73,814	10.1

Source: US Census Bureau, State and County QuickFacts, 2010

Table 2.3-2: Age and Gender Profile, Neuse River Basin, 2010

Area	Under 5	Under 18	65 and older	Female
State of North Carolina	6.6	23.9	12.9	51.3
Beaufort	5.8	22.0	18.4	51.8
Carteret	4.9	18.9	19.0	50.6
Craven	7.4	23.4	15.3	50.3
Duplin	7.3	25.4	14.2	50.8
Durham	7.4	22.5	9.8	52.3
Edgecombe	6.6	24.5	14.3	53.6
Franklin	6.6	24.5	12.7	50.2
Granville	5.7	22.3	12.4	46.6
Greene	6.5	23.2	12.5	46.4
Harnett	8.1	27.8	10.4	51.0
Johnston	7.6	27.8	10.2	50.8
Jones	6.1	21.7	17.3	51.9
Lenoir	6.4	24.1	16.0	52.3
Nash	6.1	2423.9	14	51.7
Onslow	9.6	25.3	7.5	46.4
Orange	5.1	20.9	9.6	52.2
Pamlico	4.6	17.9	21.7	49
Person	6	23.1	15.2	51.5
Pitt	6.7	22.5	9.9	52.8
Sampson	6.9	25.7	14.3	51
Wake	7.3	26	8.5	51.3
Wayne	7.1	24.9	13.1	51.1
Wilson	6.7	24.7	14.2	52.3

Source: US Census Bureau, State and County QuickFacts, 2010

Table 2.3-3: Ethnic Profile, Neuse River Basin, 2010

Area	% White	% African American	% Hispanic
State of North Carolina	68.5	21.6	8.4
Beaufort	68.2	25.6	6.6
Carteret	89.3	6.1	3.4
Craven	70	22.4	6.1
Duplin	57.2	25.3	20.6
Durham	46.4	38	13.5
Edgecombe	38.8	57.4	3.7
Franklin	66	26.7	7.9
Granville	60.4	32.8	7.5
Greene	50.8	37.3	14.3
Harnett	68.3	20.9	10.8
Johnston	74.2	15.1	12.9
Jones	63	32.4	3.9
Lenoir	53.4	40.5	6.6
Nash	55.9	37.2	6.3
Onslow	74	15.6	10.1
Orange	74.4	11.9	8.2
Pamilico	76.3	22	3.1
Person	68.3	27	4
Pitt	58.9	34.1	5.5
Sampson	56.7	27	16.5
Wake	66.3	20.7	9.8
Wayne	58.8	31.4	9.9
Wilson	52	39	9.5
Basin % Totals	62.9	28.1	8.7

Source: US Census Bureau, State and County QuickFacts, 2010

2.4 Economy

Generally, a strong wholesale and retail trade, government and service sectors characterize North Carolina's economy. North Carolina's temperate weather and extensive coastline and mountains attracts vacationers and other visitors, and helps make the state a significant destination for people all over the country. Agricultural production is also an important sector of the state's economy, and is especially significant to portions of the study area. Compared to the national economy, the manufacturing sector has played less of a role in North Carolina recently, but high technology manufacturing has begun to emerge as a significant sector in the state over the last two decades. The Neuse Basin, like the rest of North Carolina has seen a shift from an agrarian and manufacturing based economy, to that of a service economy. Farm employment has decreased an average of 14% from 2000 to 2008 in the basin, while nonfarm employment has increased an average of 10% during that same time period. While declining, agriculture remains an important source of revenue for the basin and state's economy. Within the entire basin, agriculture (cultivated crops and pasture) accounts for approximately 29.5 percent of the land use (NCDENR 2009), and in 2008, agriculture provided North Carolina with about 9.7 billion in revenues and within the Neuse Basin, over $500 million in agricultural commodities was sold (USDA 2009).

The unemployment rate for North Carolina is 10.6percent (2011 Average), while the unemployment rate for the Neuse Basin is 10.2 percent, which represents 125,000 persons over the age of 16 that are in the labor force

Personal per capita income in North Carolina is $25,000 (2009), but is somewhat lower in the Neuse study area, at $22,000. As well as having a lower than average per capita income, the study area's median household income is comparable to that of the county and state. At $ 42,000, it falls short of the state average ($44,000). 2009 Census data reports seem to indicate a higher than state average household occupancy rate, at 2.6 persons per household in the study area while the state average household sizes is 2.4. In 2009 it was reported that 16.2 percent of North Carolina's population lived below the poverty level, while 18.2 percent of residents in the Neuse Basin were below the poverty level. Nationally, the poverty level was 14.3 percent in 2009. Table 2.4-1 and 2.4-2 contains updated income and poverty statistics for the basin and State.

Table 2.4-1: Income and Poverty Profile, Neuse River Basin

Area	Per Capita Income (2009 Dollars)	Per Capita Income as a Percent of State Average	Median Household Income (2009 Dollars)	Median Household Income as a Percentage of State Average	Persons Below Poverty Level % (2009)
State of North Carolina	$24,547	NA	$43,754	NA	16.2
Beaufort	$22,220	91%	$38,829	89%	19.3
Carteret	$26,588	108%	$44,036	101%	13.1
Craven	$23,968	98%	$41,021	94%	16.1
Duplin	$16,333	67%	$31,026	71%	24.3
Durham	$27,698	113%	$48,770	111%	16.4
Edgecombe	$16,417	67%	$32,172	74%	25.7
Franklin	$20,537	84%	$43,359	99%	13.7
Granville	$21,201	86%	$46,305	106%	14.8
Greene	$17,275	70%	$38,733	89%	23.0
Harnett	$19,338	79%	$42,792	98%	17.3
Johnston	$22,661	92%	$49,501	113%	17.4
Jones	$18,752	76%	$35,079	80%	18.3
Lenoir	$18,877	77%	$34,213	78%	21.0
Nash	$23,327	95%	$39,770	91%	15.6
Onslow	$20,783	85%	$41,161	94%	15.1
Orange	$32,198	131%	$51,944	119%	16.9
Pamilico	$21,669	88%	$39,918	91%	18.6
Person	$22,016	90%	$42,559	97%	14.6
Pitt	$21,622	88%	$36,339	83%	25.5
Sampson	$18,295	75%	$33,937	78%	21.7
Wake	$32,234	131%	$63,770	146%	10.2
Wayne	$20,036	82%	$40,291	92%	20
Wilson	$20,698	84%	$39,511	90%	20.3

Source: US Census Bureau, State and County QuickFacts, 2010

Table 2.4-2: Employment Profile, Neuse River Basin

Area	LaborForce	Employed	Unemployed	Rate %
State of North Carolina	4512770	4036343	476427	10.6
Beaufort	20481	18141	2340	11.4
Carteret	32,186	29,347	2,839	8.8
Craven	41,802	37,413	4,389	10.5
Duplin	24,403	22,196	2,207	9
Durham	141,849	130,544	11,305	8
Edgecombe	23,945	20,214	3,731	15.6
Franklin	27,447	24,629	2,818	10.3
Granville	25,339	22,662	2,677	10.6
Greene	9,202	8,264	938	10.2
Harnett	47,640	42,302	5,338	11.2
Johnston	77,842	70,244	7,598	9.8
Jones	4,565	4,066	499	10.9
Lenoir	26,540	23,539	3,001	11.3
Nash	46,707	40,955	5,752	12.3
Onslow	65,982	60,375	5,607	8.5
Orange	68,987	64,498	4,489	6.5
Pamlico	5,229	4,700	529	10.1
Person	18,848	16,766	2,082	11
Pitt	82,080	73,804	8,276	10.1
Sampson	31,444	28,705	2,739	8.7
Wake	456,623	418,320	38,303	8.4
Wayne	52,837	48,145	4,692	8.9
Wilson	39,753	34,708	5,045	12.7

North Carolina Department of Commerce Division of Employment Security, 2010

3.0 RECREATION

This section explores possible recreation plans for the Neuse River Basin Watershed Project sites. The plans are limited to the project footprints and the tributaries of the Neuse River Basin. Recreation features are included in the project as an incidental benefit. Features should be appropriate in size and scale. Recreation benefits cannot justify a plan, nor impact the primary purpose of ecosystem restoration (CECW-A 1999). Due to the incidental effect of these recreation elements, a determination of acceptable design to meet Corps standards has not been completed at this time.

All potential features will be compatible with the environmental purposes of the study; recreation will not detract from the project generated environmental or socioeconomic benefits. Recreation features will enhance and build upon the proposed ecosystem restoration project.

Project recreation may include: hiking, biking, equestrian, nature study, picnicking, fishing, hunting, canoeing, kayaking, and other non-invasive recreation forms. Consideration should be given for a canoe/kayak launch areas. Boardwalks and educational kiosks may be appropriate in some instances. Boat and canoe ramps may also be considered in basin at this time, but no final decisions have been made yet regarding their construction. Specific features and public access structures will be described in forthcoming documents. Demand for regional recreation will be assessed through the North Carolina State Comprehensive Outdoor Recreation Plan (SCORP) and collaboration with the North Carolina Department of Environment and Natural Resources (NCDENR) and the various state and federal agencies involved in the planning process.

3.1 Potential Changes in Value of Recreation

The Neuse River Basin project can support a significant amount of outdoor recreation in eastern and central North Carolina, with a significant portion of expenditures coming from locals and tourists alike. Based on the recent adverse effects related to environmental degradation it may be concluded that improving the environmental quality of the ecosystem would substantially support and sustain local recreation-based businesses. Given the potential levels of expenditures and consumer surplus in the future, a small percentage increase in the quantity or quality of project-related recreation could represent an increase in recreation value. There are potential recreation resources that would be associated directly with the construction of the impoundment. The uses presently considered compatible with resource protection and passive recreation include: freshwater fishing, horseback riding, hiking, off-road bicycling, wildlife viewing and nature study.

4.0 PLAN FORMULATION

Alternatives are combinations of management measures combined, as needed, to address the problem suite identified at each of the sites, and to address site-specific objectives. Environmental benefits derived from implementation of an alternative are defined as the increase in AAFUs gained from that alternative, when compared to the No-Action Alternative. Costs used for alternatives comparison all done to the same level of detail, and differ from those that are shown for the TSP, due to refinement of the details associated with the TSP, and the final results of the Cost-Effectiveness/Incremental Cost Analysis.

4.1 Adkin Branch Restoration Opportunity Area

Objective: Over the 50-year project life, improve connectivity and increase currently degraded in-stream habitat function in the lower degraded (2,500 foot reach) of Adkin Branch, which currently impairs connectivity between upstream reaches of Adkin Branch and the Neuse River, to a level that is comparable to upstream areas of the reach that have already had in-stream restoration, and which also currently provide a full array of functions and values.

This site-specific objective would address the degraded riparian and aquatic habitat. The following restoration measures were identified as opportunities to improve biological integrity and restore damaged or eliminated natural riparian buffers.

Measure A - Revegetate banks

Banks that are sparsely vegetated or barren would be planted with appropriate riparian trees and shrubs. This measure would promote Bank Stability and enhance habitat value in this portion of the riparian zone. There are two distinct revegetation areas:

Measure A1 - This measure would revegetate both banks on the upper ~200 ft of the stream reach.

Measure A2 - This measure would revegetate the degraded left bank on the lower ~950 ft of the stream reach. The right bank of this segment is well vegetated and not in need of restoration.

The width of the riparian zone evaluated for revegetation is relatively narrow and would primarily benefit the stream rather than the entire riparian corridor and floodplain. Both Measures A1 and A2, benefits would increase over time and would not be fully realized until year 25, when the affected vegetation density and quality would be maximized.

Measure B - Add in-stream woody debris

This measure consists of the placement of large woody debris within the channel to restore degraded in-stream habitat in about 30 percent of the channel throughout the entire stream reach. To meet the objective of restoring habitat connectivity to upstream and downstream reaches, this measure would need to be implemented through the entire 2,535-ft stream length.

The benefits to stream ecological function from measure B are expected to be fully realized immediately following construction and maintained for the entire 50-year period of analysis. Additional measures do not contribute materially to environmental function, and were therefore, dropped from further consideration.

The locations of proposed measures at Adkin Branch are shown in Figure 4-1. Remaining restoration alternatives for this site are measures A1, A2, and B. Site alternatives can be individual measures or combinations of any of the three identified measures. Preliminary costs and benefits (AAFUs) from all the possible alternatives are shown in Table 4-1. AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details on calculation of benefits are contained in Appendix K. Of note, Table 5-1 indicates that the benefit from implementing measure A2 is greater than the benefit for implementing measure A1. Both of those measures provide a benefit over the No Action Alternative. Measure A1 provides a greater functional index lift because it is revegetating both banks, rather than just one bank as in A2; however, the total stream acreage being benefited by A2 is greater and leads to a greater total average annual functional unit benefit. Measure B benefits the largest amount of stream acreage; however, it also provides the lowest lift to the functional index. The output from this table was used in the cost-effective/incremental cost analysis presented in Section 5.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

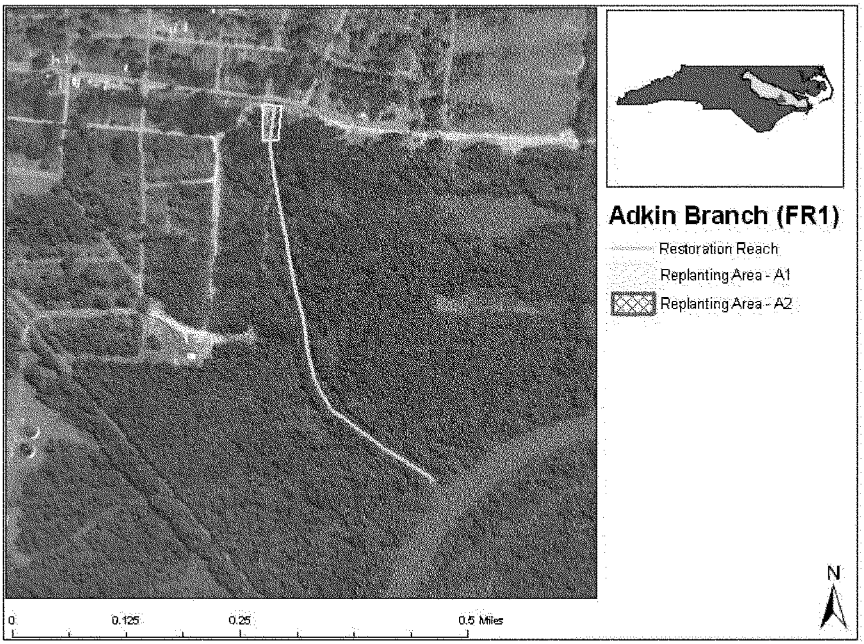


Figure 4-1. Location of Adkin Branch and proposed measures.

Table 4-1. Preliminary costs, Acres restored, and AAFU Benefits for each possible alternative at Adkin Branch

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A1	0	0.1	0	0	0.03	0	0.1	0	$91,700
A2	0	1	0	0	0.1	0	1	0.1	$97,200
B	0	2.2	0	0	0.18	0	2.2	0.2	$99,000
A1A2	0	1.1	0	0	0.13	0	1.1	0.1	$103,000
A1B	0	2.2	0	0	0.21	0	2.2	0.2	$104,705
A2B	0	2.2	0	0	0.28	0	2.2	0.3	$110,300
A1A2B	0	2.2	0	0	0.31	0	2.2	0.3	$116,000

Notes:
Ac refer to the number of ac being improved by the given alternative. The site contains 2.2 total stream ac.
Total AAFUs are rounded to the nearest tenth of a unit.

** cost breakdown and annualized costs are located in Attachment A*

4.2 Gum Thicket and Cedar Creeks Restoration Opportunity Area

Objective: Restore functions within the approximately 60 acres of highly degraded existing estuarine wetland within the Gum Thicket and Cedar Creek sub-estuaries, increasing estuarine wetland function over the 50-year period of analysis.

This site-specific objective would address degradation of emergent wetlands identified in Section 4. Gum Thicket and Cedar Creek are separable segments that run along the shoreline within the Neuse River estuary. The following restoration measures were identified as opportunities to restore degraded emergent wetlands, improve biological integrity, and increase the quantity and quality of degraded oyster reef habitat.

Reach 1 - Gum Thicket

Gum Thicket is the approximately 4,300 ft southern segment of a larger 10,800 foot-long degraded estuarine ecosystem. It centers on Gum Thicket Creek, a valuable natural estuarine creek. The 2,200 ft of shoreline upstream of the Gum Thicket reach is currently protected by rock revetment and a rock sill along that portion of the shoreline.

Reach 2 - Cedar Creek

Cedar Creek is the 6,500 ft northern segment of the larger 10,800 foot-long degraded estuarine ecosystem. The wetlands in this reach are similar in quality to those in the Gum Thicket reach, although there is more extensive ditching present. Potential restoration measures at this candidate site are as follows:

Measure A1 - Parallel rock sill

This measure would consist of an approximately 3,500 foot-long straight rock sill parallel to the existing Gum Thicket shoreline (Measure 1A) or an approximately 5,200 foot-long rock sill parallel the Cedar Creek shoreline (Measure 2A). Optimization studies indicate that ecosystem output per unit cost is maximized at a distance of about 60 feet offshore (distance between the landward toe of the sill and the existing shoreline). An approximately 30 foot wide rock sill would stabilize the shoreline by attenuating wave action and reducing wave energy before reaching the shoreline. A sill would also provide benefits in improved water quality from decreased siltation, provide attachment substrate for shellfish, and provide resident and anadromous fish habitat. Enhanced environmental outputs from the rock sill would accrue from minimizing further degradation at approximately 59 acres of existing marsh (44 acres at Gum Thicket Reach and 15 acres at Cedar Creek), and incidentally protecting 12 acres of marsh and open water complex (5 acres in Gum Thicket Reach and 7 acres in Cedar Creek Reach).

Measure A2 - Marsh (high and low) planting

Marsh planting would create a *living shoreline* consisting of planted and open water areas, and increase nursery habitat for resident fish and shellfish.

Functional ratings for the existing marsh were measured using NC WAM and multiplied by the without-project eroding acreage to determine the environmental output from the rock sill. The functional rating was multiplied by marsh acreage to determine the benefit from planting.

Measure B1 - Meandering rock sill

This measure is conceptually similar to Measure A and functions in much the same manner; however, the rock sill plan design would be optimized to provide increased area for marsh planting and, for reach 1 only, additional oyster habitat. Rather than simply paralleling the shoreline, a more curved structure would create additional surface area along the sill where feasible, according to water depth. The meandering rock sill feature would be approximately 4,500 ft long in the Gum Thicket reach (Measure 1B) and 6,700 ft long in the Cedar Creek reach (Measure 2B). It would protect the same acreage of existing marsh as compared to Measure A, but create about 15 ac of new marsh-open water complex (6 ac in Gum Thicket Reach and 9 ac in Cedar Creek Reach).

Measure B2 - Marsh (high and low) planting

This measure would consist of planting suitable for implementation with Measure B1.

Measures A and B are mutually exclusive.

Alternatives for the site were built by generating different combinations of measures at each reach and assembling different combinations of reaches. Alternative 1A2B, for instance, consists of a parallel rock sill at Gum Thicket and a meandering rock sill at Cedar Creek.

The erosion rates used in the analysis of future without-project conditions were based on historic rates of sea level rise. Shoreline erosion rates under higher sea level rise scenarios, while considered for each alternative, would be expected to be higher for the future without-project condition, which in turn would result in higher environmental benefit outputs being produced by the various project alternatives. Therefore, the environmental benefit outputs presented in this section can be considered conservative.

Figure 4-2 shows the location of the area and proposed rock sill locations. Table 4-2 shows the preliminary costs and benefits of the alternatives. Measures are presented as providing benefits compared to the No Action Alternative. AAFUs are based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details on calculations of ecosystem benefits are contained in Appendix K. The differences in AAFUs shown in Table 4-2 are based on differences in acreage being benefited by each alternative, rather than differences in the functional index. The output from this table was used in the cost-effective/incremental cost analysis presented in Section 5.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

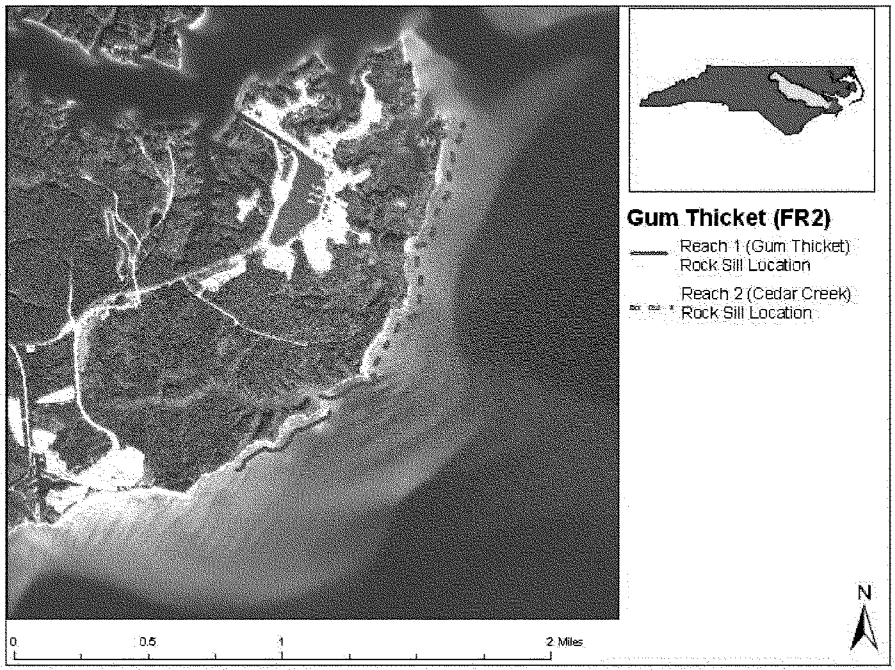


Figure 4-2. Location of Gum Thicket Creek and Cedar Creek and proposed rock sill alternatives.

Table 4-2. Preliminary costs and benefits from possible alternatives at Gum Thicket and Cedar Creek

Alternative	Wetland acres	Stream acres	Oyster acres	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total acres	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
1A	58.1	0	0.6	27.3	0	0.54	49.6	27.8	$7,044,000
1B	60.8	0	0.8	28.7	0	0.72	51.2	29.4	$8,997,000
1AC	58.1	0	1.3	27.3	0	1.17	50.3	28.5	$8,604,000
1BC	60.8	0	1.7	28.7	0	1.53	52.1	30.2	$9,603,000
2A	36.3	0	0	14.9	0	0	22.2	14.9	$10,514,000
2B	40.4	0	0	16.9	0	0	24.2	16.9	$13,628,940
1A2A	94.4	0	0.6	42.2	0	0.54	71.8	42.7	$17,558,000
1A2B	98.5	0	0.6	44.2	0	0.54	73.8	44.7	$20,672,940
1B2A	97.1	0	0.8	43.6	0	0.72	73.4	44.3	$19,511,000
1B2B	101.2	0	0.8	45.6	0	0.72	75.4	46.3	$22,625,940
1AC2A	94.4	0	1.3	42.2	0	1.17	72.5	43.4	$19,118,000
1AC2B	98.5	0	1.3	44.2	0	1.17	74.5	45.4	$22,232,940
1BC2A	97.1	0	1.7	43.6	0	1.53	74.3	45.1	$20,117,000
1BC2B	101.2	0	1.7	45.6	0	1.53	76.3	47.1	$23,231,940

Note:
Wetland ac are the expected difference in wetland acreage at the site between the with- and without-project (No Action) conditions at the end of the period of analysis.

* *cost breakdown and annualized costs are located in Attachment A

4.3 Kinston East Wetland Restoration Opportunity Area

Objective Restore functions and improve connectivity between existing tracts of bottomland hardwood forest over the 50-year period of analysis by restoring 14.5 ac of bottomland hardwood forest at the Kinston East Wetland Complex.

The following potential restoration measures were identified as opportunities to restore damaged or eliminated natural riparian buffers along the Neuse River:

Measure A - Remove fill material and create hydrologic connections with surrounding bottomland hardwood forest

A volume of fill material that currently interferes with the hydrologic connectivity of the site to adjacent channel features would be excavated to match the elevation of the adjacent bottomland hardwood forest (4 ft). Removal of this fill would restore floodplain functions by reconnecting the area hydrologically with the Neuse River, allowing overbank flows to flood the area periodically. This measure would restore hydrologic function to 14.5 ac of bottomland hardwood forest. Because it is adjacent to existing bottomland hardwood forest, the adjacent area is expected to eventually revegetate with appropriate species, without any additional planting. The functional ratings of this restored bottomland hardwood are assumed to eventually be the same as those of the existing adjacent forest; however, the habitat function rating would not reach this point until year 30 of the project. Functional ratings for the water quality and hydrology outputs are assumed static for the entire period of analysis.

Measure B - Plant vegetation

Once the restoration site was hydrologically restored to a condition suitable for habitat sustainability, the site could be planted with appropriate bottomland seedlings at a standard planting density. This measure is dependent on implementing Measure A as an initial implementation phase, due to a lack of current suitable hydrologic input. Planting vegetation would advance achievement of optimal ecosystem outputs by approximately 5 years over Measure A alone (no planting) (i.e., habitat function would maximize at year 25 rather than at year 30). Additionally, under Measure B, the *vegetation composition* habitat sub-function and *surface storage and retention* hydrology sub-function would score a 1.0 at year 0 (immediately following construction) and be maximized throughout the period of analysis. If the measure is not implemented, the sub-functions would score 0.1 and 0.5, respectively, at year 0 and maximize at a score of 1.0 at year 30.

The location of East Wetland complex is shown in Figure 4-3. Possible restoration measures for this site are Measure A or Measure A in combination with Measure B. Preliminary costs and benefits from all the possible alternatives are shown in Table 4-3. Measures are presented as providing benefits above the No Action Alternative. AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. The table indicates that measure B (planting vegetation) does not provide much additional AAFU benefit.

The output from the table is used in the cost-effective/incremental cost analysis presented in Section 5.1, which is used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

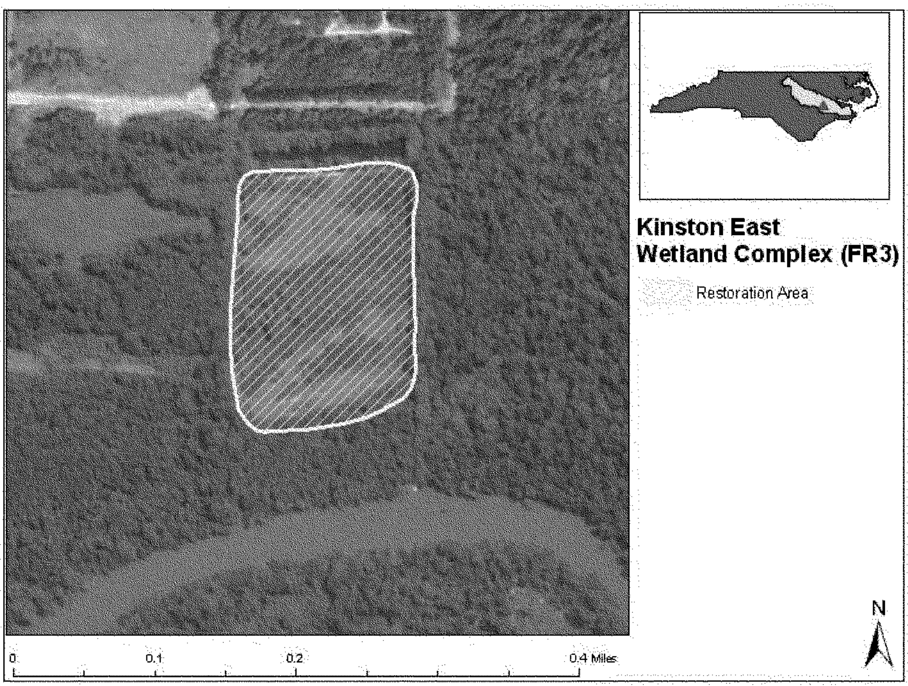


Figure 4-3. Location of Kinston East Wetland Complex restoration area.

Table 4-3. Preliminary costs and benefits from possible alternatives at Kinston East Wetland Complex

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A	14.5	0	0	11	0	0	14.5	11	$4,024,700
AB	14.5	0	0	11.2	0	0	14.5	11.2	$4,340,100

Note: Ac refer to the number of ac that are being improved by the given alternative.

* cost breakdown and annualized costs are located in Attachment A

4.4 Ellerbe Creek Restoration Opportunity Area

Objective: Restore wetland and stream function in approximately 3,700 ft of Ellerbe Creek and its associated riparian area and improve connectivity to already restored upstream and downstream portions of the stream, over the 50-year life of the project.

The following restoration measures were proposed for this reach of Ellerbe Creek as an opportunity to improve biological integrity and restore damaged or eliminated natural riparian buffers:

Measure A - Excavate and revegetate banks

Streambanks would be excavated where feasible to a 3:1 slope or gentler, and a floodplain bench would be created to better connect the stream and existing floodplain. Existing vegetation in excavated areas would be replaced with appropriate riparian wetland vegetation.

Three distinct restoration sites suitable for excavation/replanting exist:

Measure A1 - This measure would excavate/replant approximately 6.2 acres on the left bank of the upstream portion of Ellerbe Creek. This area consists of medium-quality forested wetland, which would be supported by having overbank hydrology restored to a more natural state. Short-term impacts from initial vegetation removal would be surpassed by the long-term ecological enhancement after hydrologic connection with the channel.

Measure A2 - This measure would excavate/replant approximately 5.3 acres on the left bank of the downstream portion of Ellerbe Creek. This area consists of low- to medium-quality forested wetland, which would be supported by having overbank hydrology restored to a more natural state; more natural in that these areas would have hydroperiods more consistent with what would have occurred before the stream's earlier modifications. Short-term impacts from initial vegetation removal would be surpassed by the long-term ecological enhancement associated with hydrologic connection with the channel. Habitat quality would initially decline in the area from removing vegetation; however, it would eventually be improved over current levels during the period of analysis.

Measure A3 - This measure would excavate approximately 2.8 acres on the right bank of the downstream portion of Ellerbe Creek. The area is upland with a sparsely vegetated riparian layer. Infrastructure, including sewer lines, in the area would need to be removed or relocated. Excavation and replanting could restore this area to wetland.

For Measures A1, A2, and A3, functional unit benefits to stream and wetlands would increase over time and not be fully realized until year 25, when the functions and values of the area would be maximized. For simplicity, benefits are assumed to increase linearly until year 25.

Measure B - Create step pools

Boulders and woody debris could be placed in-stream to improve geomorphic and habitat functions by creating riffle and pool sequences. In order to establish sufficient density and functionality, it would have to be performed within at least 30 percent of the stream profile. To meet the goal of improving connectivity to upstream and downstream reaches, which would be accomplished by having a continuous area of suitable habitat for aquatic species, this measure would need to be implemented through the entire 3,780-ft stream length of this reach of Ellerbe Creek.

Measure C - Re-meander channel

The stream channel could also be re-graded to restore its natural stream meander wavelength through the reach. Re-establishing the natural meander sequence would create about 2,300 ft (0.5 ac) of additional stream habitat, with a corresponding 0.5 ac less of wetland restored in the excavated area. This measure could be done only if Measures A1, A2, and A3 are all implemented.

The benefits to stream ecological function from Measures B and C are expected to be fully realized immediately following construction and maintained for the entire period of analysis.

The location of this reach of Ellerbe Creek and some of the proposed measures are shown in Figure 4-4. Possible restoration alternatives for this site could involve each of the individual measures alone or in combination with one another (with exceptions as noted in the description of measures above). Preliminary costs and benefits from all the possible alternatives are shown in Table 4-4. Measures are presented comparing each alternative to the No Action Alternative. AAFUs are based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 5.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

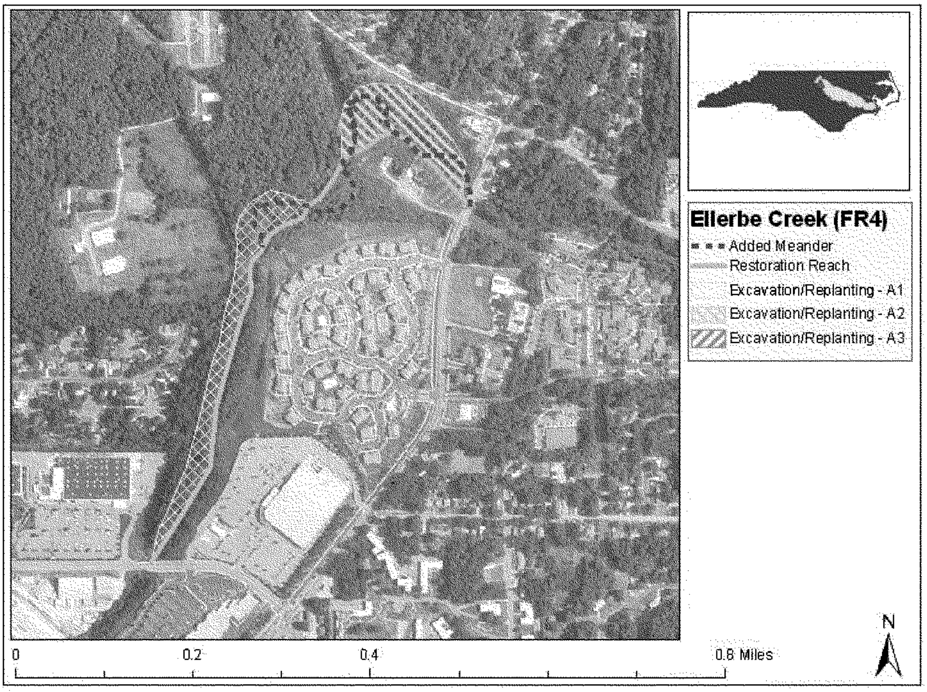


Figure 4-4. Location of Ellerbe Creek and proposed measures.

Table 4-4. Preliminary costs, acres restored, and AAFU Benefits for each possible alternative at Ellerbe Creek

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A1	6.2	0.6	0	1.78	0.08	0	6.8	1.9	$465,660
A2	5.3	0.3	0	1.84	0.06	0	5.6	1.9	$362,323
A3	2.8	0.3	0	2.15	0.06	0	3.1	2.2	$220,357
A1A2	11.5	0.9	0	3.62	0.14	0	12.4	3.8	$827,983
A1A3	9	0.9	0	3.93	0.14	0	9.9	4.1	$686,017
A2A3	8.1	0.3	0	3.99	0.06	0	8.4	4.1	$582,680
A1A2A3	14.3	0.9	0	5.77	0.14	0	15.2	5.9	$1,048,340
A1B	6.2	0.6	0	1.78	0.43	0	6.8	2.2	$481,422
A2B	5.3	0.3	0	1.84	0.41	0	5.6	2.3	$378,085
A3B	2.8	0.3	0	2.15	0.41	0	3.1	2.6	$236,119
A1A2B	11.5	0.9	0	3.62	0.49	0	12.4	4.1	$843,745
A1A3B	9	0.9	0	3.93	0.49	0	9.9	4.4	$701,779
A2A3B	8.1	0.3	0	3.99	0.41	0	8.4	4.4	$598,442
A1A2A3B	14.3	0.9	0	5.77	0.49	0	15.2	6.3	$1,064,102
A1A2A3C	13.8	1.4	0	5.58	0.39	0	15.2	6.0	$1,136,065
A1A2A3BC	13.8	1.4	0	5.58	0.73	0	15.2	6.3	$1,156,475
B	0	0.9	0	0	0.35	0	0.9	0.4	$15,762

Notes: * cost breakdown and annualized costs are located in Attachment A

Ac refer to the number of ac that are being improved by the given alternative. The site contains 0.9 total stream ac and 11.5 wetland ac.
Total AAFUs are rounded to the nearest tenth of a unit.

4.5 Little River Dam near Goldsboro Restoration Opportunity Area

Objective: Restore habitat connectivity for 46 miles of the upstream reaches of the Little River, which is currently cut of from its downstream reaches by the Little River Dam. The upstream reaches of the Little River are an important former spawning habitat for anadromous fish species. The lack of connectivity also affects water temperature, dissolved oxygen and other stream properties.

A series of management measures was considered for this site. A reasonable estimate of fish passage efficiency around the dam, based on 2009 spring flow conditions, is 70 percent (Raabe and Hightower 2010). One potential measure would increase passage efficiency.

The potential measures for this site are as follows:

Measure A - Build dam gate

An approximately 20 ft section of the existing 100 ft-wide, 4 ft-high concrete dam could be removed. Either a hydraulic gate or a stop log structure would be installed within the 20 ft opening. The gate in the existing dam would remain open during the anadromous fish migration season (i.e., about January to May). Only during low-flow conditions (i.e., July to September) would the City of Goldsboro close the gate to use the upstream (secondary) water intake structure. Fish passage efficiency for the measure was estimated to be 99 percent.

Measure B - Build rock ramp

A six-tier rock ramp, constructed of large boulders at an approximately 20:1 slope could be built at the dam. The ramp would provide better passage under normal flow conditions but would not be as useful under low-flow conditions. Fish passage efficiency for this measure was estimated to be 80 percent.

Measure C - Remove dam

The existing dam could be removed. This measure would require modifications at the City of Goldsboro's secondary water intake area to maintain the city water supply after loss of the dam. Passage efficiency for this measure would be 100 percent because the dam would no longer obstruct fish passage.

The location of the Goldsboro low-head dam and the portion of the Little River that the location of the Goldsboro low-head dam and the portion of the Little River that would be affected by its removal are shown in Figure 4-5. Preliminary costs and benefits from all the possible site specific alternatives are shown in Table 5-5. Alternatives are presented in comparison to the No Action Alternative AAFUs were based on the acreage being restored, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix K. In this case, Measure C resulted in the highest

AAFU benefit because it provided the greatest increase in passage efficiency. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 5.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

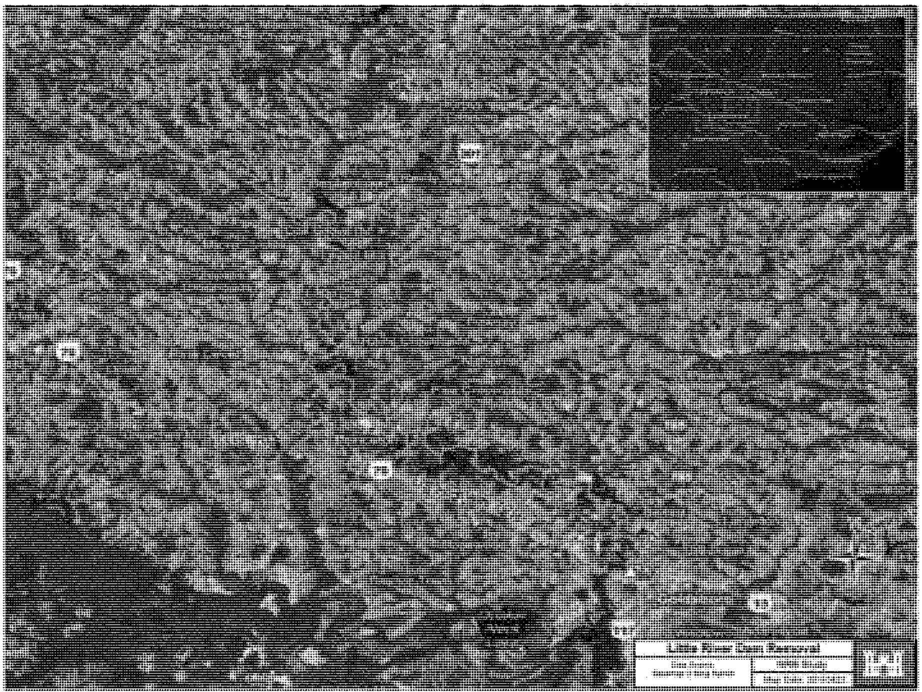


Figure 4-5. Location of Goldsboro dam and portion of the Little River that would be affected by dam removal.

Table 4-5. Preliminary costs, acres affected, and AAFU benefits for each possible site specific alternative at Little River/Goldsboro Dam

Alternative	Wetland ac	Stream ac	Oyster ac	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total ac	Total AAFU benefit	Cost
No Action	0	0	0	0	0	0	0	0	$0
A	0	509.2	0	0	109.9	0	509.2	109.9	$180,835
B	0	509.2	0	0	37.9	0	509.2	37.9	$240,650
C	0	509.2	0	0	113.7	0	509.2	113.7	$1,163,605

Note: Ac refer to the number of ac that are being affected by the given alternative.

** cost breakdown and annualized costs are located in Attachment A*

4.6 Neuse River Oyster Growing Area (OGA)

Objective: In the Neuse River Estuary, restore up to 100 ac of oyster reef habitat to address historic and projected habitat losses and protect the restored habitat areas.

Building new deepwater reefs was determined to be the only method practicable to restore sustainable reef habitat and associated functional output. This measure would modify existing sandy soft bottoms that no longer support reefs, providing an opportunity to increase the quantity and quality of oyster reef habitat.

Potential sites were screened and selected as described in Appendix L. Gum Thicket (Site 2 in Figure 3-2) was also evaluated for oyster suitability so that an oyster measure could be considered as a component of alternatives formulated for that site.

Alternatives considered included: (1) Building new deep water reefs, (2) Restoring existing low output reefs by addition of new cultch, and (3) Designating existing high output reefs as sanctuaries to preclude impacts associated with harvest. Alternative is considered feasible. Alternative 2 was not considered technically feasible since low population reefs would not sustain suitable cultch and quickly revert to the previous degraded condition. For Alternative 3, existing NC sanctuary regulation only allows "Oyster Sanctuary" designation at previously low value bottoms where new reefs have been constructed. Therefore, alternatives 2 and 3 were eliminated from further detailed analysis.

A recently approved Estuary Restoration Act Project, known as Little Creek Sanctuary, is to be located in the lower Neuse River in Pamlico Sound, NC, approximately 10 miles east of the town of Oriental and 108 miles north-west of Little Creek (N35° 02.616' W76°30.889'). This 10 acre site is proposed for construction and monitoring beginning early 2012 and includes alternate materials, in addition to conventional stone design. If the use of alternate materials is found to be as productive as and less costly than conventional designs, they will be incorporated in the design of the TSP during PED (Planning, Engineering and Design).

The proposed design was based on existing State methods and materials previously used for deepwater oyster reef construction. The proposed materials have been proven by extensive field application. The proposed reef architecture was modified to more closely match the form of nearby successful reference reefs. Alternative materials could be used if found to reduce cost without detracting from project outputs.

Potential Reef Sanctuary sites include the following and are illustrated in Figure 4-6.

(1) Mid River Reef Cells with FIs 1.0,

(2) Mid River Reef Cells with FIs 0.9

(3) Mid River Reef Cells with FIs 0.7

(4) North Shore Vicinity Reef Cell with FI 1.0, and

(5) South Shore Sanctuary FI 0.9

New high-output reef areas could be constructed to be managed as sanctuaries by the State. This measure could add suitable cultch and provide firm substrate where soft bottom exists. Oyster density was assumed to be equal to that of nearby reference reefs by year three. Three development levels representing small, standard, and large areas were evaluated at each potential location:

(a) 20-ac reef service area

(b) 30-ac reef service area

(c) 40-ac reef service area

A one acre reef service area, including reef top, side slopes, and adjacent enhanced mud bottom, requires a productive 0.13 acre reef top area. This is consistent with the ratio of reef top to sanctuary area in the existing Neuse River Sanctuary. NCDMF would manage the measures defined in this study as sanctuaries. Sanctuaries would be identified by a series of buoys to preclude oyster harvest.

Benefits realized by restoration of former sites as new sanctuary reefs would not be fully realized until year three, when oyster recruitment and growth is expected to equal that of natural reefs. For simplicity, benefits were assumed to increase linearly until year three. Each Functional Index (FI) was applied over a project area and annualized, and an AAFU was computed.

The cost of constructed oyster reef is dependent on the amount of rock material. For planning purposes, the transportation costs to carry material to reef locations were found to be negligible between the various locations because both an upriver and downriver staging location was identified. Therefore, costs were assumed to be the same for areas of the same size.

A 4-ft reef height was proposed to allow 1 ft of settling and still provide three feet above the bottom substrate. If during PED, detailed geotechnical investigation identifies solid footing, the 1 foot allowance could be reduced or eliminated. Further, oyster restoration work in the Chesapeake Bay has found that one to two feet of elevation is sufficient to support sustainable oyster growth. Any reduction in reef height would reduce constructed cost.

As indicated in Section 4.1.1.4, AAFUs were based on the acreage being restored; reef top plus service area, multiplied by a functional index (ranging from 0.0 to 1.0). Details of those calculations are contained in Appendix L. In this case, Measures M2C and N3 resulted in the highest AAFU benefits, because the selected area provided the greatest increase in habitat quality (FI = 1.0) over the largest area (40 ac). Preliminary costs and benefits from all the possible alternatives are shown in Table 4-6. The output from the table was used in the cost-effective/incremental cost analysis presented in Section 5.1, which was used to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs.

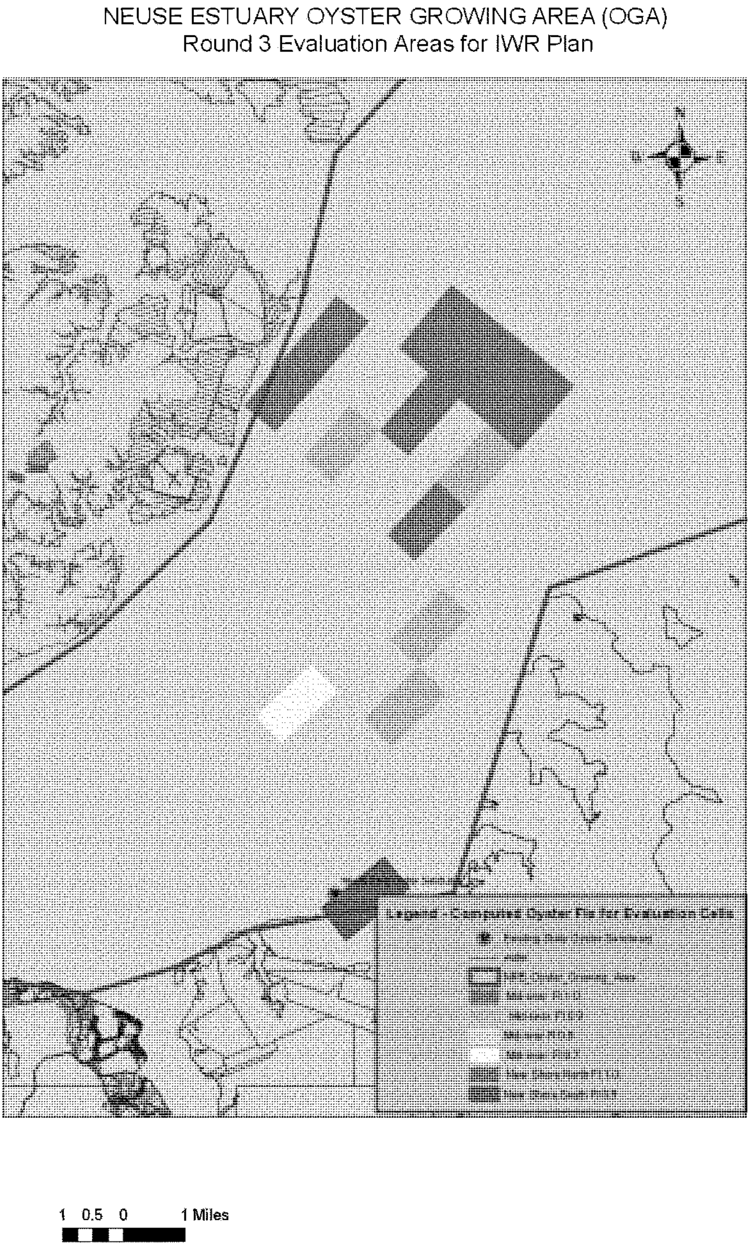


Figure 4-6. Neuse River Estuary oyster growing area.

Table 4-6. Preliminary costs, acres affected, and AAFU benefits for each possible alternative for Oyster Reef Habitat

Measures				Wetland Ac	Stream Ac	Oyster Ac	Wetland AAFU Benefit	Stream AAFU Benefit	Oyster AAFU Benefit	Total Ac	Total AAFU Benefit	Cost
New Mid-river Reef Sanctuary												
1) No Action				0	0	0	0	0	0	0	0	0
2) FSI =	1.0											
A1	a	20	Sanctuary Ac.	0	0	20	0	0	19.4	20	19.4	$ 3,352,226
A2	b	30	Sanctuary Ac.	0	0	30	0	0	29.1	30	29.1	$ 4,978,945
A3	c	40	Sanctuary Ac.	0	0	40	0	0	38.8	40	38.8	$ 6,605,664
3) FSI =	0.9											
A4	a	20	Sanctuary Ac.	0	0	20	0	0	17.5	20	17.5	$ 3,352,226
A5	b	30	Sanctuary Ac.	0	0	30	0	0	26.2	30	26.2	$ 4,978,945
A6	c	40	Sanctuary Ac.	0	0	40	0	0	34.9	40	34.9	$ 6,605,664
5) FSI =	0.7											
A7	a	20	Sanctuary Ac.	0	0	20	0	0	13.6	20	13.6	$ 3,352,226
A8	b	30	Sanctuary Ac.	0	0	30	0	0	20.4	30	20.4	$ 4,978,945
A9	c	40	Sanctuary Ac.	0	0	40	0	0	27.2	40	27.2	$ 6,605,664
New North Shore Reef Sanctuary												
1) No Action												
2) FSI =	1.0											
B1	a	20	Sanctuary Ac.	0	0	20	0	0	19.4	20	19.4	$ 3,352,226
B2	b	30	Sanctuary Ac.	0	0	30	0	0	29.1	30	29.1	$ 4,978,945

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Measures				Wetland Ac	Stream Ac	Oyster Ac	Wetland AAFU Benefit	Stream AAFU Benefit	Oyster AAFU Benefit	Total Ac	Total AAFU Benefit	Cost
B3	c	40	Sanctuary Ac.	0	0	40	0	0	38.8	40	38.8	$ 6,605,664
Expand Existing South Shore Reef Sanctuary												
1) No Action		6	Sanctuary Ac.	0	0	6	0	0	5.2	6	5.2	0
3) FSI =	0.9											
C1	a	14	Sanctuary Ac.	0	0	14	0	0	12.2	14	12.2	$ 2,381,843
C2	b	24	Sanctuary Ac.	0	0	24	0	0	20.9	24	20.9	$ 4,009,196
C3	c	34	Sanctuary Ac.	0	0	34	0	0	29.6	34	29.7	$ 5,636,549

** cost breakdown and annualized costs are located in Attachment A*

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5.0 PLAN SELECTION

The following sections compare the combinations of site alternatives presented in the previous section using cost-effective/incremental cost analysis (CE/ICA). First, CE/ICA was performed on the array of alternatives for each site, and the results were used to select a single alternative from each site for further consideration. Another CE/ICA was then performed on this final array of alternatives. These results, in combination with a comparison of alternatives in Section 5.2 using the four (4) accounts (national economic development, environmental quality, regional economic development, and other social effects), was used to establish the National Ecosystem Restoration plan (NER) as presented in Section 5.3.

5.1 Cost-Effectiveness/Incremental Cost Analysis (CE/ICA)

The environmental benefits and costs presented in the previous section were the inputs for a CE/ICA. The purpose of the analysis was to evaluate the effectiveness and efficiency of the site alternatives at producing environmental outputs. Guidance on the conduct of CE/ICA is in IWR Report #95-R-1, USACE, May 1995. The end product of a CE/ICA is the identification of a set of *best buy* plans. Best buy plans are the alternatives that provide the greatest increase in environmental output for the least increase in cost. Initially, all cost-effective alternatives (a cost-effective alternative is one where no other alternative can achieve the same level of output at a lower cost, or greater level of output at the same or less cost) are arrayed by increasing output to clearly show changes in cost (i.e., increments of cost) relative to changes in output (i.e., increments of output) of each cost-effective alternative plan compared to the without-project condition. The plan with the lowest incremental costs per unit of output of all plans is therefore considered the first best buy plan. After the first best buy plan is identified, all larger cost-effective plans are compared to the first best buy plan in terms of increases in (increments of) cost and increases in (increments of) output. The alternative plan with the lowest incremental cost per unit of output (for all cost-effective plans larger than the first best buy plan) is the second best buy plan. This process is continued until all the best buy alternative plans are identified.

The results of the initial analysis conducted to compare alternatives at each project area are presented in Figures 5-1 through 5-7. These figures display the incremental costs and benefits for the best buy plans at each of the sites (with the exception of the No Action Alternative, which is always a Best Buy Plan). The IWR Plan software was used to conduct the CE/ICA.

Evaluation of the best buys from the initial analysis identified an array of best buy alternatives for comparison over the entire watershed. The PDT compared the best buys from each project area to determine whether the incremental environmental benefits justified the incremental costs. Based on this comparison, a single best buy alternative was selected from each project area, which was then used to create basin-wide alternatives.

At Adkin Branch, the CE/ICA identified only one best buy alternative (Figure 5-1). The best buy (A1A2B) at Adkin Branch is a combination of bank revegetation at the upper 200 ft of both banks and lower 950 ft of the left bank with the addition of in-stream woody debris.

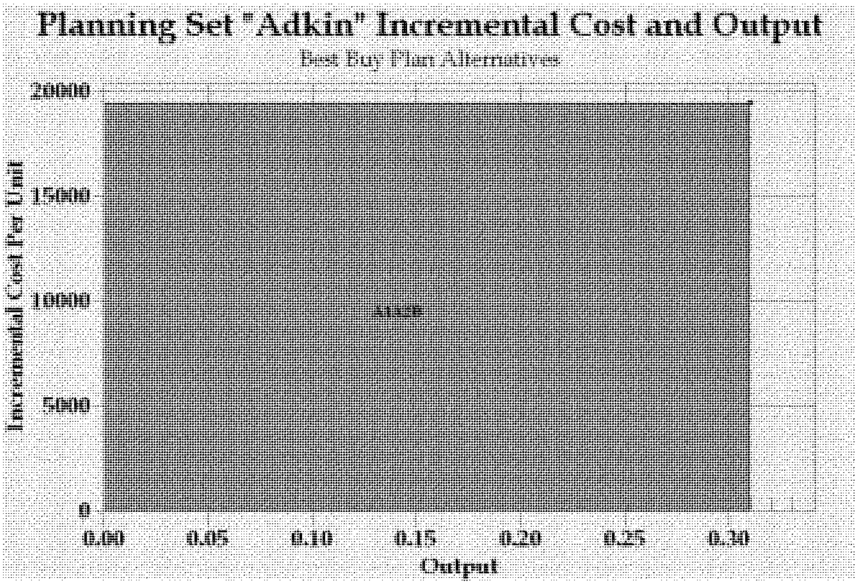

Figure 5-1. Incremental costs and benefits of Best Buy plans at Adkin Branch site.
Alternative A1A2B is fully revegetating the stream banks and adding in-stream woody debris.

Five restoration alternatives were best buys in the Gum Thicket and Cedar Creek analysis (Figure 5-2). As shown in Figure 5-2, after the second best buy alternative (1A2A) the incremental benefits of the larger plans are minimal but the incremental costs per additional unit of output are relatively high. Therefore, the second best buy alternative (1A2A) is the recommended alternative from this site. The alternative consists of parallel rock sill and marsh plantings at both Gum Thicket and Cedar creeks.

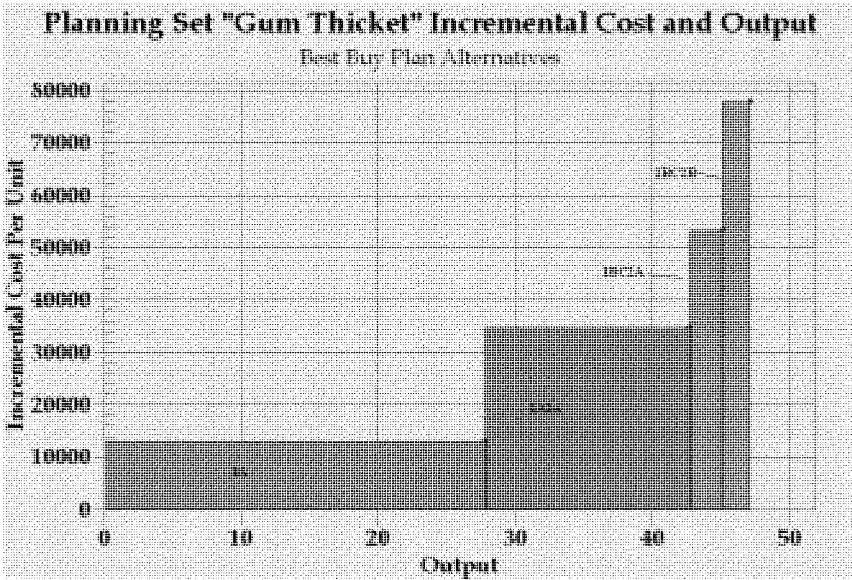

Figure 5-2. Incremental costs and benefits of Best Buy plans at the Gum Thicket/Cedar Creek site.

Descriptions of the plans are as follows: 1A = parallel sill at Gum Thicket Reach, 1A2A = parallel sills at Gum Thicket and Cedar Creek reaches, 1BC2A = meandering sill + added oyster habitat at Gum Thicket Reach, parallel sill at Cedar Creek Reach, 1BC2B = meandering sill + added oyster habitat at Gum Thicket Reach, meandering sill at Cedar Creek Reach.

At the East Wetland Complex in Kinston, both of the analyzed alternatives were best buy plans (Figure 5-3). The PDT did not feel that the best buy that maximized environmental benefits (alternative B) was justified because of the high incremental cost for a minimal additional output (0.2 habitat units [HU] at about $82,000 per unit of output). The restoration measure to excavate the site, without planting trees (alternative A) was selected as the preferred alternative from this site.

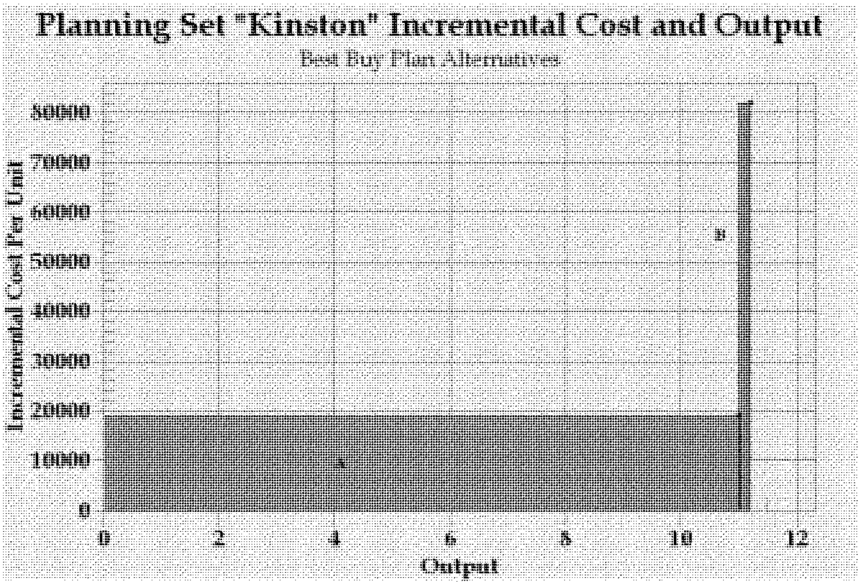

Figure 5-3. Incremental costs and benefits of Best Buy plans at Kinston site.
Alternative A is excavating the site to its natural elevation, alternative B is excavating and planting trees at the site.

The smallest best buy (B) at Ellerbe Creek was selected because it did not adversely affect the riparian corridor. After site visits, it was determined that restoration measures to excavate the channel would potentially affect existing wetlands. As a result, the best buy with the least effect on the riparian corridor, creating step pools, was identified for further consideration.

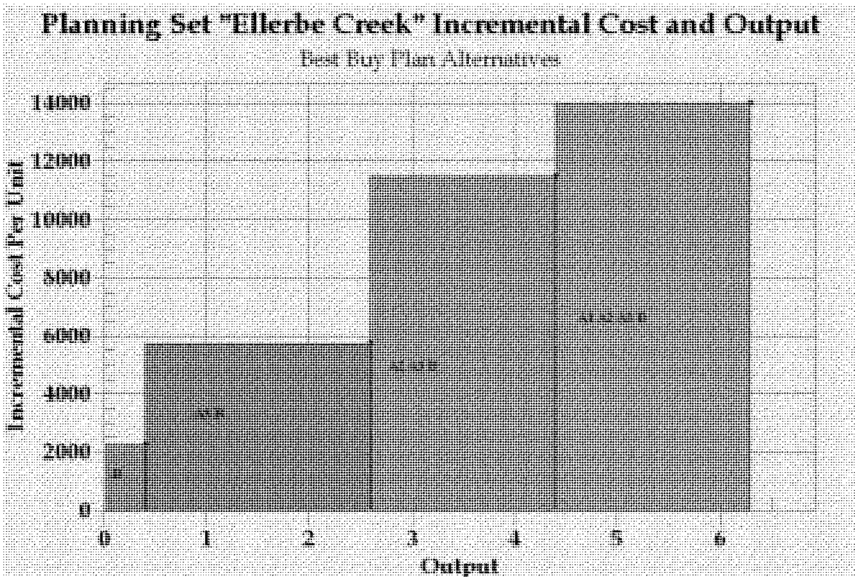

Figure 5-4. Incremental costs and benefits of Best Buy plans at Ellerbe Creek site.
Alternative B is creating step pools, A3B is excavating and replanting reach 3 plus creating step pools, A2A3B is excavating and replanting reaches 2 and 3 plus creating step pools, and alternative A1A2A3B is excavating and replanting reaches 1, 2, and 3 and creating step pools.

There were two Best Buy plans at the Little River site (Figure 5-5). Relative to Alternative A (building a dam gate), the larger best buy plan (Alternative C - removing the dam) has a very high incremental cost for a relatively smaller benefit. Additionally, removing the dam would pose some risks to the city's secondary water supply. Therefore, Alternative A was selected as the recommended alternative from this site.

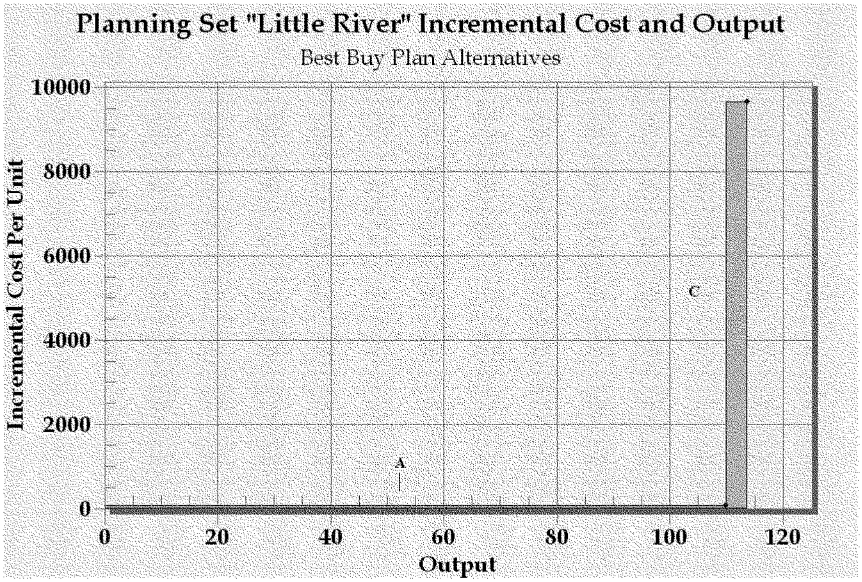

Figure 5-5. Incremental costs and benefits of Best Buy plans at Little River site.
Alternative A is building a dam gate, Alternative C is removing the dam.

There were 5 best buy plans for the oyster growing area project, with relatively similar incremental costs (Figure 5-6). The recommended alternative was the best buy plan that came closest, when combined with existing sanctuary, to meeting the ORSC's (Oyster Reef Steering Committee) goal of providing 100 ac of oyster sanctuary in the Neuse River Estuary. This is alternative A3B3, which creates 40 sanctuary acres at the Mid-River area and 40 sanctuary acres at the North Shore area.

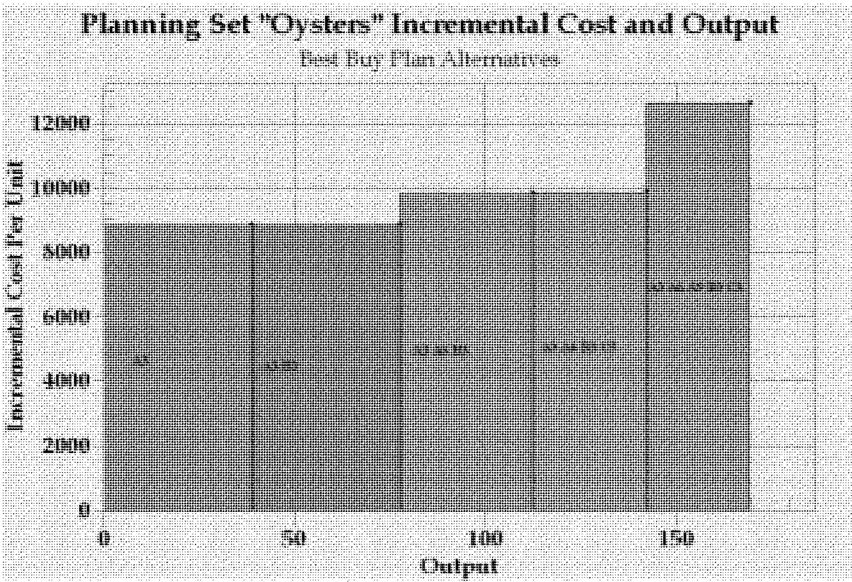

Figure 5-6. Incremental costs and benefits of Best Buy plans at Oyster Growing Area site.

Finally, the selected best buy alternatives (Table 5-1) were used to generate potential basin-wide alternatives. A letter code based on the site was used to represent each alternative. The basin-wide alternatives consist of every possible combination of one or more of the selected site alternatives. A CE/ICA was performed again on this array of Basin alternatives. The same costs and benefits that were used in the comparison of alternatives at each site were also used for this basin-wide alternatives CE/ICA. Figure 5-7 and Table 5-2 presents the best buy alternatives from this analysis.

Table 5-1. Basin-wide best buy alternatives (final array)

Site	Code	Description
Adkin Branch	A	Add in-stream woody debris, revegetate along 1,150 ft of bank length
Gum Thicket/ Cedar Creek	G	Build a 3,500 ft sill along Gum Thicket reach and 5,200 ft sill along Cedar Creek reach
East Wetland Complex at Kinston	K	Remove fill material from 14.5 ac of former bottomland hardwood forest
Ellerbe Creek	E	Create in-stream step pools through adding boulders and woody debris
Little River	L	Build a dam gate structure
Oyster Growing Areas	O	Create 40 ac of sanctuary in Mid-River site and 40 ac in North Shore site.

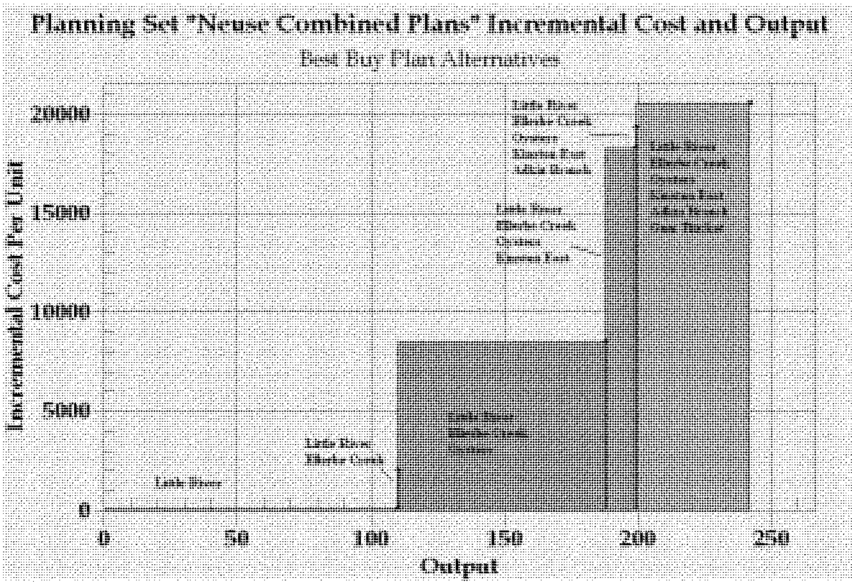

Figure 5-7. Final basin-wide best buy alternatives.

Best Buy Plan	Total Output (FU)	Total Cost ($1,000)	Incremental Cost ($1,000)	Incremental Output (FU)	Incremental Cost Per Unit of Output ($1,000)	Average Cost ($1000/FU)
Alternative A						
No Action	0	0	0	0	0	
Alternative B						
L	109.9	9,038	9,038	109.9	82	82
Alternative C						
EL	110.3	9,837	799	0.4	1,998	89
Alternative D						
ELO	187.9	669,514	659,677	77.6	8,501	3,563
Alternative E						
EKLO	198.9	870,493	200,979	11.0	18,271	4,377
Alternative F						
AEKLO	199.2	876,285	5,792	0.3	19,307	4,399
*Modified G						
GKLO	241.2	1,746,411	870,126	42.0	20,717	7,241
Alternative G						
AEGKLO	241.9	1,753,002	876,717	42.7	20,532	7,247
A=Adkin Branch, E=Ellerbe Creek, G=Gum Thicket, K=Kinston East Wetland, L=Little River, O=Oyster Reefs						
*Modified G is not a best buy plan but it is virtually identical to in cost and benefits to alternative G Total Cost breakdown for the TSP is located in Attachment A						

Table 5-2. Basinwide best buy alternatives

6.0 REGIONAL ECONOMIC IMPACTS

The following regional economic impacts will be addressed based on the interest of the local sponsor and the surrounding Pender and Onslow counties. Local governments seek to preserve the tax base and encourage the growth in overall property values, to create stability in the labor force and the employment of the labor force. The steady growth of the local community and surrounding region is considered a worthy goal by the state and local governments. Displacement of people, businesses and farms in the study area is not a desirable outcome that sometimes may result from either continued storm damages or even some types of construction.

6.1 Preserve Tax Base and, Property Values

IWR Report 96-PS-1, FINAL REPORT: An Analysis of the U.S. Army Corps of Engineers Shore Protection Program, June 1996 supports this conclusion as follows. "Corps projects have been found to have no measurable effect on development, and it appears that Corps activity has little effect on the relocation and/or construction decisions of developers, homeowners, or housing investors." Therefore no changes in land use with a long-term storm damage reduction plan are claimed in this economic analysis. No increase in damages or project induced developments in the Neuse study area are claimed.

6.2 Employment Stability

Tourism is highly valued as a source of employment and income. Employment related to recreation can be less than ideal because of the seasonal nature of recreation and tourism. Increased recreation visitation may improve the income of service industries in the two county study area. It is unlikely that employment will be significantly impacted with or without storm damage reduction measures. Gains or losses in income or employment are considered regional impacts.

6.3 Displacement of People, Businesses, and Farms

Implementation of damage reduction measures under consideration is not expected to displace people, businesses, or farms.

7.0 OTHER SOCIAL EFFECTS

The OSE account considers the effects of alternative plans in areas that are not already contained in the NED and RED accounts. The categories of effects contained within the OSE account include:

- Urban and community impacts
- Life, health, and safety factors
- Displacement

7.1 Potential Urban and Community Impacts

An urban and community impact is the principal category of potential OSE impacts associated with the alternative restoration plans. This category of impacts includes effects on income distribution, employment distribution, population distribution and composition, and quality of community life. Some urban and community impacts have previously been addressed in this appendix. For example, regional income effects and fiscal impacts were discussed in the RED analysis. The OSE assessment of urban and community impacts considers both the potential for exposure to the effects of the alternative restoration plans and the degree of vulnerability to potential impacts. Exposure refers to whether an individual or community is subject to the OSE of the alternative plans. Vulnerability refers to the ability of that individual or community to respond or adjust to those effects.

Potential urban and community impacts of the alternative restoration plans could result from: (1) land acquisition and potential relocation of populations for reservoir and other project construction features, (2) reduced agricultural activity associated with taking the reservoir lands out of cultivation, and (3) construction activity associated with plan implementation. In general, construction activity is considered to have positive impacts. At the local scale, construction and O&M activities associated with the alternative restoration plans can have positive effects to local residents and communities by providing jobs, increasing local wages, increasing local sales, increasing tax revenues and generally benefiting the local economy. There are a variety of social and economic factors that are important determinants of an individual or community's ability to cope with adversity. One of the most important economic factors in the ability of individuals and groups to respond is the number of employment alternatives available locally. The ability to find another job depends on the education and training of the work force as well as the needs of local economic concerns, such as other farms, agricultural-related services, or some other local business. The socio-economic makeup of the community is also an important consideration of the ability of individuals and the community at large to cope with the adverse effects of large-scale agricultural land conversion. Some groups in society are recognized as having less opportunity to respond to adversity. These groups include ethnic and racial minorities, the elderly, and the poor. Tables 2.3-2, 2.3-3 and 2.4-1 presents a socio-economic vulnerability profile for the local counties. This profile contains information that indicates the ability of the county population to respond to social and economic adversity. It is important to recognize that the county scale may not accurately reflect the ability of any given community or groups within a community to accommodate potential changes associated with the alternative restoration plans.

Table 2.3-2 contains the 2009 racial/ethnic mix of each county in the study area, as well as population over 65 years of age, unemployment, 2009 per capita income, and the expected changes in employment and income.

The surrounding counties have a wide range of ethnic compositions, proportions of elderly population, unemployment rates, and per capita incomes. These socio-economic characteristics suggest that the rural counties of the study area– those that are expected to provide locations for new storage reservoirs– are areas that are least able to accommodate the associated economic and social effects on local communities. However, in these rural areas the affected populations should be relatively small.

Although the restoration of the estuaries and riverine system is a unique undertaking, there have been other projects and programs with similar goals and socio-economic contexts. One study conducted by the U.S. Department of the Interior assessed the national and regional economic impacts of not allowing timber harvests in certain old-growth forests in Oregon in order to protect the northern spotted owl. One aspect of this study investigated the re-employment of timber workers who had been displaced by the cessation of local logging activities. Surveys of displaced loggers suggested that they found that 57 percent of displaced workers reported post-displacement wages equal to or above their previous wages. According to the bureau of labor statistics, 92 percent of displaced workers find new jobs within one year, and the remaining eight percent find jobs within two years.

7.2 Other Social Effects

The Other Social Effects (OSE) account considers the effects of alternative plans in areas that are not already contained in the NED and RED accounts. The categories of effects contained within the OSE account include:

- Urban and community impacts
- Life, health, and safety factors
- Displacement, long-term productivity
- Energy requirements and energy conservation

The Neuse River Basin alternative plans could result in beneficial and adverse OSE within the study area. An urban and community impact is the principal category of potential OSE impacts associated with the alternative restoration plans. This category of impacts includes effects on income distribution, employment distribution, population distribution and composition, and quality of community life. There are several possible social effects that the Neuse River Basin project could impact. The project has the potential to raise property values in the surrounding area, increase attractiveness to the community, increase recreational opportunities, and improve environmental health such as water and air quality among other impacts. All of these factors could change the surrounding demographics of the community. It may or may not affect Environmental Justice issues. A major social impact is the change in land available for development. Urban sprawl may have led to this land being used for residential or commercial development. This could reduce the available housing opportunities and possibly raise housing prices. At the same time, since there would be no development on the project site, it could decrease energy demand and improve environmental quality. The footprints of the projects would determine to what extent these impacts could occur.

8.0 ENVIRONMENTAL JUSTICE

Executive Order (E.O.) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires the federal government to achieve environmental justice by identifying and addressing high, adverse and disproportionate effects of its activities on minority and low-income populations. E.O. 12898, Environmental Justice, states that the proposed action would not result in adverse human health or environmental effects. Any impacts of the action would not be disproportionate towards any minority or low-income population. The activity does not (a) exclude persons from participation in, (b) deny persons the benefits of, or (c) subject persons to discrimination because of their race, color, or national origin. The activity would not impact "subsistence consumption of fish and wildlife." It requires the analysis of information such as the race, national origin, and income level for areas expected to be impacted by environmental actions. It also requires federal agencies to identify the need to ensure the protection of populations relying on subsistence consumption of fish and wildlife, through analysis of information on such consumption patterns, and the communication of associated risks to the public.

The Neuse River basin has a large percentage of people that claim minority ethnicity. Of the million residents in the basin during the year 2009, over one half are of minorities. In the Neuse basin the African- American population is , which makes up percent of the county's population. The study area has a population that is percent Hispanic. The Native-American population of the study area represents less than one percent of the aggregate population of the study area.

The Neuse River Basin project would provide benefits to the quality of life by improving the natural environment. The project features of wetland restoration and improved water discharge are by design in locations remote from urban populations such that negative impacts are eliminated for all communities. In public outreach efforts to date, no potential environmental justice issues have been identified.

The project features are located based upon hydrologic characteristics, land availability and inter-connection to existing canals and structures to optimize operations. Furthermore, in the consideration of the project site, urban areas are avoided to eliminate the negative impacts typically associated with site location of large projects. Through "willing seller agreements" a variety of land rights have been or will be acquired that allow the use of land for the resulting improvements to the human quality of life and the intended environmental benefits intended by the impoundment.

These environmental benefits provide quality of life improvements to all people and primarily to people in the communities within the study area. By the nature of design, this operating procedure will maintain if not improve flood damage reduction. This would improve the quality of human life by providing increased wildlife activity; a special bonus for those who appreciate seeing increases in fish and bird populations. This logically translates to the increased benefits in enjoyment, aesthetics, and economics for recreational activities.

9.0 REFERENCES

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Attachment A

Cost Tables for Neuse River Basin Alternatives

Note:

The attached tables contain the preliminary costs and annualized costs used in the in the incremental cost assesment of the Neuse River Basin report. Preliminary costs were provided by USACE contractor, Tetra Tech, for Adkin Branch, Ellerbe Creek, Gum Thicket, and Kinston and were annualized at the 4.625% discount rate. These values were used in the initial screening process. Tetra Tech, however, did not provide preliminary costs for Little River or Oyster components of the project, and were completed in house, and were annualized at 4.625% as well.

The annualized values of the TSP are included in this attachment as well, and are annualized at the 4% discount rate.

Adkin Branch Costs

		Quantity	Total 1	Contingencies	E&D	Construction	Operations & PM	Totals
Measure	A1							
	Plant riparian vegetation at $12,000 acres -	.33 acres	$3,960	$792	$475	$317	$198	**$5,742**
	A2							
	Plant riparian vegetation at $12,000 acres -	.65 acres	$7,800	$1,560	$936	$624	$390	**$11,310**
	B							
	Place Woody Debris - semi-buried, non-anchored logs w/root wads at $1,000 each - $9,000	9 logs	$9,000	$1,800	$1,080	$720	$450	**$13,050**
	Site Prep							
	$59,250 - identical for all alternatives		$59,250	$11,850	$7,110	$4,740	$2,963	**$85,913**

General Markups	Contingencies	20%
	Engineering & Design	12%
	Construction	8%
	Operations & PM	5%

Adkin Branch, Annualized Costs, 4%

	A1	A2	B	A1A2	A1B	A2B	A1A2B
Total Construction	**$91,700**	**$97,200**	**$99,000**	**$103,000**	**$104,705**	**$110,300**	**$116,000**
Real Estate	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Total	**$91,700**	**$97,200**	**$99,000**	**$103,000**	**$104,705**	**$110,300**	**$116,000**
IDC Construction	**$405**	**$551**	**$562**	**$584**	**$594**	$626	**$658**
IDC Real Estate	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Total IDC	**$405**	**$551**	**$562**	**$584**	**$594**	**$626**	**$658**
TOTAL INVESTMENT	**$92,105**	**$97,751**	**$99,562**	**$103,584**	**$105,299**	**$110,926**	**$116,658**
Period of Analysis	**50**	**50**	**50**	**50**	**50**	**50**	**50**
Annualization	**$4,756**	**$5,047**	**$5,141**	**$5,349**	**$5,437**	**$5,728**	**$6,024**
O&M	**$190.23**	**$201.89**	**$205.63**	**$213.94**	**$217.48**	**$229.10**	**$240.94**
Present Worth of Annualization + O&M	**$4,756**	**$5,047**	**$5,141**	**$5,349**	**$5,437**	**$5,728**	**$6,024**

Gum Thicket/Cedar Creek Costs for Alternatives

NEUSE RIVER BASIN (5-ft Total Height)				
Reach Meander - Gum Thicket				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	15,000	TON	$112.15	$1,682,250.00
Limestone	16,000	TON	$66.35	$1,061,600.00
Transfer Rock to Barge	22,000	CY	$7.00	$154,000.00
Placement of Rock	31,000	TON	$73.00	$2,263,000.00
Geotextile	15,000	SY	$4.50	$67,500.00
Oyster Habitat	1	LS	$1,477,755.00	$1,477,755.00
Place Sand Fill	25,000	CY	$28.25	$706,250.00
Plant Marsh Vegetation	3.1	AC	$24,075.00	$74,632.50
			Subtotal	$7,682,752.50
			Engineering & Design (@ 12%)	*$921,930.30*
			Construction (@8%)	*$614,620.20*
			Operations & PM (@5%)	*$384,137.63*
			Contingency (@ 20%)	*$1,920,688.13*
			Total	**$9,603,440.63**
Reach Parallel - Gum Thicket				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	12,000	TON	$112.15	$1,345,800.00
Limestone	12,000	TON	$66.35	$796,200.00
Transfer Rock to Barge	17,100	CY	$7.00	$119,700.00
Placement of Rock	24,000	TON	$73.00	$1,752,000.00
Geotextile	12,000	SY	$4.50	$54,000.00
Oyster Habitat	1	LS	$878,105.00	$878,105.00
Place Sand Fill	19,000	CY	$28.25	$536,750.00
Plant Marsh Vegetation	2.4	AC	$24,075.00	$57,780.00
			Subtotal	$5,736,100.00
			Engineering & Design (@ 12%)	*$688,332.00*
			Construction (@8%)	*$458,888.00*
			Operations & PM (@5%)	*$286,805.00*
			Contingency (@ 20%)	*$1,434,025.00*
			Total	**$8,604,150.00**
Reach Meander - Cedar Creek				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	22,000	TON	$112.15	$2,467,300.00
Limestone	24,000	TON	$66.35	$1,592,400.00
Transfer Rock to Barge	33,000	CY	$7.00	$231,000.00
Placement of Rock	46,000	TON	$73.00	$3,358,000.00
Geotextile	19,000	SY	$4.50	$85,500.00
Place Sand Fill	37,000	CY	$28.25	$1,045,250.00
Plant Marsh Vegetation	4.6	AC	$24,075.00	$110,745.00
			Subtotal	$9,085,960.00
			Engineering & Design (@ 12%)	*$1,090,315.20*
			Construction (@8%)	*$726,876.80*
			Operations & PM (@5%)	*$454,298.00*
			Contingency (@ 20%)	*$2,271,490.00*
			Total	**$13,628,940.00**
Reach Parallel - Cedar Creek				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	17,000	TON	$112.15	$1,906,550.00
Limestone	18,000	TON	$66.35	$1,194,300.00
Transfer Rock to Barge	25,000	CY	$7.00	$175,000.00
Placement of Rock	35,000	TON	$73.00	$2,555,000.00
Geotextile	17,000	SY	$4.50	$76,500.00
Place Sand Fill	29,000	CY	$28.25	$819,250.00
Plant Marsh Vegetation	3.6	AC	$24,075.00	$86,670.00
			Subtotal	$7,009,035.00
			Engineering & Design (@ 12%)	*$841,084.20*
			Construction (@8%)	*$560,722.80*
			Operations & PM (@5%)	*$350,451.75*
			Contingency (@ 20%)	*$1,752,258.75*
			Total	**$10,513,552.50**

Gum Thicket, Annualized Costs, 4%

	1A	1B	1AC	1BC	2A	2B	1A2A	1A2B	1B2A	1B2B	1AC2A	1AC2B	1BC2A	1BC2B	Thicket
Total Construction	$7,044,000	$8,997,000	$8,604,000	$9,603,000	$10,514,000	$13,628,940	$17,558,000	$20,672,940	$19,511,000	$22,625,940	$19,118,000	$22,232,940	$20,117,000	$23,231,940	$3,839,000
Real Estate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Total	$7,044,000	$8,997,000	$8,604,000	$9,603,000	$10,514,000	$13,628,940	$17,558,000	$20,672,940	$19,511,000	$22,625,940	$19,118,000	$22,232,940	$20,117,000	$23,231,940	$3,839,000
IDC Construction	$31,109	$51,034	$48,804	$54,471	$59,639	$77,307	$99,594	$117,263	$110,672	$128,341	$108,443	$126,112	$114,110	$131,779	$1,952,164
IDC Real Estate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total IDC	$31,109	$51,034	$48,804	$54,471	$59,639	$77,307	$99,594	$117,263	$110,672	$128,341	$108,443	$126,112	$114,110	$131,779	$1,952,164
TOTAL INVESTMENT	$7,075,109	$9,048,034	$8,652,804	$9,657,471	$10,573,639	$13,706,247	$17,657,594	$20,790,203	$19,621,672	$22,754,281	$19,226,443	$22,359,052	$20,231,110	$23,363,719	$5,791,164
Period of Analysis	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Annualization	$365,322	$467,193	$446,786	$498,662	$545,968	$707,719	$911,746	$1,073,498	$1,013,161	$1,174,913	$992,753	$1,154,505	$1,044,629	$1,206,381	$299,026
O&M	$14,612.87	$18,687.73	$17,871.43	$19,946.46	$21,838.70	$28,308.77	$36,469.85	$42,939.91	$40,526.44						
Present Worth of Annualization + O&M	$365,322	$467,193	$446,786	$498,662	$545,968	$707,719	$911,746	$1,073,498	$1,013,161	$1,174,913	$992,753	$1,154,505	$1,044,629	$1,206,381	$299,026

Kinston East Costs

				Total	Conting.	E&D	Constr.	Operations & PM	Total w/ GM
Measure	A	Excavate fill and haul offsite - $25.00 CY	14.5 acres x 4 ft depth = 93,570 CY	$2,339,250	$467,850.0	$280,710.00	$187,140.00	$116,962.50	$3,391,913
Measure	B	Plant Bottomland Vegetation - $15,000/acre	14.5 acres	$217,500	$43,500.0	$26,100.00	$17,400.00	$10,875.00	$315,375
Site Prep.		Identical for all alternatives		$436,400	$87,280.0	$52,368.00	$34,912.00	$21,820.00	$632,780

General Markups	Contingencies	20%
	Engineering & Design	12%
	Construction	8%
	Operations and PM	5%

Kinston East Wetland, Annualized Costs, 4%

	A	AB
Total Construction	$4,024,700	$4,340,100
Real Estate	$0	$0
Total	$4,024,700	$4,340,100
IDC Construction	$17,775	$24,618
IDC Real Estate	$0	$0
Total IDC	$17,775	$24,618
TOTAL INVESTMENT	$4,042,475	$4,364,718
Period of Analysis	50	50
Annualization	$208,732	$225,371
O&M	$8,349	$9,015
Present Worth of Annualization + O&M	$208,732	$225,371

Ellerbe Creek Costs

			Unit Cost	Units	Cost	Conting.	E & D	Construction	O & PM	Total
Measure	A1	Real Estate	$10,000/acre	6.2	$62,000	$12,400	$7,440	$4,960	$3,100	**$89,900**
		Bottomland Hardwood Planting	$15,000/acre	6.2	$93,000	$18,600	$11,160	$7,440	$4,650	**$134,850**
		Excavate and Haul Offsite	$25/CY	5,000	$125,000	$25,000	$15,000	$10,000	$6,250	**$181,250**
										$406,000
	A2	Real Estate	$10,000/acre	5.3	$53,000	$10,600	$6,360	$4,240	$2,650	**$76,850**
		Bottomland Hardwood Planting	$15,000/acre	5.3	$53,000	$10,600	$6,360	$4,240	$2,650	**$76,850**
		Excavate and Haul Offsite	$25/CY	4,275	$106,875	$21,375	$12,825	$8,550	$5,344	**$154,969**
										$308,669
	A3	Real Estate	$10,000/acre	2.8	$28,000	$5,600	$3,360	$2,240	$1,400	**$40,600**
		Bottomland Hardwood Planting	$15,000/acre	2.8	$42,000	$8,400	$5,040	$3,360	$2,100	**$60,900**
		Excavate and Haul Offsite	$25/CY	2,259	$56,475	$11,295	$6,777	$4,518	$2,824	**$81,889**
										$183,389
	B	Step Pools - Rock	$94/ton	36	$3,384	$677	$406	$271	$169	**$4,907**
		Step Pools - Logs	$1,000/log	6	$6,000	$1,200	$720	$480	$300	**$8,700**
										$13,607
	B and C	Excavate and Haul Offsite	$25/CY	2420	$60,500	$12,100	$7,260	$4,840	$3,025	**$87,725**
		Step Pools - Rock	$94/ton	54	$5,076	$1,015	$609	$406	$254	**$7,360**
		Step Pools - Logs	$1,000/log	9	$9,000	$1,800	$1,080	$720	$450	**$13,050**
										$108,135
Site Prep.	A1				41145	$8,229	$4,937	$3,292	$2,057	**$59,660**
	A2				37003	$7,401	$4,440	$2,960	$1,850	**$53,654**
	A3				25495	$5,099	$3,059	$2,040	$1,275	**$36,968**
	B				1486	$297	$178	$119	$74	**$2,155**
										$152,437
General Markups		Contingencies	20%							
		Engineering & Design	12%							
		Construction	8%							
		Operations & PM	5%							

Ellerbe Creek, Cost Annualization @4.625	A1	A2	A3	A1A2	A1A3	A2A3	A1A2A3	A1B	A2B	A3B	A1A2B	A1A3B	A2A3B	A1A2A3B	A1A2A3C	A1A2A3BC	B
Total Construction	$375,760	$285,473	$179,757	$661,233	$555,517	$465,230	$840,990	$391,522	$301,235	$195,519	$676,995	$571,279	$480,992	$856,752	$1,136,065	$1,156,475	$15,762
Real Estate	$89,900	$76,850	$40,600	$166,750	$130,500	$117,450	$207,350	$89,900	$76,850	$40,600	$166,750	$130,500	$117,450	$207,350	$0	$0	$0
Total	$465,660	$362,323	$220,357	$827,983	$686,017	$582,680	$1,048,340	$481,422	$378,085	$236,119	$843,745	$701,779	$598,442	$1,064,102	$1,136,065	$1,156,475	$15,762
IDC Construction	$1,660	$1,619	$1,020	$3,279	$2,679	$2,639	$4,298	$1,749	$1,709	$1,109	$3,368	$2,769	$2,728	$4,388	$6,444	$6,560	$89
IDC Real Estate	$494	$494		$988	$494	$494	$988	$494	$494		$988	$494	$494	$988			
Total IDC	$2,154	$2,113	$1,020	$4,267	$3,173	$3,133	$5,286	$2,243	$2,203	$1,109	$4,356	$3,263	$3,222	$5,376	$6,444	$6,560	$89
TOTAL INVESTMENT	$467,814	$364,436	$221,377	$832,250	$689,190	$585,813	$1,053,626	$483,665	$380,288	$237,228	$848,101	$705,042	$601,664	$1,069,478	$1,142,509	$1,163,035	$15,851
Period of Analysis	50	50	50	$100	$100	$100	$150	$100	$100	$100	$150	$150	$150	$200	50	50	50
Annualization	$24,155	$18,818	$11,431	$42,973	$35,586	$30,248	$54,404	$24,974	$19,636	$12,249	$43,792	$36,405	$31,067	$55,222	$58,993	$60,053	$818
O&M	$966.22	$752.70	$457.23	$1,719	$1,423	$1,210	$2,176	$966	$753	$457	$1,719	$1,423	$1,210	$2,176			
Present Worth of Annualization + O&M	$24,155	$18,818	$11,431	$42,973	$35,586	$30,248	$54,404	$24,974	$19,636	$12,249	$43,792	$36,405	$31,067	$55,222	$58,993	$60,053	$818

Little River/Goldsboro Dam, Annualization, 4%

	A	B	C
Total Construction	$180,835	$240,650	$1,163,605
Real Estate	$0	$0	$0
Total	$180,835	$240,650	$1,163,605
IDC Construction	$799	$1,365	$6,600
IDC Real Estate	$0	$0	$0
Total IDC	$799	$1,365	$6,600
TOTAL INVESTMENT	$181,634	$242,015	$1,170,205
Period of Analysis	50	50	50
Annualization	$9,379	$12,496	$60,423
O&M	$375.14	$499.86	$2,416.93
Present Worth of Annualization + O&M	$9,379	$12,496	$60,423

Neuse Oyster Reef Restoration, Annualization, 4%

	A1	A2	A3	A4	A5	A6	A7	A8	A9	B1	B2	B3	C1	C2	C3
Total Construction	$3,352,226	$4,978,945	$6,605,664	$3,352,226	$4,978,945	$6,605,664	$3,352,226	$4,978,945	$6,605,664	$2,381,834	$4,009,196	$5,636,549	$598,442	$1,064,102	$1,136,065
Real Estate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total	$3,352,226	$4,978,945	$6,605,664	$3,352,226	$4,978,945	$6,605,664	$3,352,226	$4,978,945	$6,605,664	$2,381,834	$4,009,196	$5,636,549	$598,442	$1,064,102	$1,136,065
IDC Construction	$14,805	$28,242	$37,469	$19,015	$28,242	$37,469	$19,015	$28,242	$37,469	$13,510	$22,741	$31,972	$3,395	$6,036	$6,444
IDC Real Estate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total IDC	$14,805	$28,242	$37,469	$19,015	$28,242	$37,469	$19,015	$28,242	$37,469	$13,510	$22,741	$31,972	$3,395	$6,036	$6,444
TOTAL INVESTMENT	$3,367,031	$5,007,187	$6,643,133	$3,371,241	$5,007,187	$6,643,133	$3,371,241	$5,007,187	$6,643,133	$2,395,344	$4,031,937	$5,668,521	$601,837	$1,070,138	$1,142,509
Period of Analysis	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Annualization	$173,856	$258,545	$343,017	$174,073	$258,545	$343,017	$174,073	$258,545	$343,017	$123,683	$208,188	$292,693	$31,076	$55,256	$58,993
O&M	$6,954.24	$10,341.80	$13,720.67	$6,962.93	$10,341.80	$13,720.67	$6,962.93	$10,341.80	$13,720.67						
Present Worth of Annualization + O&M	$173,856	$258,545	$343,017	$174,073	$258,545	$343,017	$174,073	$258,545	$343,017	$123,683	$208,188	$292,693	$31,076	$55,256	$58,993

Neuse River, Tentatively Selected Plan, 4% Discount Rate						
	Oysters	Kinston East	Little River	Gum Thicket/ Cedar Creek	Sums	Sum plus Contingency
Construction	$9,080,344	$3,143,826	$426,872	$11,274,963	$23,926,005	**$29,907,506**
PED	$907,991	$314,367	$42,685	$1,127,443	$2,392,486	**$2,990,607**
Construction Management	$541,342	$187,425	$25,448	$672,179	$1,426,394	**$1,782,992**
Total Construction	**$10,529,677**	$3,645,618	**$495,005**	$13,074,584	$40,819,469	**$34,681,105**
Construction Schedule						
Real Estate	**$6,256**	$60,875	**$28,193**	$153,419	$402,162	**$248,743**
Total	**$10,535,933**	$3,706,493	**$523,198**	$13,228,003	$41,221,631	**$34,929,848**
IDC Construction	**$209,214**	$72,431	**$9,832**	$246,944	$785,366	**$981,707**
IDC Real Estate	**$212**	$2,060	**$954**	$5,191	$13,609	**$17,011**
Total IDC	**$209,426**	$74,491	**$10,786**	$252,136	$798,974	**$998,718**
TOTAL INVESTMENT	**$10,745,359**	$3,780,984	**$533,984**	$13,480,139	$43,221,741	**$35,928,566**
Period of Analysis	**50**	$50	**50**	50		
Annualization	**$500,199**	$176,006	**$24,857**	$627,503	$1,956,068	**$2,445,084**
O&M (4% Average Annual Cost)	**$20,008**	$7,040	**$994**	$25,100	$78,243	**$97,803**
Present Worth of Annualization + O&M	**$520,207**	$183,046	**$25,851**	$652,603	$2,034,310	**$2,542,888**

Appendix H: Fish and Wildlife Coordination Act

June 25, 2003

Colonel Charles R. Alexander
District Engineer, Wilmington District
U. S. Army Corps of Engineers
P. O. Box 1890
Wilmington, NC 28402-1890

Attention: Mr. Hugh Heine, Environmental Resources Section

Dear Colonel Alexander:

In accordance with our Scope of Work for FY 2003, the U. S. Fish and Wildlife Service is pleased to provide this Planning Aid Letter (PAL) for the Neuse River Basin Study (NRBS). This study is being pursued in the General Investigation Program of the U. S. Army Corps of Engineers (Corps) and is being conducted in response to a resolution adopted by the U.S. House of Representative on July 23, 1997. This resolution requested that the Secretary of the Army review the report of the Chief of Engineers (House Document 175, 89th Congress) and other pertinent reports to determine whether modifications were advisable to the report recommendations regarding flood control, environmental protection, restoration, and related purposes. The purpose of the feasibility study is to identify a number of watershed projects that can be initiated under the Continuing Authority Program (CAP), primarily Section 206 of the Water Resources Development Act of 1996, as amended. This letter contains early scoping comments and does not constitute the report of the Department of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661-667d).

Study Area

The Neuse River Basin (NRB) is the third largest basin in North Carolina and is one of only three basins located entirely within the state. The NRB covers 6,192 square miles. The basin contains 3,443 miles of stream and river channels (Powell 1999). The river originates in the Piedmont northwest of Durham in Person and Orange Counties. The major tributaries include the Eno, Flat, Little, and Trent Rivers and well as Crabtree, Swift, and Contentnea Creeks. The NRB can be divided into 14 subbasins (North Carolina Department of Environment and Natural Resources [hereafter NCDENR] 2001, p. 15) which vary in size. These subbasins which are designated from 01 to 14 form a convenient framework, e.g., Subbasin 01, to discuss the different areas of the Neuse River watershed and will be referenced in this report. There are 17 counties which comprise most of the NRB (NCDENR 2001, Figure 2). While the basin may contain smaller sections of other counties, these 17 counties, listed in Appendix 1, form the basis for this study.

The upper 22 miles of the river's mainstem is impounded behind the Falls of the Neuse Reservoir Dam that creates a large multi-use reservoir northeast of Raleigh. Below the dam the river flows about 185 miles southeasterly past the cities of Raleigh (Wake County), Smithfield (Johnston County), Goldsboro (Wayne County), and Kinston (Lenoir County) until it reaches the tidal waters near the Town of Street's Ferry (Craven County), upstream from New Bern (Craven County). Below Street's Ferry the river broadens dramatically and changes into a tidal estuary that eventually flows into Pamlico Sound.

Much of the land area in the basin is used for agriculture or commercial forestry. Urban development in the upper basin is concentrated around Raleigh, Durham (Durham County), and Cary (Wake County) and around Goldsboro, Kinston, and New Bern in the lower basin.

Significant Fish and Wildlife Resources in the Study Area

The Neuse River originates in the Piedmont region and flows through both the upper and lower coastal plains. Kellison et al. (1998) give a broad overview of the wildlife associated with major alluvial floodplains in the South. They note that these floodplains provide some of the most important fish and wildlife habitats in the region. The high fertility supports high forest productivity which in turn produces more high-quality food and browse than is found on poorer sites. The extensiveness and denseness of unbroken floodplain forests are as important as the habitat itself. A comprehensive report on the fishes of the NRB was prepared in the early 1960s (Bayless and Smith 1962).

On the coastal plain, broad, flat areas adjacent to the Neuse River represent major alluvial floodplains that, unless altered by man, are invariably forested (Kellison et al. 1998), and are referred to as bottomland hardwoods (BLH) (Kellison et al. 1998, p. 300). While many of these floodplain areas in the NRB have been developed, it is likely that these areas once contained, and could be restored to, BLH. Excellent reviews of the physical and biological characteristics of BLH are available (Wharton et al. 1982, Harris et al. 1984, Sharitz and Mitsch 1993, Kellison et al. 1998). Boaters on the Neuse River report (Powell 1999) an "amazing amount of wildlife" such as wood ducks (*Aix sponsa*) and other waterfowl, blue heron (*Ardea herodias*), belted kingfisher (*Megaceryle alcyon*), deer (*Odocoileus virginianus*), wild turkeys (*Meleagris gallopavo*), muskrats (*Ondatra zibethicus*), and beaver (*Castor canadensis*). Red shouldered hawks (*Buteo lineatus*) nest in the bottomland forests along the Neuse.

Forested alluvial floodplains are important to many birds as breeding, wintering, and migrating stop-over habitat (Kellison et al. 1998, p. 314). These forests provide food and cover for wildlife throughout the year. Seasonal flooding produces shallow, warm water areas where many kinds of water life spawn and feed (Harris et al. 1984, p. 7). Flooded BLHs are nurseries for many fish species. The web page of the North Carolina Division of Parks and Recreation (http://ils.unc.edu/parkproject/visit/clne) notes that the Cliffs of the Neuse State Park (Wayne County) has 420 plant species, an abundant and diverse animal life, and wetland and aquatic habitats for reptiles and amphibians.
Four areas having significant biological diversity (NCDENR 2001, pp. 24-25) are:

1 Headwater rivers in Subbasin 01 which include the upper Flat River, Little River, and the Eno River;

1. Middle portion of the Little River in Johnston County (Subbasin 06);

2. Middle portion of the Neuse River which contains many species not found in tributaries; and,

3. Better tributaries of the Trent River in Subbasin 11, especially Island Creek.

Rare and Protected Species in the Study Area

The NRB also provides habitat for many threatened or endangered species, listed under Federal and/or State legislation. While many terrestrial plants and animals would benefit from higher quality riparian areas and improved water quality, the most direct beneficiaries would be aquatic species, especially fish and mussels within the basin. The NCDWQ reports that several rare or unusual invertebrate species were collected during recent surveys (NCDENR 2001, pp. 25-26), including mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), beetles (Coleoptera), dragonflies/damselflies (Odonata), midges Chironomidae), and snails (Gastropods). Two species of rare crayfish (Cambaridae) were found in the NRB (NCDENR 2001, p. 26).

The eight mussels (Pelecypoda) listed as either Federally endangered or a Federal Species of Concern (FSC) in the 17 counties that comprise most of the Neuse River Basin are given in Appendix 2. Both the dwarf wedge mussel (*Alasmidonta heterodon*) and the Tar spinymussel (*Elliptio steinstansana*) are listed as endangered reflecting an assessment that the species is in danger of extinction throughout all or a significant portion of its range. The greatest mussel diversity within the NRB occurs in the Flat River in the northern part of the basin and the Little Rivers in Johnston County (NCDENR 2001, p. 26). The dwarf wedge mussel occurs mainly near the fall line with the best populations occurring in the Johnston County portion of the Little River. The Atlantic pigtoe (*Fusconaia masoni*), a FSC, occurs in the Little River of Johnston County and the Flat River in Person and Durham Counties. The yellow lance (*Elliptio lanceolata*), a FSC, also occurs mainly near in fall line in the watershed of Middle, Swift, and Mill Creeks. The yellow lampmussel (*Lampsilis cariosa*), a FSC, is found in the Flat, Little, Eno, and Little Rivers.

The Neuse River waterdog (*Necturus lewisi*), an amphibian with a state status of "Special Concern" occurs in the NRB. The species inhabits rivers and large streams within the Neuse and Tar River drainages. On a global scale this species is considered very rare or local throughout its range, or found locally in a restricted area.

North Carolina is home to nearly 200 native species of freshwater fish. Of these, approximately 21% are designated endangered, threatened, or special concern within the state (LeGrand et al. 2001). Based on data of the NCDENR and Menhinick (1991), 97 species of fish are known from the NRB. Six species of fish are listed as either Federally endangered or a FSC in the 17 counties that comprise most of the Neuse River Basin (Appendix 3). The shortnose sturgeon (*Acipenser brevirostrum*), the single Federally endangered fish within the basin, is a bottom dwelling, anadromous fish that moves from the ocean and estuaries into freshwater between February and May and spawns from April through June. Threats to the species include overfishing and degradation of its habitat by erosion, siltation, toxic pollution, and dams that interfere with upstream migration to spawning areas. The species is under the jurisdiction of the National Marine Fisheries Service.

The five State fish species of special concern within the NRB are the least brook lamprey (*Lampetra aepyptera*), Atlantic sturgeon (*Acipenser oxyrhynchus*), bridle shiner (*Notropis bifrenatus*), the Neuse River population of the Carolina madtom (*Notropis furiosus*), and the eastern Piedmont population of the Carolina darter (*Etheostoma collis lepidinion*) (NCDENR 2001, pp. 29). The least brook lamprey, a nonparasitic fish occurs in warm, mostly slow, sandy, slightly acidic, and small creeks. The species is listed as State threatened and has a State rank of S2 indicating that it is imperiled in North Carolina because of rarity or because of some factor(s) making it vulnerable to extirpation. Within the basin it is currently found in Wake and Franklin Counties. The Atlantic sturgeon is considered rare in the State. The NCDENR conducted fish community assessment in several watersheds of the NRB in 2000 (NCDENR 2001, pp. 26-29). One Carolina darter was collected in Smith Creek (Granville County) and three bridle shiners, also a FSC, were collected from Batchelor Creek (Craven County).

Fish and Wildlife Problems in the Neuse River Basin

Congressional asked the Corps to address three broad problems, or needs, within the basin, i.e., flooding, environmental protection, and restoration. In many ways these problems are interrelated and actions taken for one goal would benefit other goals. In the planning stage, the NRBS the Corps should consider the following problems facing fish and wildlife resources.

Flooding Can Be Harmful to Fish and Wildlife Resources - Many areas within the NRB are prone to flooding. Flood damage is often related to clearing floodplains for agricultural production or constructing home, businesses, and infrastructure. This process not only increases the risk to human life and property, but eliminates valuable fish and wildlife habitat. Protecting existing riparian areas within floodplains and restoring such areas where inappropriate development has occurred are recognized ways to reduce flood damage. Within the NRB the Service recognizes three concerns associated with fish and wildlife resources:

4. The loss of natural riparian vegetative communities along with the fragmentation and degradation of other areas;

5. The decline in water quality, e.g., low dissolved oxygen and increased sedimentation, due to point and non-point source runoff into waterways of all sizes, including ephemeral streams; and,

6. The loss of hydrologic connective for aquatic organisms along the waterways due to dams

The Loss and Fragmentation of Natural Riparian Areas - A landscape in which isolated patches of natural areas are separated by developed areas is detrimental to plant and animal communities. Animals of limited mobility and plants of limited dispersal ability may become reproductively isolated from other members of their species. The theory of island biogeography has provided a basis for the idea that plants and animals in subdivided units of a larger area are more susceptible to inbreeding and accidental extinction from infrequent, natural catastrophes. One major, long-term impact of habitat fragmentation is the inability of healthy individuals in one area to migrate and repopulate a nearby area of suitable habitat in which members of the species have been eliminated due to short-term, adverse conditions. By increasing inbreeding and restricting recolonization of nearby suitable habitat, fragmentation can lead to the gradual extirpation of a species from a large area in which the total acreage of all habitat blocks has declined by only a small amount.

Approximately one-third of North American freshwater fish species (Williams et al. 1989) qualify for classification as "endangered," "threatened," or "special concern" at the Federal level, and habitat loss is a primary cause. In North Carolina, 21% of freshwater fishes are designated as endangered, threatened, or of special concern at the state level (LeGrand et al. 2001).

Federally endangered and threatened species are particularly affected by secondary and cumulative impacts associated with urban development due to their sensitivity to habitat alterations. A high proportion of listed species occurs within rapidly developing areas of the state. Some have lost major reaches of their habitats within the past few decades and others are in danger of being extirpated from entire river basins.

Many native species of aquatic organisms have become highly imperiled as a result of land-based and near-water development. Approximately 72% of North American freshwater mussel species qualify for classification as "endangered," "threatened," or "special concern" at the Federal level (Williams et al. 1993), and habitat loss is a primary culprit. North Carolina is home to more than 60 species of freshwater mussels. Unfortunately, 50% of these species are designated as endangered, threatened, or special concern within the State. As an example, the Carolina Elktoe (*Alasmidonta robusta*), a mussel known only from a tributary of the Catawba River in Mecklenburg County has apparently been extirpated from the state, and is probably extinct.

A recent report (NCDENR 2002) summarizes the functions of forested riparian zones. Natural forested areas within the NRB help to:

1. Reduce pollutants and filter runoff;
2. Improve air quality and lower ozone levels;
3. Maintain stable water flows;
4. Sustain natural channel morphology;
5. Maintain water and air temperature by providing shade;
6. Stabilize stream banks;
7. Provide most of the organic carbon and nutrients to support the aquatic food web;
8. Provide sources of large woody debris for the stream channel;
9. Reduce the severity of floods;
10. Facilitate the exchange of groundwater and surface water; and,
11. Provide critical wildlife habitat

Decline in Water Quality - The decline in freshwater species is a direct reflection of declining quality in the streams and rivers of North Carolina (NCDENR 2002). Development along the Neuse has damaged or eliminated the natural riparian buffers which naturally filter runoff from uplands. Nonpoint runoff from both urban (stormwater and suspended sediments) and rural, agricultural areas is the main contributor to water quality degradation (NCDENR 2001, p. 17). Swift Creek has elevated turbidity from development in south Raleigh and rapidly urbanizing Johnston County. The Neuse River mainstem shows a spike in nitrate-nitrite-nitrogen below Raleigh which declines with distance downstream (NCDENR 2001, p. 17). Contentnea Creek has experienced high nutrient concentrations and these high levels caused elevated nutrients at Neuse River sites downstream. Contentnea and Little Contentnea Creeks may have low summer dissolved oxygen (DO) concentrations (NCDENR 2001, p. 19). The NCDENR (2001, p. 24) lists 13 sites within six subbasins of the Neuse with declining water quality based on sampling of benthic macroinvertebrates.

The NCDENR (2001, p. 21) notes that studies in the Neuse River Estuary (Subbasin 10) indicate that the fauna of the lower Neuse River is controlled by periods of very low DO, or hypoxia, during the summer months. Algal blooms in which nutrient rich water produces a large amount of algae are a major cause of low DO. When the algae die, the bacterial decomposition requires DO. The number of algal blooms has increased over time in Subbasin 10, often accompanied by extreme swings in DO. Summer algal blooms (especially dinoflagellates) have been a common and chronic problem in Subbasin 10 for many years with the most severe blooms occurring during the 1990-1995 period.

Nonpoint runoff contributes to water quality degradation in the Falls of the Neuse Reservoir Watershed (Subbasin 01) (NCDENR, 2001, p. 17). Point source dischargers also contribute to severe water quality problems near Durham, especially in Ellerbe and Knap of Reeds Creeks. In Subbasin 02, Falls Lake to southern Johnston County, nonpoint runoff contributes to water quality degradation (NCDENR, 2001, p. 17).

Loss of Hydrologic Connective along the Waterways Due to Dams - A major concern along North Carolina rivers is the blockage of movement of aquatic organisms by dams. Dams may block some fish, especially anadromous fish, from portions of their historic habitat. Restoration of access to historic habitats and removing dams as barrier to upstream-downstream moving of aquatic organisms would have significant benefits to fish and wildlife resources.

A closely related concern is the effort to control flood damage using structural measures, e.g., dikes and levees, to separate water within major channels from their historic floodplains. Seasonal flooding produces shallow, warm water areas where many kinds of water life spawn and feed (Harris et al. 1984, p. 7). Flooded BLHs are nurseries for many fish species. The nonstructural approach, such as elevating or relocating houses and businesses, retains this link. Harris et al. (1984, p. 14) note that when a BLH forest is drained, channelized, dike, and cleared, it can no longer perform the same functions in the landscape. Important functions of an interconnected river-floodplain ecosystem include water control and purification, groundwater recharges, soil enrichment, erosion control, and support for downstream fishing industries (Harris et al. 1984, p. 14).

Resource Opportunities and Service Recommendations for Planning Objectives

The present study presents an opportunity to address the major problems cited in the Congressional Resolution. Tibbetts (1999) present a broad overview of efforts to reduce flood damage in North Carolina. He notes that communities could diminish their risk of flood damage by purchasing wetlands and open spaces along waterways to protect these areas from development. Local governments could also improve stormwater drainage systems, enact special building standards in flood-prone areas, and direct public facilities and infrastructure away from floodplains. The best tool for reducing flood damage is the development of comprehensive plans and ordinances to limit new development in flood-prone areas. Such efforts can lead directly to fulfilling the two other objects of the present study, environmental protection and restoration. Limiting development within floodplains protects natural fish and wildlife habitats. Land previously impacted could be purchased and restored to natural riparian areas. Efforts to protect and restore riparian habitats would also enhance water quality. The Service believes this effort should be addressed in six major areas which are considered below. Much of the following discussion is based on a guidance memorandum produced in 2002 to address and mitigate secondary and cumulative impacts to aquatic and terrestrial wildlife resources and water quality (NCDENR 2002).

1. Riparian Buffers - The NRBS should seek to determine where natural, riparian vegetative communities have been lost and reestablish these communities. Wide, contiguous riparian buffers have greater and more flexible potential than other options to maintain biological integrity (Horner et al. 1999) and could ameliorate many ecological issues related to land use and environmental quality (Naiman et al. 1993). As expansion of developed areas continues into the watershed, wildlife habitats can change, become fragmented, and even disappear. Riparian buffers provide travel corridors and habitat areas for wildlife displaced by development. Native forested buffers should be established and maintained along each side of perennial and intermittent streams at a minimum of 100 feet and 50 feet, respectively. Furthermore, buffers should also be established on ephemeral streams due to the important functions that they provide as headwater streams (Alexander et al. 2000; Peterson et al. 2001). Buffers should be measured horizontally from the edge of the stream bank (Knutson and Naef 1997), which may result in wider buffers on higher gradients, and must be provided over the entire stream length, including headwater streams. If development occurs within these designated buffers, a minimum of 30% of such development area should be left as greenspace which would include buffers and wetlands. These greenspaces should have connections to natural resources in the area.

In distinguishing between perennial, intermittent, and ephemeral streams, delineations should be conducted according to U. S. Army Corps of Engineers or North Carolina Division of Water Quality methodologies. This information can be found at http://h2o.enr.state.nc.us/ncwetlans/strmfrm.html (accessed May 2002). U. S. Geological Survey (USGS) maps underestimate the extent of streams. Recent research has shown that USGS maps can underestimate total stream lengths in the Piedmont of North Carolina by 25% (Gregory et al. in press). The Corps could assist local government in upgrading the classification of streams within their jurisdiction.

2. Utility Infrastructure - Sewer lines, water lines, and other utility infrastructure should be kept out of riparian buffer areas (Knutson and Naef 1997; and references therein). All utility crossings should be kept to a minimum, which includes careful routing design and the combination of utility crossings into the same right-of-way (provided there is not a safety issue). Discontinuous buffer segments can impair riparian functions disproportionate to the relative occurrence of the breaks in the buffer (May and Homer 2000; Van Sickle 2000), and multiple crossings can result in cumulative impacts. The directional bore (installation of utilities beneath the riverbed and thus avoiding impacts to the stream and buffer) stream crossing method should be used for utility crossings wherever practicable, and the open cut stream crossing method should only be used when the water level is low and stream flow is minimal. Manholes or similar access structures should not be allowed within buffer areas. Stream crossings should be near perpendicular (75^{o} to 105^{o}) to stream flow and should be monitored at least every three months for maintenance needs during the first 24 months of the project and then annually thereafter. Sewer lines associated with crossing areas should be maintained and operated at all times to prevent the discharge to land or surface waters. There should be a minimum setback of 50-100 feet on all streams, lakes, and wetlands for these structures. In circumstances where minimum setbacks cannot be attained, sewer lines should be constructed of ductile iron or other substance of equal durability. Pesticides (including insecticides and herbicides) should not be used for maintenance of rights-of-way within 100 feet of perennial streams and 50 feet of intermittent streams, or within floodplains and wetlands associated with these streams.

Force mains should be used to the greatest extent practicable. Gravity sewer lines should be installed to follow along the outside of the 100-year floodplain contour unless topographic features, existing development, or other conditions restrict this technique. Public and private sewer lines adjacent to streams should parallel streams and be sited as far as practicable from stream and tributary corridors (Knutson and Naef 1997; and references therein). To maintain the integrity of riparian buffers or the full extent of the 100-year floodplain, sewer lines should be sited with a minimum 200-foot buffer around perennial streams and a 100-foot buffer for intermittent streams. No new sewer lines or structures should be installed or constructed in the 100-year floodplain or within 50 feet of wetlands associated with a 100-year floodplain (Knutson and Naef 1997; and references therein).

Septic tanks, lift stations, wastewater treatment plants, sand filters, and other pretreatment systems should not be located in areas subject to frequent flooding (areas inundated at a 10-year or less frequency) unless designed and installed to be watertight and to remain operable during a 10-year storm. Mechanical or electrical components of treatment systems should be above the 100-year flood level or otherwise protected against a 100-year flood (As per rule 15A NCAC 18A .1950 - Location of Sanitary Sewage Systems).

Only aerial crossings elevated sufficiently to reduce the risk of flood damage or directional boring stream crossings should be allowed. The placement of these crossings should be limited to major stream or creek confluences. All water lines and utilities should follow roads or meet the requirements associated with sewer line placements (Killebrew 1993; Knutson and Naef 1997; and references therein).

Where practicable, all permanent roadway crossings of streams and associated wetlands should require bridges to eliminate the need for fill and culverts. If culverts must be used, the culvert should be designed to allow passage of aquatic organisms. Generally, this means that the culvert or pipe invert is buried at least one foot below the natural streambed. If multiple cells are required, the second and/or third cells should be placed so that their bottoms are at stream bankfull stage. This will allow sufficient water depth in the culvert or pipe during normal flows to accommodate movements of aquatic organisms. If culverts are long and sufficient slope exists, baffle systems should be used to trap gravel and provide resting areas for fish and other aquatic organisms. If multiple pipes or cells are used, at least one pipe or box should be designed to remain dry during normal flows to allow for wildlife passage. In addition, culverts or pipes should be situated so that no channel realignment or widening is required. Widening the stream channel at the inlet or outlet of structures usually causes a decrease in water velocity causing sediment deposition that will require future maintenance. Riprap should not be placed on the streambed.

3. Floodplain Development - Local governments should prohibit commercial or residential development within the 100-year floodplain. Undeveloped floodplains strongly influence aquatic systems, support a combination of riparian and upland vegetation used by aquatic and terrestrial wildlife, supply a rich source of food to aquatic communities (Junk et al. 1989), and provide an important sediment trapping function (Palik et al. 2000). The filling of floodplains increases the potential for flooding of adjacent properties and interferes with the natural hydrologic process of the waterways. It also disrupts the continuity of migration corridors for wildlife. As noted, developers should set aside a portion of the land to be developed as greenspace and concentrate these areas along the streams and rivers. Site practices for infill and brownfield development have been issued by the U. S. Environmental Protection Agency (EPA) (http://www.epa.gov; accessed May 2002) and the Center for Watershed Protection (http://www.cwp.org/; accessed May 2002). Floodplain maps may need to be updated to reflect development in the watershed. Floodplain remapping studies in Charlotte showed that buildout conditions would result in a floodplain width change from an average of 429 feet to 611 feet (http://www.co.mecklenburg.nc.us/coeng/storm/floodinfo/floodmaps.htm; accessed May 2002).

The removal of large trees at the edges of construction corridors should be avoided. Efforts should be made to maintain a closed canopy over streams to reduce water temperatures.

Disturbed areas should be re-seeded with seed mixtures that are beneficial to wildlife. Native, annual small grains appropriate for the season are preferred and recommended (See http://www.esb.enr.state.nc. us/wetplant/wetland_plants.htm, and http://www.co.mecklenburg.nc.us/coeng/Storm/services/vegetation/vegetation.htm). Where feasible, woody debris and logs from corridor clearing should be used to establish brush piles and downed logs adjacent to the cleared right-of-way to improve habitat for wildlife. Corridor areas should be allowed to revegetate into a brush/scrub habitat that would maximize benefits to wildlife. For land adjacent to residential areas, a native shrub/grass option is also beneficial.

Maintenance should focus on trimming trees, instead of tree removal in areas within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein). To minimize impacts to nesting wildlife, corridor maintenance should be minimal, and mowing should be prohibited between April 1 and October 1. A maintenance schedule should be established that incorporates only a portion of the area - one third of the area, for example - each year instead of the entire project every three or four years. Insecticides and herbicides should not be used within 200 feet of streams, floodplains, and associated wetlands (Knutson and Naef 1997; and references therein) except when needed to protect native flora and fauna from exotics and when using appropriately labeled products, such as biopesticides (http://www.epa.gov/pesticides/biopesticides/; accessed May 2002).

4. Restrict Impervious Surfaces - Multiple studies have shown that stream degradation occurs at approximately 10% coverage by impervious surfaces (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Homer 2000; Stewart et al. 2000; Paul and Meyer 2001). The Wake County Watershed Management Plan Task Force performed a correlation analysis of impervious surfaces to watershed classification based on water quality data, and they found that watersheds of unimpaired streams averaged 8% imperviousness, impacted streams averaged 11%, and degraded streams averaged 24% (http://projects.ch2m.comlWakeCounty/; accessed May 2002). Water quality would be improved by limiting impervious surfaces to less than 10% of the watershed (Schueler 1994; Arnold and Gibbons 1996; Doll et al. 2000; Mallin et al. 2000; May and Homer 2000; Stewart et al. 2000; Paul and Meyer 2001). The construction of roadways and other impervious surfaces in new neighborhoods can produce short-term direct impacts as well as long-term cumulative effects.
Local government should provide sufficient open space to effectively reduce impervious surfaces so that pre-development hydrographic conditions are maintained. To achieve no net change in the hydrology of the watershed, building codes can specify the installation of grassed swales in place of curb and gutter and on-site stormwater management (i.e., bio-retention areas or other attenuation measures) to prevent direct discharges of stormwater into streams. These designs often cost less to install (Kwon 2000) and significantly reduce environmental impacts from residential development. Information regarding financing stormwater management can be found at < http://www.stormwaterfinance.urbancenter.iupui.edu/ >(accessed May 2002).

Many of these recommendations have been applied in Maryland to protect the Chesapeake Bay from water quality degradation (Maryland Department of the Environment 2000). Suggested examples to accomplish the <10% impervious goal are using conventional designs at a level of <10% imperviousness or using conservation clusters with higher densities, with dedicated open space and other stormwater control measures to mimic the hydrograph consistent with an impervious coverage of less than 10%. Reduction of road widths is one method to reduce overall impervious surface coverage. The N. C. Department of Transportation (NCDOT) has issued road guidelines that allow for the reduction in street widths when compared to standard secondary road guidelines. This material can be found at http://www.doh.dot.state.nc.us/operations/tnd.pdf (accessed May 2002). In addition, there are site planning practices that, when incorporated with the above mentioned road building guidelines, can further reduce the amount of impervious surfaces within a site. Some of these measures are contained in the document Better Site Design (Center for Watershed Protection; http://www.cwp.org/; accessed May 2002).

5. Erosion and Sedimentation Control - The NRBS should determine where water quality standards have been degraded. Based on this information, efforts should be undertaken to prevent any further decline and then work to improve the ability of these waters to support the biological productivity of a more natural assemblage of aquatic organisms. The Corps should assist municipalities in incorporating the elements listed below into their erosion and sediment control plans. Sediment is considered the most important cause of water pollution in the United States (Waters 1995) and construction is considered the most damaging phase of the development cycle to aquatic resources (Brown and Caraco 2000).

a. Minimize clearing and grading and only perform these operations in the context of an overall stream protection strategy;

b. Protect waterways by preventing clearing adjacent to waterways and stabilize drainage ways;

7. Phase construction for larger construction sites (~25 acres) to reduce the time and area that disturbed soils are exposed;

8. Stabilize soils as rapidly as possible (<2 weeks) by establishing a grass or mulch cover;

9. Protect steep slopes and avoid clearing or grading existing steep slopes as much as possible;

10. Establish appropriate perimeter controls at the edge of construction sites to retain or filter concentrated runoff from relatively short distances before it leaves the site;

11. Employ advanced settling devices that contain design features which include greater wet or dry storage volume, perforated risers, better internal geometry, use of baffles, skimmers and other outlet devices, gentler side-slopes, and multiple cell construction;

12. Implement a program to certified contractors so that trained and experienced personnel are on-site; and,

13. Sedimentation impacts should be minimized by regular inspection of erosion control measures and sediment control devices should be maintained in effective condition at all times. Erosion and sediment controls should be reassessed after storms. The incorrect installation of erosion control structures and those not properly maintained can result in sedimentation impacts to nearby streams and wetlands.

6. Improve Waterborne Movement Along Waterways - The present study could also improve habitat connectivity for aquatic organisms by removing barriers to waterborne movement, e.g., removing dams. Removal of the Quaker Neck Dam in 1998 provided anadromous fishes such as the striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) with 127 river kilometers (79 miles) of additional spawning habitat between Goldsboro and Raleigh. Since that time, information from electro-fishing, radio-telemetry, and egg/larval sampling has shown that both species are taking advantage of the restored habitat. The extent to which migratory fishes use the upstream habitat depends on spring flows, which are affected by rainfall and operation of the Falls of the Neuse Dam. With relatively high spring flows in 2003, substantial numbers of American shad and striped bass migrated to the base of Milburnie Dam. Electro-fishing catch rates were higher in the section of the river below Milburnie Dam than in any of the sections further downstream. Radio-telemetry studies and observations of spawning activity have shown that American shad primarily spawn at relatively shallow sites, often containing larger substrates such as gravel, cobble, and bedrock. This type of habitat (relatively high-gradient, with rocky riffle sections) is found almost exclusively upstream of Smithfield but is not very common in reaches now accessible to anadromous fishes. Additional habitat of this type would be found upstream of Milburnie Dam. Resident migratory fish are also likely to benefit by removal of Milburnie Dam as several species aggregate below the dam during the spring spawning season. The Service requests that the Corps use their Neuse River Model to evaluate what effect the removal of Milburnie Dam would have on (1) flooding, (2)wetlands, and (3) the Corp's ability to manage Falls Lake.

Scope and Level of Future FWCA Coordination

The natural connection between North Carolina rivers and their historic floodplains serves not only to enhance fish and wildlife resources, but also serves to improve water quality and mitigate flooding, the Service recommends that Corps planning for the Neuse River Basin focus on a limited number of objective measures. This PAL does not suggest that the Corps implement these conservation measures on its own. Recommended measures will certainly require a coordinated effort between state and local governments as well as private organizations and individuals. With limited resources available within the Corps' CAP, the best approach may be to provide technical and financial assistance to city and county governments. Such assistance may be in the form of model laws, ordinances, or zoning procedures. We urge the Corps to develop partnerships with local governments and non-governmental organizations to both plan and implement the conservation measures discussed above. Actions the Corps could undertake include:

14. Assisting local governments to conduct workshops for developers and landowners on conserving riparian buffers and improving water quality;

15. Assisting local governments in developing model ordinances and zoning plans which address the conservation measures discussed;

16. Assisting local governments in updating floodplain maps and developing plans for the phased relocation of threatened homes and businesses out of the 100-year floodplain and restoring these areas as natural riparian buffers;

17. Working with the U. S. Natural Resources Conservation Service and the North Carolina Cooperative Extension Service on efforts underway to control nitrogen runoff from agricultural field by establishing wetland systems within drainage canals, a form of controlled drainage;

18. Providing financial assistance to local governments, perhaps in the form of a small grant program, to design and implement utility infrastructure;

19. Providing a portion of the funds needed to purchase and manage conservation easements in the most important areas of the NRB;

20. Working with the NCDOT and/or The Center for Transportation and the Environment (http://www.itre.ncsu.edu/cte/) to enhance their ongoing efforts to avoid and minimize the adverse environmental impacts of road and utility construction near sensitive waterways within the NRB; and

21. Providing technical and financial assistance for the removal of dams, specifically the use of the Neuse River Model to determine the feasibility of removing Milburnie Dam

If this work proceeds to the feasibility stage, the Service is prepared to provide a more comprehensive FWCA report. This report would focus on discussions of the fish and wildlife resources likely to occur in the project area and their habitat requirements. Measures to maintain and improve these habitats would be considered along with additional information the Corps might provide on the scope and funding available.

The Service appreciates the opportunity to provide these comments early in your planning effort. Please advise us of any action taken by the Wilmington Corps District. If you have questions regarding this PAL, please contact Howard Hall at 919-856-4520, ext. 27 or by e-mail at < howard_hall@fws.gov >.

Sincerely,

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Appendix 1. Counties that comprise most of the Neuse River Basin, listed approximately from upstream (northwest) to downstream (southeast). Source: Figure 2, North Carolina Department of Environment and Natural Resources. 2001. Basinwide Assessment Report - Neuse River Basin.

Person

Orange

Granville

Durham

Franklin

Wake

Nash

Johnston

Wilson

Wayne

Greene

Lenoir

Pitt

Craven

Jones

Pamlico

Carteret

Appendix 2. Federally listed mussels in the 17 counties that comprise most of the Neuse River Basin (Figure 2, North Carolina Department of Environment and Natural Resources. 2001. Basinwide Assessment Report - Neuse River Basin). Endangered refers to a taxon "in danger of extinction throughout all or a significant portion of its range." A Federal species of concern (FSC) is a taxon that may or may not be listed in the future (formerly C2 candidate species or species under consideration for listing for which there is insufficient information to support listing). Additional information on the species that occur in each county and details of habitat requirements for endangered species may be obtained on the Raleigh Field Office web page < http://www.nc-es.fws.gov/es/cntylist/>.

Species	Status
Atlantic pigtoe (*Fusconaia masoni*)	FSC
Brook floater (*Alasmidonta heterodon*)	FSC
Dwarf wedge mussel (*Alasmidonta heterodon*)	Endangered
Green floater (*Lasmigona subviridus*)	FSC
Savanna lilliput (*Toxolasma pullus*)	FSC
Tar spinymussel (*Elliptio steinstansana*)	Endangered
Yellow lampmussel (*Lampsilis cariosa*)	

FSC

Yellow lance (*Elliptio lanceolata*)

FSC

Appendix 3. Federally listed fish in the 17 counties that comprise most of the Neuse River Basin (Figure 2, North Carolina Department of Environment and Natural Resources. 2001. Basinwide Assessment Report - Neuse River Basin). Endangered refers to a taxon "in danger of extinction throughout all or a significant portion of its range." A Federal species of concern (FSC) is a taxon that may or may not be listed in the future (formerly C2 candidate species or species under consideration for listing for which there is insufficient information to support listing). Additional information on the species that occur in each county and details of habitat requirements for endangered species may be obtained on the Raleigh Field Office web page < http://www.nc-es.fws.gov/es/cntylist/>. The shortnose sturgeon is under the jurisdiction of the National Marine Fisheries Service.

Species	Status
Bridle shiner (*Notropis bifrenatus*)	FSC
Carolina darter (*Etheostoma collis lepidinion*)	FSC
"Carolina" redhorse (*Moxostoma* sp.)	FSC
"Neuse" madtom (*Noturus furiosus*) population 1	FSC
Pinewoods shiner (*Lythrurus matutinus*)	FSC
Shortnose sturgeon (*Acipenser brevirostrum*)	Endangered

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Tier 1 Preliminary Evaluation of Pollutant Sources to the Impounded Reaches of Five Dams in the Neuse River Basin, North Carolina

December 2008

U.S. Department of the Interior
Fish and Wildlife Service

Ecological Services
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

Tier 1 Preliminary Evaluation of Pollutant Sources to the Impounded Reaches of Five Dams in the Neuse River Basin, North Carolina

Executive Summary:

Impounded reaches behind dams can trap and accumulate sediments through time. In some cases, those sediments can accumulate contaminants, and at high concentrations those contaminants can have adverse toxicological effects in-place as well as upon movement downstream. We used the framework of the U.S. Environmental Protection Agency / U.S. Army Corps of Engineers technical guidance manual on disposal of dredged material in inland waters to evaluate the potential for sediment contamination within the impoundments created by five small dams on the Neuse River and tributaries in Wake, Wayne, Wilson, and Lenoir Counties, North Carolina. A tier 1 review of existing information on pollutant sources and sinks, similar to an initial environmental audit, was conducted. This report presents the methods, results, and recommendations from the tier 1 assessment.

Review of existing information (State and federal databases on pollutant sources, previous environmental assessments, and limited analytical chemistry data for Neuse River and Crabtree Creek, Little River, Contentnea Creek and Southwest Creek) indicated no known significant organic or inorganic pollutant problems in a one-mile assessment area surrounding the impounded reaches of each dam.

Much of the assessment area for the dams on Little River, Contentnea Creek and Southwest Creek remains in an undeveloped rural character (forestry and small farms). No issues of concern were identified during the database or file reviews for these dams' assessment areas, and their current breached condition makes them very ineffective sediment traps. No further sediment characterization work is recommended at these three sites unless confirmatory sampling (expected to show only background levels of pollutants) is desired.

The assessment areas for Milburnie dam on the Neuse River and Lassiter Mill dam on Crabtree Creek are urbanized and are in watersheds with known water quality degradation. Two large municipal and one industrial facility having documented controlled or uncontrolled releases of pollutants were identified within the assessment area of Milburnie dam. Highway run-off is a concern for the assessment areas of both Milburnie dam and Lassiter Mill dam, and biological monitoring data indicate impairment of the benthic communities in these two watersheds, attributed to urbanization influence. If sediment disturbing activities are proposed at these assessment areas, they warrant additional data collection (i.e., a tier 2 assessment), with an emphasis on heavy metals and hydrocarbons (markers of urban run-off and other sources). Also, additional review of the implications of low level PCB contamination in Crabtree Creek should be conducted if further work is proposed at that facility. The U.S. Fish and Wildlife Service is available to help with these next steps.

Preface

To assess the the potential for sediment contamination at five dams in North Carolina's Neuse River basin, the U.S. Fish and Wildlife Service assisted the U.S. Army Corps of Engineers (Wilmington District) in a review of existing information on potential pollutant sources to sediments behind the dams. The work was completed by Sara Ward (Ecologist / Environmental Contaminant Specialist) and Tom Augspurger (Ecologist / Environmental Contaminant Specialist) in the U.S. Fish and Wildlife Service's Raleigh Field Office and was funded through a transfer agreement between the U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers.

This final report addresses peer review comments received on a July 2008 draft. Review comments were received from natural resource specialists with U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, North Carolina Division of Waste Management, and North Carolina Division of Water Quality.

Questions, comments, and suggestions related to this report are encouraged. Inquires can be directed to the U.S. Fish and Wildlife Service at the following address:

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Tier 1 Preliminary Evaluation of Pollutant Sources to the Impounded Reaches of Five Dams in the Neuse River Basin, North Carolina

Introduction

Impoundments are well recognized stressors to many species of riverine fishes, amphibians, mussels, crayfishes, and insects (Richter et al. 1997). Neves et al. (1997) and Watters (2000) reviewed effects of impoundments on freshwater mollusks, noting flow changes, population fragmentation, water quality problems and sediment issues. Dams also alter normal nutrient dynamics of riverine systems (Freeman et al 2003) and can degrade water quality within the impounded reach as well as downstream (Arnwine et al. 2006). Removal of dams has re-established important anadromous fish runs in North Carolina and has restored habitat and improved water quality for a variety of species. One issue among the many to consider in evaluating the risks and benefits of dam removal is the chemical nature of the sediments accumulated behind the dam. Impounded reaches behind some dams accumulate silt and detritus through time, and both organic and inorganic contaminants have a strong affinity for the silt and organic fraction of sediments (Anderson et al. 1987; Rodgers et al. 1987). In addition to their potential in-place effects, contaminated sediments can impair surface waters and associated aquatic life upon mobilization and transfer of water-soluble pollutants to the water column.

The degree of the concern is a function of site-specific pollutant loading based on age of the dam, dominant landuses, pollutants discharged into the watershed, and extent of watershed development. While there is no sediment evaluation protocol specific to dams, the issue is very similar to evaluating sediments proposed for dredging and disposal. The U.S. Environmental Protection Agency and U.S. Army Corps of Engineers (USEPA/USACE 1998) have a guidance manual on disposal of dredged sediments which recommends a phased approach to sediment evaluation. The phases start with a 'tier 1' assessment of the potential for sediment contamination to be an issue warranting any further consideration.

This report documents the U.S. Fish and Wildlife Service's (Service) tier 1 evaluation of potential pollutant sources to impoundments created by five Neuse River basin dams (Figure 1). Our work started with a reconnaissance of each dam to examine adjacent land uses and make a qualitative assessment on the degree to which they could trap sediments of concern; the five structures are described below:

Bridges Lake Dam (Milburnie Dam), Wake County, Neuse River (Figure 2)

Milburnie dam has a small hydroelectric plant and is relatively undeveloped immediately upstream but extensively developed (US1 and US401 corridors) further upstream. The dam is about 13-feet tall and creates a significant impoundment on the Neuse River. The dam is intact and capable of retaining sediments. No instream assessment was conducted to determine the magnitude of accumulated sediments. It is noted that the upstream Falls Lake dam has impounded the Neuse River since 1983; the size of that structure makes it an efficient sediment trap for inputs to the upper Neuse River system.

Lassiter Mill Dam, Wake County, Crabtree Creek (Figure 3)

Lassiter Mill is an historic structure within the City limits of Raleigh. The surrounding land use is now suburban homes, but the Crabtree Valley Mall and other commercial development along US70 are within the upstream assessment area. The dam is intact and capable of retaining sediments; however its low height is such that significant sediment movement through the system during high flows would be expected. No instream assessment was conducted to determine the magnitude of accumulated sediments.

Unnamed Dam, Wilson County, Contentnea Creek near Wilson (Figure 4)

The unnamed dam on Contentnea Creek is located between Buckhorn dam and Wiggins Mill dam. This dam has been breached but still creates an impoundment during low flows. The only sediment trapping likely to be a concern appears to be along the left bank near the dam (away from the breached area of the dam which is on the right bank). The riparian corridor near the dam is very well vegetated with mature forest cover. No instream assessment was conducted to determine the magnitude of accumulated sediments.

Unnamed Dam, Wayne County, Little River near Goldsboro (Figure 5)

The unnamed dam on Little River is near Goldsboro's water treatment plant. It has been breached but still impounds water at low flows. It appears that not enough of an impoundment remains to be concerned with sediment mobilization downstream following any dam-debris removal or complete dam removal (i.e., sediments likely have been and will continue to move downstream through the remaining impoundment via the breach).

Kellys Millpond Dam, Lenoir County, Southwest Creek (Figure 6)

Kellys Pond is an old millpond and the dam is now mostly breached, but much of the mill structure remains. The lake formerly formed by the dam is now a wetland and floodplain of Southwest Creek. The channel upstream from the dam is abut 80% vegetated (emergent and scrub-shrub vegetation) with about 20% of the banks still exposed and erosive. It appears that not enough of an impoundment remains to be concerned with sediment mobilization downstream following any debris removal or dam removal (i.e., sediments likely have been and will continue to move downstream through the remaining impoundment via the breach).

Municipal, industrial, and agricultural interests in each watershed are potential pollution sources that warrant an assessment of the potential for sediment contamination behind the dams. Tier 1 is a review of existing information on pollutant sources and sinks, similar to an initial environmental audit; no new data are collected but existing data, records, files, and reports are reviewed and synthesized. This remainder of this report presents the methods, results, and recommendations from the tier 1 assessment.

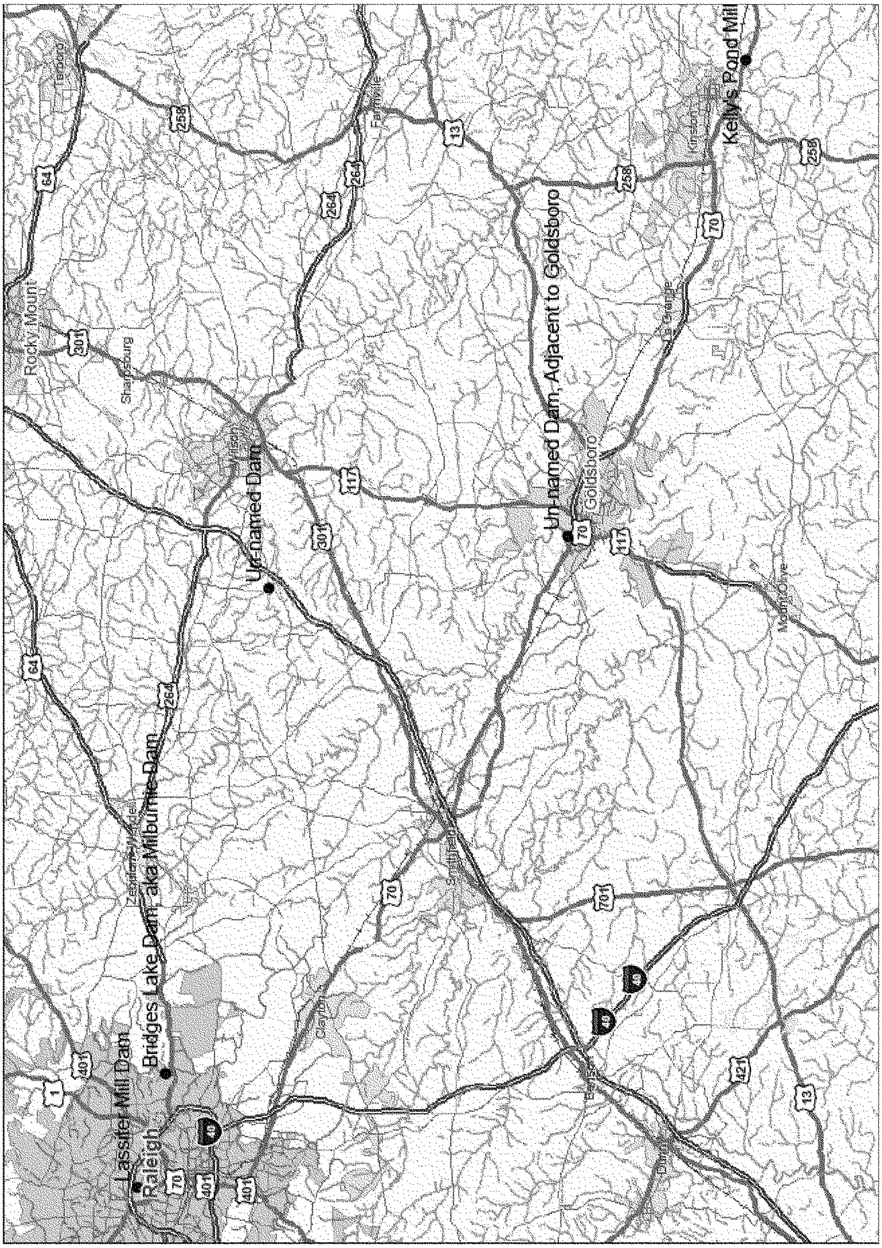

Figure 1. Locations of five dams in North Carolina's Neuse River basin that were the subject of this assessment

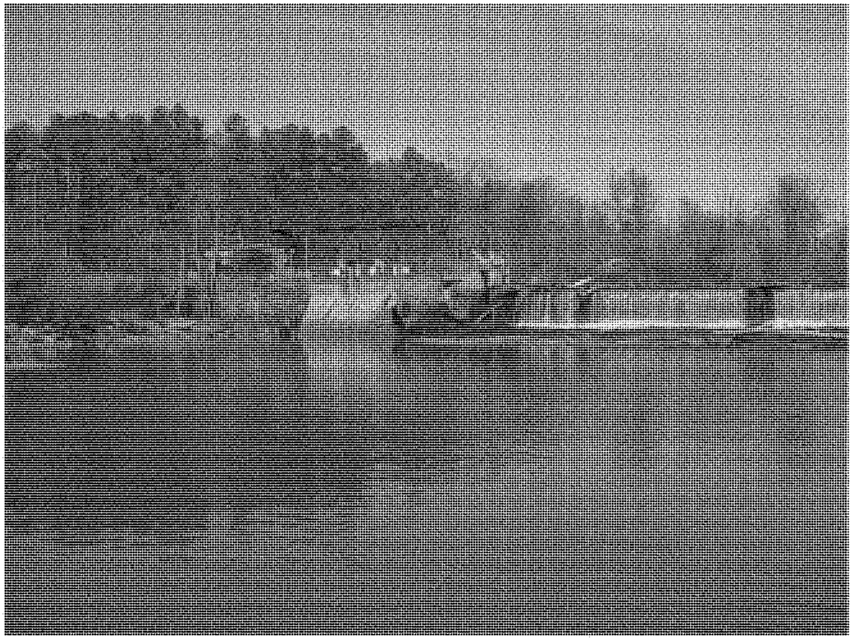

Figure 2. Bridges Lake (Milburnie) Dam, Wake County, Neuse River (USFWS photo)

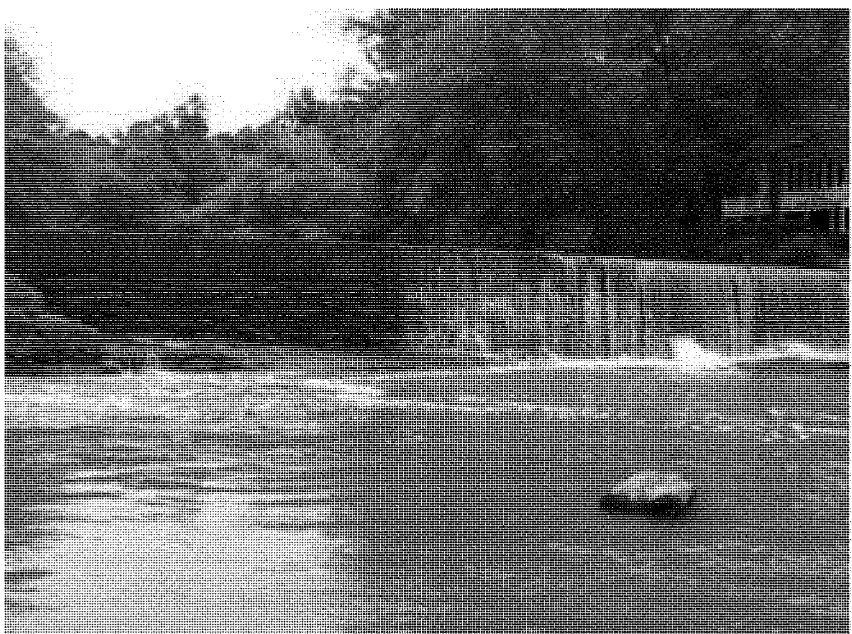

Figure 3. Lassiter Mill Dam, Wake County, Crabtree Creek
(http://raleighnature.com/2008/06/29/lassiter-mill-and-raleigh-mill-history/)

Figure 4. Unnamed Dam, Wilson County, Contentnea Creek near Wilson (USFWS photo)

Figure 5. Unnamed Dam, Wayne County, Little River near Goldsboro (USACE photo)

Figure 6a. Kellys Millpond Dam (downstream), Lenoir County, Southwest Creek (USFWS photo)

Figure 6b. Kellys Millpond Dam (upstream), Lenoir County, Southwest Creek (USFWS photo)

Methods

There are no regulations or standards that dictate the approach to be used in evaluating potential sediment contamination at dam sites. However, there are pertinent well-established procedures aimed at guiding evaluation of the potential for contaminant-related impacts from sediments proposed for dredging. The joint U.S. Environmental Protection Agency and U.S. Army Corps of Engineers technical guidance manual on evaluation of dredged sediment was used to guide our evaluation of dam sediment contamination potential with additional guidance from recent sediment assessment manuals (MacDonald and Ingersoll 2002a, 2002b).

The USEPA/USACE Inland Testing Manual employs a tiered approach to evaluation of the potential for contaminated sediment impacts. Evaluations start with a tier 1 assessment (using readily available existing information to assess the potential for a contaminated sediment concern) and proceeding in a step-wise fashion through tiers 2 (surface water and sediment chemistry), tier 3 (toxicity and bioaccumulation testing) and tier 4 (case-specific lab and field testing) only to the extent necessary to address the issue. In other words, all assessments start with tier 1; they may end there or proceed to higher tiers if additional data are needed to guide the management decision. In general, absence of pollutant sources would indicate little need for aggressive work to characterize any potential contaminants. Likewise, any proposed sampling should be guided by identification of specific issues identified in the tier 1 review.

Our tier 1 assessment started with database searches to examine the potential for contaminant inputs to the impounded reaches. We chose an assessment area defined as the stream-reach impounded by each structure, plus a one-mile buffer laterally and upstream. This approach is consistent with the American Society of Testing and Materials *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process* (ASTM 2005).

We examined databases and files maintained by State and federal natural resource management agencies. Databases reviewed included *BasinPro8*, a product of the North Carolina Center for Geographic Information and Analysis (NCCGIA), the USEPA's *Envirofacts Database* (facilities with air and water waste discharge permits, solid or hazardous waste sites, and facilities handling hazardous materials), and databases administered by the North Carolina Division of Water Quality (NCDWQ) and North Carolina Division of Waste Management (NCDWM). Data layers related to pollutant sources were reviewed within *BasinPro8* for our assessment area. Data within *Envirofacts* and State databases were searched for Wake, Wayne, Wilson and Lenoir Counties with sites then screened-in or screened-out for further review based on specific location information. Collectively, these mapping tools and databases retrieved known information from the following primary sources (with the administrative contact listed in parentheses):

National Priorities List (Superfund Sites)	(USEPA)
Inactive Hazardous Waste Sites	(NCDWM)
Old Landfills	(NCDWM)
Active Solid Waste Permits	(NCDWM)
CERCLIS Sites (known or suspected unregulated waste sites)	(USEPA)
Resource Conservation and Recovery Act Sites (hazardous waste generation, transport, disposal)	(USEPA)

National Pollutant Discharge Elimination System Sites (NPDES, surface water discharge sites)	(NCDWQ)
Sewage Sludge Land Application Sites	(USEPA)
Underground Storage Tanks	(NCDWQ)
Aerometric Information Retrieval System (AIRS)	(USEPA)
Toxic Release Inventory	(USEPA)

A geographic information systems (GIS) map was made for each dam assessment area which notes the proximity of pollutant sources to the impoundments behind the dams. For facilities located within the one-mile assessment area, individual State files were reviewed at NCDWM or NCDWQ. Some major sites located outside the buffer were also considered. File reviews gathered information on pollutants discharged from the facilities, potential contaminant pathways from facilities to the rivers or creeks upstream of the dams, and environmental monitoring data for the facilities.

We reviewed environmental studies for this portion of the Neuse River basin prepared by others (NCDWQ, Service, U.S. Geological Survey [USGS], and others) with an emphasis on water and sediment chemistry. We also conducted a reconnaissance of each site. A final component of the assessment was the peer review comments we received on a July 2008 draft report; the input received from U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, North Carolina Division of Waste Management, and North Carolina Division of Water Quality reviews was incorporated into this final report.

Results

Database Searches and GIS Maps

Figures 7a through 7e depict potential pollutant sources identified using *BasinPro* software within the one mile assessment area on either side of the watercourses upstream of each dam.

Table 1 is a list of the major (discharge $\geq$ 0.5 million gallons per day [MGD]) National Pollutant Discharge Elimination System (NPDES) point sources of discharged treated municipal or industrial effluent. Only two major dischargers (Burlington Industries/Riverplace II LLC [NC0001376] and Wake Forest Wastewater Treatment Plant [also known as Smith Creek Wastewater Treatment Plant NC0030759]) were identified within the one-mile buffer of the project sites, and both these facilities discharge to the main stem of the Neuse River upstream of Milburnie dam. No major discharges were located in the assessment area of the other dams. Three minor NPDES facilities were identified upstream of Milburnie dam (River Mill Wastewater Treatment Plant [NC0056278], Neuse Crossing Wastewater Treatment Plant [NC0064408], and Riverwalk Mobile Home Park Wastewater Treatment Plant [NC0039292]). These small discharges were not further considered due to their small size and the nature of the discharges. There were no minor discharges identified for the other four assessment areas.

Figures 7a through 7e also identify the locations of known or suspected hazardous waste sites. These facilities (listed in Table 2) were further evaluated by reviewing their files at NCDWM.

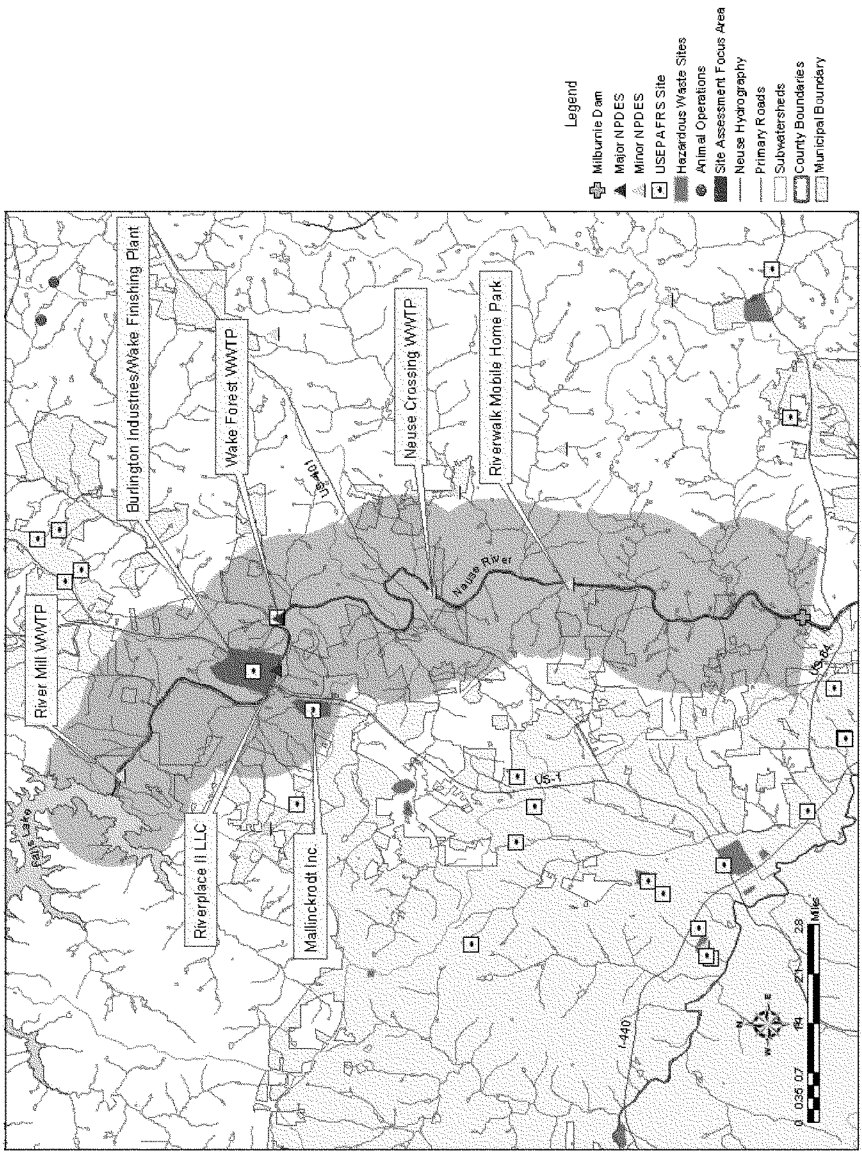

Figure 7a. Sites identified in NCCGIA's *BasinPro* software in and near buffer of Milburnie Dam impounded area

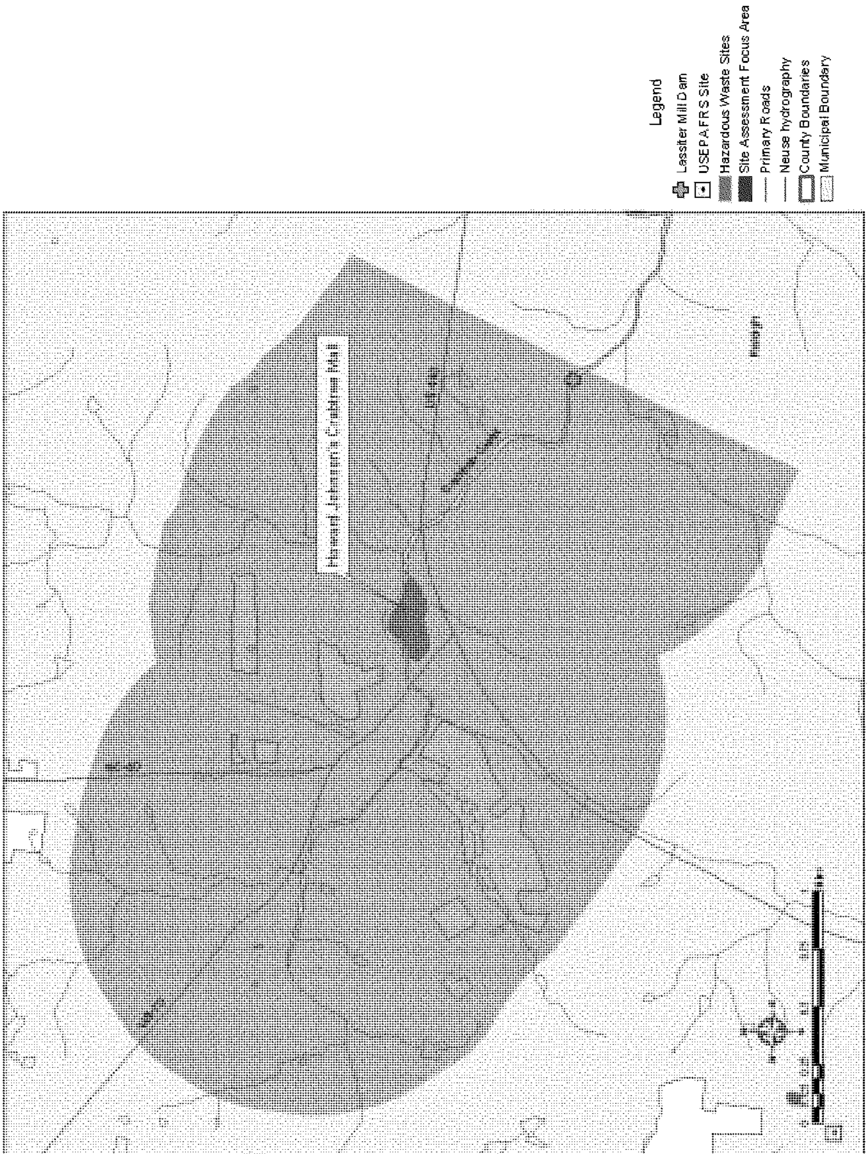

Figure 7b. Sites identified in NCCGIA's *BasinPro* software in and near buffer of Lassiter Mill Dam impounded area

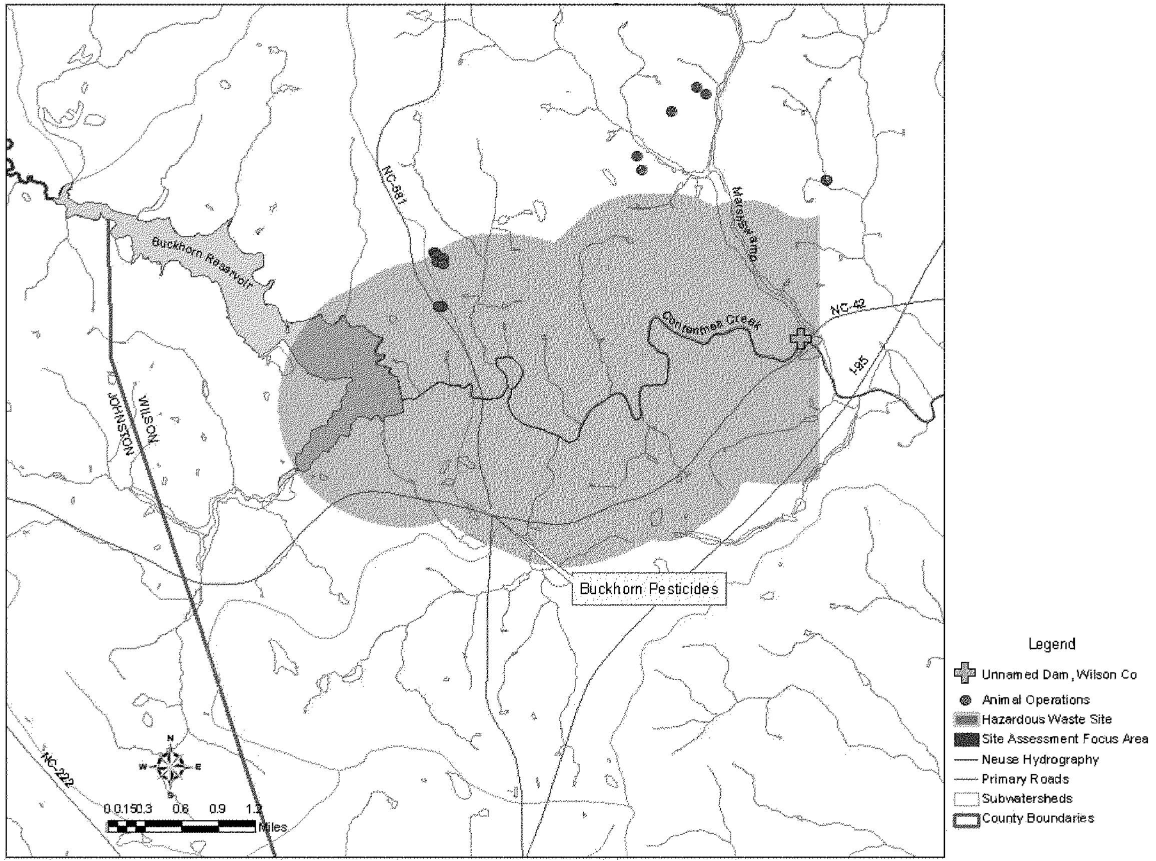

Figure 7c. Sites identified in NCCGIA's *BasinPro* software in and near buffer of Contentnea Creek unnamed dam impounded area

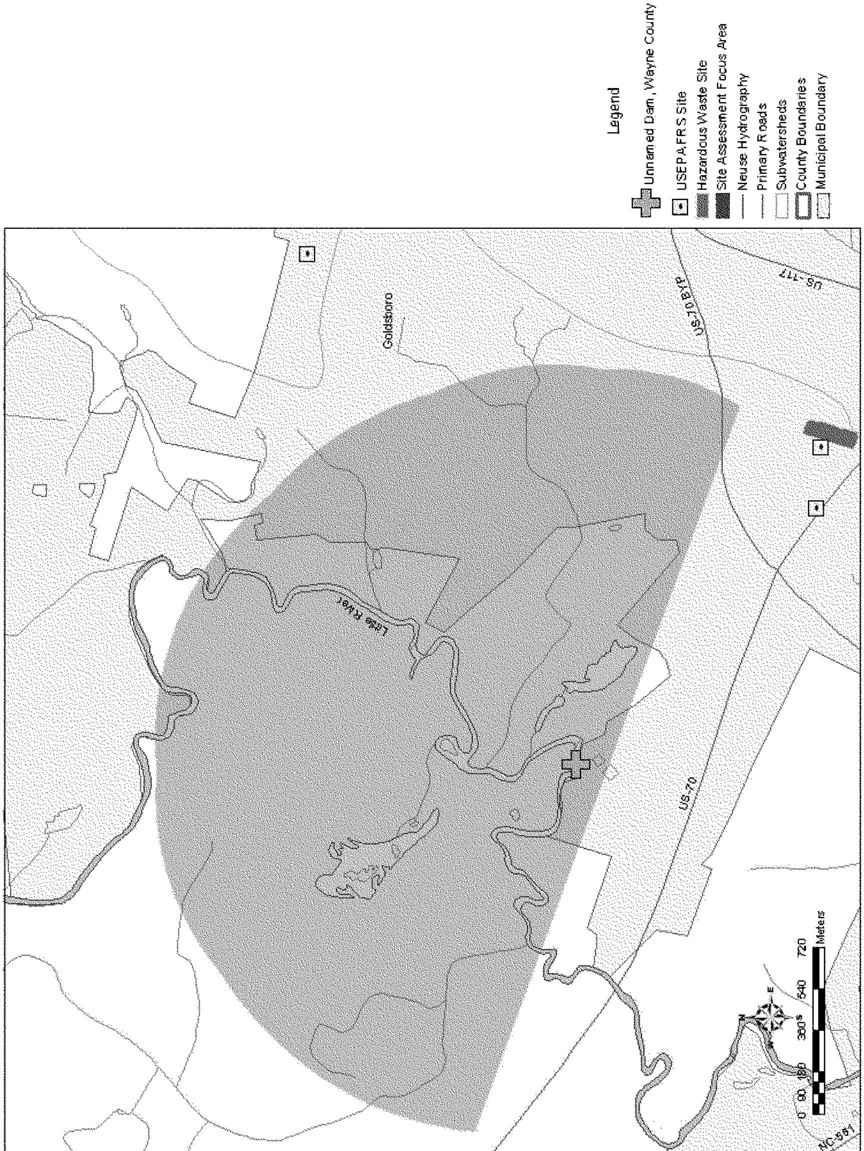

Figure 7d. Sites identified in NCCGIA's *BasinPro* software in and near buffer of Little River unnamed dam impounded area

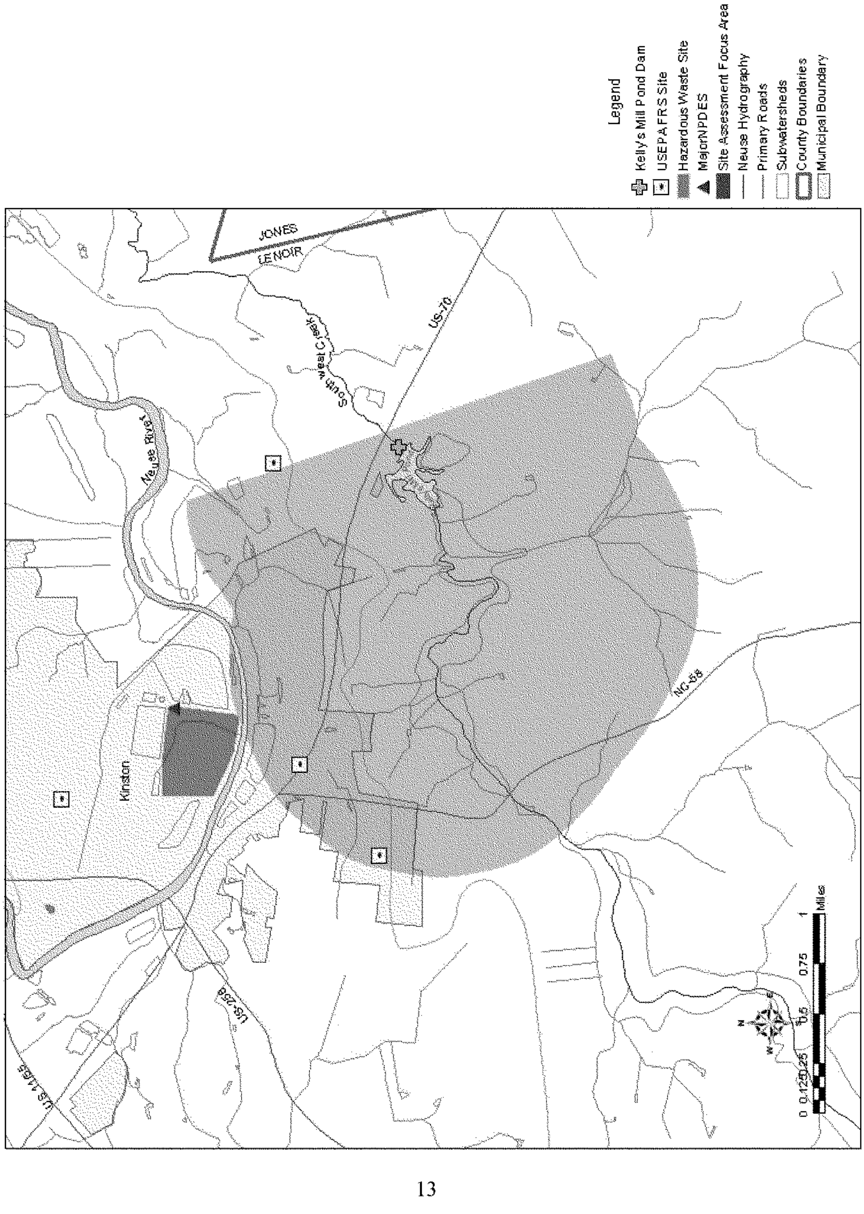

Figure 7e. Sites identified in NCCGIA's *BasinPro* software in and near buffer of Kellys Mill Pond Dam impounded area

Table 1. Major dischargers to Milburnie dam impounded reach assessment area permitted under the National Pollutant Discharge Elimination System (NPDES). There were no major discharges into the assessment areas of the other four dams.

Dam	Facility	Permit number	Discharge (MGD)[1,2]
Milburnie	Burlington Industries/Wake Finishing Plant (Riverplace II LLC)	NC0001376	5.0
	Wake Forrest (or Smith Creek) WWTP	NC0030759	6.0

[1] Permitted discharge volume, in Million Gallons per Day (MGD)
[2] Source: NCDWQ 2008: http://h2o.enr.state.nc.us/NPDES/PublicNotices.html (accessed 03/26/08)

Table 2. Known or suspected hazardous waste sites in the Neuse River basin dam assessment areas identified using NCCGIA *BasinPro* software and State and federal databases

Facility	Site number	Type of Facility[1]
Lassiter Mill Dam		
Howard Johnson's/Crabtree Valley Mall	NCD980845903	HSDS
Arrow Drive – Crabtree Creek	NONCD0001170	IHWS
Milburnie Dam		
Burlington Industries/Wake Finishing Plant (Riverplace II LLC)	NCD980557664	HSDS, IHWS, TRI, RCRIS
Mallinckrodt Inc.	NCD980729297	HSDS, TRI, RCRIS, AIRS
RC Motor Company	NONCD0002377	IHWS
Weavexx Corp	NONCD0002701	IHWS
Unnamed Dam, Wilson Co		
Buckhorn Pesticides	NCD980845119	HSDS, IHWS
Unnamed Dam, Wayne Co	None	
Kellys Mill Pond Dam	None	

[1] IHWS (Inactive Hazardous Waste Site Inventory)
HSDS (Hazardous Substance Disposal Site from NCCGIA *BasinPro8* software
TRI (Toxic Release Inventory database)
AIRS (Aerometric Information Retrieval System)
CERCLIS (Comprehensive Environmental Response, Compensation and Liability Information System)
RCRIS (Resource Conservation and Recovery Act Information System)

Individual Site Reviews - National Pollutant Discharge Elimination System (NPDES) Facilities

To further evaluate facilities identified as potential pollutant sources of concern by the database searches, individual NPDES permits were reviewed for the two major dischargers to the Neuse River within the Milburnie dam assessment area. There were no major discharges into the assessment areas of the other four dams.

The Burlington Industries/Wake Finishing Plant (Riverplace II, LLC) wastewater treatment facility [NC0001376] discharged up to 5 million gallons per day (MGD) of knitted fabric dyeing and finishing operation wastewater to the Neuse River. The plant was built in 1948 and closed in 1996 when Burlington Industries closed its knitted fabric operations. It was sold to an investment group, Riverplace LLC in 1999. The facility has had an NPDES permit to discharge since 1979. While the current NPDES permit has expired (1999), it is listed as pending review / renewal in the NCDWQ database. Records reviewed indicate there was no discharge from December 2006 through January 2007, with only discharges during five months dating back to August 2004 (all at much less than 1 MGD). Quarterly chronic whole effluent toxicity tests were performed historically, and the facility passed 18 of 19 tests between 1992 and 1996 (NCDWQ 1996). Effluent toxicity testing was not required in more recent years due to the low discharge volume. The waste stream was a signficant source to the Neuse River because, at 5 MGD, it would represent 12% of the base flow during a 7Q10 (lowest stream flow for seven consecutive days that would be expected to occur once in ten years) low flow event.

The Wake Forest (or Smith Creek) wastewater treatment plant [NC0030759] is permitted to discharge up to 6 MGD of treated municipal wastewater to the Neuse River. The Smith Creek plant was constructed in 1976 by the Town of Wake Forest and transferred to Raleigh in July 2005. The facility was originally permitted in 1981 and most recently re-permitted in January 2008. While having received permits to discharge 6 MGD, the facility is currently operating at much lower flows under a provision in their permit for 2.4 MGD release until needed expansion. The facility has had 14 compliance inspections over the past decade with no violations. Chronic whole effluent toxicity tests are also performed, and the facility has typically been in compliance, passing 67 of 70 tests between 1996 and 2005 (NCDWQ 1996, 2001, 2008).

Hazardous Waste Sites

To further evaluate the facilities identified as potential pollutant sources of concern by the database searches, file reviews were conducted on June 5, 2008. Four sites are included in NCCGIA's *BasinPro8* dataset for hazardous substance disposal sites (HSDS) (Table 2) within our assessment areas, of which, two (Burlington Industries and Buckhorn Pesticides) are also listed on the State's Inactive Hazardous Waste Site Inventory (IHWS). Three additional sites (Arrow Drive – Crabtree Creek [NONCD0001170], RC Motor Company [NONCD0002377], and Weavexx Corporation [NONCD0002701]) are also included on the IHWS Inventory and are found within the area of interest (although they were not listed in the NCCGIA's *BasinPro8* dataset and are therefore not depicted in Figures 2a through 2e). A summary of each site preliminarily identified as a concern is provided here.

The Howard Johnson's/Crabtree Valley Mall (NCD980845903) site was a solid waste disposal area on the south side of Crabtree Creek, located at the intersection of US70 and I-440 (Raleigh Beltline). Site inventory information provided by the City of Raleigh (1985) indicated the site originally comprised of 16-acres of "low and swampy" land and was used between about 1959 and 1968 for disposal of household wastes and yard wastes. In the early 1970's the hotel (originally Howard Johnson's and now Holiday Inn) was built on top of the fill with about 5 acres of the filled area now under parking lot pavement. Test borings at the site in 1985 revealed trash such as glass, cloth, paper, plastic, wood and metal fragments mixed with soil. A sample from Crabtree Creek indicated low levels of metals, and a groundwater sample taken by NCDWM in the early 1980's revealed low levels of arsenic and phenol. The site was assigned a low priority for follow-up. Site characterization sampling in 1995 and 1996 indicated no concerns with leachate production of site soils but did evidence arsenic, cadmium, chromium, lead, benzene and chlorobenzene slightly above State groundwater standards. Low groundwater exceedences, the developed nature of the site, and the lack of evidence of hazardous waste disposal at the facility all factored into a recommendation that no further action be taken at the site following the most recent review (GeoTechnologies, Inc. 1999). The USEPA and NCDMW have generally concurred with that assessment, and a the site was given a "no further action" status by the USEPA in 1992 and NCDWM in 1999 (NCDENR 1999). Based on the nature of wastes disposed at the site and the results of several previous characterizations, the site does not warrant specific follow-up in the dam evaluation.

The Burlington Industries (NCD980557664) site is a 260-acre textile plant. Waste issues reportedly include a landfill for operational wastes prior to the 1980s. Fly ash, alum sludge, and sewage sludge were deposited at a small (130,000 square feet) area onsite adjacent to US1. The site previously contained a wastewater treatment system, dismantled prior to 1970, which was reported by plant staff to have received additional plant wastes after it was abandoned. The facility drained to the Neuse River. A separate issue at the facility was a ravine where 10 to 15 55-gallon drums of unidentified textile wastes were buried, as reported to USEPA by the plant environmental management. A NCDWM preliminary assessment (1987) and site investigation (1989) of both areas, including analyses of Neuse River sediment samples near the waste treatment system outfall and soils from the drum site found no pollutants at levels of concern. Follow-up sampling was performed in 1992 and no groundwater contamination in excess of State standards was found. The site was given a "no further action" status by the USEPA (USEPA 1995). Following a review of all site data, Waters Edge Environmental petitioned the State for a "no further action status" in 2005 which was granted in 2007 (NCDENR 2007). The site does not warrant specific follow-up in the dam evaluation.

Mallinckrodt Inc. (NCD980729297) (NCD042091975) is a 613-acre parcel with about 35-acres consisting of a specialty chemical facility that has been active since 1966. The facility is a major producer of acetyl para-aminophenol (APAP), para-aminophenol (PAP) and acetaminophen, and they have hazardous waste permits for aniline still bottoms from industrial boilers fed with aniline-liquid tar. Other products used in bulk include nitrobenzene, hydrogen, sulfuric acid and ammonia with ammonium sulfate as a production byproduct. The facility land-applies some wastewater residuals and discharges stormwater from a surface water collection pond under an NPDES permit. The facility is within the assessment area of Milburnie dam, but there are no known in-stream concerns. Groundwater beneath the facility ultimately discharges to the Neuse

River. The site's listing on the hazardous site index is related to historic on-site tannin production pits (active from 1966 to 1972 and filled-in in 1973). The pits contained acetone, methyl isobutyl ketone, acetic acid, toluene, isopropanol, ethanol and sodium hydroxide. On-site waste disposal (surface wastewater treatment basins – closed since the early 1990s when waste treatment moved to aboveground tanks) and an on-site landfill are other concerns. Site files at NCDWM indicate a long history of site assessment work on small portions of the overall site. Most recent analytical data indicate minimal shallow groundwater contamination from the former tannin pits and no concerns with the bedrock aquifer. However, extremely high concentrations of a variety of compounds were found in the transition zone between the upper and deep aquifer (Solutions-IES, 2005) most likely from a source other than the former tannin beds (perhaps the manufacturing area or former waste treatment ponds). Groundwater contamination discharges to some surface water features draining ultimately to the Neuse River, and these surface water features showed some inorganic chemical contaminants. Site-wide, the contaminants in groundwater that exceed State water quality standards are acetone, methyl isobutyl ketone, methyl ethyl ketone, phenol, methyl phenol, formaldehyde, benzoic acid, benzene, toluene, ethyl benzene, xylene, PCE, 1-2, DCA, 1,2-DCP, dichloromethane, chloroform, aniline, 2-nitrobenzene, n-nitrosodimethylamine, ammonia, sulfate, nitrate and chloride. While not site-wide, shallow and deep groundwater has been impacted by these pollutants. These exceedences of State standards will require corrective measures to be assessed, but the majority of the site contamination is within the site boundary. Due to the known contamination at the site and the uncertain extent to which surface water may have been impacted by waste disposal and spills through the years, the sediments adjacent to the site area recommended for additional assessment.

Weavexx Corporation (NONCD0002701) is the only facility for which records were retrieved which is not mapped in Figure 2. It is located north of the intersection of US1 and US1 Alternate, about 2.6 miles south of the town of Wake Forest. Operations at this facility ceased in 2003, and the extent of hazardous waste issues appears limited to a particular manufacturing area which has been remediated (removal of concrete slab, soil excavation and removal, confirmatory sampling (AWARE Environmental Inc., 2005)). The extent of contamination appears to have been defined and addressed and no off-site concerns were expected. The site does not need any specific follow-up relative to the dam evaluation.

Buckhorn Pesticides (NCD980845119) was an emergency soil and debris removal site following a March 1985 fire at an old storage building housing containers of DDT, endrin, dieldrin, parathion, and malathion (NCDENR 1985). Twenty-one soil samples taken in 1985 showed significant soil contamination near the building, and USEPA removed 175 cubic yards of soil following the fire. The site remains on the States IHWS list based on its history. Because the site has been remediated and is 1,500 feet from Buckhorn Creek (nearest surface water), it does not warrant follow-up in the dam evaluation.

Inquiries with the NCDWM Central Files did not locate site-specific information on Arrow Drive – Crabtree Creek [NONCD0001170] or RC Motor Company [NONCD0002377]. No additional information is available on these sites at present.

Searches for records within Wake, Wayne, Wilson, and Lenoir Counties also identified several facilities which were in the vicinity, but outside the assessment area and therefore not of concern in this assessment (e.g., Kinston Demolition Landfill [NCD075588913] which is near Southwest Creek and the Kellys Millpond assessment area but is located north of the Neuse River, and therefore, isolated from the assessment area; also, Westinghouse Meter and Light [NCD003195963], near the Milburnie dam and Lassiter Mill dam assessment areas but in the Crabtree Creek watershed downstream of Lassiter Mill dam).

One site that is outside the assessment areas does need to be discussed. The Ward Transformer Company, Inc. site (EPA ID: NCD003202603) is a Superfund site north of Aviation Parkway near Raleigh Durham International Airport which manufactures and services transformers and other electrical equipment. The site is contaminated with polychlorinated biphenyls (PCBs) from historic operations. Site drainage is to an unnamed tributary to Little Brier Creek, and Little Brier Creek flows to Brier Creek Reservoir, Lake Crabtree, and Crabtree Creek. While well upstream of Lassiter Mill dam assessment area, the potential for passing migratory fish above Lassiter Mill makes review of PCB data from Crabtree Creek pertinent.

Contractors collected sediment upstream of Lassiter Mill dam as part of a remedial assessment of contamination originating from the Ward site. The sediment sampling effort primarily focused on unnamed tributaries to Brier Creek and Little Brier Creek as well as Brier Creek Reservoir; however, several samples collected between November 2003 and March 2006 provide additional information about the potential for PCB contamination to have migrated downstream of Lake Crabtree. Two samples were collected from Brier Creek (between Brier Creek Reservoir and Lake Crabtree) corresponding to a maximum Aroclor 1260 concentration of 0.28 mg/kg (SD-66) in surface sediment. This sample consisted of predominantly (60%) fine silt and sand (31%) with limited clay present. Seven grab samples were collected from the vicinity of the relic Brier Creek and Crabtree Creek stream channel/floodplain (now submerged in Lake Crabtree) to further assess the potential for downstream contaminant transport. Maximum Aroclor 1260 (0.48 mg/kg) and PCB Congener TEQ concentrations (1,100 ng/kg, mammal) were found in surface sediment in a single sample (SD-39). A total of 12 sediment samples were collected in Crabtree Creek between Lake Crabtree and Crabtree Creek's confluence with the Neuse River. Descriptive information regarding the sample matrix was not available for four samples collected in 2004. Surface sediment Aroclor 1260 concentrations were less than 0.063 mg/kg in all samples. Subsequent sampling (n = 7) indicated a maximum Aroclor 1260 concentration of 0.049 mg/kg. Sample consistency was characterized as follows: 50 to 95 percent sand material with limited silt (five to 48 percent) and clay (one to six percent). While these concentrations are low, it is not clear that sediment depositional areas have been sampled for worst case scenario. Additional risk assessment evaluations should be explored to address impacts to moving fish upstream if that is envisioned.

Aerometric Information Retrieval System (AIRS) Facilities

Of the 334 facilities included in the AIRS database for Wake County, five in Raleigh are in the vicinity of the Milburnie and Lassiter Mill dam sites and are included in the NC Division of Air Quality's emission inventory as Title V (large emitters of one or more priority air pollutants) facilities: Cargill, City of Raleigh Wilders Grove Landfill, Evergreen Packaging, North Carolina State University Central Heat Plant, and North Wake County Landfill Facility. Of these facilities, several are designated as major sources of the following hazardous air pollutants (HAPs) based on exceeding annual emissions thresholds reported in the 2004) toxic air pollutant point source emissions reports (NCDENR 2006): hexane and glycol ethers.

Five of 79 AIRS facilities in Wilson County are located near the unnamed dam site on Contentnea Creek and are considered Title V sources (Alliance One International Co., Inc, Bridgestone/Firestone Inc., Carolina Classic Manufacturing Inc., Kencraft Manufacturing Inc., and Saint Gobain Containers). The HAPs released in excess of thresholds defined for major HAP sources include hexane, methyl isobutyl ketone, methylene chloride, sulfuric acid, toluene, styrene, and methyl methacrylate.

Of the 70 AIRS facilities in Wayne County, three are found in Goldsboro near the unnamed Wayne County dam site (Cooper Standard Automotive – Fedelon Trail, Franklin Baking Company, and Progress Energy H.F. Lee Plant). The HAPs released at these facilities in excess of major source thresholds include butadiene, acetophenone, glycol ethers, methanol, toluene, acetaldehyde, hydrogen chloride, hydrogen fluoride, selenium, and sulfuric acid. Although not above HAP thresholds for major source designation, mercury compounds were released in significant quantities (105 pounds) from the Progress Energy facility.

Two AIRS facilities (Masterbrand Cabinets Inc. and UNIFI Kinston, LLC) of the 44 found in Lenoir County were located in Kinston near the Kellys Millpond dam and HAPs released in excess of thresholds defined for major sources include ethyl acetate, ethyl benzene, methanol, toluene, xylene, acetaldehyde, acetic acid, dioxane, ethylene glycol, hydrogen chloride, and hydrogen fluoride. Based on the HAP releases in counties where the impounded reaches of the five dams occur, there appears to be potential for localized influence of VOCs and metals (Unnamed Wayne County dam site) emissions on surface water resources via deposition.

Underground Storage Tank (UST) Incidents

The UST database identified 1647 incidents of releases in Wake County. Of these releases, ten impacted surface waters within a one-mile radius of the impounded reach for Lassiter Mill dam: Amaco Station #825, Han Dee Hugo #47, Exxon 4-0010 North Hills, Carolina Country Club, Browning Ferris Industries (or BFI Waste Industries), William Doucette Residence, Flink Property, Brooks Elementary School, Exxon 4-6215 Crabtree Valley, and Exxon 4-3001 Avery Upchurch. No incidents were reported to impact the site assessment area for the Milburnie dam.

The UST database identified 467 incidences of releases in Wayne County, of which, one reportedly impacted surface water and was located within one mile of the Little River. In Wilson County, 332 UST incidents are included in the database, and of the five affecting surface water, none were located in the site assessment area for the unnamed Wilson County dam on Contentnea Creek. Twenty one (of 430) UST incidents were reported to impact surface waters in Lenoir County; however, none were within the site assessment area for Kellys Millpond dam.

Reports and Other Data – Surface Water

Water quality information was available from the NCDWQ's basinwide assessment reports (NCDWQ 1996, 2001, 2006) and basinwide water quality management plans (NCDWQ 2002, 2008). Overall results of biological and chemical monitoring indicate main stem Neuse River water quality ratings of good-fair (relatively low in the State's rating system) in the Milburnie dam assessment area since the early 1980s. Water quality ratings of poor to good-fair were assigned for Crabtree Creek upstream of Lassiter Mill dam in 2000 and 2005. Water quality was not rated in the assessment areas for the remaining three dams (unnamed dams in Wilson and Wayne Counties and Kellys Millpond dam) (NCDWQ 2006).

Water chemistry is monitored in the assessment area of three of the Neuse River basin dams by NCDWQ at several stations:

Milburnie Dam

J1890000	Neuse River near Falls Lake, Wake County
J2330000	Neuse River at SR 2215, Wake County
J2360000	Milburnie Dam, Wake County

Lassiter Mill Dam

J2850000	Crabtree Creek near SR 1795, Wake County
J3000000	Crabtree Creek near SR 1649, Wake County
J3210000	Lassiter Mill Dam, Wake County

Unnamed Dam, Wilson County

J6740000	Contentnea Creek near Lucama, Wilson County

Common elemental contaminants included in monitoring at these sites include arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel and mercury. Concentrations for most of these metals were at or below detection limits (NCDWQ 2008). Copper and iron concentrations frequently exceed the State action level of 7 µg/L (ppb) and 1 mg/L (ppm), respectively (http://www.epa.gov/storet/). Impacts of urbanization are noted from both the Neuse River upstream of Milburnie dam and several stations in Crabtree Creek (NCDWQ 1996, 2001, 2006).

Reports and Other Data - Sediments

No sediment data for the impounded reaches were located. Some regional sediment quality overviews were helpful (Childress and Treece 1996, Skrobialowski 1996, Woodside and Simerl 1996), but these USGS publications were largely summaries that lacked site-specific data. We worked with the USGS Water Resources office in Raleigh to retrieve data for individual stations from their database; of 843 Albemarle-Pamlico area sediment sample site results retrieved from their database (covering a period from December 1991 to August 2002), only one station, sampled a single time, overlapped with our assessment areas. A December 1992 sample of sediments from Crabtree Creek at US 1 in Raleigh contained arsenic (4.4 ug/g dry weight), cadmium (0.3 ug/g dry weight), chromium (59 ug/g dry weight), copper (36 ug/g dry weight), lead (51 ug/g dry weight), mercury (0.05 ug/g dry weight), nickel (20 ug/g dry weight), and zinc (130 ug/g dry weight). Of these values, the threshold effects concentrations (TECs) reported by MacDonald et al (2000) are exceeded for chromium (TEC = 43.4 ug/g dry weight), copper (TEC = 31.6 ug/g dry weight), lead (TEC = 35.8 ug/g dry eight), and zinc (TEC = 121 ug/g dry weight). The TECs are not criteria or standards, they represent best professional judgment of the authors and cooperators on concentrations of contaminants in whole sediment below which adverse effects to sensitive aquatic organisms are not expected to occur. Exceedences of the TECs indicate these heavy metals may merit additional attention in evaluation of this urban watershed. None of the Crabtree Creek values exceed the probable effects concentrations (PECs, or concentrations of contaminants in whole sediment above which adverse effects to sediment-dwelling organisms may be expected) reported by MacDonald et al (2000).

Another source of actual sediment data retrieved was for the Little River near Lowell Dam from the Service's previous sediment study there (U.S. Fish and Wildlife Service 2005a,b). The Service collected and analyzed sediments for elemental contaminants and polycyclic aromatic hydrocarbons. Eighty-eight percent of all elemental contaminant results were less than TECs at this site well up-stream of the un-named Little River dam near Goldsboro. No samples exceeded the PECs.

Reviews

Review comments on a July 2008 draft version of this report were received from the NCDWM and NCDWQ. The NCDWM staff indicated agreement with our methodology, noting that the databases we searched include all those inventories maintained by NCDWM that contain sites relevant to the study. Because those databases may not include all sites currently in NCDWM inventories, they canvassed other solid and hazardous waste staff to inquire whether or not there are newer sites of consequence located in the five drainage areas, and found none.

The NCDWQ's review concurred with the findings in our draft report. They noted in particular the need for additional consideration of PCBs at Lassiter Mill dam if any sediment-disturbing work is proposed there. They noted also that the recommended follow-up work at Milburnie dam was appropriate because of the developed nature of, and discharges into, the watershed. In addition to the facilities we reviewed, NCDWQ notes that impacts from extensive development, a salvage yard, and landfills may have contributed to pollution of the Neuse River sediments in the upstream area. The NCDWQ concurred with the recommended focus on heavy metals and hydrocarbons.

Summary and Recommendations

Collectively, these data indicate no known major organic or inorganic pollutant problems in the one-mile assessment area surrounding the impounded reaches of the dams.

Much of the assessment area for the dams on Little River, Contentnea Creek and Southwest

Creek remains in an undeveloped rural character (forestry and small farms). No issues of concern were identified during the database or file reviews for these dams' assessment areas, and their current breached condition makes them very ineffective sediment traps. No further sediment characterization work is recommended at these three sites unless confirmatory sampling (expected to show only background levels of pollutants) is desired.

The assessment areas for Milburnie and Lassiter Mill dams are urbanized with known water quality degradation. Two large municipal and one industrial facility having documented controlled or uncontrolled releases of pollutants were identified within the assessment area of Milburnie dam. Highway run-off is a concern for the assessment areas of both Milburnie and Lassiter Mill dams, and biological monitoring data indicate impairment of the benthic communities in these two watersheds, attributed to urbanization influence. There were no sediment sample results available for the impounded reaches making a direct assessment difficult, so new data area needed. If sediment disturbing activities are proposed at these assessment areas, they warrant additional data collection (i.e., a tier 2 assessment), with an emphasis on heavy metals and hydrocarbons (markers of urban run-off and other sources). Also, additional review of the implications of low level PCB contamination in Crabtree Creek should be conducted if further work is proposed at that facility.

The Service is available to assist the USACE and partners in developing and implementing a sampling and analysis plan for the impounded reach of Milburnie. Elemental contaminants and polycyclic aromatic hydrocarbons (PAHs) should be evaluated in all samples. These classes of compounds include many common pollutants, are good markers of urbanization, and have consensus-based freshwater effects sediment quality guidelines (MacDonald et al. 2000, USEPA 2000b) with which to evaluate the results. While North Carolina has no sediment quality standards or guidelines, the consensus based guidelines have been widely used elsewhere. The State of Florida recommended these for use as guidance in many of their programs, including evaluation of dredged material and risk assessment of contaminated sites (MacDonald et al. 2003). In a review by experts on sediment assessment, application of such sediment quality guidelines was found to offer good utility in site assessment (Wenning and Ingersoll 2002). Sample results can also be compared to bioaccumulation-based sediment quality guidelines (Ingersoll et al. 1997). This approach would have the advantage of evaluating pollutants of concern with pre-defined criteria upon which to gage the significance of results. All samples should also be analyzed for total organic carbon and grain size to aid in interpretation of results. Because of the history of mixed waste discharged upstream of Milburnie dam, sediment toxicity tests with sensitive freshwater organisms should be conducted along with the sediment chemistry. Recommended toxicity tests include the 28-day *Hyallela azteca* (freshwater amphipod) survival and growth assay with bulk sediment, and the 48-hour *Ceriodaphnia dubia* (freshwater cladoceran) survival bioassay with sediment elutriate. This battery would help evaluate the toxicity of sediments, both in-place and upon re-suspension. Each assay has established protocols and contract labs routinely run these assays (*H. azteca* survival and growth assay with bulk sediment by USEPA 2000a, ASTM 2007 and the elutriate tests with *C. dubia* via USEPA 1993).

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August 11, 2008

Colonel Jefferson M. Ryscavage
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402-1890

Attention: Mr. Hugh Heine, Environmental Resources Section

Dear Colonel Ryscavage:

In accordance with our Transfer Funding Agreement and Scope of Work for FY 2008, the U. S. Fish and Wildlife Service (Service) has enclosed our Draft Fish and Wildlife Coordination Act (FWCA) Report for the Neuse River Basin Project. This report identifies fish and wildlife resources in the project area; provides our assessment of project impacts on these resources; and lists the Service's recommendations for avoiding, minimizing, and compensating for impacts on these resources. This report, when revised to a final, will constitute the Service's report in accordance with Section 2(b) of the FWCA (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The Service appreciates the opportunity to provide this report. If you have any questions or comments, please contact Howard Hall at 919-856-4520, ext. 27 or by e-mail at Howard_Hall@fws.gov.

Sincerely,

Pete Benjamin
Field Supervisor

Attachment

NEUSE RIVER BASIN PROJECT,

NORTH CAROLINA

DRAFT FISH AND WILDLIFE COORDINATION ACT REPORT

Prepared by:

Howard F. Hall and A. Mike Wicker

Under the Supervision of:

Pete Benjamin
Field Supervisor

U.S. Fish and Wildlife Service
Ecological Services Raleigh Field Office
Raleigh, North Carolina

August 2008

SECTION 1 - INTRODUCTION

Authority

This report is provided under authority of Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) of 1958 (48 Stat. 401, as amended; 16 U.S.C. 661-667d). The FWCA established two important federal policies which are: (1) fish and wildlife resources are valuable to the nation; and, (2) the development of water resources is potentially damaging to these resources. In light of these principles, the FWCA mandates that:

> ". . . wildlife conservation shall receive equal consideration and be coordinated with other factors of water-resource development programs through effectual and harmonious planning, development, maintenance, and coordination of wildlife conservation and rehabilitation."

The FWCA essentially established fish and wildlife conservation as a coequal purpose or objective of federally funded or permitted water resources development projects.

In order to fully incorporate the conservation of fish and wildlife resources in the planning of water resources development, the FWCA mandates that federal agencies consult with the U. S. Fish and Wildlife Service (Service) and the state agency with the responsibility for fish and wildlife resources in the project area. The state agency with this responsibility is the North Carolina Wildlife Resources Commission (NCWRC).

Consultation during project planning is intended to allow state and federal resource agencies to determine the potential adverse impacts on fish and wildlife resources and develop recommendations to avoid, minimize, and/or compensate for detrimental impacts. Therefore, this report will:

1. Describe the fish and wildlife resources at risk in the project area;

2. Evaluate the potential adverse impacts, both direct and indirect, on these resources;

3. Develop recommendations to avoid, minimize, or compensate for any unavoidable, adverse environmental impacts; and,

4. Present an overall summary of findings and the position of the Service on the project.

This draft report will be submitted to the North Carolina Wildlife Resources Commission (NCWRC) for their review and comments. The report, when finalized, will include a letter of concurrence from the NCWRC and will constitute the formal report of the Service under Section 2(b) of the FWCA.

Subject of This Report

The Neuse River Basin Feasibility Study is being pursued under the U.S. Army Corps of Engineers' General Investigation (GI) Program. The U.S. Army Corps of Engineers (Corps) is partnering with the North Carolina Department of Environment and Natural Resources (NCDENR) to conduct the study. The Integrated Feasibility Report and Environmental Impact Statement (EIS) are being developed in response to the following resolution adopted July 23, 1997:

> "Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control, environmental protection and restoration, and related purposes."

Planning objectives used to formulate measures for the Neuse River Basin Feasibility Study included (U. S. Army Corps of Engineers [hereafter USACE 2007], p. i): (1) maintain and/or restore the Neuse River Basin ecosystem through 2057; and, (2) reduce flood damages in the Neuse River Basin watershed through 2057. More recently, the second goal is no longer included (USACE 2008, pp. 1-2).

The Neuse River Basin Feasibility Study is a focused study. The study is an effort that is intended to be collaborative with the actions of others working in the watershed, with identification of areas that fit within the Corps mission areas. The focus of the study was driven in part by the North Carolina Division of Water Resources' (the study's local cost sharing partner) willingness to participate in specific areas. The planning objective being used to formulate measures for the Neuse River Basin Feasibility Study is to maintain and/or restore the Neuse River Basin ecosystem through 2057. The measures being considered to address this objective include: (1) prioritize and restore streams, wetlands, and riparian buffers for the enhancement and restoration of aquatic ecosystems and related habitats; (2) restore access to pre-existing spawning grounds for anadromous fish species by removing or bypassing obstructions in the Neuse River and its tributaries where practicable; and, (3) restore marsh, submerged aquatic vegetation (SAV) and oyster (*Crassostrea virginica*) reefs in the Neuse Estuary.

The feasibility study will analyze the problems and opportunities, and express desired outcomes as planning objectives. Alternatives will be developed to address the planning objectives. The alternatives will include a plan of no action and various combinations of measures that address planning objective. The economic and environmental impacts of the alternatives will be evaluated and a feasible plan selected.

This year the Corps stated (USACE 2008, p. 4) that recommended plans will be formulated to address the needs of the Neuse River Basin at the basin-wide scale. Plan components will be developed by the workgroups to address needs (study objectives) identified above for the individual focus areas. All Alternative Ecosystem Restoration Plans will be subjected to a Modified Habitat Evaluation Procedure, cost will estimated for each plan and Institute for Water Resources (IWR) Plan will be used to evaluate alternatives for inclusion in the recommended plan.

Prior Studies and Reports

The Corps' Chief of Engineers submitted a report on the Neuse River Basin Project to the Secretary of the Army on March 9, 1965. The report was based on several congressional Resolutions between 1946 and 1956. At that time the project focused on "improvements in the interest of flood control and allied purposes" in the basin.

The Service provided the Corps with a Planning Aid Letter (PAL) on July 13, 1983 (U. S. Fish and Wildlife Service [hereafter USFWS] 1983). The PAL indicated that the project sought to provide an increased and more reliable water supply for industrial and municipal consumers and relief from flood damage.

The Corps issued a Draft Reconnaissance Report in July 1999 (USACE 1999). This report presents a brief outline of studies, reports, and water projects within the basin starting in 1932. The report notes that the decline in water quality of the Neuse River Basin has taken place over many years. The aquatic resource deterioration has paralleled the increase in urban development and intensive agriculture. The Corps developed a Project Study Plan (PSP) in January 2002 (USACE 2002).

The Service has provided the Corps with a revised Planning Aid Letter (USFWS 2003). At that time, the purpose of the feasibility study was to identify a number of watershed projects that could be initiated under the Continuing Authority Program (CAP), primarily Section 206 of the Water Resources Development Act of 1996, as amended.

A draft report of the Freshwater Wetlands, Streams, and Riparian Buffer Restoration Work Group has been released (USACE 2005). The Corps released an Integrated Feasibility Report and Draft Environmental Impact Statement (USACE 2007). While specific actions had not been developed, this report updated planning objectives, study organization, and plan formulation. The most recent information on the project was contained in the Scope of Work (USACE 2008) for this report.

Need for Federal Action

Within the Neuse River Basin there has been considerable water quality degradation; alteration and destruction of the estuarine habitat; alteration of river flow; and declines in aquatic populations (USACE 2007, p. 2). Development within riparian corridors has created a landscape in which isolated patches of natural areas are separated by developed areas. Such fragmentation is detrimental to plant and animal communities. Animals of limited mobility and plants of limited dispersal ability may become reproductively isolated from other members of their species. The theory of island biogeography has provided a basis for the idea that plants and animals in subdivided units of a larger area are more susceptible to inbreeding and accidental extinction from infrequent, natural catastrophes. One major, long-term impact of habitat fragmentation is the inability of healthy individuals in one area to migrate and repopulate a nearby area of suitable habitat in which members of the species have been eliminated due to short-term, adverse conditions. By increasing inbreeding and restricting recolonization of nearby suitable habitat, fragmentation can lead to the gradual extirpation of a species from a large area in which the total acreage of all habitat blocks has declined by only a small amount.

The problems related to the degradation of aquatic resources in the Neuse River Basin are likely the result of a combination of factors. More runoff of higher nutrient concentration and silt enters the basin as a result of increased agriculture and urbanization activities in the watershed. Furthermore, the original riparian buffers and wetlands, which remove nutrients and siltation before runoff enters the waterways, have been lost. This has contributed to deterioration in ecosystem habitat due to an increase in siltation and nutrients, especially nitrogen. The degraded ecosystem has affected wildlife, fishing, and water contact recreation in the Neuse River basin. The high nutrient levels in the lower Neuse River are believed to contribute to outbreaks of the toxic microbe, *Pfiesteria piscida* (USACE 2008, p. 4).

Dams may block some fish, especially anadromous fish, from portions of their historic habitat. Restoration of access to historic habitats and removing dams as barrier to upstream-downstream moving of aquatic organisms would have significant benefits to fish and wildlife resources. Removal of the Quaker Neck Dam in 1998 provided anadromous fishes such as the striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*) with 127 river kilometers (79 miles) of additional spawning habitat between Goldsboro and Raleigh. Since that time, information from electro-fishing, radio-telemetry, and egg/larval sampling has shown that both species are taking advantage of the restored habitat. The extent to which migratory fishes use the upstream habitat depends on spring flows, which are affected by rainfall and operation of the Falls of the Neuse Dam. With relatively high spring flows in 2003, substantial numbers of American shad and striped bass migrated to the base of Milburnie Dam. Electro-fishing catch rates were higher in the section of the river below Milburnie Dam than in any of the sections further downstream. Radio-telemetry studies and observations of spawning activity have shown that American shad primarily spawn at relatively shallow sites, often containing larger substrates such as gravel, cobble, and bedrock. This type of habitat (relatively high-gradient, with rocky riffle sections) is found almost exclusively upstream of Smithfield but is not very common in reaches now accessible to anadromous fishes. Additional habitat of this type would be found upstream of Milburnie Dam. Resident migratory fish are also likely to benefit by removal of Milburnie Dam as several species aggregate below the dam during the spring spawning season.

The Neuse River Estuary is an important nursery area and its shallow waters, marsh, submerged aquatic vegetation (SAV), and reefs provide habitat for fishery resources, which in turn supports the local coastal economy. In the estuary, soil erosion is severely damaging the shoreline since it ultimately degrades the physical, chemical, and biological properties of the area. (USACE 2008, p. 7). Historically much of the Pamlico Sound including the Neuse River Estuary was fringed by extensive oyster reefs, but signs of over harvesting were evident in the 1900s. Many of the oyster reefs of the Neuse River Estuary, which historically supported high oyster populations were apparently harvested away or destroyed by historic fishing practices. The lower Neuse River shoreline, especially near the town of Oriental, is severely degraded by erosion with portions of the lower Neuse shoreline retreating at a rate of over nine feet/year. Sediment from eroding shorelines in combination with increase nutrient loading and loss of oyster filtering capacity have reduced water clarity causing SAV loss that destabilizes bottom sediments, further reducing water clarity (USACE 2008, p. 7).

Purpose of Federal Action

At the broadest level, the comprehensive investigation seeks to develop, evaluate, and implement a collaborative and sustainable watershed-based approach to environmental restoration. The planning effort decided to address three issues which are: (1) freshwater wetland, stream, and riparian buffer restoration; (2) anadromous fish habitat restoration; and, (3) estuarine resource restoration.

The purpose of the Corps' efforts is to investigate and recommend appropriate federal solutions to accomplish ecosystem restoration in the Neuse River Basin. A related purpose of this study is to recommend collaborative and sustainable watershed-based solutions. The Wilmington Corps District and the non-federal sponsor, the State of North Carolina, will cooperatively conduct the Neuse River Basin Feasibility Study.

The purpose of the feasibility study is to develop and evaluate basin wide alternatives to improve water quality, restore anadromous fish passage, wetlands, stream, riparian buffer, and oyster habitat. The focus of this study is to identify resource problems, needs, and opportunities and develop solutions.

The national objectives are general statements not specific enough for direct use in plan formulation. Planning objectives reflect the problems and opportunities and represent desired positive changes. The planning objectives to be used in formulation and evaluation of alternative plans include: (1) prioritize and restore streams, wetlands, and riparian buffers for the enhancement and restoration of aquatic ecosystems and related habitats; (2) restore pre-existing spawning grounds for anadromous fish species by removing or bypassing obstructions in the Neuse River and its tributaries where practicable; and (3) restore marsh, submerged aquatic vegetation (SAV) and oyster reefs in the Neuse Estuary. Overall, the project seeks to maintain and/or restore the Neuse River Basin ecosystem through 2057.

Scope of This Report

This report will address current plans for the Neuse River Study, primarily as outlined in the Corps' SOW (USACE 2008). The Corps' investigation of the problems and opportunities in the study area led to the establishment of three measures to address the objectives for the Neuse River Basin Study. First, the project will prioritize and restore streams, wetlands, and riparian buffers for the enhancement and restoration of aquatic ecosystems and related habitats. At this time, a scoring system and GIS data has identified about 18 candidate sites for further evaluation including an array of stream restoration, wetland creation, bank stabilization, best management practices and preservation plans. From these 18 candidate sites, the study has chosen four stream restoration sites which are (1) Ellerbe Creek in Durham; (2) Swift Creek in Craven County; (3) Gum Thicket Creek in Pamlico County; and, (4) the City of Kinston restoration projects.

Second, the project will seek to restore access to pre-existing spawning grounds for anadromous fish species by removing or bypassing obstructions in the Neuse River and its tributaries where practicable. Environmental agencies involved in anadromous fish management describe dams as the most detrimental obstruction to migration. Stream obstructions in the Neuse have reduced the spawning area for these fish. A reduction in spawning area means fewer eggs produced and, therefore, fewer fish. Declines are expected to continue unless corrective measures are taken.

The Corps and the North Carolina Division of Water Resources are conducting a study to identify all aquatic obstructions within the State of North Carolina. Using data from NC Wildlife Resources Commission, Paddlers' Guide in North Carolina, and NCDENR, Division of Land Resources (State Dam Safety Program), about 26 obstructions within the Neuse River Basin have been identified for further evaluation. This dam database will be very useful in the future and the Corps should be commended for this effort. At this time, the Corps is considering the modification and/or removal of five obstructions which are: (1) Millburnie Dam in Wake County; (2) Lassiter Dam in Raleigh; (3) City of Goldsboro Dam on the Little River; (4) Dam on Contentnea Creek in Wilson County; and, (5) Kelly's Pond on Southwest Creek near Kinston in Lenoir County (USACE 2008, p. 6). The Service prioritizes these projects with one being the highest priority as: (1) Millburnie Dam; (2) City of Goldsboro Dam; (3) Kelly's Pond; (4) Lassiter Dam; and, (5) the dam on Contentnea Creek.

The third broad measure of action is the restoration of coastal marshes, submerged aquatic vegetation (SAV), and oyster reefs in the Neuse Estuary. The Lower Neuse Estuary has been identified by the North Carolina Oyster Restoration Plan Steering Committee (NCORPSC) as being of high priority for oyster restoration. Study efforts to date have identified a need for restoration or construction of 10 or more sanctuary oyster reefs totaling 50-200 acres in the lower Neuse Estuary. In addition, wetland restoration with drainage ditch Best Management Practices will be investigated on lands draining to Bay River, Broad Creek, Swan Creek, Jones Bay and Middle Bay.

SECTION 2 - PROJECT AREA

The Neuse River Basin is the third largest basin in North Carolina, encompassing a total area of 6,234 square miles. The river basin is one of only four basins located entirely within the state and incorporates parts or all of 18 counties (NCDENR 2001, Figure 2).

The Neuse River originates in north central North Carolina in Person and Orange Counties and flows southeasterly until it reaches tidal waters near Streets Ferry upstream of New Bern. The river broadens dramatically at New Bern and changes from a free-flowing river to a tidal estuary known as the Neuse River Estuary, which eventually flows into Pamlico Sound. The upper one-third of the basin lies in the Piedmont physiographic province while the lower two-thirds of the basin lie in the mid-Atlantic Coastal Plain physiographic province.

The basin contains 3,443 miles of stream and river channels (Powell 1999). The major tributaries include the Eno, Flat, Little, and Trent Rivers and well as Crabtree, Swift, and Contentnea Creeks. The basin can be divided into 14 subbasins (North Carolina Department of Environment and Natural Resources [hereafter NCDENR] 2001, p. 15) which vary in size. These subbasins which are designated from 01 to 14 form a convenient framework to discuss the different areas of the Neuse River watershed and will be referenced in this report.

The upper 22 miles of the river's mainstem is impounded behind the Falls of the Neuse Reservoir Dam that creates a large multi-use reservoir northeast of Raleigh. Below the dam the river flows about 185 miles southeasterly past the cities of Raleigh (Wake County), Smithfield (Johnston County), Goldsboro (Wayne County), and Kinston (Lenoir County) until it reaches the tidal waters upstream from New Bern (Craven County).

Much of the land area in the basin is used for agriculture or commercial forestry. Urban development in the upper basin is concentrated around Raleigh, Durham (Durham County), and Cary (Wake County) and around Goldsboro, Kinston, and New Bern in the lower basin. Agricultural land comprises 35 percent of the basin, 34 percent of the basin is forest, wetlands and open water account for 22 percent, scrub growth and barren land account for 4 percent, and the remainder (5 percent) is developed. The combined population of the basin is about 1.5 million people.

This section will consider the basic physical characteristics, major plants, and important invertebrates of each community. These community attributes are important in supporting vertebrate populations that will be discussed later.

Major Biological Communities

Within the subbasins established by the North Carolina Division of Water Quality, the headwaters are designated as Subbasin 1 and the lower regions which constitute the Neuse River Estuary are designated as Subbasins 10, 13, and 14. The biological communities within the basin are numerous and diverse. This report will provide only a broad outline of the communities within three major regions of the basin. These regions are: (1) the Piedmont; (2) the Coastal Plain; and, (3) the Estuary.

Piedmont

The riparian areas along the waterways that constitute the Neuse River in the Piedmont have historically been forested. The natural communities that occur, or once occurred, along these waterways in North Carolina have been described (Schafale and Weakley 1990). The basic hydrology, vegetation, and dynamics are generally known for the Piedmont levee forest (Schafale and Weakley 1990, pp. 165-167), Piedmont swamp forest (Schafale and Weakley 1990, pp. 167-169), Piedmont bottomland forest (Schafale and Weakley 1990, pp. 169-5-167), and Piedmont alluvial forest (Schafale and Weakley 1990, pp. 175-177).

The Eno River corridor contains some of the most scenic and biologically important natural areas within the entire eastern piedmont because of its geology and wide riparian corridors (NCDENR 2006, p. 11). The diverse array of wildlife found here includes a nationally significant fauna of freshwater mussels, snails, salamanders, fish, and other aquatic species. An example of a relatively natural Piedmont riparian area would be the Eno River State Park in Orange County. The website (< http://www.ncparks.gov/Visit/enri/ecology.php >) that discusses the ecology of the area notes that birds serenade everywhere in the park. The calls of the red-tailed hawk (*Buteo jamaicensis*), barred owl (*Strix varia*), and crows (*Corvus brachyrhynchos*) mingle with the melodies of more than one-hundred kinds of song birds. Wood ducks (*Aix sponsa*), great blue herons (*Ardea herodias*), and belted kingfishers (*Megaceryle alcyon*) thrive around the river. Wild turkeys (*Meleagris gallopavo*) are often seen in the forest.

Within the park ridges, slopes, and flood plains are once again thick with vegetation. Oak, beech, poplar, maple, dogwood, pine, and hickory dominate the uplands. Sycamore, birch, and hornbeam shade the river banks. Mountain laurel, Catawba rhododendron and ferns grow on the slopes and bluffs. Wildflowers bloom in the fields and forest from February through November. Vines such as greenbrier, grape, and trumpet flower are part of the backdrop of natural beauty at the park.

Coastal Plain Communities

The river floodplains of North Carolina contain a diversity of wetland communities (Schafale and Weakley 1990, pp. 142-165). Broad, flat areas adjacent to the Neuse River represent a major alluvial floodplain that, unless altered by man, is invariably forested (Kellison et al. 1998), and are referred to as bottomland hardwoods (BLH) (Kellison et al. 1998, p. 300). While the project area has been developed, it is likely that the area, once contained, could be restored to BLH. Excellent reviews of the physical and biological characteristics of BLH are available (Wharton et al. 1982, Harris et al. 1984, Sharitz and Mitsch 1993, Kellison et al. 1998).

An example of a relatively unspoiled area along the Neuse River in the Coastal Plain would be the Cliffs of the Neuse State Park in Wayne County. The website presenting the ecology of this area (< http://www.ncparks.gov/Visit/clne/ecology.php >) that the river margins, flood plains, rolling uplands and ravines are home to an unusual mixture of trees, shrubs and herbaceous plants. More than 420 species of plants have been recorded here.

Estuarine Communities

The larger estuarine areas in the project are contained within Subbasin 10 of the NCDENR. Most of the waters in this subbasin are estuarine, including the Neuse River and the downstream portion of most of its main tributaries (NCDENR 2006, p. 94). Subbasin 10 is contained within the Level IV ecoregions of the Nonriverine Swamps and Peatlands; Carolina Flatwoods; and Mid-Atlantic Floodplains and Low Terraces (Griffith et al. 2002). Specifically, the catchments of Upper Broad Creek are comprised of Mid-Atlantic Floodplains and Low Terraces ecoregions and are characterized by large, low gradient and tannic rivers, deep-water swamps, and extensive bottomland hardwood wetlands and cypress-gum swamps (Griffith et al. 2002). The catchment of the Southwest Prong of Slocum Creek is contained within Carolina Flatwoods ecoregion and is typified by poorly drained soils and very low topographic relief with large areas of Carolina bays and pocosins (Griffith et al. 2002). Freshwater is confined primarily to the upper segments of tributaries. Land use in the subbasin is mostly a mix of forest and agriculture. Overall, runoff remains the most important cause of non-point source pollution in this subbasin. Although large-scale agricultural operations are common in this subbasin, there are also large tracts of protected forest and pocosin wetlands associated with Croatan National Forest and the Light Ground Pocosin. Moderate residential growth continues throughout most of the subbasin although the largest concentrations of suburban impacts are associated with the towns of New Bern, Havelock, and Oriental.

Phytoplankton blooms occur throughout the year, but the greatest problems are associated with summer blooms (NCDENR 2001, p. 21). Most blooms occurred in the Neuse River between Broad Creek and Oriental, with few blooms occurring near the mouth of the river. The mesohaline section of the river becomes strongly stratified in summer, leading to oxygen depletion of bottom waters. Summer algae blooms (especially dinoflagellates) have been a common and chronic problem in this subbasin for many years. During the prior basin cycle, the most severe algal blooms occurred during 1990 and 1995. Both years were periods of high flow in spring and early summer, followed by a period of prolonged summer low flow. Almost all summer low-flow periods during 1997-2000 produced high algal biovolumes and algal blooms. The lowest summer algal populations were found during 1996, a year with both normal spring and summer flows.

Studies indicate that the fauna of the lower Neuse River is controlled by periods of very low dissolved oxygen (hypoxia) during summer months (NCDENR 2001, pp. 140-141). Hackney, et al. (1998) looked at sediment data from the Neuse River produced by the U. S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP), and suggested that high contaminant levels also may influence the benthic fauna in this area. Sediment contaminants found in Neuse River samples included DDT, arsenic, PCBs, nickel, and chromium.

SECTION 3 – FISH AND WILDLIFE CONCERNS AND PLANNING OBJECTIVES

As noted, the major planning objective being used to formulate measures for the Neuse River Basin Feasibility Study is to maintain and/or restore the Neuse River Basin ecosystem through 2057. The Service strongly supports efforts to improve habitat quality for fish and wildlife resources in the Neuse River Basin. We are especially pleased with plans to restore anadromous fish habitat through the removal of dams or the construction of fish passageways at dam sites.

Fish and Wildlife Concerns

The most fundamental concern of the Service is to enhance and protect the habitats of federal trust resources. We seek the restoration of anadromous fish spawning habitat and the recovery of federal protected species. The Service also seeks to conserve rare endemic species within the Neuse River Basin in order to prevent the need for formal listing of these species in the future.

With the exception of measures to remove obstructions for anadromous fish, specific actions taken at individual wetland, stream, or estuarine waters, while certainly beneficial, may have limited value when the entire Neuse River Basin is considered. While the restoration of wetlands, streams, riparian buffers, and estuarine resources may need to provide specific, on-the-ground work, any efforts to extend the environmental benefits to other areas within the basin would enhance fish and wildlife resources.

Planning Objectives

Planning documents of the Corps indicate that the broad environmental problems within the Neuse River Basin have been correctly identified. For the restoration of wetlands, stream, and riparian buffers, there should be clear criteria for selecting the actual sites for work. These sites should be selected with the view that they could serve as models for future work. In order to facilitate the use of the selected sites as templates for future federal, state, and/or local environmental restoration/enhancement efforts, the project should consider an environmental education component to show the public and elected official the benefits of the restoration work.

SECTION 4 - EVALUATION METHODS

Descriptions of natural resources present within the study area and the preliminary assessment of the environmental impacts of the proposed project are based on previous studies for similar projects, published literature, and personal communications with knowledgeable individuals. Published reports and studies were examined to determine their relevance to the proposed project. The Service has not undertaken any field research specifically for this report.

SECTION 5 – EXISTING FISH AND WILDLIFE RESOURCES

The large project area contains a wide diversity of habitat types and supports a rich array of fish and wildlife species. Rather than provide extensive lists of the species that could occupy the various sections of the project area, the Service will note a few selected species for certain habitats and provide references which the Corps can use in developing the feasibility report and Environmental Impact Statement.

General Fish and Wildlife Resources

Streams, Wetlands, and Riparian Buffer

The Neuse River originates in the Piedmont region and flows through both the upper and lower coastal plains. Kellison et al. (1998) give a broad overview of the wildlife associated with major alluvial floodplains in the South. They note that these floodplains provide some of the most important fish and wildlife habitats in the region. The high fertility supports high forest productivity which in turn produces more high-quality food and browse than is found on poorer sites. The extensiveness and denseness of unbroken floodplain forests are as important as the habitat itself. A comprehensive report on the fishes of the Neuse River Basin was prepared in the early 1960s (Bayless and Smith 1962).

The Integrated Feasibility Report (IFR) and Draft EIS provided (USACE 2007, pp 34-35) a brief introduction to the fauna of the project area. This discussion included information on the wildlife of the Eno River and the Cliffs of the Neuse State Parks.

On the coastal plain, broad, flat areas adjacent to the Neuse River represent major alluvial floodplains that, unless altered by man, are invariably forested (Kellison et al. 1998), and are referred to as bottomland hardwoods (BLH) (Kellison et al. 1998, p. 300). Boaters on the Neuse River report (Powell 1999) an "amazing amount of wildlife."

Forested alluvial floodplains are important to many birds as breeding, wintering, and migrating stop-over habitat (Kellison et al. 1998, p. 314). These forests provide food and cover for wildlife throughout the year. Seasonal flooding produces shallow, warm water areas where many kinds of water life spawn and feed (Harris et al. 1984, p. 7). Flooded BLHs are nurseries for many fish species.

Fish - The Corps' Integrated Feasibility Report states (USACE 2007, p. 27) that a comprehensive report on the fishes of the Neuse River Basin was prepared in the early 1960s (Bayless and Smith 1962). This report is still considered to be a good characterization of the fish in the Neuse River Basin. According to Bayless and Smith (1962), bowfin (*Amia calva*), redfin pickerel (*Esox americanus*), chain pickerel (*Esox niger*), bluehead chub (*Hybopsis leptocephala*), swallowtail shiner (*Notropis procne*), channel catfish (*Ictalurus punctatus*), American eel (*Anguilla rostrata*), Mosquitofish (*Gambusia affinis*), redbreast sunfish (*Lepomis auritus*), bluegill (*Lepomis macrochirus*), and Johnny darter (*Etheostoma flabellare*) are some of the most abundant fishes found within the project area. A total of about 95 species, representing 27 families were collected during the fishery survey of the Neuse River and its tributaries (Bayless and Smith 1962).

The recent basinwide assessment provides a list of fish in the basin (NCDENR 2006, pp. 126-128). The list also provides an assessment of tolerance to polluted conditions and the trophic guild of adults.

Anadromous Fish

Anadromous fish species such as striped bass (*Morone saxatilis*), hickory shad (*Alosa mediocris*), American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), shortnose sturgeon (*Acipenser brevirostrum*), and Atlantic sturgeon (*Acipenser oxyrhynchus*), have historically formed a significant component of the fishery resource of the Neuse River estuarine system. These species use the Neuse River estuary to access upper river spawning and nursery areas. The catadromous American eel, (*Anguilla rostrata*) that resides in the upper river passes through the Neuse Estuary to and from its offshore spawning grounds. The presence of many species of anadromous fish in the region is documented in the Freshwater Fishes of North Carolina (Menhinick, 1991).

The State water quality plan stated (NCDENR 2002, p. 38) that from 1952 to 1998, spawning migrations of anadromous fish were impeded by Quaker Neck Dam, a low-head dam located near Goldsboro, and in most years spawning areas were limited to areas downstream of the dam. However, with the removal of Quaker Neck Dam in 1998, 74 miles of historical spawning habitat were restored. Anadromous species, in particular striped bass and American shad, now migrate upstream as far as Milburnie Dam near Raleigh, but the extent of upstream migration in a given year is highly dependent on river flows. Hickory shad, blueback herring and alewife are generally found from Goldsboro downstream to New Bern. The Corps notes (USACE 2007, p. 28) that in 2000 the NCWRC designated certain areas of the Neuse River as inland primary nursery areas, including the area from Pitchkettle Creek upstream to Milburnie Dam. The restoration of anadromous fish populations through the restoration of spawning habitat is a top conservation priority of the Service's Raleigh Field Office.

Estuarine Resources

Some estuarine dependent species reside in the estuary as larvae or juveniles, using the estuary as nursery or feeding habitat, but spawn offshore in the Atlantic Ocean. Typical species that use the estuary as nursery habitat include Atlantic menhaden, (*Brevoortia tyrannus*); Atlantic croaker, (*Micropogon*); spot, (*Leiostomus xanthurus*); penaeid shrimp; mullet, (*Mugil* spp.); and weakfish, (*Cynoscion regalis*). Species that are permanent residents include such species as bay anchovies, (*Anchoa mitchilli*); killifishes, (*Fundulus* spp.); and silversides, (*Menidia* spp.).

The estuary is likely to provide winter habitat for migratory waterfowl. While specific data for the Neuse Estuary are not available, data from the Pamlico River Estuary, less than 50 miles to the north, indicate 19 species of overwintering waterfowl (Copeland et al. 1984, pp. 45, 47, Table 22). Over 75 percent of birds consisted of ruddy duck (*Oxyura jamaicensis*), canvasback (*Aythya valisineria*), and scaup (*Aythya* spp.).

In North Carolina, oysters are often found in dense bands in the mid to high intertidal zone at the lower edge of the salt marsh (Peterson and Peterson 1979, p. 19). Below this band of oyster is usually an open mud or sand flat which may contain more oysters in the form of an oyster "reef." However, in North Carolina, most oyster reefs are subtidal (Peterson and Peterson 1979, p. 19).

Rare and State Protected Species

Over an area as large as the Neuse River Basin there are numerous species with special status in the State of North Carolina. Since the project is primarily directed toward aquatic resources, species living in or near the water should merit the greatest consideration. The planning process should consider project impacts on the priority aquatic species found in the Neuse River Basin as listed in the North Carolina Wildlife Action Plan (NCWAP) (North Carolina Wildlife Resources Commission [hereafter NCWRC 2005, pp. 374-375). The species listed in the NCWAP include 25 fish, 17 mussels, four crayfish, and two snails.

Other species not included in the NCWAP should be considered. The Neuse River waterdog (also known as the Carolina waterdog or Carolina mudpuppy) (*Necturus lewisi*) is an amphibian with a state status of "Special Concern" and endemic to the State. The species inhabits rivers and large streams within the Neuse and Tar River drainages. On a global scale this species is considered very rare or local throughout its range, or found locally in a restricted area.

There are two fish with special State status that are not Federal Species of Concern (FSC) (NCDENR 2006, p. 140). A FSC is under consideration for listing, but there is insufficient information to support listing at this time. These species may or may not be listed in the future. These are the least brook lamprey (*Lampetra aepyptera*) and Atlantic sturgeon (*Acipenser oxyrhynchus*). The least brook lamprey is small, nonparasitic species that inhabits creeks which are warm, slow, sandy, and slightly acidic (Rohde et al. 1994, pp. 59-60). The species has a State status of threatened. Within the project area there are current records in Wake and Franklin Counties and historic records in Jones and Pitt Counties. The Atlantic surgeon is a State species of Special Concern (NCDENR 2006, p. 140). The species spends much of its life in estuaries and the ocean, but moves into freshwater to spawn (Rohde et al. 1994, p. 61).

Federally Species of Concern and Federally Protected Species

Three fish have special state status and are also listed as a FSC. These are the bridle shiner (*Notropis bifrenatus*), the Neuse River population of the Carolina madtom

(*Notropis furiosus*), and the eastern Piedmont population of the Carolina darter (*Etheostoma collis lepidinion*) (NCDENR 2006, p. 140). In 2004 and 2005, the Carolina darter was collected from Smith Creek in Granville County as part of NCDWQ's fish community monitoring program. This was the only listed species captured in the Neuse River basin at any of the fish community sites. The Carolina madtom has a State status of Special Concern and is considered an endemic species in the Tar and Neuse River basins. However, the species was not collected from any stream in 2005. It has never been collected by NCDWQ Staff from the Neuse River Basin.

The Integrated Feasibility Report lists two additional fish as FSC (USACE 2007, p. 32) as FSCs. These are the pinewood shiner (*Lythrurus matutinus*) and Carolina redhorse (*Moxostoma* sp.). The pinewood shiner is restricted to the Tar and Neuse drainages and occupies midwater areas in sandy runs and pools in creeks and small rivers (Rohde et al. 1994, p. 91). While recent surveys may change the known distribution of the Carolina redhorse, the North Carolina Natural Heritage Program list of rare species states that this fish occurs in the Cape Fear and Pee Dee drainages.

Within the Neuse Basin there are two species of federally protected freshwater mussels (USACE 2007, p. 32). Both the dwarf wedgemussel (*Alasmidonta heterodon*) and the Tar River spinymussel (*Elliptio steinstansana*) are listed as endangered. This status reflects an assessment that the species is in danger of extinction throughout all or a significant portion of its range. Both species also have a State status of endangered.

The dwarf wedgemussel occurs in at least 25 stream reaches along the Atlantic Coast from New Brunswick, Canada, to North Carolina. The dwarf wedgemussel inhabits creek and river areas with a slow to moderate current and a sand, gravel, or muddy bottom. Toxic effects from industrial, domestic, and agricultural pollution are the primary threats to this mussel's survival. In the project area, the species occurs mainly near the fall line. Populations have been reported in the Johnston County portion of the Little River (USACE 2007, p. 30). Other populations may exist in portions of Swift Creek and Middle Creek which enter the Neuse near Smithfield in Johnston County.

The Tar River spinymussel lives in relatively silt-free uncompacted gravel and/or coarse sand in fast-flowing, well oxygenated stream reaches. It is found in association with other mussels, but it is never very numerous. It feeds by siphoning and filtering small food particles that are suspended in the water. The only known location for this species in the Neuse Basin is Little River.

The shortnose sturgeon (*Acipenser brevirostrum*) is the only federally endangered fish within the basin. The species inhabits the lower sections of larger rivers and coastal waters along the Atlantic coast. It may spend most of the year in brackish or salt water and move into fresh water only to spawn. The species feeds on invertebrates (shrimp, worms, etc.) and stems and leaves of macrophytes. Threats to the species include overfishing and degradation of its habitat by erosion, siltation, toxic pollution, and dams that interfere with upstream migration to spawning areas. The species is under the jurisdiction of the National Marine Fisheries Service

The recovery of federally listed species and the conservation of rare species with the goal of obviating the need to list them in the future are top priorities of the Raleigh Field Office and we encourage the Corps to focus basin-wide restoration activities on efforts that will benefit these species. More specific information on special status species can be found in the North Carolina Natural Heritage Program (NCNHP) database which contains excellent data on the special status species, both federal and state. This database can be accessed by topographic quadrangle (quad) of the U. S. Geological Survey (USGS). Data from USGS quads provide the most project-specific information on species which should be considered in permitting this project. The occurrence data of special status species within a given quad can be obtained on the internet at < http://www.ncnhp.org/Pages/heritagedata.html >.

SECTION 6 - FUTURE FISH AND WILDLIFE RESOURCES WITHOUT PROJECT

The North Carolina Division of Water Quality (NCDWQ) notes that the populations of counties that are wholly or partly contained within the Neuse River Basin increased by over 414,000 people between 1900 and 2000. Durham, Johnston and Wake are growing the fastest in the upper basin, with Pitt County growing the fastest in the lower basin (NCDENR 2002, p. xvi). The populations of these counties are expected to grow by more than 867,000 by 2020 to almost three million people. With the increased population there will be increased drinking water demands and wastewater discharges. There will also be loss of natural areas and increases in impervious surfaces associated with construction of new homes and businesses.

As noted in the Integrated Feasibility Report (IFR), increased urban growth and development are expected to continue throughout the watershed (USACE 2007, pp. 9-10). Increased population growth will lead to heavier demands on aquatic resources, continued deterioration of ecosystem habitat due to the losses of wetlands and riparian buffers, increased siltation, and increased stormwater runoff. The rate of degradation is being reduced through implementation by the State of a stringent Neuse River Nutrient Sensitive Waters Management Plan, regulating new construction and land use management. However, nutrients recycled within the riverbed sediments will remain for years.

Wetlands, Stream, and Riparian Buffers

The Integrated Feasibility Report (IFR) discusses future conditions without project implementation (USACE 2007, pp. 8-10). The report notes that water quality in the Neuse River Basin currently reflects basin land-use changes associated with increased population growth. Non-point source pollution from agriculture and silviculture has degraded aquatic habitat. For example, animal waste byproducts from the hundreds of hog farms within the basin cause increased levels of nitrates and phosphates, which can lead to excess growth of aquatic plants, such as algae, and decreased dissolved oxygen levels, (especially during summer months) resulting in fish kills and high fecal coliform bacteria counts. Bank erosion and the subsequent turbidity and sedimentation can result from channelization of streams for agriculture.

Anadromous Fish Habitat Restoration

With increased growth, additional roads will be required and thereby increase the number of stream crossings within the basin. While the North Carolina Department of Transportation is implementing policies to reduce obstacles to the passage of aquatic organisms at state-constructed road crossings, construction for private residential and commercial development may lead to the placement of new roadway culverts that create additional barriers to the migration and spawning of anadromous fish.

Estuarine Resources

The IFR addresses future conditions of estuarine resources that are likely if remedial actions are not undertaken (USACE 2007, p. 19). This report states that the Neuse watershed is under increasing developmental pressure. Without projects to address current aquatic ecosystem degradation and population growth, associated urbanized land development will further negatively impact the river, estuarine organisms and their habitat. The rate of degradation is expected to increase due to multiple factors such as increased impervious surface area, which will increase point and non-point source pollutant loading, sedimentation, and stream bank erosion from increasing flash flows.

An increasing population leads to increased water demands and wastewater discharges (NCWRC 2005, p. 376). Rapid population growth leads to high sediment runoff from construction. More homes contribute to an increase in lawn fertilizer runoff. Heavy metal runoff contributes to elevated mercury levels in fish tissue. These point and non-point runoff sources accumulate in the Pamlico Sound, where researchers at the University of North Carolina at Wilmington found one-third of the sediments contaminated with chemicals and toxic metals (Powell 1999). Additionally, atmospheric deposition of nitrogen from cars and factories can lead to decreased water quality. Large quantities of nutrients, especially nitrogen, from non-point sources are considered the greatest threat to water quality of the Neuse River estuary. There are over 400 point source waste discharge permits for the basin from municipal wastewater treatment plants, industrial facilities, small package treatment plants, and large urban and industrial stormwater. Municipal point source waste pollution contributes 13 and 23 percent of nitrogen and phosphorus, respectively (Powell 1999).

In many areas, sea level rise, storm waves, and boat wakes will continue to generate erosive energy that will preclude natural reestablishment of shoreline marshes without restoration (USACE 2007, p. 19). Physical damage to the historic high profile oyster reefs have left many of them in contact with periodic deep water hypoxia (low dissolved oxygen) where they cannot naturally rebuild on their own. Reduced water clarity is expected to continue to limit the growth of SAV.

Federally Protected Species

Without efforts to improve water quality, freshwater mussel populations, both protected and more common species, will continue to decline. Future conditions may include more runoff of higher nutrient concentration and silt entering the basin as a result of increased agriculture and urbanization activities in the watershed. Many of the original riparian buffers and wetlands, which remove nutrients and siltation before runoff entered the waterways, have been lost. Some additional losses of this natural filtering capacity can be expected. These conditions which have contributed to the deterioration in mussel habitat due to an increase in siltation and nutrients, especially nitrogen, can be expected to continue and may become worst.

Fish species, both resident and anadromous species, are likely to experience a decline in habitat quality. The shortnose sturgeon, already listed as federally endangered, would continue to experience degradation of its habitat by erosion, siltation, toxic pollution, and dams that interfere with upstream migration to spawning areas. Other rare species may need to be listed in the future absent conservation efforts to address continuing threats to these species.

Summary of Future Fish and Wildlife Resources Without the Project

Overall, without efforts to control habitat degradation some segments of aquatic species in the basin are likely to experience suboptimal survival and reproductive success. The reduced access caused by waterway obstructions to spawning areas of anadromous fish is especially detrimental to the recovery of these species. Stream obstructions in the Neuse River have reduced the spawning area for these fish. A reduction in spawning area means fewer eggs produced and, therefore, fewer fish. Declines are expected to continue unless corrective measures are taken.

Stream obstructions can also prevent the colonization of new areas by freshwater mussels, including those with federal and/or state special status. A fish host carries the mussel larvae, or glochidia, attached to its gills or fins. The glochidia develop into juveniles on the host fish and later drop off to settle in a new area. Colonization of new area is prevented when the fish host is blocked from areas where adult mussels could survive.

SECTION 7 - ALTERNATIVES CONSIDERED

Freshwater Wetlands, Stream, and Riparian Buffer Restoration

Wetlands have been effectively drained throughout North Carolina for a variety of reasons including agriculture, forestry and urban development (USACE 2005, p. 19). These are important areas where water quality protection and habitat can be restored through a number of techniques including reestablishing streams in their historical floodplains, plugging ditches and removing fill material. Potential restoration sites would include prior converted farmlands, previously developed floodplains that have been evacuated after a Federal Emergency Management Agency (FEMA) buy out, and other degraded sites existing in the Neuse River watershed (USACE 2005, p. 19). Project activities could include removal of abandoned structures, hydrologic restoration, and revegetation with appropriate native wetland vegetation.

In order to develop preliminary alternatives for further evaluation, a screening process was developed to prioritize potential restoration sites (USACE 2007, p. 10). This screening process was coordinated with the internal and external Project Delivery Team members for consensus. The Ecosystem Ranking Criteria and additional screening and prioritization objectives were used to reflect the feasibility of implementing restoration projects in the study area, and were used to rank sites for further field investigation. The Ecosystem Ranking Criteria used in this evaluation process include habitat scarcity, connectivity, special status species, hydrologic character, geomorphic condition, plan recognition, and self-sustaining. Additional criteria used for the ranking of potential restoration sites in the basin include habitat degradation, stakeholder interest, impacts to adjacent projects, areas facing urban and suburban development, land availability, and absence of known Hazardous, Toxic, and Radioactive Wastes (HTRW) issues.

Alternative for wetland restoration and drainage ditch best management practices (BMP) will be identified using the screening criteria. The Peer Review Plan contains a report on the Initial Prioritization of Streams in the Neuse River Basin (Tetra Tech, Inc. 2007). Table 1 of that report contains a comparison of the Wilmington's District's objectives (e.g., habitat degradation, land availability, adjacent projects), the Corps' ecosystem ranking objectives (e.g., habitat scarcity, hydrologic character, connectivity, self-sustaining), and other indicators (e.g., Index of Biological Integrity, anadromous fish, Significant Natural Heritage Area, flood buyout).

One specific alternative is work at Gum Thicket Creek in Pamlico County (USACE 2008, pp. 4-5). This site has is an approved Preliminary Restoration Plan under Section 206 of the Flood Control Act of 1960, but has not been funded. Work at the site could include construction of protective rock sill, replacement of eroded estuarine substrate, and planting of appropriate marsh and riparian vegetation. Such restoration and/or creation can be designated as a "living shorelines" (USACE 2007, p. 22). Project plans expect that these "living shorelines would benefit the estuarine environment. Examples of the living shorelines that Wilmington District has constructed are: Roanoke Island Festival Park, Dare County, NC, Section 206 (constructed and monitored) and the Wanchese Marsh Creation and Protection, Dare County, NC, Section 204. These projects include construction of protective rock sills, replacement of eroded estuarine substrate, and planting of appropriate marsh and riparian vegetation. Since Gum Thicket Creek is located in the Neuse River Estuary, this project will be considered as a potential plan component for the Neuse River Basin project, unless 206 funds become available. It is expected that similar restoration efforts would benefit other area of the Neuse estuarine shoreline.

Stream restoration projects may include preservation or restoration or a combination of the two. Stream restoration projects may consist of constructing natural meanders in the stream channel and planting vegetation on the stream banks to promote the natural stability of the stream ecosystem. Work may be directed at the restoration of hydrology in wetlands that have been effectively drained for agriculture, forestry or development. Hydrology restoration could include reestablishing streams in their historical floodplains, plugging ditches and removing fill material. Base aerial photograph was used to assess shoreline erosion status, and estuarine marsh conditions to identify opportunities for restoration, prioritize restoration sites and serve as a baseline to assess the benefits of any restoration efforts.

Corps planning has considered the selection and preservation of ecologically or otherwise identified impacted lands within the Neuse River Basin (USACE 2007, p. 12). Large expanses of the Neuse Basin are relatively pristine and should be protected from future development. The Triangle Land Conservancy (TLC) is actively working to protect 4,068 acres in the Neuse Lowlands. Preservation could be by means of a conservation easement or acquisition (USACE 2008, p. 4).

Anadromous Fish Habitat Restoration

As noted previously, the Corps and the North Carolina Division of Water Resources are conducting a study to identify all aquatic obstructions within the State of North Carolina (USACE 2008, p. 6). Using data from NC Wildlife Resources Commission, Paddlers' Guide in North Carolina, and the Division of Land Resources (State Dam Safety Program), about 26 obstructions within the Neuse River Basin have been identified for further evaluation. The database should be very useful in future work to increase anadromous fish habitat.

Estuarine Resource Restoration

The estuarine restoration efforts could include: (1) wetland restoration; (2) Best Management Practices (BMP) in shoreline drainage ditches; (3) marsh planting; (4) planting submerged aquatic vegetation (SAV); (5) construction of new oyster sanctuary reefs; and/or (6) rebuilding of damaged oyster reefs (USACE 2008. p. 7). Oyster restoration plans will be developed based on geospatial analysis of biological and physical data as well as water quality data from updates of existing models. Water quality predictions and other physical descriptors as described above will be used to calculate a Habitat Suitability Index (HSI) predicting the potential for establishment of sustainable oyster reefs at a given site. Opportunities for SAV, marsh and shoreline restoration will be identified from North Carolina SAV Working Group SAV maps. These data will be compared to previous NC DWQ assessments to establish potential work areas.

SECTION 8 – EVALUATION OF ALTERNATIVES AND SELECTION OF THE PREFERRED ALTERNATIVE

Freshwater Wetlands, Stream, and Riparian Buffer Restoration

The screening procedure employed by Tetra Tech, Inc. would be considered in the selection of the sites for work (Tetra Tech 2007). Recent information indicates that the scoring system and Geographic information system (GIS) data have identified about 18 candidate sites for further evaluation including an array of stream restoration, wetland creation, bank stabilization, best management practices, and preservation plans. Aside from the screening procedure, some locations in the Corps' Section 206 Program (Flood Plain Management Services Program) that have not been funded may be considered for the Neuse River Basin Project. From these 18 candidate sites, the Corps has selected four restoration sites: Ellerbe Creek in Durham, Swift Creek in Craven County, Gum Thicket Creek in Pamlico County, and the City of Kinston restoration projects (USACE 2008, p. 5).

Anadromous Fish Habitat Restoration

Since the goal of this project component is to open up as much potential anadromous fish habitat as possible, a major criterion for the selection of sites would be the amount of habitat opened up. To this end, the Anadromous Fish Habitat Restoration Study Group will develop a process (i.e., criteria system) to prioritize or rank these obstructions for possible removal or modifications (USACE 2007, p. 17). Once the study group has developed a ranking system for these aquatic obstructions, the ranking system will be coordinated with all members of the Project Delivery Team, public, and review agencies. Prior to any aquatic obstruction removals or modifications the following steps would be completed:

1. New water levels will be determined using HEC-RAS and coordinated with FEMA, Environmental Protection Agency, Region IV and the State of North Carolina. This is to ensure that the proposed removal would not cause any adjacent or downstream impacts to the land owners;

2. Sediment testing upstream and downstream of the impoundments must be completed. The proposed removal must not discharge any heavy metals or other pollutants downstream; and,

3. Appropriate safety, cultural and environmental clearances would be completed.

As noted previously, the Service's ranking for these projects with one being the highest priority would be: (1) Millburnie Dam; (2) City of Goldsboro Dam; (3) Kelly's Pond; (4) Lassiter Dam; and, (5) the dam on Contentnea Creek.

Estuarine Resource Restoration

The Corps will evaluate data to determine the oyster restoration component of the project (USACE 2007, p. 29). A survey will be conducted as a component of the Neuse River Basin Feasibility study that will locate, map, and quantify the occurrence of both live and non-viable oyster reefs based on the investigation of 139 points collected from various sources including North Carolina Division of Marine Fisheries, local fishermen, and U. S. Geological Survey charts. Bottom habitat mapping of both live and non-viable reefs will also be conducted. High profile oyster reefs are a persistent feature in the Neuse Estuary having been recorded on bathymetric charts by the U.S. Coast Guard and Geodetic survey as far back as 1868. An ongoing study funded by North Carolina Sea Grant will rectify the location of several historic Neuse estuary reefs identified on various bathymetric maps, survey the current extent, and verify the presence of live oyster using a scallop dredge.

SECTION 9 – PREFERRED ALTERNATIVE

Wetlands, Streams, and Riparian Buffers

The latest planning information that this component of the project will focus on: (1) Ellerbe Creek in Durham; (2) Swift Creek in Craven County; (3) Gum Thicket Creek in Pamlico County; and, (4) the City of Kinston restoration projects. The level of information on actual work varies among these sites.

Ellerbe Creek is located in the Neuse River Subbasin 01. Point source dischargers contribute to severe water quality problems in Ellerbe Creek. Ellerbe Creek is also severely impacted by urban runoff. Ellerbe Creek exhibits consistently high specific conductance, nirate+nitrite - N levels, and fecal coliform. Primary influences were likely John Umstead Hospital Waste Water Treatment Plant (WWTP) and the Northern Durham Water Reclamation Facility. Ellerbe Creek, located downstream of the Durham WWTP has been designated by the NCDENR as a 303(d) stream. North Carolina is required by the Federal Clean Water Act to maintain a list of stream segments that do not meet water quality standards. This list is called the 303(d) List because of the section of the Clean Water Act that makes the requirement. Potential actions at Ellerbe Creek include: (1) the construction of off-site stormwater/sedimentation basins; (2) planting of trees for canopy/shade; (3) instream habitat creation (i.e., boulder clusters and construct riffles and pools, etc.); (4) stream restoration (i.e., meanders, channel benches, etc.); and, (5) purchase/revegetation as needed of riparian buffer areas.

Swift Creek is located in the Neuse River Subbasin 09 (Pitt and Craven Counties). Swift Creek had a Good-Fair benthos rating in 1991, but only a Fair rating in 1995 and 2000. Additionally, the lower site on Swift Creek (near Askin) is more prone to phytoplankton blooms and low dissolved oxygen concentrations. Other research (Kuenzler, et al 1977) has shown that channelized streams in this catchment export large amounts of nitrogen and phosphorus to downstream systems. Diatom blooms were recorded in lower Swift Creek in 1997 and 1998. Clayroot Swamp is functioning as an agricultural drainage ditch. Habitat problems include a lack of bends, no canopy, uniform sandy runs, very little stream habitat, no riffles or pools, and poor riparian buffer on one bank. Potential actions include: (1) construction of off-site stormwater/sedimentation basins, (2) planting of trees for canopy/shade; (3) instream habitat creation (i.e., boulder clusters and construct riffles and pools, etc.); and, purchase/revegetation as needed of riparian buffers.

No specific information is available on the restoration projects in Kinston. However, the work may involve tributaries to the Neuse River.

Work at Gum Thicket Creek may include construction of protective rock sill, replacement of eroded estuarine substrate, and planting of appropriate marsh and riparian vegetation. The work would seek to establish a "living shoreline" where salt marsh vegetation is established landward of a low rock sill.

Anadromous Fish Habitat Restoration

The Corps is now proposing to modify and/or remove the following five sites: (1) Millburnie Dam in Wake County; (2) Lassiter Dam in Raleigh; (3) City of Goldsboro Dam on the Little River; (4) Dam on Contentnea Creek in Wilson County; and, (5) Kellys Pond Mill on the Southwest Creek (USACE 2008, p. 6). Current plans state that the project would "modify and/or remove" these structures.

Estuarine Resource Restoration

A survey will be conducted as a component of the Neuse River Basin Feasibility study that will locate, map, and quantify the occurrence of both live and non-viable oyster reefs based on the investigation of 139 points collected from various sources including NCDMF, local fishermen, and USGS charts (USACE 2007, p. 29). Bottom habitat mapping of both live and non-viable reefs will also be conducted. High profile oyster reefs are a persistent feature in the Neuse Estuary.

SECTION 10 - IMPACTS OF THE PREFERRED ALTERNATIVE

Wetlands, Streams, and Riparian Buffers

In general, wetland and stream restoration may cause short-term adverse impacts such as increased turbidity. However, the overall long-term benefits generally far out weigh the brief problems caused during the actual work.

The construction of low rock sill should be planned with great care. Since these structures cover estuarine bottoms, the presence of submerged aquatic vegetation (SAV) in the area should be assessed. Even effort should be made to avoid placing the sill on existing SAV or potential SAV habitat. Even without SAV, these structures result in a loss of shallow estuarine bottoms. The planning process should discuss the balance between the benefits to be derived from creating a "living shoreline" and the permanent loss of estuarine bottoms.

Anadromous Fish Habitat Restoration

The restoration of anadromous fish habitat by modifying or removing obstructions to fish passage has tremendous benefits for this resource. However, careful planning should be undertaken if long-standing dams are to be removed. Such removal has the potential released accumulated sediment that can be harmful to downstream organisms.

Estuarine Resource Restoration

There are few, if any, significant adverse impacts associated with the construction of oyster reef sanctuaries. As with the construction of low rock sills, such construction should not be harmful to SAV or potential SAV sites, if properly designed and located.

SECTION 12 – CONSERVATION MEASURES

Overall, the proposed work will benefit fish and wildlife resources in the Neuse River Basin. Conservation measures for the project are mainly directed at maximizing these benefits and employing resources in the most advantageous manner.

Wetlands, Streams, and Riparian Buffers

The limited funds available for this aspect of the project should be directed to wetlands and streams that provide habitat to the most significant fish and wildlife resources. While project planning has employed a process of prioritization for work sites, it is unclear whether this process fully considered several factors important to the Service and was fully integrated with the stream and wetland work of the North Carolina Ecosystem Enhancement Program (NCEEP).

A major priority of the Raleigh Field Office is the conservation of federally listed mussels. In this regard, the greatest conservation benefit within the Neuse River Basin would be improving habitat for the dwarf wedgemussel and the Tar River spinymussel. These species have a limited range within Swift Creek, Middle Creek, and the Little River of Wake and Johnston Counties.

The conservation benefits of the project would also be enhanced by greater consideration of the "priority areas for habitat restoration" identified in the North Carolina Wildlife Action Plan for the Neuse River Basin (NCWRC 2005, p. 378). The nine priority areas are based on the work of the North Carolina Natural Heritage Program, data of the NCWRC, and the Nature Conservancy biodiversity assessment of the Southeastern United States (Smith et al. 2002). Some of the nine areas are the same or similar to those where federally listed mussels occur, or have historically occurred, such as Middle Creek, Moccasin Creek, Turkey Creek, and the Middle Neuse River and tributaries. However, the four stream and wetland areas identified in the current Scope of Work (USACE 2008, p. 5) are not considered priority areas by the NCWRC.

The NCEEP uses a watershed approach to determine priority areas for implementation of stream and wetland mitigation projects. The broad outline of the NCEEP process for determining watersheds for stream and wetland projects is available at (< http://www.nceep.net > under the heading of "Determining Priority Watershed for Stream and Wetland Projects). Within the web sites of the NCEEP, there is a listing of specific watersheds that exhibit both the need and opportunity for wetland, stream, and riparian buffer restoration < http://www.nceep.net/services/restplans/neuse_2003.pdf >. The listing is dated November 2002 and was developed by the former Wetland Restoration Program. This 2002 listing does mention Ellerbe Creek (Subbasin 01) and Swift Creek (Subbasin 09). While Kinston (Subbasin 05) appears to be in a targeted watershed, it is unclear which stream or streams would be affected by the proposed "City of Kinston restoration projects." However, the NCEEP is currently updating the procedures for selecting "Targeted Local Watersheds" and writing the associated "River Basin Restoration Priorities." Therefore, it is not clear how the proposed restoration work has been coordinated with the most recent plans of the NCEEP.

The conservation benefits of the Corps' project would be greatly enhanced by focusing restoration efforts on the most sensitive areas. The greatest priority should be areas that would benefit extant mussel populations or those areas that were occupied in the recent past and may be suitable for reestablishing these species. Another priority would be the areas identified in the North Carolina Wildlife Action Plan (NCWRC 2005, p. 378). All considerations of work sites should incorporation the restoration efforts of the NCEEP in order to avoid a duplication of effort and work to fill gaps where the NCEEP is not proposing work in an area of high value to fish and wildlife resources.

The 11 potential benefits given in the project Scope of Work (USACE 2008, p. 5) would significantly improve habitat quality for both aquatic and some terrestrial species. A useful source of information in planning this work is the collaborative effort by 15 federal agencies, including the Corps of Engineers, entitled "Stream Corridor Restoration" (Federal Interagency Stream Corridor Restoration Working Group [hereafter FISCRWG] 2001). This document is available online at < http://www.nrcs.usda.gov/technical/stream_restoration/newtofc.htm >.

The first step in the planning process should be an assessment of any problems associated with water quality and/or stream geomorphology. The planning process should address the broader range of system-wide, or watershed level, problems which may be degrading the streams of the project area. The planning process should be based on a detailed watershed map which includes streams, riparian buffers, floodplains, public and/or protected lands, greenway trails (existing and proposed), developed land, land where development site plans are already approved, and undeveloped land.

The planning process should consider limitations on the amount of impervious surface within the drainage area of each impaired stream. The Corps should work with the local sponsor to reduce the extent of impervious surface within the watershed.

Stream restoration work should consider that natural stream may be characterized as having: (1) greater sinuosity than channelized streams; (2) diverse instream habitats including coarse woody debris, undercut banks and root mats, macrophytes and leaf packs; (3) frequent pools of varied depths; (4) stable vegetated banks which provides shade; and, (5) more stable flows than channelized streams during periods of low precipitation (NCDENR 2006, p. 152). This project should seek to reestablish these characteristics in stream that have been adversely impacted.

Restoring wetland plant communities should seek to establish the vegetation that would naturally occur on the site. The planning process should determine a target community for the site. The target community could be selected from the list given by Schafale and Weakley (1990) which includes the natural plants in communities such as piedmont/mountain swamp forest, nonriverine swamp forests, wet pine flatwoods, and salt marsh. Once the target community has been established, the need for planting can be determined if no natural seed source is available in adjacent areas. If planting is necessary, the species should be selected based on the dominant plants of that community and plants should come from a genetic stock characteristic of the local area.

The Service supports the use of low sills as an alternative to bulkheads for shoreline stabilization. However, sills should be designed to allow adequate water exchange. Rogers and Skrabel (2001, p. 21) note that it is necessary to allow trapped water to return to open water without causing excessive localized currents around the structure. Estuarine marshes depend on regular flooding for nutrients and to carry away sediment and pollutants. To facilitate this exchange sills are designed to be porous with water flowing between the stones or through gaps in the structure.

Restoration work should include a plan to monitor the performance of the restored area. Many of the basic aspects of monitoring stream corridor restoration are available (FISRWG 2001, Chapter 9). The monitoring program may include performance evaluation, trend assessment, risk assessment, and/or baseline characterization.

Anadromous Fish Habitat Restoration

The Service support efforts to increase access of anadromous fish to their historic spawning areas. While dam removal is the best method to restore habitat, other methods such as using rock arch weirs, fish bypasses, roughened channels, and conventional fish ladders can be useful.

The potential for sediment contamination should be determined with a tiered contaminant evaluation conducted by an agency contaminants expert prior to removing any dam. The decision on whether or not a dam should be removed will hinge, in part, on either the lack of contaminant risk or the ability to effectively manage that risk. Dam demolition should be staged so that the initial portion removed directs flow into the main channel downstream and away from the banks. This staging of demolition is intended to avoid bank erosion and repositioning of the stream channel. The demolition of the rest of the dam should wait until after the head pond is dewatered. In the case of breached dams with no or minimal headpond staging a tiered evaluation for contaminants may be unnecessary. Contaminant evaluation is also unnecessary for fish ladders or rock arch weirs.

Estuarine Resource Restoration

Oysters are a key component of a healthy estuary and oyster reef restoration is a laudable goal. However, as stated in the study, restoration needs to proceed at a scale that is large enough to be meaningful.

SECTION 12 - RECOMMENDATIONS

In accordance with the FWCA, the Service offers the following recommendations in order to avoid, minimize, and mitigate adverse impacts on fish and wildlife resources. These brief recommendations are based on all the information presented and analyzed in the preceding sections of this report. These recommendations should not be considered without a thorough understanding of the entire report, specifically the conservation measures presented in the preceding section.

Wetlands, Streams, and Riparian Buffers

1. The selection of sites should provide the greatest possible benefits to federally listed species and other aquatic species that have experienced population declines and loss of habitat. The site selection process should:

a. Consider the known ranges of the dwarf wedgemussel and Tar River spinymussel as well as areas where these species occurred in the recent past (and potential reestablishment sites) in the selection of areas for wetland and stream restoration and/or enhancement.

b. Consider the sites identified by the NCWRC as priority areas for freshwater conservation in the Neuse River Basin (NCWRC 2005, p. 378) in the selection of areas for wetland and stream restoration and/or enhancement. Consider benefits to the priority fish, mussels, crayfish, and snails identified by the NCWRC in the Neuse River Basin (NCWRC 2005, p. 374-375). Those locations where the NCWRC priority areas included federally endangered mussels should receive the highest priority for the work of this project.

c. Coordinate the wetland and stream restoration and/or enhancement undertaken by this project with the Targeted Local Watersheds designated by the North Carolina Ecosystem Enhancement Program (NCEEP) in the Neuse River Basin. This coordination should seek to complement of the work of the NCEEP and avoid any duplication of effort.

d. Provide a clear explanation for the selection of each site for wetland and stream restoration and/or enhancement with a discussion of the extent to which the site would benefit federally listed mussels and other priority aquatic species (NCWRC 2005, p. 374-375). The factors leading to a selected site that would not benefits these priority species of Service and the NCWRC should be identified and discussed.

2. With regard to any wetlands restoration work, the Service recommends:

a. Each wetland restoration site should be planned with a definite target community as a goal. A description of the natural communities of North Carolina is provided by Schafale and Weakley (1990).

b. If planting is required the species should be selected to reflect those found in the natural climax, steady-state community to be established on the site. The genetic stock of the planted vegetation should match that which occurs in the project area. If the desired vegetation exists adjacent to the restoration site, natural recruitment can be used as part of the restoration effort;

3. With regard to stream restoration, the Service recommends:

a. The planning process should consider applicable material from the Stream Mitigation Guidelines (SMG) developed by Corps regulatory and other resource agencies in the State of North Carolina. These guidelines are available online at < http://www.saw.usace.army.mil/WETLANDS/Mitigation/stream_mitigation.html >. These guidelines note that project plan shall be designed to achieve the maximum level of improvement and should result in the restoration of the channel to its most probable natural state, given the individual constraints of the project location;

b. Additional guidance in planning and implementing stream corridor restoration can found in the document prepared by the Federal Interagency Stream Corridor Restoration Working Group. This document, entitled Stream Corridor Restoration - Principles, Processes, and Practices, was originally produced in 1998 and revised in 2001 and is available on the internet at < http://www.nrcs.usda.gov/technical/stream_restoration/newtofc.htm >; and,

c. In order to maintain the natural hydrology of a restored stream, the project should seek to reduce excessive runoff into the stream by protecting an adequate riparian corridor and/or limiting or reducing impervious surface in the watershed.

4. With regard to restoring natural estuarine shorelines and controlling shoreline erosion, the Service recommends:

a. The planning process should consider the excellent information given by Rogers and Skrabel (2001) in the North Carolina Sea Grant (NCSG) publication entitled "Managing Erosion on Estuarine Shorelines." Additional information on natural processes causing shoreline erosion and the efficacy of various control measures is provided in another NCSG publication entitled "Drowning the North Carolina Coast: Sea-level Rise and Estuarine Dynamics" (Riggs and Ames 2003).

b. If low rock sills are constructed, they should be kept at a low elevation, no more than six inches to a foot above normal high water, in order to allow storm-induced waves to pass over the top (Rogers and Skrabel 2001, p. 20). A low rock sill should be porous with water flowing between the stones or through gaps in the structure in order to prevent water from being trapped by the structure (Rogers and Skrabel 2001, p. 21). Water trapped landward of the structure should be able to return to open water without causing excessive local currents around the structure. The ends of the structure should be left open to allow additional water interchange and to avoid trapping larger fish (Rogers and Skrabel 2001, p. 21).

c. The construction of low rock sills should not result in a permanent loss of submerged aquatic vegetation (SAV). Such structure should only be constructed in areas which are not occupied by SAV or potential SAV areas. If such areas are covered by a low rock sill, compensatory mitigation should be provided.

5. For all restoration work, the Service recommends:

a. A monitoring program should be established for each restoration site. The program should extend long enough to confirm that the desired wetland hydrology, wetland vegetation, and/or stream properties are successful and self-sustaining.

b. Each restoration site should have an adaptive management strategy that could rectify failures in achieving the desired wetland hydrology, wetland vegetation, and/or stream properties. Adaptive management actions may include additional work to achieve wetland hydrology, additional work to replant desired vegetation or remove harmful undesirable vegetation, and/or additional work on stream channel design that fails to accommodate one or more bankfull events.

c. Each restoration site should be permanently protected against all activities which would reduction the water quality and habitat functions and values provided by the site. There should be a site-specific document which outlines future activities that will be permitted and those activities which are prohibited. In general, development and major alterations of vegetation should be prohibited. A specific agency or private organization should be designed to enforce the protection provisions in perpetuity, the same as measures employed for wetland and stream mitigation sites. Project planning should review the "Process for Preservation of Mitigation Property" employed by the Regulatory Division of the Wilmington District and available online at < http://www.saw.usace.army.mil/WETLANDS/Mitigation/preservation.html >. This process notes that "there are several preservation mechanisms applicants may propose to use to preserve mitigation property, including, in general order of preference, conservation easements, restrictive covenants, and conservation declaration of restrictions. Fee conveyance to an acceptable conservation organization may also be acceptable."

d. Final project plans should contain details of the financial arrangements, such as an endowment, that would ensure successful monitoring, management, and protection of each restoration site.

Anadromous Fish Habitat Restoration

6. Some dams that block anadromous fish from reaching historically important spawning habitat can not be removed. Although dam removal is the only sure way to allow fish to get past dams there are several other methods. These techniques in order of preference are listed below:

a. Full Rock Arch Weir with one foot or less vertical drop for every 20 feet of horizontal distance. This is the only option that solves the biggest problem in fish passage which is the fish finding and using the structure. Since a full rock arch weir uses the whole stream a fish merely needs to swim upstream to swim over the dam. Consequently this solution is much preferred over any of the remaining solutions. All of the remaining solutions listed below are only effective if they are well maintained whereas the full rock arch weir is a very low maintenance solution.

b. Fish bypass, basically a stream or channel around the dam with slow enough water velocity to accommodate all native fishes including anadromous species. Only full rock arch weirs and fish bypass are capable of passing all of the species of anadromous fish species that occur in North Carolina. The other two options below are only recommended when neither full arch weirs and fish bypass are not possible because of practical considerations and when the stream is smaller and would not be expected to support important spawning habitat for striped bass and sturgeon (smaller than a major tributary of the Neuse River). Examples of major tributaries to the Neuse River are Trent River, Little River, Contentnea Creek, Middle Creek, and Crabtree Creek. In some special cases such as Lassiter's Mill Dam on Crabtree Creek (a historical structure) the only available option may be the ones listed below and although not the best solution for fish may be the best solution for all things considered.

c. Roughened channel, a channel around the dam designed to have velocities that are appropriate for the target anadromous fish species (not recommended for sturgeon and striped bass), usually a shorter and higher velocity path than the fish bypass.

d. Conventional fish ladder such as a pool and weir or standard denil. These can be effective for shad and herring but are not very effective for striped bass and sturgeon.

7. In the piedmont, the transition from 3rd order to 2nd order stream should be used to estimate the upstream limit for fish passage. For the coastal plain where river herring are a priority, any sized stream is a candidate for fish passage because herring will spawn in intermittent streams, ditches and inundated swamps. Larger sized streams are a higher priority for fish passage and in many instances providing passage at large streams will allow access into many smaller streams as well and is likely the most effective method to accomplish that endpoint.

8. Dams considered for action in this plan have been prioritized using our input and the Service endorses that procedure. The Service prioritizes these projects with one being the highest priority as: (1) Millburnie Dam; (2) City of Goldsboro Dam; (3) Kelly's Pond Mill; (4) Lassiter Dam; and, (5) the dam on Contentnea Creek.

Estuarine Resource Restoration

In order to restore oyster as a key component of a health estuary on a meaningful scale, the Service recommends that the project:

9. Reduce cost and broaden the objectives of oyster restoration projects. Armoring sand mounds with marl and shell, as suggested in the study, is less costly than using shell alone.

10. Consider using oyster reefs to reduce shoreline erosion and to promote SAV colonization.

11. Try to incorporate oyster aquaculture (work with Sea Grant) into living shoreline erosion projects.

12. Conduct oyster reef restoration demonstration projects be done on how to mitigate the impacts of dredge disposal.

13. Determine the cost efficacy of using oysters to sequester carbon and nitrogen to see if it could receive funding for carbon offsets and nutrient reduction.

14. Look at techniques used in other countries to maximize yields of oysters using native stocks.

15. Consider the use of reef balls to establish oyster reefs and to provide breakwaters to reduce shoreline erosion.

16. Consider landscape architecture application of oyster reefs to enhance the natural utility of the reefs and to compliment the stability of navigational channels helping to offset the loss of a natural look that accompanies shoreline development.

17. Use a multidisciplinary approach (biology, water quality, climate change, aquaculture, academia, coastal developers).

18. Consider oyster reef restoration with the restoration of impoverished fish stocks.

19. Upgrade existing granite shoreline or sills by filling the voids in between granite pieces with marl and or shell to enhance colonization of oysters in areas that have the appropriate environmental prerequisites.

20. Calculate the potential ecosystem benefits in terms that the general public can understand and hopefully support.

21. Work with the North Carolina Division of Marine Fisheries and the National Marine Fisheries Service to see if a coordinated plan for oyster reef sanctuaries could be consistent with their agency mandates and how best to implement such an approach if it could be.

SECTION 13 – SUMMARY OF FINDINGS AND POSITION OF THE SERVICE

Overall, the goals of the proposed study would benefit fish and wildlife resources in the limited areas selected for work. Since the sites for on-the-ground work would be relatively small in comparison to the entire basin, these sites should be carefully selected to achieve the greatest benefits for anadromous fish, federally listed species, and those rare and/or endemic species which could become listed if current declines in habitat quality continue. The recommendations contained in the report would enhance the project. The position of the Service is strong support for this effort.

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SECTION 12 - RECOMMENDATIONS

In accordance with the FWCA, the Service offers the following recommendations in order to avoid, minimize, and mitigate adverse impacts on fish and wildlife resources. These brief recommendations are based on all the information presented and analyzed in the preceding sections of this report. These recommendations should not be considered without a thorough understanding of the entire report, specifically the conservation measures presented in the preceding section.

Wetlands, Streams, and Riparian Buffers

1. The selection of sites should provide the greatest possible benefits to federally listed species and other aquatic species that have experienced population declines and loss of habitat. The site selection process should:

a. Consider the known ranges of the dwarf wedgemussel and Tar River spinymussel as well as areas where these species occurred in the recent past (and potential reestablishment sites) in the selection of areas for wetland and stream restoration and/or enhancement.

b. Consider the sites identified by the NCWRC as priority areas for freshwater conservation in the Neuse River Basin (NCWRC 2005, p. 378) in the selection of areas for wetland and stream restoration and/or enhancement. Consider benefits to the priority fish, mussels, crayfish, and snails identified by the NCWRC in the Neuse River Basin (NCWRC 2005, p. 374-375). Those locations where the NCWRC priority areas included federally endangered mussels should receive the highest priority for the work of this project.

c. Coordinate the wetland and stream restoration and/or enhancement undertaken by this project with the Targeted Local Watersheds designated by the North Carolina Ecosystem Enhancement Program (NC EEP) in the Neuse River Basin. This coordination should seek to complement of the work of the NC EEP and avoid any duplication of effort.

d. Provide a clear explanation for the selection of each site for wetland and stream restoration and/or enhancement with a discussion of the extent to which the site would benefit federally listed mussels and other priority aquatic species (NCWRC 2005, p. 374-375). The factors leading to a selected site that would not benefits these priority species of Service and the NCWRC should be identified and discussed.

USACE Response: We agree. The selection of restoration sites considered the known ranges of the Federally listed dwarf wedgemussel and Tar River spinymussel, NCWRC priority areas as discussed in their 2005 Wildlife Action Plan, stream restoration work proposed and completed by NC EEP, and provided a clear explanation of the site election process. For example, the Anadromous Fish work group found dwarf wedgemussel and Tar River spinymussel habitat upstream of the existing Crantock Dam on Middle Creek and Goldsboro's low-head notched dam on the Little River. Representatives from the USFWS, NC State University, NCWRC, and the Corps visited Crabtree Creek, Middle Creek, Mill Creek, Little River and the main-stem of the Neuse River between Milburnie Dam and Falls Dam all considered by the NCWRC 2005 Wildlife Action Plan as priority areas. For the stream restoration sites, portions of Ellerbe Creek in Durham and Adkins Branch in Kinston were being restored by NC EEP. In the case of Ellerbe Creek, the Corps looked at working on a section of the creek that would connect two previously NC EEP restored areas. Lastly, we discussed in Sections 3 and 4 in the Feasibility Study how the Tentatively Selected Plan was arrived at and what steps we used in this process.

2. With regard to any wetlands restoration work, the Service recommends:

a. Each wetland restoration site should be planned with a definite target community as a goal. A description of the natural communities of North Carolina is provided by Schafale and Weakley (1990).

b. If planting is required the species should be selected to reflect those found in the natural climax, steady-state community to be established on the site. The genetic stock of the planted vegetation should match that which occurs in the project area. If the desired vegetation exists adjacent to the restoration site, natural recruitment can be used as part of the restoration effort;

USACE Response: The Gum Thicket and Cedar Creek shoreline restoration site is planned to be restored as Salt Marsh community, which is described in Schafale and Weakley (1990). The lower zone along the eroded shoreline may be planted in smooth cordgrass (*Spartina alterniflora*) and the higher zones could be planted in black needle rush (*Juncus roemerianus*), giant cordgrass (*Spartina cynosuroides*), and salt meadow hay (*Spartina patens*). The proposed planted marsh species would reflect the genetic stock of the project area as we did at the Festival Park and Wanchese Marsh restoration projects. Currently, the Corps is in the very early stages of formulating and designing these restoration projects in the Neuse River basin study. We will continue to coordinate any wetland restoration work with all State and Federal agencies during the final planning, design, and construction of these sites.

3. With regard to stream restoration, the Service recommends:

a. The planning process should consider applicable material from the Stream Mitigation Guidelines (SMG) developed by Corps regulatory and other resource agencies in the State of North Carolina. These guidelines are available online at < http://www.saw.usace.army.mil/WETLANDS/Mitigation/stream_mitigation.html >. These guidelines note that project plan shall be designed to achieve the maximum level of improvement and should result in the restoration of the channel to its most probable natural state, given the individual constraints of the project location;

b. Additional guidance in planning and implementing stream corridor restoration can found in the document prepared by the Federal Interagency Stream Corridor Restoration Working Group. This document, entitled Stream Corridor Restoration - Principles, Processes, and Practices, was originally produced in 1998 and revised in 2001 and is available on the internet at < http://www.nrcs.usda.gov/technical/stream_restoration/newtofc.htm >; and,

c. In order to maintain the natural hydrology of a restored stream, the project should seek to reduce excessive runoff into the stream by protecting an adequate riparian corridor and/or limiting or reducing impervious surface in the watershed.

USACE Response: Dduring the planning process for the stream restoration sites both of these referenced Regulatory and USDA websites were used. However, as indicated in Section 3 and 4 of the feasibility study, the very high cost of stream restoration (i.e., land costs, utility relocation costs, etc.) versus benefits accrued, at this time none of the stream restoration sites were selected in the Tentatively Selected Plan.

4. With regard to restoring natural estuarine shorelines and controlling shoreline erosion, the Service recommends:

a. The planning process should consider the excellent information given by Rogers and Skrabel (2001) in the North Carolina Sea Grant (NCSG) publication entitled "Managing Erosion on Estuarine Shorelines." Additional information on natural processes causing shoreline erosion and the efficacy of various control measures is provided in another NCSG publication entitled "Drowning the North Carolina Coast: Sea-level Rise and Estuarine Dynamics" (Riggs and Ames 2003).

b. If low rock sills are constructed, they should be kept at a low elevation, no more than six inches to a foot above normal high water, in order to allow storm-induced waves to pass over the top (Rogers and Skrabel 2001, p. 20). A low rock sill should be porous with water flowing between the stones or through gaps in the structure in order to prevent water from being trapped by the structure (Rogers and Skrabel 2001, p. 21). Water trapped landward of the structure should be able to return to open water without causing excessive local currents around the structure. The ends of the structure should be left open to allow additional water interchange and to avoid trapping larger fish (Rogers and Skrabel 2001, p. 21).

c. The construction of low rock sills should not result in a permanent loss of submerged aquatic vegetation (SAV). Such structure should only be constructed in areas which are not occupied by SAV or potential SAV areas. If such areas are covered by a low rock sill, compensatory mitigation should be provided.

USACE Response: We agree. The Corps is familiar with the information found within the NCSG publication entitled "Managing Erosion on Estuarine Shorelines" by Rogers and Skrabel (2001). Both the existing Festival Park and Wanchese Marsh in Dare County, North Carolina restoration areas relied heavily of this document. In fact, Ms. Skrabel helped plant marsh at the Festival Park wetland restoration site. The overall Gum Thicket and Cedar Creek restoration plan to install an offshore rock sill, plant marsh, and provide additional oyster habitat is in its initial planning phase. During the final planning and design process, we will continue to coordinate construction plans with the USFWS, NMFS, NC DCM, NCWRC, NCDWQ, and other State/Federal agencies. The Corps will ensure that the design (height, openings, and location) of the offshore rock sill is consistent with Rogers and Skrabel (2001). Additionally, we will make sure that the shoreline stabilization of Gum Thicket and Cedar Creek will not adversely affect SAV's in the Neuse River estuary.

5. For all restoration work, the Service recommends:

a. A monitoring program should be established for each restoration site. The program should extend long enough to confirm that the desired wetland hydrology, wetland vegetation, and/or stream properties are successful and self-sustaining.

b. Each restoration site should have an adaptive management strategy that could rectify failures in achieving the desired wetland hydrology, wetland vegetation, and/or stream properties. Adaptive management actions may include additional work to achieve wetland hydrology, additional work to replant desired vegetation or remove harmful undesirable vegetation, and/or additional work on stream channel design that fails to accommodate one or more bankfull events.

c. Each restoration site should be permanently protected against all activities which would reduction the water quality and habitat functions and values provided by the site. There should be a site-specific document which outlines future activities that will be permitted and those activities which are prohibited. In general, development and major alterations of vegetation should be prohibited. A specific agency or private organization should be designed to enforce the protection provisions in perpetuity, the same as measures employed for wetland and stream mitigation sites. Project planning should review the "Process for Preservation of Mitigation Property" employed by the Regulatory Division of the Wilmington District and available online at < http://www.saw.usace.army.mil/WETLANDS/Mitigation/preservation.html >. This process notes that "there are several preservation mechanisms applicants may propose to use to preserve mitigation property, including, in general order of preference, conservation easements, restrictive covenants, and conservation declaration of restrictions. Fee conveyance to an acceptable conservation organization may also be acceptable."

d. Final project plans should contain details of the financial arrangements, such as an endowment, that would ensure successful monitoring, management, and protection of each restoration site.

USACE Response: Currently, the Corps is in the initial planning process for all of the restoration sites selected. We will continue to work with the State and Federal agencies during the final planning, design, and construction process to ensure that these restoration sites have the required monitoring plans and/or adaptive management strategies. Moreover we will ensure that these sites are protected by permanent easements to guarantee that they function for the life of the project.

Anadromous Fish Habitat Restoration

6. Some dams that block anadromous fish from reaching historically important spawning habitat can not be removed. Although dam removal is the only sure way to allow fish to get past dams there are several other methods. These techniques in order of preference are listed below:

a. Full Rock Arch Weir with one foot or less vertical drop for every 20 feet of horizontal distance. This is the only option that solves the biggest problem in fish passage which is the fish finding and using the structure. Since a full rock arch weir uses the whole stream a fish merely needs to swim upstream to swim over the dam. Consequently this solution is <u>much preferred</u> over any of the remaining solutions. All of the remaining solutions listed below are only effective if they are well maintained whereas the full rock arch weir is a very low maintenance solution.

b. Fish bypass, basically a stream or channel around the dam with slow enough water velocity to accommodate all native fishes including anadromous species. Only full rock arch weirs and fish bypass are capable of passing all of the species of anadromous fish species that occur in North Carolina. The other two options below are only recommended when neither full arch weirs and fish bypass are not possible because of practical considerations and when the stream is smaller and would not be expected to support important spawning habitat for striped bass and sturgeon (smaller than a major tributary of the Neuse River). Examples of major tributaries to the Neuse River are Trent River, Little River, Contentnea Creek, Middle Creek, and Crabtree Creek. In some special cases such as Lassiter's Mill Dam on Crabtree Creek (a historical structure) the only available option may be the ones listed below and although not the best solution for fish may be the best solution for all things considered.

c. Roughened channel, a channel around the dam designed to have velocities that are appropriate for the target anadromous fish species (not recommended for sturgeon and striped bass), usually a shorter and higher velocity path than the fish bypass.

d. Conventional fish ladder such as a pool and weir or standard denil. These can be effective for shad and herring but are not very effective for striped bass and sturgeon.

USACE Response: We understand that there are a number of alternatives in providing fish passage around dam structures. we have looked at several of these options in the Neuse River basin. As you indicated, we are currently looking at a fish ladder at the Lassiter's Mill Dam on Crabtree Creek. We will keep these options open.

7. In the piedmont, the transition from 3rd order to 2nd order stream should be used to estimate the upstream limit for fish passage. For the coastal plain where river herring are a priority, any sized stream is a candidate for fish passage because herring will spawn in intermittent streams,

ditches and inundated swamps. Larger sized streams are a higher priority for fish passage and in many instances providing passage at large streams will allow access into many smaller streams as well and is likely the most effective method to accomplish that endpoint.

USACE Response: The Corps understands that removing blockages to fish passage on larger streams would provide access into many smaller streams. We have worked closely with Dr. Joe Hightower, NC State University and his graduate students (Ms. Summer Burclick and Mr. Joshua Raabe), Mike Wicker, USFWS, and representatives from the NC Wildlife Resources Commission looking at which tributaries of the Neuse River basin provide the best habitat for anadromous fish. Dr. Hightower and his graduate students have indicated that streams flows (maybe above 500 cfs) and bottom sediment characteristics are important features for anadromous fish habitat. Additionally, Ms. Summer Burclick stated that her research on the Neuse River indicated that Crabtree Creek, Swift and Middle Creeks, Mill Creek, and the Little River are important anadromous fish habitat. Contentnea Creek was sampled by Ms. Burclick but because of the bottom substrate (mud/silt), it did not appear to be acceptable habitat for anadromous fish.

8. Dams considered for action in this plan have been prioritized using our input and the Service endorses that procedure. The Service prioritizes these projects with one being the highest priority as: (1) Millburnie Dam; (2) City of Goldsboro Dam; (3) Kelly's Pond Mill; (4) Lassiter Dam; and, (5) the dam on Contentnea Creek.

USACE Response: The Corps agrees with the Services prioritization of these dam removal projects. However, as you are aware the Millburnie Dam's property owner has decided to use the dam as a mitigation bank and is pursuing the necessary authorizations to accomplish this. The City of Goldsboro's low-head notched dam has been chosen to be within the Tentatively Selected Plan. The landowner at Kelly's Pond has decided to restore the collapsed portion of the dam and adjacent dike. The proposed fish ladder at Lassiter Dam on Crabtree Creek was not chosen since Dr. Tom Augspurger, USFWS indicated that the PCB's were found in sediment upstream of the dam. Lastly the dam upstream of the City of Wilson's water supply dam (Wiggins Mill dam) on Contentnea Creek, did not provide habitat for the Federally listed dwarf wedgemussel or anadromous fish. Additionally, this dam on Contentnea Creek was partially collapsed and did provide the resident fish populations with access up and downstream of this site.

<u>Estuarine Resource Restoration</u>

In order to restore oyster as a key component of a health estuary on a meaningful scale, the Service recommends that the project:

9. Reduce cost and broaden the objectives of oyster restoration projects. Armoring sand mounds with marl and shell, as suggested in the study, is less costly than using shell alone.

USACE Response: We agree. Proposed plans were formulated using rock mounds top dressed with shell cultch. During value engineering investigations use of sand as a core fill material was recommended. Detailed plans will be developed during PED. This action would reduce cost without additional impacts. We are currently investigating use of sheet pile to ensure sand containment for Manteo 204, if found feasible this could further reduce rock requirements and associated cost and footprint without reducing the reef top area.

10. Consider using oyster reefs to reduce shoreline erosion and to promote SAV colonization.

USACE Response: Oyster reefs alone would not provide needed shore protection; however, oyster reefs were incorporated into the rock sill plan along the eroded shoreline of Gum Thicket and Cedar Creek. We believe that the open water area, located between the offshore rock sill and the planted marsh would provide the necessary quiet/still water for SAV colonization.

11. Try to incorporate oyster aquaculture (work with Sea Grant) into living shoreline erosion projects.

USACE Response: We agree. If natural spat set does not occur at any of the oyster reef projects or along the eroded shorelines of Gum Thicket and Cedar Creek, our adaptive management plan would be to seed "spat on shell" from aquaculture practices.

12. Conduct oyster reef restoration demonstration projects be done on how to mitigate the impacts of dredge disposal.

USACE Response: The Corps is not planning to accomplish this measure within the Neuse River Basin Feasibility Study. However, this proposal is being investigated for the proposed Manteo Section 204 beneficial use of dredge material project. Any cost savings or improved habitat findings may be incorporated into the Neuse Basin Feasibility Study.

13. Determine the cost efficacy of using oysters to sequester carbon and nitrogen to see if it could receive funding for carbon offsets and nutrient reduction.

USACE Response: This recommendation is considered to beyond the scope of the Neuse River Basin Feasibility Study. However, the Corps will discuss this comment with the NC Oyster Restoration Steering Committee (NC ORSC).

14. Look at techniques used in other countries to maximize yields of oysters using native stocks.

USACE Response: Again this recommendation is considered to beyond the scope of the Neuse River Basin Feasibility Study, but this comment will be raised to the NC ORSC, (for their consideration).

15. Consider the use of reef balls to establish oyster reefs and to provide breakwaters to reduce shoreline erosion.

USACE Response: The Corps decided not to use reef balls to either establish oyster reefs or to provide breakwaters to reduce shoreline erosion. We believe that either sand/rock mounds seeded with oyster clutch or offshore rock sills would be more reliable construction technique.

16. Consider landscape architecture application of oyster reefs to enhance the natural utility of the reefs and to compliment the stability of navigational channels helping to offset the loss of a natural look that accompanies shoreline development.

USACE Response: The use of matrix of reefs rather than one large structure will expand the shoreline length and the service area increasing habitat output. A totally submerged structure at Gum Thicket and Cedar Creek would not provide the needed shoreline protection and is not proposed. Moreover, within the Neuse River Feasibility Study, stabilization of navigation channels is not proposed.

17. Use a multidisciplinary approach (biology, water quality, climate change, aquaculture, academia, coastal developers).

USACE Response: We agree. This multidisciplinary approach was used in all of the work groups (i.e., Anadromous Fish, Oyster Reef, and Stream Restoration). For example, the oyster model was developed by a multidisciplinary team and considered, water quality, reef structure and biological factors. The NC ORSC served as the Estuarine Work Group and allowed input from academia, state fishery managers, NGO's, and fishermen.

18. Consider oyster reef restoration with the restoration of impoverished fish stocks.

USACE Response: The Corps did consider contributions of oyster reef restoration to fishery resources. We understand that the proposed oyster reef restoration will provide habitat for fishery resources in the Neuse River basin.

19. Upgrade existing granite shoreline or sills by filling the voids in between granite pieces with marl and or shell to enhance colonization of oysters in areas that have the appropriate environmental prerequisites.

USACE Response: Oyster reefs were incorporated along the outside toe of the Gum Thicket and Cedar Creek offshore rock sill. The filling of voids is not proposed since the voids serve to disperse wave energy and are required for the needed level of shore protection. The voids also provide fish habitat.

20. Calculate the potential ecosystem benefits in terms that the general public can understand and hopefully support.

USACE Response: The Corps agrees with this recommendation. The Environmental Benefits Analysis is found in Section 4 of the Feasibility Study and clearly describes the ecosystem benefits of the selected plan. For example, the benefits of oyster reef sanctuaries were calculated based on habitat quality and quantity and outputs presented in understandable narrative and quantified in terms of Functional Units.

21. Work with the North Carolina Division of Marine Fisheries and the National Marine Fisheries Service to see if a coordinated plan for oyster reef sanctuaries could be consistent with their agency mandates and how best to implement such an approach if it could be.

USACE Response: The Corps is working with NCDMF in collaboration with the NC ORSC to evaluate how proposed new reef placement recommended by this study and expansion of the existing Neuse sanctuary would contribute the sustainability of the existing NCDMF Albemarle Pamlico Oyster Sanctuary Program. Preliminary finding indicate the proposed sites would provide a useful contribution of larvae and are supported by the NCDMF and the NC ORSC.

Appendix I: Preliminary Screening

Table 1 Scoring System for Ecological Integrity Tier

Fish Community		
Average of IBI Ratings in HUC[1] Code Score		
Excellent	5	5
Good	4	4
Good/Fair	3	3
Fair	2	2
Poor	1	1
Not Evaluated	No Data	
No Data	No Data	
[1]The most recent observation was used for multiple observations at a single site.		
Benthic		
Average of Bioclass in HUC[2] Code Score		
Excellent	5	5
Good	4	4
Good/Fair	3	3
Fair/Not Impaired	2	2
Poor	1	1
Not Evaluated	No Data	
No Data	No Data	
[2]The most recent observation was used for multiple observations at a single site.		
Anadromous Fish		
Anadromous Fish Spawning Areas Code Score		
Intersects with spawning area	Yes	5
Does not intersect	No	1

Aquatic NHEO

Natural Heritage Element Occurrences - Aquatic Species[3]	Code	Score
At least 10 Existing Aquatic NHEOs	10 or More Existing	5
Contains under 10 Existing Aquatic NHEOs, but more existing than historic	Majority Existing	4
Contains more historic than existing aquatic NHEOs (max historic is 7 per HUC, basinwide)	Majority Extirpated	3
Contains wetland NHEOs but does not contain aquatic NHEOs	Wetland, No Aquatic	2
Contains upland NHEOs but does not contain aquatic or wetland NHEOs	Upland, No Aquatic or Wetland	1
Contains no NHEOs (assumed not surveyed) No Data	No Data	

[3]Based on "Type" field in Natural Heritage GIS data

NCGAP Wetlands

Proportion of Wetland Species Alliance[4] in HUC	Upper Limit	Score
Top 20%	69%	5
Mid-Upper 20%	26%	4
Middle 20%	14%	3
Mid-Lower 20%	9%	2
Lowest 20%	5%	1

[4] Includes all wetland species alliances, including maritime wetlands and wetlands designated as NCWRC priorities for NCEEP preservation.

Significant Natural Heritage Areas

Significance Level	Code	Score
Contains at least one SNHA of National Significance	National	5
Contains at least one SNHA of State Significance (no National)	State	4
Contains at least one SNHA of Regional Significance (no National or State)	Regional	3
Contains at least one SNHA of Local Significance (no National, State, or Regional)	Local	2
Does not contain an SNHA but has been considered/surveyed by NH program (NHEOs present)	No SNHA	1
Not surveyed	No Data	

NCGAP Priority Terrestrial - NCGAP Priority Terrestrial Species Alliances		
Proportion of Priority Land Cover[5] in HUC Upper Limit Score		
Top 20%	36%	5
Mid-Upper 20%	25%	4
Middle 20%	20%	3
Mid-Lower 20%	14%	2
Lowest 20%	10%	1
No priority land cover in HUC	0%	0

[5]Based on NCWRC priority habitats identified for NCEEP projects.

Table 2 Indicator Metrics by 14-Digit HUC

HUCODE	Ecological Integrity						
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial
03020105010010	No Data	No Data	No	Wetland, No Aquatic	54%	State	4%
03020105010020	No Data	No Data	No	No Data	25%	Regional	2%
03020105010030	No Data	No Data	No	No Data	24%	Regional	1%
03020105010040	No Data	No Data	Yes	No Data	43%	No Data	3%
03020105020010	No Data	No Data	No	Upland, No Aquatic or Wetland	36%	No SNHA	0%
03020105020020	No Data	No Data	No	Wetland, No Aquatic	41%	State	0%
03020105020030	No Data	No Data	No	Wetland, No Aquatic	51%	State	0%
03020105090012	No Data	No Data	No	No Data	0%	No Data	0%
03020106050010	No Data	No Data	No	Majority Existing	15%	National	0%
03020106050050	No Data	No Data	No	Majority Existing	53%	National	1%
03020106050060	No Data	No Data	No	No Data	0%	No Data	0%
03020106050070	No Data	No Data	No	Majority Extirpated	19%	National	0%
03020201010010	5.0	3.5	No	Majority Existing	2%	State	25%
03020201010020	4.0	3.3	No	10 or More Existing	2%	State	25%
03020201010030	No Data	4.0	No	10 or More Existing	2%	State	23%
03020201010040	5.0	4.0	No	10 or More Existing	3%	State	30%
03020201010050	No Data	2.0	No	Majority Existing	5%	State	21%
03020201020010	4.0	3.0	No	10 or More Existing	3%	State	26%
03020201020020	5.0	3.0	No	Majority Existing	2%	State	23%
03020201020030	No Data	3.5	No	Majority Existing	2%	State	29%
03020201020040	No Data	3.0	No	Majority Extirpated	6%	National	21%
03020201030010	No Data	No Data	No	Majority Existing	2%	National	22%
03020201030020	4.5	3.4	No	10 or More Existing	2%	National	23%
03020201030030	5.0	3.4	No	10 or More Existing	2%	National	29%
03020201030040	5.0	4.5	No	10 or More Existing	2%	National	19%
03020201030050	5.0	4.0	No	No Data	12%	National	16%
03020201040010	No Data	No Data	No	Upland, No Aquatic or Wetland	2%	Regional	25%
03020201040020	No Data	1.5	No	Majority Existing	9%	National	13%
03020201050010	1.0	1.5	No	Wetland, No Aquatic	9%	State	10%
03020201050020	No Data	1.0	No	Upland, No Aquatic or Wetland	6%	State	12%
03020201050030	No Data	2.0	No	Majority Existing	5%	State	16%
03020201050040	No Data	No Data	No	No Data	28%	No Data	1%
03020201060010	No Data	No Data	No	Wetland, No Aquatic	7%	National	14%
03020201060020	4.0	4.0	No	Majority Existing	7%	State	14%
03020201060030	No Data	No Data	No	Wetland, No Aquatic	34%	State	1%
03020201065010	3.0	3.7	No	No Data	3%	No Data	16%
03020201065020	No Data	3.0	No	No Data	2%	No Data	17%
03020201065030	2.0	3.0	No	Majority Existing	3%	State	16%
03020201065040	No Data	No Data	No	Wetland, No Aquatic	2%	No SNHA	14%
03020201065050	No Data	No Data	No	Majority Extirpated	4%	No SNHA	2%
03020201070060	4.0	3.0	No	No Data	3%	No Data	17%
03020201070070	5.0	2.0	No	Wetland, No Aquatic	4%	Regional	13%

HUCODE	Ecological Integrity						
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial
03020201070080	No Data	2.6	No	Majority Extirpated	13%	Regional	19%
03020201070090	No Data	No Data	No	Majority Extirpated	5%	Regional	12%
03020201070100	No Data	2.0	No	Upland, No Aquatic or Wetland	4%	No SNHA	16%
03020201070110	No Data	1.7	No	Majority Extirpated	3%	Regional	14%
03020201070120	No Data	3.0	No	No Data	7%	Regional	17%
03020201080010	No Data	1.5	No	Wetland, No Aquatic	4%	State	14%
03020201080020	4.5	1.9	No	10 or More Existing	2%	State	11%
03020201090010	2.8	1.4	No	Majority Existing	5%	Regional	14%
03020201100010	No Data	No Data	Yes	Upland, No Aquatic or Wetland	5%	No Data	10%
03020201100020	4.0	No Data	No	Majority Existing	6%	Local	13%
03020201100030	No Data	3.0	Yes	Majority Existing	5%	Regional	14%
03020201100040	No Data	No Data	No	No Data	4%	No Data	35%
03020201100050	No Data	2.7	Yes	Majority Existing	8%	Regional	36%
03020201110010	2.0	1.6	No	Majority Existing	4%	State	14%
03020201110020	No Data	No Data	No	No Data	6%	State	14%
03020201110030	2.0	2.8	No	10 or More Existing	10%	National	17%
03020201110040	No Data	No Data	No	Majority Existing	6%	National	15%
03020201110050	No Data	2.0	No	Majority Existing	6%	National	19%
03020201110060	No Data	3.0	No	10 or More Existing	7%	National	32%
03020201110070	No Data	4.0	Yes	10 or More Existing	11%	National	31%
03020201120010	4.0	2.8	No	Majority Existing	5%	State	16%
03020201120020	3.0	2.0	No	10 or More Existing	7%	State	30%
03020201120030	5.0	2.0	Yes	10 or More Existing	12%	State	27%
03020201130010	No Data	No Data	No	Upland, No Aquatic or Wetland	4%	No Data	26%
03020201130020	No Data	No Data	No	No Data	8%	No Data	31%
03020201130030	No Data	2.5	Yes	Wetland, No Aquatic	9%	Local	26%
03020201140010	No Data	4.0	Yes	Majority Extirpated	31%	State	25%
03020201140020	No Data	No Data	Yes	No Data	6%	No Data	29%
03020201150010	No Data	No Data	No	Wetland, No Aquatic	4%	Local	26%
03020201150020	No Data	3.0	Yes	Wetland, No Aquatic	7%	State	27%
03020201150030	No Data	3.0	No	Wetland, No Aquatic	6%	Regional	27%
03020201150040	No Data	3.0	Yes	Majority Extirpated	8%	Regional	24%
03020201150050	No Data	2.0	Yes	Majority Existing	28%	State	27%
03020201160010	No Data	2.0	No	No Data	13%	Local	21%
03020201170010	No Data	No Data	No	Upland, No Aquatic or Wetland	10%	No SNHA	23%
03020201170020	No Data	No Data	Yes	Majority Extirpated	11%	No SNHA	24%
03020201170030	No Data	1.0	No	No Data	8%	No Data	17%
03020201170040	No Data	No Data	No	No Data	20%	No Data	18%
03020201170050	No Data	No Data	No	No Data	7%	No Data	16%
03020201170060	No Data	3.0	Yes	Majority Existing	15%	No SNHA	21%
03020201180010	4.0	3.0	No	Majority Existing	6%	National	11%
03020201180020	No Data	4.0	No	10 or More Existing	7%	National	15%
03020201180030	No Data	No Data	No	No Data	6%	No Data	21%

HUCODE	Ecological Integrity						
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial
03020201180040	5.0	3.5	Yes	10 or More Existing	11%	National	31%
03020201180050	4.0	2.0	Yes	Majority Existing	10%	National	18%
03020201180060	No Data	No Data	Yes	No Data	13%	National	26%
03020201180070	No Data	No Data	No	Wetland, No Aquatic	10%	Local	33%
03020201180080	No Data	3.0	Yes	Majority Existing	12%	National	29%
03020201190010	No Data	No Data	No	No Data	12%	No Data	20%
03020201200010	No Data	No Data	Yes	Majority Extirpated	16%	National	22%
03020201200020	No Data	3.3	Yes	No Data	13%	National	18%
03020201200030	No Data	No Data	No	Majority Extirpated	17%	No SNHA	16%
03020201200040	No Data	4.0	Yes	Upland, No Aquatic or Wetland	15%	No SNHA	8%
03020202010010	No Data	No Data	No	No Data	4%	No Data	22%
03020202010020	No Data	No Data	No	Upland, No Aquatic or Wetland	8%	No SNHA	15%
03020202010021	No Data	2.0	No	No Data	4%	No Data	14%
03020202010022	No Data	2.0	Yes	Wetland, No Aquatic	6%	No SNHA	16%
03020202010030	No Data	No Data	Yes	No Data	28%	Local	22%
03020202010040	No Data	No Data	No	No Data	9%	No Data	18%
03020202010050	No Data	No Data	Yes	Wetland, No Aquatic	17%	State	18%
03020202020010	No Data	No Data	Yes	No Data	16%	No Data	19%
03020202020020	No Data	No Data	No	No Data	5%	No Data	32%
03020202020030	No Data	4.0	Yes	No Data	10%	State	29%
03020202030010	No Data	No Data	No	No Data	4%	No Data	20%
03020202030020	No Data	No Data	No	No Data	3%	No Data	18%
03020202030030	No Data	No Data	No	No Data	9%	No Data	20%
03020202030040	No Data	3.0	Yes	Majority Extirpated	13%	No SNHA	20%
03020202040010	No Data	3.0	No	Upland, No Aquatic or Wetland	5%	No SNHA	21%
03020202040020	No Data	2.0	Yes	No Data	13%	No Data	16%
03020202040030	No Data	No Data	Yes	No Data	10%	No Data	12%
03020202050010	No Data	No Data	No	Majority Extirpated	20%	No SNHA	9%
03020202050020	No Data	No Data	No	No Data	15%	No Data	6%
03020202050030	No Data	No Data	Yes	Majority Extirpated	15%	No SNHA	18%
03020202050040	No Data	4.0	No	No Data	12%	No Data	18%
03020202060010	No Data	No Data	No	No Data	10%	No Data	14%
03020202060020	No Data	No Data	No	No Data	7%	No Data	20%
03020202060030	No Data	No Data	Yes	Majority Existing	8%	No SNHA	13%
03020202060040	No Data	No Data	Yes	Majority Extirpated	27%	No SNHA	14%
03020202070010	No Data	No Data	No	Wetland, No Aquatic	29%	Regional	11%
03020202070020	No Data	No Data	Yes	Majority Extirpated	25%	No SNHA	10%
03020202080010	No Data	2.0	Yes	Majority Extirpated	31%	State	10%
03020202080020	No Data	No Data	Yes	Majority Extirpated	23%	Regional	10%
03020202090010	No Data	1.0	No	Majority Extirpated	18%	No SNHA	12%
03020202090020	No Data	No Data	Yes	Majority Existing	41%	State	5%
03020202090030	No Data	1.5	No	Upland, No Aquatic or Wetland	22%	State	13%
03020202090040	No Data	No Data	No	No Data	31%	State	8%

HUCODE	Ecological Integrity						
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial
03020202090050	No Data	No Data	No	No Data	38%	No Data	8%
03020202090055	No Data	No Data	No	Wetland, No Aquatic	24%	No SNHA	7%
03020202090060	No Data	2.0	Yes	Wetland, No Aquatic	39%	National	9%
03020202090070	No Data	No Data	Yes	Wetland, No Aquatic	22%	No SNHA	21%
03020202090080	No Data	No Data	Yes	Wetland, No Aquatic	69%	National	11%
03020202100010	No Data	No Data	Yes	Wetland, No Aquatic	17%	No SNHA	14%
03020202100020	No Data	3.0	Yes	No Data	29%	State	8%
03020203010010	4.0	2.0	No	10 or More Existing	6%	State	23%
03020203010020	No Data	2.5	No	10 or More Existing	9%	National	32%
03020203020010	No Data	1.0	No	No Data	9%	No Data	24%
03020203020020	No Data	3.0	No	Majority Existing	13%	Regional	26%
03020203020030	No Data	2.0	Yes	Majority Extirpated	17%	Regional	21%
03020203020040	No Data	1.0	No	No Data	8%	No Data	25%
03020203020050	No Data	2.8	Yes	Majority Extirpated	18%	Regional	25%
03020203030010	No Data	No Data	No	No Data	13%	No Data	25%
03020203030020	No Data	No Data	No	No Data	13%	No Data	23%
03020203030030	No Data	No Data	No	No Data	6%	No Data	25%
03020203030040	No Data	No Data	Yes	No Data	25%	No Data	21%
03020203040010	No Data	No Data	No	Wetland, No Aquatic	11%	No SNHA	21%
03020203040020	No Data	2.0	No	No Data	13%	No Data	25%
03020203040030	No Data	No Data	No	No Data	11%	No Data	34%
03020203040040	No Data	2.0	Yes	No Data	15%	No Data	26%
03020203050010	No Data	No Data	Yes	Majority Extirpated	14%	No SNHA	23%
03020203050020	No Data	No Data	Yes	No Data	10%	No Data	26%
03020203050030	No Data	2.0	Yes	No Data	10%	No Data	26%
03020203050040	No Data	No Data	Yes	Majority Extirpated	15%	No SNHA	22%
03020203050050	No Data	No Data	No	No Data	7%	No Data	21%
03020203050060	No Data	4.0	Yes	No Data	21%	Regional	15%
03020203060010	No Data	No Data	No	No Data	11%	No Data	19%
03020203060020	No Data	No Data	No	No Data	9%	No Data	24%
03020203060030	No Data	3.0	No	No Data	5%	No Data	23%
03020203060040	No Data	2.0	No	No Data	7%	No Data	21%
03020203060050	No Data	No Data	No	No Data	11%	No Data	26%
03020203070010	No Data	No Data	No	Majority Extirpated	10%	No SNHA	33%
03020203070020	No Data	No Data	No	No Data	12%	No Data	32%
03020203070030	No Data	No Data	No	No Data	13%	Local	26%
03020203070040	No Data	No Data	No	No Data	12%	No Data	26%
03020203070050	No Data	2.0	Yes	Majority Extirpated	11%	No SNHA	23%
03020204010010	No Data	No Data	Yes	Majority Existing	19%	Regional	9%
03020204010020	No Data	No Data	No	No Data	24%	No Data	14%
03020204010021	No Data	No Data	Yes	No Data	25%	No Data	13%
03020204010030	No Data	No Data	Yes	Majority Extirpated	28%	No SNHA	17%
03020204010031	No Data	No Data	No	No Data	16%	No Data	20%

HUCODE	Ecological Integrity						
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial
03020204010040	No Data	2.5	Yes	Majority Extirpated	41%	State	12%
03020204010050	No Data	2.0	No	Majority Extirpated	26%	No SNHA	11%
03020204010051	No Data	No Data	No	Majority Extirpated	27%	No SNHA	16%
03020204010060	No Data	No Data	No	Majority Extirpated	30%	No SNHA	10%
03020204010070	No Data	4.0	Yes	Majority Extirpated	41%	State	10%
03020204010071	No Data	No Data	No	Majority Extirpated	27%	No SNHA	12%
03020204010080	No Data	4.0	Yes	Majority Existing	24%	State	14%
03020204010090	No Data	No Data	Yes	Majority Extirpated	61%	National	6%
03020204010100	No Data	No Data	No	Wetland, No Aquatic	25%	National	17%
03020204020010	No Data	No Data	No	Majority Existing	19%	State	7%
03020204020020	No Data	No Data	No	Wetland, No Aquatic	18%	State	12%
03020204020030	No Data	3.0	Yes	Majority Existing	57%	National	9%
03020204020040	No Data	No Data	Yes	No Data	41%	Regional	12%
03020204020050	No Data	No Data	No	Majority Existing	5%	No SNHA	3%
03020204020060	No Data	No Data	No	Wetland, No Aquatic	10%	Regional	3%
03020204030010	No Data	No Data	No	Majority Existing	45%	State	8%
03020204030020	No Data	No Data	Yes	Wetland, No Aquatic	37%	Regional	12%
03020204030030	No Data	No Data	Yes	Majority Existing	42%	Regional	12%
03020204030040	No Data	No Data	No	Majority Existing	35%	State	5%
03020204030050	No Data	No Data	Yes	No Data	26%	Local	6%
03020204040010	No Data	No Data	Yes	No Data	18%	No Data	2%
03020204050010	No Data	No Data	Yes	Majority Extirpated	18%	State	6%
03020204050020	No Data	No Data	Yes	10 or More Existing	47%	National	6%
03020204050030	No Data	No Data	Yes	Majority Existing	32%	State	7%
03020204050040	No Data	No Data	No	Wetland, No Aquatic	33%	State	4%
03020204050050	No Data	No Data	No	Majority Existing	26%	State	2%
03020204060010	No Data	No Data	Yes	Majority Existing	26%	Regional	2%
03020204060020	No Data	No Data	No	Majority Existing	22%	No SNHA	1%
03020204070010	No Data	No Data	No	Majority Existing	30%	State	1%

Table 3 Indicator Scores by 14-Digit HUC

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020105010010			1	2	5	4	5	3.4
03020105010020			1		5	3	5	3.5
03020105010030			1		5	3	5	3.5
03020105010040			5		4		3	4.0
03020105020010			1	1	2	1	1	1.2
03020105020020			1	2	4	4	5	3.2
03020105020030			1	2	2	4	0	1.8
03020105090012			1		2		0	1.0
03020106050010			1	4	2	5	0	2.4
03020106050050			1	4	2	5	0	2.4
03020106050060			1		2		0	1.0
03020106050070			1	3	2	5	0	2.2
03020201010010	5.0	3.5	1	4	4	4	4	3.6
03020201010020	4.0	3.3	1	5	2	4	0	2.8
03020201010030		4.0	1	5	2	4	0	2.7
03020201010040	5.0	4.0	1	5	2	4	1	3.1
03020201010050		2.0	1	4	5	4	5	3.5
03020201020010	4.0	3.0	1	5	2	4	0	2.7
03020201020020	5.0	3.0	1	4	2	4	1	2.9
03020201020030		3.5	1	4	5	4	5	3.8
03020201020040		3.0	1	3	5	5	5	3.7
03020201030010			1	4	2	5	0	2.4
03020201030020	4.5	3.4	1	5	4	5	4	3.8
03020201030030	5.0	3.4	1	5	5	5	5	4.2
03020201030040	5.0	4.5	1	5	4	5	5	4.2
03020201030050	5.0	4.0	1		5	5	5	4.2
03020201040010			1	1	3	3	2	2.0
03020201040020		1.5	1	4	3	5	2	2.8
03020201050010	1.0	1.5	1	2	5	4	5	2.8
03020201050020		1.0	1	1	4	4	4	2.5

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020201050030		2.0	1	4	5	4	5	3.5
03020201050040			1		3		2	2.0
03020201060010			1	2	5	5	5	3.6
03020201060020	4.0	4.0	1	4	4	4	3	3.4
03020201060030			1	2	2	4	1	2.0
03020201065010	3.0	3.7	1		2		1	2.1
03020201065020		3.0	1		5		5	3.5
03020201065030	2.0	3.0	1	4	4	4	4	3.1
03020201065040			1	2	4	1	3	2.2
03020201065050			1	3	5	1	5	3.0
03020201070060	4.0	3.0	1		5		5	3.6
03020201070070	5.0	2.0	1	2	5	3	5	3.3
03020201070080		2.6	1	3	4	3	4	2.9
03020201070090			1	3	5	3	5	3.4
03020201070100		2.0	1	1	2	1	1	1.3
03020201070110		1.7	1	3	5	3	5	3.1
03020201070120		3.0	1		2	3	1	2.0
03020201080010		1.5	1	2	4	4	3	2.6
03020201080020	4.5	1.9	1	5	2	4	1	2.8
03020201090010	2.8	1.4	1	4	4	3	3	2.7
03020201100010			5	1	5		5	4.0
03020201100020	4.0		1	4	5	2	5	3.5
03020201100030		3.0	5	4	5	3	5	4.2
03020201100040			1		5		5	3.7
03020201100050		2.7	5	4	5	3	5	4.1
03020201110010	2.0	1.6	1	4	3	4	2	2.5
03020201110020			1		5	4	5	3.8
03020201110030	2.0	2.8	1	5	5	5	5	3.7
03020201110040			1	4	5	5	5	4.0
03020201110050		2.0	1	4	4	5	5	3.5
03020201110060		3.0	1	5	5	5	5	4.0

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020201110070		4.0	5	5	4	5	4	4.5
03020201120010	4.0	2.8	1	4	5	4	5	3.7
03020201120020	3.0	2.0	1	5	5	4	5	3.6
03020201120030	5.0	2.0	5	5	4	4	4	4.1
03020201130010			1	1	4		4	2.5
03020201130020			1		2		0	1.0
03020201130030		2.5	5	2	4	2	4	3.3
03020201140010		4.0	5	3	4	4	3	3.8
03020201140020			5		5		5	5.0
03020201150010			1	2	5	2	5	3.0
03020201150020		3.0	5	2	3	4	2	3.2
03020201150030		3.0	1	2	2	3	1	2.0
03020201150040		3.0	5	3	2	3	0	2.7
03020201150050		2.0	5	4	2	4	0	2.8
03020201160010		2.0	1		5	2	5	3.0
03020201170010			1	1	2	1	0	1.0
03020201170020			5	3	2	1	1	2.4
03020201170030		1.0	1		3		2	1.8
03020201170040			1		5		5	3.7
03020201170050			1		5		5	3.7
03020201170060		3.0	5	4	5	1	5	3.8
03020201180010	4.0	3.0	1	4	3	5	2	3.1
03020201180020		4.0	1	5	5	5	5	4.2
03020201180030			1		2		0	1.0
03020201180040	5.0	3.5	5	5	2	5	0	3.6
03020201180050	4.0	2.0	5	4	4	5	3	3.9
03020201180060			5		5	5	5	5.0
03020201180070			1	2	4	2	5	2.8
03020201180080		3.0	5	4	3	5	2	3.7
03020201190010			1		5		5	3.7
03020201200010			5	3	3	5	2	3.6

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020201200020		3.3	5		5	5	5	4.7
03020201200030			1	3	5	1	5	3.0
03020201200040		4.0	5	1	5	1	5	3.5
03020202010010			1		5		5	3.7
03020202010020			1	1	4	1	4	2.2
03020202010021		2.0	1		2		0	1.3
03020202010022		2.0	5	2	5	1	5	3.3
03020202010030			5		5	2	5	4.3
03020202010040			1		5		5	3.7
03020202010050			5	2	5	4	5	4.2
03020202020010			5		5		5	5.0
03020202020020			1		2		1	1.3
03020202020030		4.0	5		4	4	3	4.0
03020202030010			1		5		5	3.7
03020202030020			1		2		1	1.3
03020202030030			1		5		5	3.7
03020202030040		3.0	5	3	2	1	1	2.5
03020202040010		3.0	1	1	5	1	5	2.7
03020202040020		2.0	5		4		3	3.5
03020202040030			5		2		1	2.7
03020202050010			1	3	3	1	1	1.8
03020202050020			1		2		0	1.0
03020202050030			5	3	4	1	3	3.2
03020202050040		4.0	1		5		5	3.8
03020202060010			1		3		2	2.0
03020202060020			1		5		5	3.7
03020202060030			5	4	2	1	1	2.6
03020202060040			5	3	4	1	5	3.6
03020202070010			1	2	4	3	3	2.6
03020202070020			5	3	2	1	1	2.4
03020202080010		2.0	5	3	2	4	1	2.8

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020202080020			5	3	2	3	0	2.6
03020202090010		1.0	1	3	5	1	5	2.7
03020202090020			5	4	2	4	1	3.2
03020202090030		1.5	1	1	2	4	1	1.8
03020202090040			1		2	4	0	1.8
03020202090050			1		2		0	1.0
03020202090055			1	2	2	1	0	1.2
03020202090060		2.0	5	2	4	5	2	3.3
03020202090070			5	2	2	1	0	2.0
03020202090080			5	2	5	5	5	4.4
03020202100010			5	2	2	1	1	2.2
03020202100020		3.0	5		4	4	4	4.0
03020203010010	4.0	2.0	1	5	4	4	3	3.3
03020203010020		2.5	1	5	4	5	3	3.4
03020203020010		1.0	1		5		5	3.0
03020203020020		3.0	1	4	4	3	3	3.0
03020203020030		2.0	5	3	5	3	5	3.8
03020203020040		1.0	1		4		3	2.3
03020203020050		2.8	5	3	5	3	5	4.0
03020203030010			1		4		4	3.0
03020203030020			1		2		1	1.3
03020203030030			1		4		3	2.7
03020203030040			5		3		2	3.3
03020203040010			1	2	2	1	1	1.4
03020203040020		2.0	1		5		5	3.3
03020203040030			1		2		1	1.3
03020203040040		2.0	5		5		5	4.3
03020203050010			5	3	3	1	1	2.6
03020203050020			5		3		2	3.3
03020203050030		2.0	5		4		5	4.0
03020203050040			5	3	2	1	1	2.4

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020203050050			1		2		1	1.3
03020203050060		4.0	5		5	3	5	4.4
03020203060010			1		4		3	2.7
03020203060020			1		4		4	3.0
03020203060030		3.0	1		4		2	2.5
03020203060040		2.0	1		2		0	1.3
03020203060050			1		2		1	1.3
03020203070010			1	3	4	1	4	2.6
03020203070020			1		5		5	3.7
03020203070030			1		5	2	5	3.3
03020203070040			1		4		3	2.7
03020203070050		2.0	5	3	3	1	2	2.7
03020204010010			5	4	2	3	1	3.0
03020204010020			1		2		0	1.0
03020204010021			5		2		0	2.3
03020204010030			5	3	3	1	2	2.8
03020204010031			1		2		0	1.0
03020204010040		2.5	5	3	2	4	0	2.8
03020204010050		2.0	1	3	2	1	0	1.5
03020204010051			1	3	2	1	0	1.4
03020204010060			1	3	2	1	0	1.4
03020204010070		4.0	5	3	2	4	1	3.2
03020204010071			1	3	2	1	1	1.6
03020204010080		4.0	5	4	2	4	1	3.3
03020204010090			5	3	2	5	1	3.2
03020204010100			1	2	4	5	5	3.4
03020204020010			1	4	3	4	2	2.8
03020204020020			1	2	5	4	5	3.4
03020204020030		3.0	5	4	4	5	3	4.0
03020204020040			5		5	3	5	4.5
03020204020050			1	4	5	1	5	3.2

HUCCODE	Ecological Integrity							
	Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	Composite Score
03020204020060			1	2	5	3	5	3.2
03020204030010			1	4	5	4	5	3.8
03020204030020			5	2	2	3	1	2.6
03020204030030			5	4	2	3	1	3.0
03020204030040			1	4	3	4	2	2.8
03020204030050			5		5	2	5	4.3
03020204040010			5		4		4	4.3
03020204050010			5	3	5	4	5	4.4
03020204050020			5	5	4	5	4	4.6
03020204050030			5	4	5	4	5	4.6
03020204050040			1	2	2	4	0	1.8
03020204050050			1	4	2	4	0	2.2
03020204060010			5	4	5	3	5	4.4
03020204060020			1	4	2	1	1	1.8
03020204070010			1	4	2	4	0	2.2

Table 4 Indicator Scores

ID	DESCRIPTION	TYPE	HUCODE[1]	Ecological Integrity Tier							
				Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	EI Composite Score
1	Upstream of Milburnie Dam	Dam Removal	03020201070110		1.7	1	3	5	3	5	3.1
1	Upstream of Milburnie Dam	Dam Removal	03020201070120		3	1		2	3	1	2.0
2	Upstream of Lassiter Mill Rd.	Dam Removal; Retrofit Fish Ladder	03020201080020	4.5	1.9	1	5	2	4	1	2.8
3	Umstead Park	Dam/Obstruction Removal	03020201080020	4.5	1.9	1	5	2	4	1	2.8
4	State Rds 1664, 1649, 2000	Restoration/BMP	Subbasin 03-04-02								
5	Crabtree Creek/New Hope Rd.	Restoration/BMP	03020201080020	4.5	1.9	1	5	2	4	1	2.8
6	Swift Creek	Proposed Reservoir/NCEEP Projects	03020201110010	2	1.6	1	4	3	4	2	2.5
7	Middle Creek (Crantock Mil Dam)	Dam Removal/Restoration	03020201120030	5	2	5	5	4	4	4	4.1
8	Mill Creek	Preservation	03020201150040		3	5	3	2	3	0	2.7
8	Mill Creek	Preservation	03020201150050		2	5	4	2	4	0	2.8
9	Adkin (Yadkin) Branch	Restoration	03020202060030			5	4	2	1	1	2.6
10	Sand Mine	Wetland Creation	03020202050030			5	3	4	1	3	3.2
11	Big Ditch	Stream and Buffer Restoration	03020201200040		4	5	1	5	1	5	3.5
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180010	4	3	1	4	3	5	2	3.1
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180050	4	2	5	4	4	5	3	3.9
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180020		4	1	5	5	5	5	4.2
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180040	5	3.5	5	5	2	5	0	3.6
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180060			5		5	5	5	5.0
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180080		3	5	4	3	5	2	3.7
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201200010			5	3	3	5	2	3.6
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201200020		3.3	5		5	5	5	4.7
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201190010			1		5		5	3.7
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180070			1	2	4	2	5	2.8
12	Little R and Buffalo Ck Wtsd	BMP/Restoration	03020201180030			1		2		0	1.0
13	Hominy Swamp	Stream and Wetland Restoration	03020203020040		1	1		4		3	2.3
14	Nahunta Swamp	Stream and Buffer Restoration	03020203060010			1		4		3	2.7
14	Nahunta Swamp	Stream and Buffer Restoration	03020203060020			1		4		4	3.0
14	Nahunta Swamp	Stream and Buffer Restoration	03020203060040		2	1		2		0	1.3
14	Nahunta Swamp	Stream and Buffer Restoration	03020203060050			1		2		1	1.3
15	Contentnea/Little Contentnea Ck Wtsd	Restoration	Subbasin 03-04-07								
16	Toisnot Swamp	Revegetation/BMP	03020203040020		2	1		5		5	3.3
17	Contentnea Ck nr Stantonsburg	Bank Stabilization	03020203020050		2.8	5	3	5	3	5	4.0
18	Core Ck at NC-55/State Rd 1001	Stream Restoration	03020202080010		2	5	3	2	4	1	2.8
19	Swift Ck at NC-118	BMP/Restoration	03020202090060		2	5	2	4	5	2	3.3
20	Swift Ck nr Askin	BMP/Restoration	03020202090060		2	5	2	4	5	2	3.3
21	Clayroot Swamp	BMP/Restoration	03020202090030		1.5	1	1	2	4	1	1.8
22	South River, Neuse Subestuary	Ditch BMPs/Stream Restoration	03020204070010			1	4	2	4	0	2.2
23	Broad and Swan Creeks, Neuse Subestuary	Ditch BMPs/Stream/Marsh Restoration	03020204060020			1	4	2	1	1	1.8
24	South Bay, Neuse Subestuary	Ditch BMPs/Stream Restoration	03020204070010			1	4	2	4	0	2.2
25	Rattan Bay, Neuse Subestuary	Ditch BMPs/Stream Restoration	03020204070010			1	4	2	4	0	2.2
26	Turnagain Bay, Neuse Subestuary	Ditch BMPs/Stream Restoration	03020204070010			1	4	2	4	0	2.2

ID	DESCRIPTION	TYPE	HUCODE[1]	Ecological Integrity Tier: Fish Community	Benthic	Anadromous Fish	Aquatic NHEO	NCGAP Wetlands	Significant Natural Heritage Areas	NCGAP Priority Terrestrial	EI Composite Score
27	Trent River near RR Bridge	Restoration/Monitoring/NSW Strat.	03020204020010			1	4	3	4	2	2.8
27	Trent River near RR Bridge	Restoration/Monitoring/NSW Strat.	03020204020050			1	4	5	1	5	3.2
28	Brice River and Trent Estuary	Restoration/Monitoring/NSW Strat.	03020204020040			5		5	3	5	4.5
28	Brice River and Trent Estuary	Restoration/Monitoring/NSW Strat.	03020204020010			1	4	3	4	2	2.8
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105010020			1		5	3	5	3.5
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105010010			1	2	5	4	5	3.4
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105010040			5		4		3	4.0
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105010030			1		5	3	5	3.5
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105020010			1	1	2	1	1	1.2
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105020020			1	2	4	4	5	3.2
29	Bay River: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105090012			1		2		0	1.0
30	Jones and Middle Bays: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105020020			1	2	4	4	5	3.2
30	Jones and Middle Bays: Neuse Subestuary, etc.	Ditch BMPs/Stream/Marsh Restoration	03020105020030			1	2	2	4	0	1.8
101	Lick Creek	Instream	03020201050030		2	1	4	5	4	5	3.5
102	Little Lick Creek	Instream/Riparian	03020201050020		1	1	1	4	4	4	2.5
103	New Light Creek	Riparian/Instream	03020201065010	3	3.7	1		2		1	2.1
104	N. Fork Little River	Instream/Riparian	03020201020010	4	3	1	5	2	4	0	2.7
105	Black Creek	Instream	03020201080010		1.5	1	2	4	4	3	2.6
106	Crabtree Creek	Instream	03020201080010		1.5	1	2	4	4	3	2.6
108	Little Creek	Instream	03020201110050		2	1	4	4	5	5	3.5
109	Swift Creek	Instream/Riparian	03020201110010	2	1.6	1	4	3	4	2	2.5
110	Neuse Bottomlands	Wetland	03020201140010		4	5	3	4	4	3	3.8
111	Little Contentnea Creek	Instream	03020203070030			1		5	2	5	3.3
111	Little Contentnea Creek	Instream	03020203070010			1	3	4	1	4	2.6
111	Little Contentnea Creek	Instream	03020203070050		2	5	3	3	1	2	2.7
113	Musselshell Creek	Instream	03020204010071			1	3	2	1	1	1.6
114	Ledge Creek	Instream/Riparian	03020201060010			1	2	5	5	5	3.6
115	Unnamed Tributary	Wetland	03020202010020			1	1	4	1	4	2.2
116	Reedy Branch	Strm/Wtlnd/Buff	03020202010010			1		5		5	3.7
117	Reedy Branch	Strm/Wtlnd/Buff	03020202010010			1		5		5	3.7
118	Upper Stoney Creek	Strm/Wtlnd/Buff	03020202010010			1		5		5	3.7
119	Howell Creek	Strm/Wtlnd/Buff	03020202010010			1		5		5	3.7
120	Yates Mill Run Borrow Pit	Wetland	03020201110020			1		5	4	5	3.8

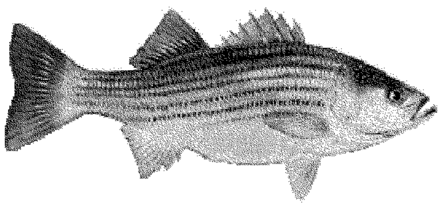
[1]Projects 4 and 15 lacked location information and could only be designated by subbasin (11-digit HUCs). These projects were not evaluated at the 14-digit HUC level.

Appendix J: Anadromous Fish Habitat Restoration and Fish Species

CRITERIA

Obstructions	Anadromous Fish	T & E Species	HTRW in Sediment	Owner's Permission	Miles of Upstream Upstream Reach	Cultural Resources	Acres of Wetlands	Connectivity	Habitat Quality	Cost
Eno River State Park	-	-								
UN-NAMED	-	-								
Pulley Pond	-	-								
Atkinson Mill Dam	-	-								
Moorewood Pond	-	-								
Parkers Mill Pond	-	-								
Tippetts	-	-								
UN-NAMED	-	-								
UN-NAMED	-	-								
UN-NAMED	-	-								
UN-NAMED	-	-								
Wendell Lake Fishing Club	-	-								
Kelly's Pond Mill	+	-								
Lakeside Mills	-	-								
Nobles Mill Dam	-	-								
Tulls Mill Pond	-	-								
UN-NAMED	-	-								
UN-NAMED	-	-								
Blackmans Pond	-	-								
Lassiter Mill Dam	+	-								
Little River Park	-	-								
Tarpleys Pond	-	-								
UN-NAMED	-	-								
UN-NAMED	-	-								
Millburnie Dam	+	-								
Un-named Dam, Adjacent to Goldsboro Water Treatment Plant	+	+								
Un-named Dam in Wilson County	-	+								

NEUSE RIVER BASIN, NORTH CAROLINA ANADROMOUS FISH HABITAT RESTORATION STUDY GROUP



striped bass (*Morone saxatilis*)

NEUSE RIVER BASIN, NORTH CAROLINA

ANADROMOUS FISH HABITAT RESTORATION STUDY GROUP

1. PROBLEM STATEMENT.

Anadromous fish species such as striped bass (*Morone saxatilis*), hickory shad (*Alosa mediocris*), American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), shortnose sturgeon (*Acipenser brevirostrum*), and Atlantic sturgeon (*Acipenser oxyrhynchus*), have historically formed a significant component of the fishery resource of the Neuse River estuarine system. At one time, more American shad and striped bass were caught in North Carolina than any other state (Smith 1907). The presence of many species of anadromous fish in the region is documented in the Freshwater Fishes of North Carolina (Menhinick 1991).

There has been an unprecedented decline in the populations of all anadromous species throughout much of their historic ranges in the Neuse River (Street 1988; Steel 1991). Water quality degradation, alteration and destruction of the estuary's habitats, alteration of river flow, and commercial and recreational overfishing are factors thought to contribute to those declines in population. Environmental agencies involved in anadromous fish management describe dams as the most detrimental obstruction to migration. Many abandoned millpond dams and small hydroelectric dams remain in piedmont North Carolina and obstruct many hundreds of miles of potential anadromous fish habitat. Several significant reservoirs serving as water supply and flood control structures, along with old millponds and beaver impoundments characterize the Piedmont region of the Upper Neuse River basin. There are 19 major reservoirs in the Neuse River basin, most being in the upper portion of the basin. The largest reservoir, the fall of the Neuse (Falls Lake), is managed by the US Army Corps of Engineers for flood control. Reservoirs are few in number in the Coastal Plain physiographic province of the Neuse due to inhibitive factors including highly pervious sands and flat topography.

As a result of greater development pressure and increased population, new highway construction is also impacting more and more streams within the Neuse River Basin. Placement of roadway pipe culverts and reinforced concrete box culverts within stream channels are partially or totally obstructing anadromous fish migration and spawning within the basin. Declines are expected to continue unless causes can be more completely understood and corrective measures taken.

2. RELATED STUDIES, REPORTS, PLANS AND PROJECTS.

The following efforts have been completed or currently underway by agencies and organizations which are applicable to the efforts of this workgroup. These efforts have been divided into three areas, which are described below.

A. Background Plans and Guidelines for the Neuse Basin Study

1. Street, M.W., A.S. Deaton, W.S. Chappell, and P.D. Mooreside. 2005. North Carolina Coastal Habitat Protection Plan. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries, Morehead City, NC. 656 pp. In accordance with the NC Fisheries Reform Act of 1997, the Department of Environment and Natural Resources has developed the Coastal Habitat Protection Plan (CHPP), to protect habitats including wetlands, spawning areas, threatened and endangered species habitat, primary and secondary nursery areas, shellfish beds, submerged aquatic vegetation and Outstanding Resource Waters. The CHPP was written to: 1. Document the ecological role and function of aquatic habitats for coastal fisheries. 2. Provide status and trends information on the quality and quantity of coastal fish habitat. 3. Describe and document threats to coastal fish habitat, including threats from both human activities and natural events. 4. Describe the current rules concerning each habitat. 5. Identify management needs. 6. Develop options for management action using the above information. The CHPP has identified that within the Neuse River Basin there are approximately 596 miles of streams that are partially or totally obstructed by dams, 154 miles of streams that are partially or totally obstructed by roadway pipe culverts and 219 miles of streams partially or totally obstructed by reinforced concrete box culverts (See Table 2.16 on page 71).

2. North Carolina Department of Environmental and Natural Resources, Division of Water Quality. Basinwide Planning Program 2002 Neuse River Basinwide Water Quality Plan. 220 pp. Basinwide water quality planning is a nonregulatory watershed-based approach to restoring and protecting the quality of North Carolina's surface waters. The NCDENR Division of Water Quality (DWQ) prepares this Basinwide water quality plan. The plan is revised at five-year intervals. While these plans are prepared by the DWQ, their implementation and the protection of water quality entail the coordinated efforts of many agencies, local governments and stakeholders in the state. Causes and sources of pollution for individual streams are provided to facilitate local restoration efforts. Section B -Chapters 10, 13 and 14 may address this workgroup's area of interest.

3. North Carolina Department of Transportation. 1997. Stream Crossing Guidelines for Anadromous Fish Passage. 4pp. In response to permit questions raised by the natural resources community concerning anadromous fish use of culverts, a multidisciplinary committee was established to review this issue. The committee consisted of representatives from the US Fish and Wildlife Service, National Marine Fisheries Service, NC Wildlife Resources Commission, NC Division of Marine Fisheries, NC Division of Environmental Management, and NC Department of Transportation. By memorandum dated May 12, 1997, the NCDOT circulated these guidelines to the agencies. NCDOT will use this document as a uniform policy on handling this issue.

B. Dams Removed (Quaker Neck, Cherry Hospital, and Rains Mill) and Proposed Dam to be Removed (Pleasant Green Road) in the Neuse River Basin

1. Quaker Neck and Cherry Hospital Dam Removals. Construction of dams on some river systems like the Neuse led to a reduction in spawning area for these fish. A reduction in spawning area meant fewer eggs produced and, therefore, fewer fish. Recognition of this problem led to the removal of dams like Quaker Neck Dam and Cherry Hospital Dam. In the case of the Quaker Neck Dam the dam owner Progress Energy (formerly Carolina Power and Light) voluntarily cooperated in the investigation of the benefits of the removal of the dam, and subsequently worked with several state and federal agencies, and private conservation organizations to effect the removal of the dam. The Quaker Neck Dam removal project restored anadromous fish access from Goldsboro to Raleigh, restoring approximately 78 miles of the main stem of the Neuse River and 925 miles of tributary streams as spawning habitat for the native anadromous fish. The Cherry Hospital Dam removal project restored 76 miles of additional tributary streams for anadromous fish habitat in the Little River tributary of the Neuse Basin (Personal Communication, Mr. Mike Wicker, Biologist, US Fish and Wildlife Service, April 2, 2005).

Studies that monitored the impacts of the Quaker Neck Dam on anadromous fish and after its removal:

a. Beasley, C.A. and J.E. Hightower. 2000. Effects of a low-head dam on the distribution and characteristics of spawning habitat used by striped bass and American shad. Trans. Am. Fish. Soc. 129: 1372-1386. Quaker Neck Dam was more like a low weir structure than a dam within the Neuse River. Carolina Power and Light used it to provide cooling water during low flow conditions. During normal flows the dam was completely under water. Twenty-five striped bass and American shad were tagged and released downstream of the Quaker Neck dam. Of the 13 striped bass and 8 American shad that migrated to the base of the dam, only 3 striped bass and 0 American shad passed the structure.

b. Bowman, S. and J.E. Hightower. 2001. American Shad and Striped Bass Spawning Migration and Habitat Selection in the Neuse River. Final Report to the North Carolina Marine Fisheries Commission. This report showed that a significant percentage of tagged striped bass and American shad released downstream of the former Quaker Dam site migrated upstream of the former dam site. A primary American shad spawning grounds was also located upstream of the removed structure.

c. Burdick, S. M., and J. E. Hightower. 2004. Distribution of spawning activity by migratory fishes in the upper Neuse River drainage. North Carolina Chapter, American Fisheries Society, Asheville, NC, Feb. 4-5, 2004. 2004/02/04. The purpose of this study was to determine the distribution of migratory fish above and below the former Quaker Neck Dam site. Within the study area, species abundance, estimated run timing and mortality of eggs and larvae were also determined. Run timing is defined as determining the approximate upstream location of eggs and larvae.

2. NC Division of Water Resources. October 1999. Final Environmental Assessment and Finding of No Significant Impact for the Proposed Demolition and Removal of the Rains Mill

Dam, near Princeton, in Johnston County, North Carolina. The North Carolina Division of Water Resources (NCDWR) and the U. S. Fish and Wildlife Service (USFWS) demolished and removed the 250-foot long, 12-foot high Rains Mill Dam and its attendant structures on the Little River, near Princeton, in Johnston County, North Carolina. Rains Mill Dam was located about 120 feet downstream of NC State Road 1002 and impounded up to a 28-acre lake. The existing concrete wingwalls on either side of the river, the old millrace, the spillways and the concrete foundation piers were attendant structures. Removal opened up 151 miles of suitable spawning and rearing habitat for diadromous fish. Elimination of the associated 28-acre impoundment will also allow reoccupation of this section of river by two species of endangered freshwater mussel (dwarf wedge mussel (*Alasmidonta heterodon*) and Tar River spinymussel (*Elliptio steinstansana*)). The dam was removed in November 1999. During a recent telephone conversation with Mike Wicker, USFWS, on 2 April 2005, he was catching American and hickory shad at the base of Lowell Dam which is about 11 miles upstream of the old Rains Mill Dam site.

3. US Army Corps of Engineers, Wilmington District. 2002. Pleasant Green Road Dam Removal, Preliminary Restoration Plan (PRP), Section 206 of the Water Resources Development Act of 1996. This project has been approved by the South Atlantic Division, but has not been yet funded. At this time the NC Division of Water Resources (NCDWR), NC Division of Parks and Recreation, USFWS, and the USACE are planning to complete the NEPA document for this project and if Federal funds are not forth coming the NCDWR will fund the removal. Benefits include the restoration of about 13.4 miles of the main stem and 42.7 miles of tributary streams of the Eno River (from Pleasant Green Road Dam upstream to the existing Ben Johnson Dam in Hillsborough). Once the Pleasant Green Road Dam is removed, a total of 57.5 miles of the Eno River and Neuse River (from the Falls Lake Dam on the Neuse River to the Ben Johnson Dam in Hillsborough) would be accessible for fish, mussel, and snail spawning and rearing.

C. Other Corps Studies on Anadromous Fish Passage Include:

1. U.S. Army Corps of Engineers, Wilmington District. 1996. Environmental Assessment, Interim Fish Passage Cape Fear River, North Carolina. This report discussed the installation of a steep-pass fishway (prefabricated fish ladder) at Lock and Dam #1. The fishway was placed at a site on the dam where American shad were known to congregate. It was expected that fish would not have difficulty finding the ladder at this location. However, after the fish ladder was in place and water flow through and around the ladder could be observed, it was determined that the attraction flow produced by the ladder was likely lost in the noise of the adjacent flows. Several surplus concrete buoy anchor blocks were placed adjacent to the ladder to help segregate fish ladder attraction flows from adjacent flows. Subsequent monitoring of fish movement by representatives of the USFWS and USACE confirmed that American shad could navigate the ladder, however; fish use was lower than expected.

2. US Army Corps of Engineers, Wilmington District. Environmental Assessment. July 2002. Finding of No Significant Impact. May 2003. Fish Bypass at Lock and Dam #1, Cape Fear River, Bladen County, North Carolina. Since construction of Lock and Dam #1 in 1915 and subsequent construction of the other locks and dams, passage of fish upstream, especially

anadromous fish has been restricted. Attempts to improve passage of these fish by locking began in 1961. Several changes in these procedures have been made over the years with the latest changes being made in 1998. In addition, a steep-pass fishway (prefabricated fish ladder) was installed in 1997 (see item C.1, above). Based on these recent changes, an estimated 61 percent of the American shad passed upstream of the dam in 1998 (Moser et. al. 2000). A recent study (CZR 2004) confirmed this American shad passage percentage along with a 47% passage of striped bass. The purpose of this study (CZR 2004) was to collect preconstruction monitoring data that can be compared to post construction-monitoring data in order to determine fish passage success. American shad and striped bass were tagged and monitored by tracking them ultrasonic transmitters with manual and fixed station receivers. The 2004 study represents the third year of preconstruction monitoring. Similar monitoring efforts were conducted by CZR during 2002 and 2003 (CZR 2002 and CZR 2003). The goal of this project is to construct a 3,800 foot long nature like bypass canal that will allow all anadromous fish to pass the dam.

3. STUDY AREA.

The Anadromous Fish Habitat Restoration project area includes all or portions of Beaufort, Carteret, Craven, Duplin, Edgecombe, Franklin, Greene, Harnett, Johnston, Jones, Lenior, Nash, Onslow, Pamlico, Pitt, Sampson, Wake, Wayne, and Wilson counties in northeastern North Carolina. The NCDENR, Division of Water Quality (NCDENR 2002) has divided the Neuse River Basin into 14 Subbasins, which are described by a six-digit code (03-04-01 to 03-04-14). The last two digits refer to the particular subbasin (e.g. Subbasin 01). The project area would be those subbasins downstream of the Falls Lake Dam or within subbasins 03-04-02 through 03-04-14.

4. TEAM MEMEBERS.

US Fish and Wildlife Service –
National Marine Fisheries Service –
NCSU/USGS –
NCDMF –
NCDWQ –
NCWRC –
Neuse River Foundation -
USEPA -
USACE -
NCDWR –
Triangle J Council of Governments
NCDOT -
Neuse River Keepers -
NC Clean Water Management Trust Fund -

5. EXISTING CONDITIONS.

The Neuse River flows about 200 miles from its headwaters in Orange and Person Counties to its mouth at the Pamlico Sound. The Neuse River Basin contains over 3,000 stream miles (i.e., main stem and tributaries) and its drainage area is approximately 6,234 square miles, which is 8.8% of the State of North Carolina. Agricultural land comprises 35% of the basin, 34% of the basin is forest, wetlands and open water account for 22%, scrub growth and barren land account for 4%, and 5% is developed (NCSU 2004). The total population of the basin is about 1.5 million people.

As indicated in Section 1 Problem Statement, above, there has been an unprecedented decline in the populations of all anadromous species throughout much of their historic ranges in the Neuse River (Street 1988; Steel 1991). Water quality degradation, alteration and destruction of the estuary's habitats, alteration of river flow, and commercial and recreational overfishing are factors thought to contribute to those declines in population.

6. FUTURE WITHOUT PROJECT CONDITIONS.

The two most rapidly growing regions in the basin are Raleigh-Durham in the upper basin and New Bern to Havelock in the lower basin. Increased urban growth and development are expected to continue throughout the watershed. With growth will come heavier demands on aquatic resources, continued deterioration of ecosystem habitat due to the losses of wetlands and riparian buffers, increases in siltation, and stormwater run off. The rate of degradation is being reduced through implementation of a stringent Neuse River Nutrient Sensitive Waters Management Plan, regulating new construction and land use management. However, nutrients recycled within the riverbed sediments will remain for years. With increased growth, additional roads will be required and thereby increase the number of stream crossings within the basin. Placement of new roadway culverts may further tend to impair migration and spawning of anadromous fish. The existing streams that are partially or totally obstructed within the river basin will continue to adversely impact the migration and spawning of anadromous fish (NCDENR 2002).

Water resource problems in the Neuse River Basin include environmental degradation. The problems related to the degradation of aquatic resources in the Neuse River Basin are likely the result of a combination of factors. More runoff of higher nutrient concentration and silt enters the basin as a result of losses of farm and forestland and increases in impervious surfaces in the watershed. Furthermore, the original riparian buffers and wetlands, which remove nutrients and siltation before runoff enters the waterways, have been lost. This has contributed to deterioration in ecosystem habitat due to an increase in siltation and nutrients, especially nitrogen. The degraded ecosystem has affected wildlife, fishing, and water contact recreation in the Neuse River basin. The high nutrient levels in the lower Neuse River are believed to contribute to outbreaks of the toxic microbe, *Pfiesteria piscida*. Other areas of interest affecting water quality in the basin are wastewater treatment, livestock waste management, agricultural fertilization, and landscape development (NCDENR 2002).

7. PRELIMINARY ALTERNATIVES.

The following preliminary alternatives have been identified and would be further modified and expanded by the Anadromous Fish Habitat Restoration Study Group. All stakeholders (including Federal, state, local government, non-governmental organizations, and private individuals) within the study group will develop additional alternatives and will be engaged in the review process. Past construction costs have been briefly discussed below but will need to be updated in light of various factors (i.e., inflation, increased construction and land costs, etc.).

No Action. Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, the USACE is required to consider the "No Action" alternative. No Action assumes that no project will be implemented by the USACE to achieve the planning objectives. The "No Action" alternative, which is synonymous with the "Without Project Condition", forms the basis from which all other alternative plans are measured. The existing streams that are partially or totally obstructed within the river basin will continue to adversely impact the migration and spawning of anadromous fish.

Dam and other obstructions (highway pipes and culverts) within the Neuse River Basin. As indicated in section 2 above, three dams have already been removed in the Neuse River Basin: 1. Quaker Neck Dam on the Neuse River, 2. Cherry Hospital Dam on the Little River, and 3. Rains Mill Dam on the Little River. According to the NCDWR, the total approximate cost to remove Quaker Neck Dam was about $206,000, Cherry Hospital Dam was approximately $60,000, and Rains Mill Dam was about $223,000.

On April 26, 2005 during an initial meeting with the Anadromous Fish Habitat Restoration Study Group, (see enclosed memo found in the Appendix). The group identified several dams and/or other obstructions for potential removal within the main stem of the Neuse River and on several tributaries. The dams were Millburnie on the main stem of the Neuse River and Barbour Mill Dam on Swift Creek. The tributaries identified by the group that may need obstructions removed are Crabtree Creek, Swift Creek, Middle Creek, and Mill Creek. Research conducted by Ms. Summer Burclick (Masters Thesis in publication) NCSU graduate student working for Dr. Hightower, indicated that these above mentioned streams were suitable spawning habitat for anadromous fish. Field inspections of these streams would be required to identify any existing obstructions. Once the field inspections have identified these obstructions, these obstructions could be prioritized and then removed.

Other dams and obstructions (highway pipes and culverts) within the basin are identified in the Coastal Habitat Protection Plan (CHPP) 2005 (Street et al, 2005) and the study group would prioritize which structures should be removed. Within the Neuse River Basin, the CHPP 2005 has identified the location of dams (Map 2.10). The CHPP 2005 has also identified the location of the highway pipes and culverts (Map 2.12).

Construction of Anadromous Fish Bypass Structures adjacent to Existing Dams. Instead of removing dams within the Neuse Basin, various fish bypass structures may be constructed. The following alternatives may be reviewed: 1) construct a rock arch rapids across the entire face of the dam, 2) construct a nature-like bypass channel, 3) combination of a rock arch rapids and nature-like bypass channel, 4) construct a rock arch rapids in a short diversion channel, and/or 5) install a fish ladder. At Lock and Dam #1 on the Cape Fear River, a steep-pass fishway (i.e., a prefabricated fish ladder) was installed in 1997 for a cost of about $100,000.

8. DATA DEFICIENCIES.

On April 26, 2005 during an initial meeting with the Anadromous Fish Habitat Restoration Study Group, several data deficiencies were identified. The four tributaries (Crabtree Creek, Swift Creek, Middle Creek, and Mill Creek) mentioned in Ms. Summer Burclick's Master's Thesis (in publication) could be field inspected. The individual would walk or float down each tributary and when an obstruction was found, it would be GPS'ed and fish sampling above and below the obstruction could be undertaken. The total cost could be less than $10,000 for this inventory and may be used as a graduate topic. Another data need would be to map the current (since removal of Quaker Neck Dam) suitable spawning habitat for anadromous fish in the Neuse River tributaries from the Falls Dam to old Quaker Neck Dam site. An individual would determine the minimum flows required for anadromous fish spawning in the Neuse River tributaries. Ms. Burclick's data could be used as a guide for determining the appropriate stream flow for streams that had successful spawning events. Once flow was determined, either stream gage or drainage area would determine the flow of the tributary. If the flow of the tributary was sufficient, then suitable spawning habitat could be mapped (i.e., rocky substrate, etc.). If insufficient flow is found on the tributary, that would be noted. Also, any obstructions within the tributary that could block spawning habitat could be mapped. Costs would be minimal and could be used as a topic for graduate study.

Before any dams and/or obstructions are removed, the USACE proposes to run the Hydrologic Engineering Centers – River Analysis System (HEC-RAS) model. The HEC-RAS model is a one-dimensional model that determines the effects of dam removal on stream flows and flood stages at various recurrence intervals. This model also determines the velocity distribution, which identifies suitable fish habitat restoration areas. The approximate cost to run the HEC-RAS model, and to coordinate the results of the model with the affected County, NC Flood Mapping Program, and FEMA for each removal would be determined on a case by case basis.

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APPENDIX

MEMORANDUM FOR RECORD

TO: The File

FROM: Hugh Heine

DATE: 27 April 2005

SUBJECT: Neuse River Basin Study, Anadromous Fish Habitat Restoration Group

1. On 26 April 2005, the following individuals met at the USFWS Office in Raleigh: Mitch Hall, USACE; Howard Hall, USFWS; Summer Burclick, NCSU; Dr. Joe Hightower, USGS; Mike Wicker, USFWS; and the writer. The purpose of this meeting was to discuss the needs and issues of Anadromous Fish Habitat Restoration in the Neuse River.

2. The following topics were discussed:

a. Has the historic anadromous fish habitat in the Neuse Basin been mapped? The upstream limit on the main stem channel is known however the limits on the tributaries need to be identified.

Response: Dr. Hightower provided copies of the literature providing historic migration and spawning areas in the Neuse River. Dr. Hightower indicated that the tributary flow rate (maybe above 500 CFS) at its confluence with the Neuse and substrate (rocky, gravel, bedrock) were important features in anadromous fish habitat. Mapping of these features may provide additional habitat areas within the basin. The following tributaries were identified in Ms. Burclick study to be important anadromous fish habitat: Crabtree Creek, Swift and Middle Creeks, Mill Creek, and the Little River. Contentnea Creek was sampled but because of the bottom substrate (mud/silt), it did not appear to be acceptable habitat.

b. We have several databases showing the locations of dams and other obstructions (highway pipes/culverts, etc.) in the Neuse River Basin, but we need to inspect/verify the location and status of each impoundment.

Response: Milburnie Dam on the main stem of the Neuse River was the group's consensus to be removed first. According to Mr. Wicker two issues need to be addressed before the dam was removed: 1. perform a HEC-RAS model at Milburnie Dam (to determine downstream flooding impacts, etc.) and 2. document the impact of the upstream wetlands once the dam was removed. Another dam that was discussed was the Barbour Mill Dam, on Swift Creek. The group indicated that an in depth field survey should be conducted within the study area, possibly within the tributaries mentioned above (Crabtree Creek, Swift and Middle Creeks, and Mill Creek). It may be best to have an individual walk or float down each stream and identify all obstructions on the tributary (dam, highway culvert, etc.). The locations of the obstructions could be GPS'ed and fish sampling could be taken at the base of each obstruction. Once all obstructions were identified on the tributaries, we would need to prioritize which obstruction should be removed first.

c. Discussed the restoration of populations of sturgeon, shad, and/or striped bass by restocking and monitoring the Neuse River Basin.

Response: The North Carolina Wildlife Resources Commission should be contacted and this issue discussed with them. Populations of sturgeon and blueback herring may be candidates for restocking. Dr. Hightower indicated that each year NCWRC monitors streams within the basin. Also NC Division of Water Quality, Water Quality Section monitors the basin every two years.

d. Regulate the flow release at Falls Dam.

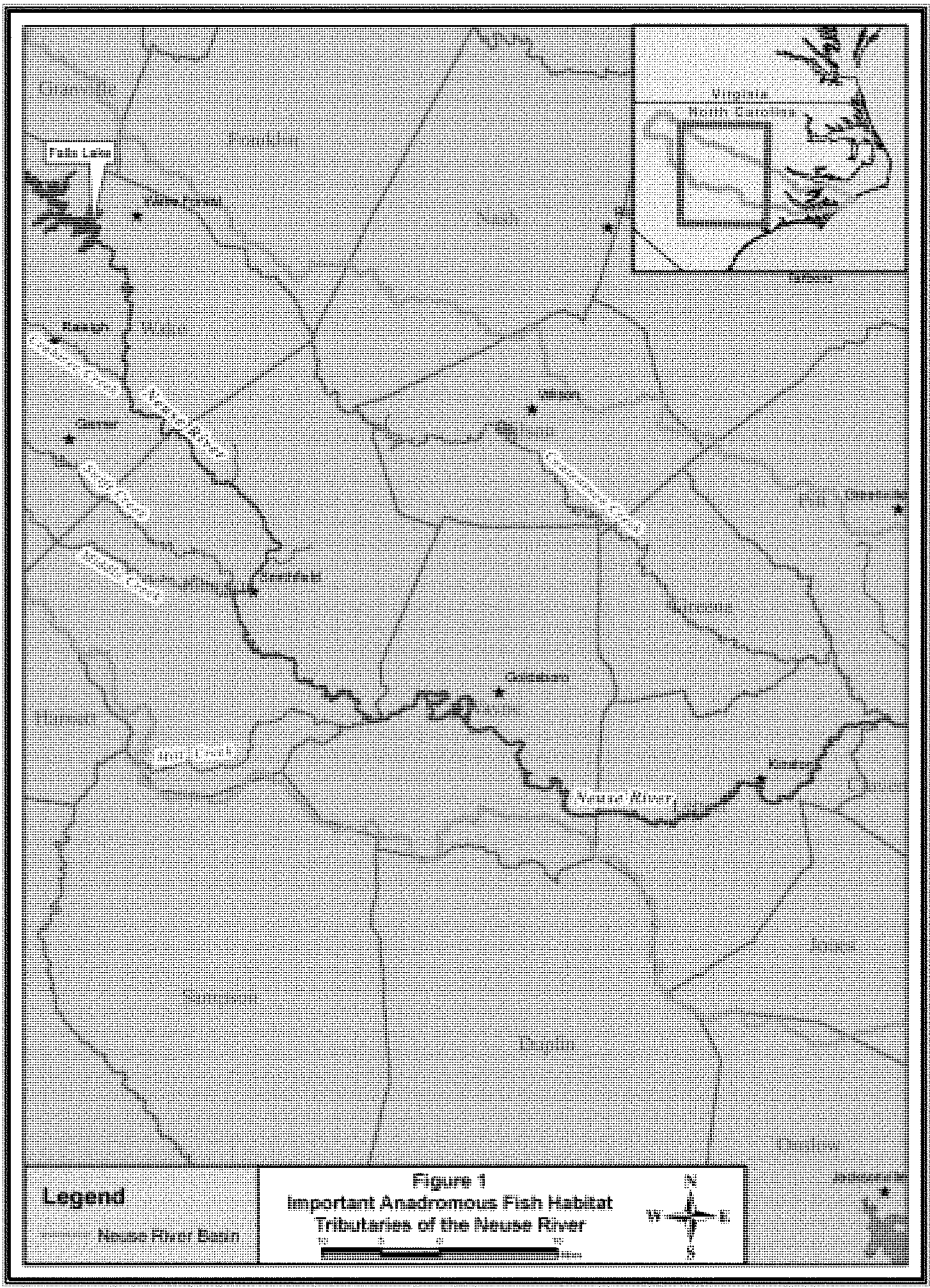
Response: Ms. Burclick indicated that flows were important in migration and spawning habitat in the Neuse River. Minimum and maximum flow releases from the dam should be studied to determine optimum flows during the anadromous migration and spawning season.

e. Placement of structure within the Neuse River Basin.

Response: This was a topic that both Dr. Hightower and Ms. Burclick brought up during the meeting. It appears that in the Northwest, salmon-spawning habitat was created using rock gravel placed within the stream channel. Both individuals stated that they believed rock structure placed within the Neuse River or its tributaries could provide spawning habitat for anadromous fish. Design of rock placement within streams would need to address keeping sediment from covering the rock and anchoring the rock so that it would not move downstream.

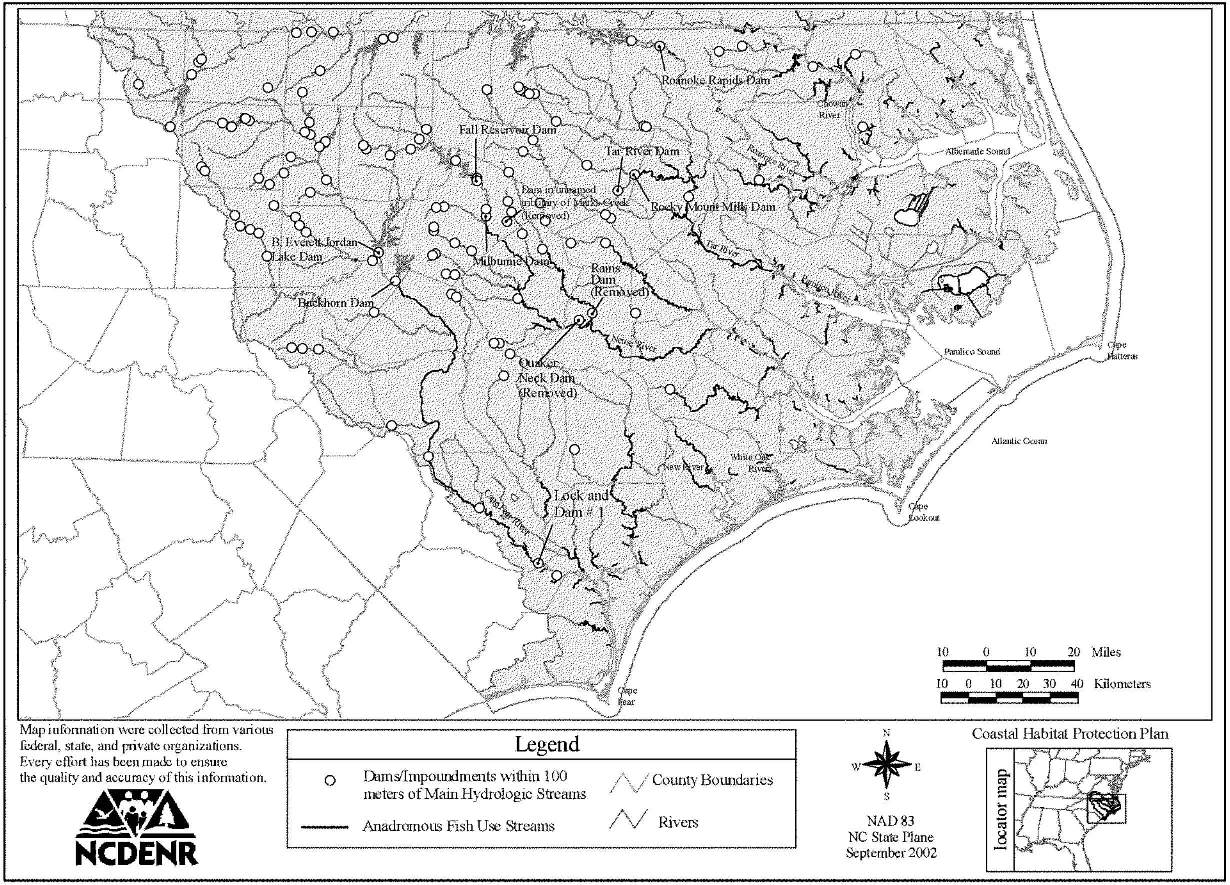
3. Another topic that Mr. Wicker brought up was the work of Jim MacBroom with Milone & MacBroom, Inc. Mr. MacBroom teaches river processes & restoration and applied hydrology. Mr. MacBroom has also experience in dam removal, fish passage at dams with fish ladders, ramps, and by-pass channels. He may be a resource that we could use for the Neuse River Study.

4. In the future, Dr. Hightower, Ms. Burclick, and Mr. Wicker may be available to meet with the study group. Ron Sechler, NMFS, Bennett Wynne, NCWRC, and Wilson Laney, NCSU should also be invited to attend future meetings of this study group.

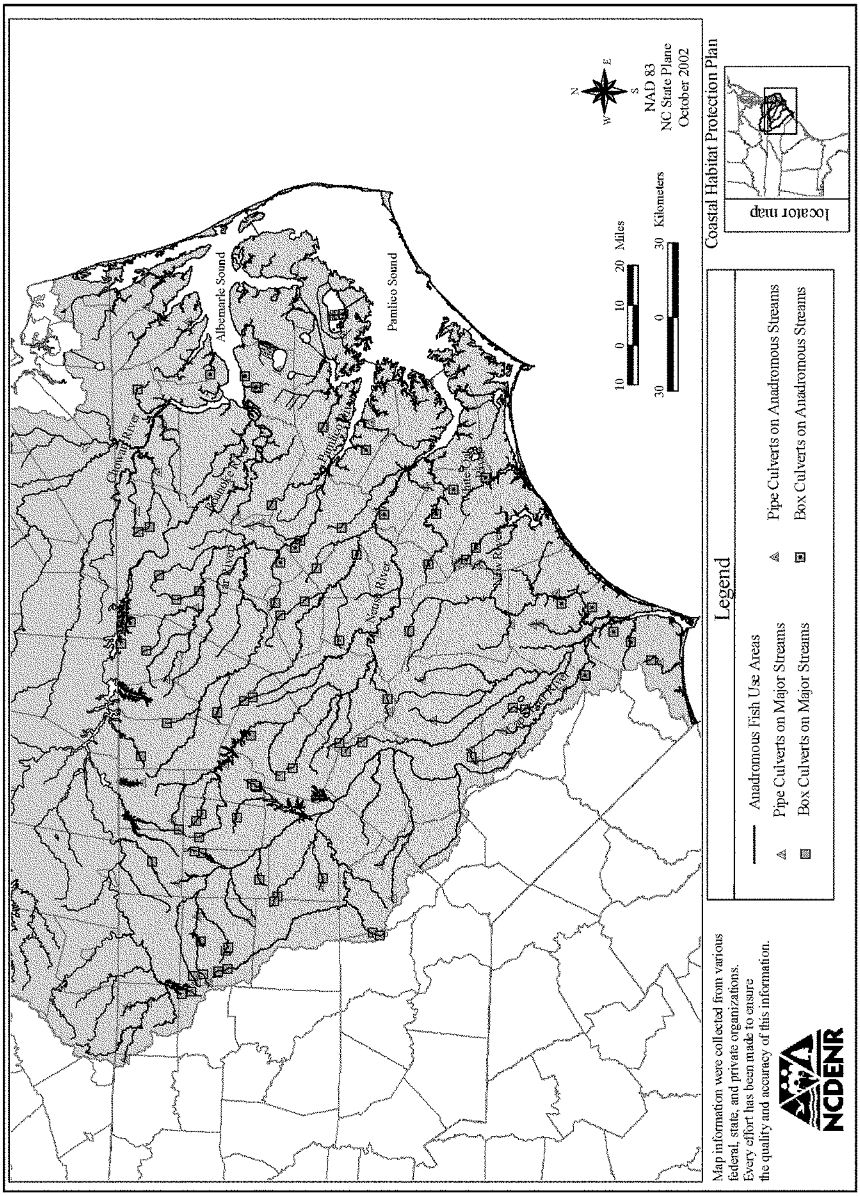


Falls Lake
Wake Forest
Raleigh
Wake
Garner
Neuse River
Smithfield
Wilson
Goldsboro
Kinston
Neuse River
Virginia
North Carolina
Legend
Neuse River Basin
Figure 1
Important Anadromous Fish Habitat
Tributaries of the Neuse River
N
W
E
S

Project Maps



Map 2.10. Location of dams on large creeks and rivers in coastal North Carolina drainages (from BasinPro3 software).



Map 2.12. Location of pipes and culverts on major streams in coastal North Carolina drainages.

STREAM CROSSING GUIDELINES

FOR ANADROMOUS FISH PASSAGE

Anadromous Fish are a valuable resource and their migration must not be adversely impacted. The purpose of this document is to provide guidance to the North Carolina Department of Transportation to ensure that replacement of existing and new highway stream crossing structures will not impede the movement of Anadromous Fish.

Applicable When:

- o Project is in the coastal plain defined by the "Fall Line" as the approximate western limit (see attached figure).
- o For perennial and intermittent streams delineated on most recent USGS 7.5 minute quadrangle maps.

General Guidelines:

- o Design and scheduling of projects should avoid the necessity of instream activities during the spring migration period. For the purposes of these guidelines "Spring" is considered to fall between February 15 and June 15. (In areas where the shortnose sturgeon may be present, the Cape Fear, Brunswick and Waccamaw Rivers, spring shall be defined as February 1 to June 15).
- o Bridges and other channel spanning structures are preferred where practical.

Technical Guidelines:

- o In all cases, the width, height and gradient of the proposed opening shall be such as to pass the average historical spring flow without adversely altering flow velocity. Spring flow should be determined from gage data if available. In the absence of this data, bankfull flow can be used as a comparative level. (Reference, "Fisheries Handbook of Engineering Requirements and Biological Criteria", Bell 1973, for fish swimming limitations.)
- o The invert of culverts shall be set at least one foot below the natural stream bed.

- Crossings of perennial streams serving watersheds greater than one square mile shall provide a minimum of four (4) feet of additional opening width (measured at spring flow elevation) to allow for terrestrial wildlife passage.

- In stream footings for bridges will be set one foot below the natural stream bed when practical.

For crossing sites which require permit review the following information will be provided as a minimum to facilitate resource agency review.

- Plan and profile views showing the existing and proposed crossing structures in relation to the stream bank and bed.

- Average historical spring flow (or bankfull flow) for the site.

- How the proposed structure will affect the velocity and stage of the spring flow (bankfull).

- Justification for any variance from the guideline recommendations.

APPENDIX N
SHEET 3 OF 3

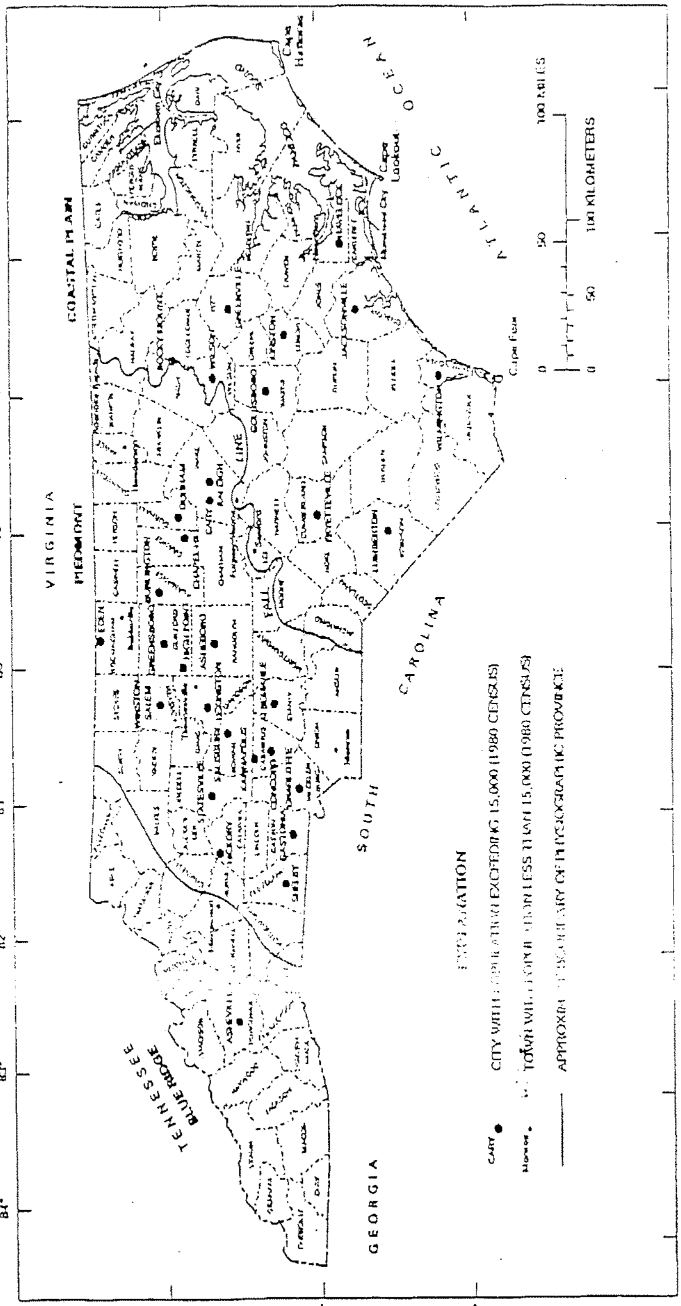


Figure 2. Counties and major population centers of North Carolina.

Neuse River Basin Study, Anadromous Fish Habitat Restoration Group Inspection Report

1. The purpose of this report is to summarize the sites visited in the Neuse River Basin and provide recommendations in light of anadromous fish habitat restoration.

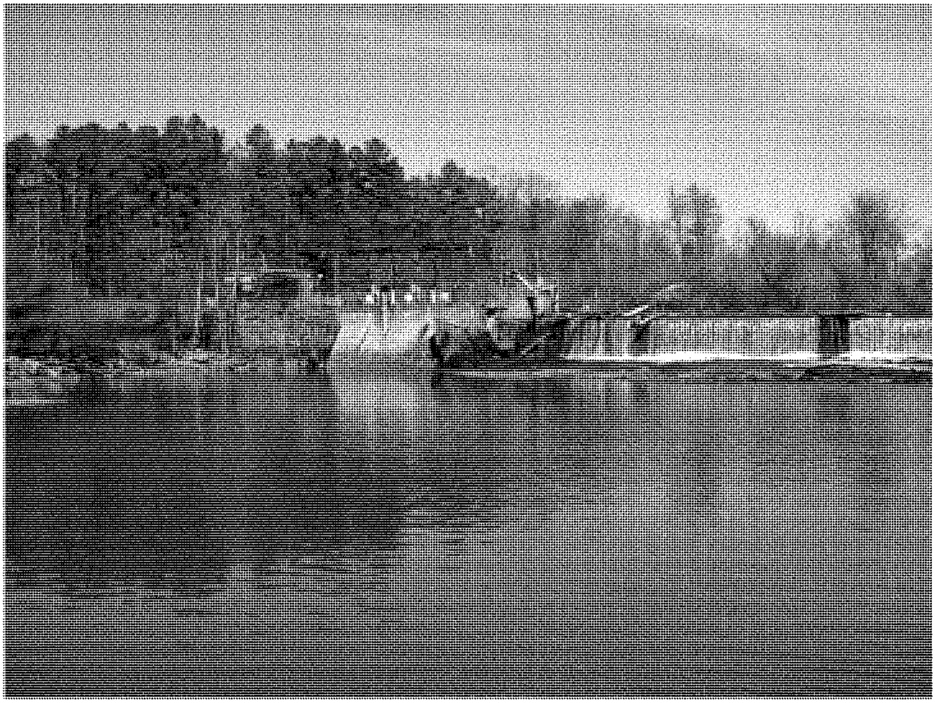
2. The following sites were inspected:

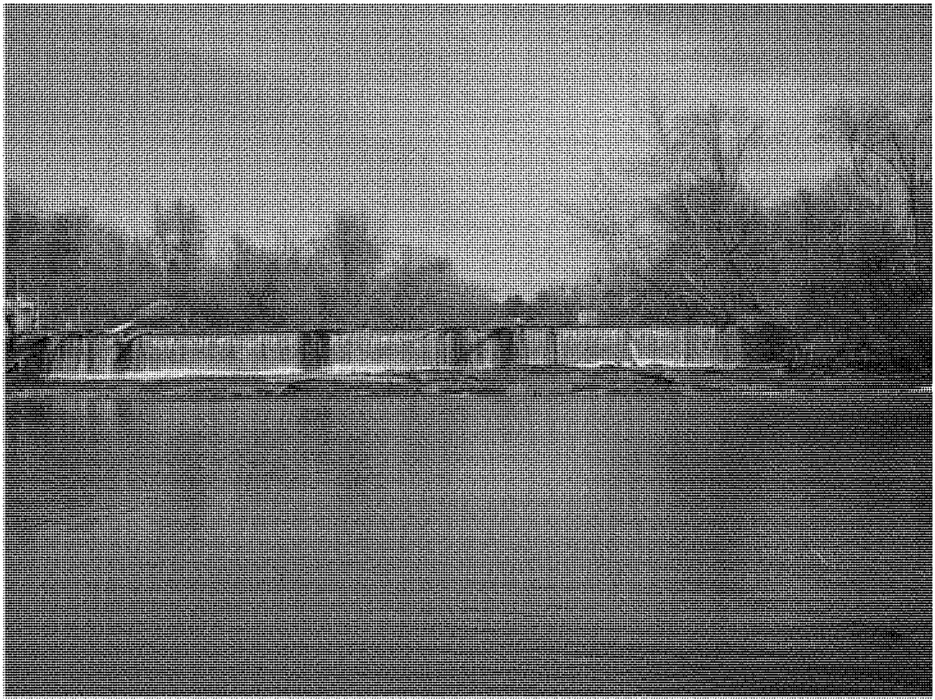
a. Milburnie Dam. The dam is located on the Neuse River upstream of US Highway 64 near Clayton, in Wake County. The 625-foot long, 15-foot high stone-masonary dam was constructed in 1903 and was used as a gristmill until the 1940's. Currently the dam is used as a hydroelectric generating facility. The dam is located about 14.7 miles downstream of Falls Reservoir. Milburnie is the last dam on the Neuse River before Falls Reservoir, which is constructed on the fall line. NC Division of Cultural Resources (NCDCR) has determined that this structure the North Carolina State Historic Preservation Officer (NCSHPO) indicated that the Pleasant Green Road Dam is unlikely to be eligible for the National Register of Historic Places and its removal would not affect any historic resources.

Impacts. Flooding impacts to downstream property, upstream wetland impacts, and cultural resources are the major issues. We will need to complete the following items: HEC-RAS evaluation, cultural phase 1 and 2 survey, delineate wetlands upstream of the dam, and up/down stream sediment analysis (to test for HTRW).

Recommendations. There are three choices; removal, fish ladder, or no action. We recommend that the dam be removed. We are in discussions with the property owner towards this goal.

Photographs:



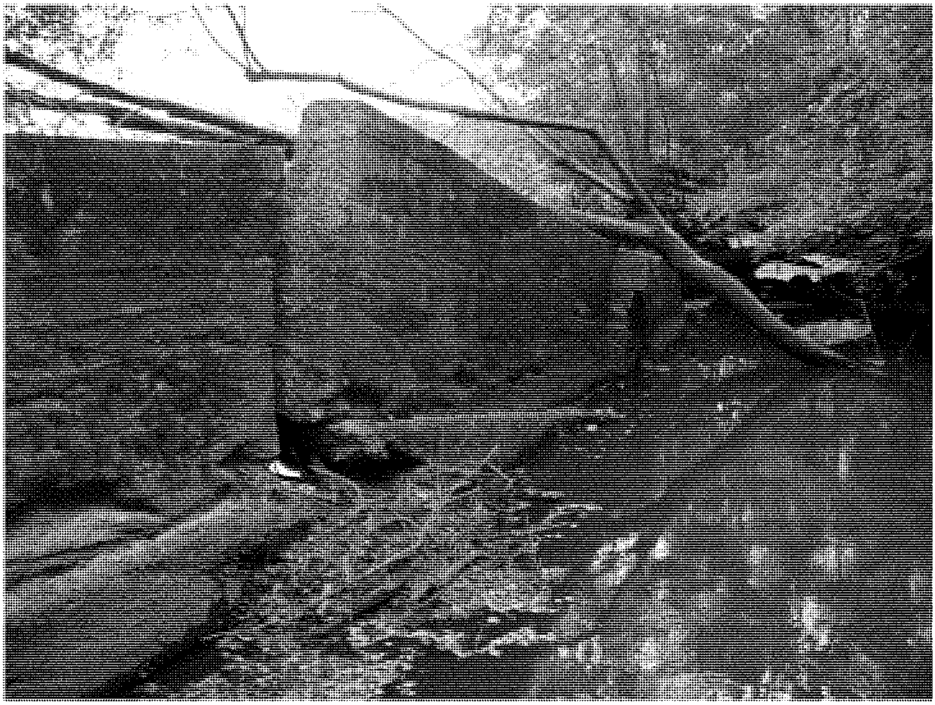


b. Crantock Dam. The partially breached Crantock Dam is located on Middle Creek upstream of the SR 1504 bridge in Johnston County. Middle Creek is a tributary to the Neuse River. The approximately 50-foot foot long concrete wing wall of Crantock Dam is blocking upstream migration of shad.

Impacts. No adverse impacts to the environment (i.e., HTRW, cultural resources, flood control, etc.) since the structure is partially collapsed.

Recommendations. Removal of the partially collapsed structure.

Photographs:

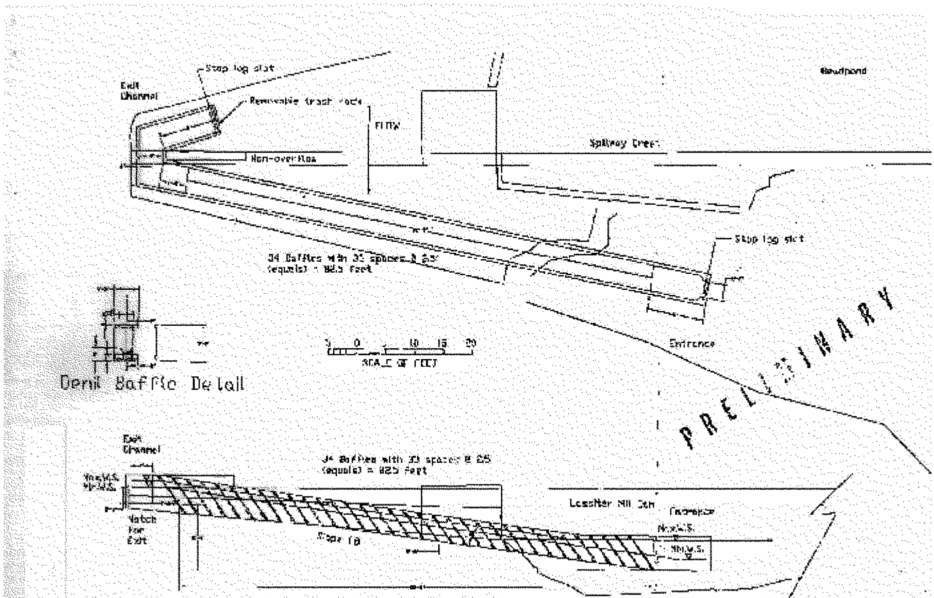


c. Lassiter Dam. Lassiter dam is located on Crabtree Creek, a tributary of the Neuse River. This structure was constructed in 1908 and the City of Raleigh has created a park on this site. The NC Division of Cultural Resources (NCDCR) has designated Lassiter Dam as an important cultural resource.

Impacts: The North Carolina State Historic Preservation Officer (NCSHPO) indicated that the Lassiter Dam is eligible for the National Register of Historic Places and its removal would affect historic resources. Additionally, the City of Raleigh and the adjacent homeowners would be against the removal of this historical structure.

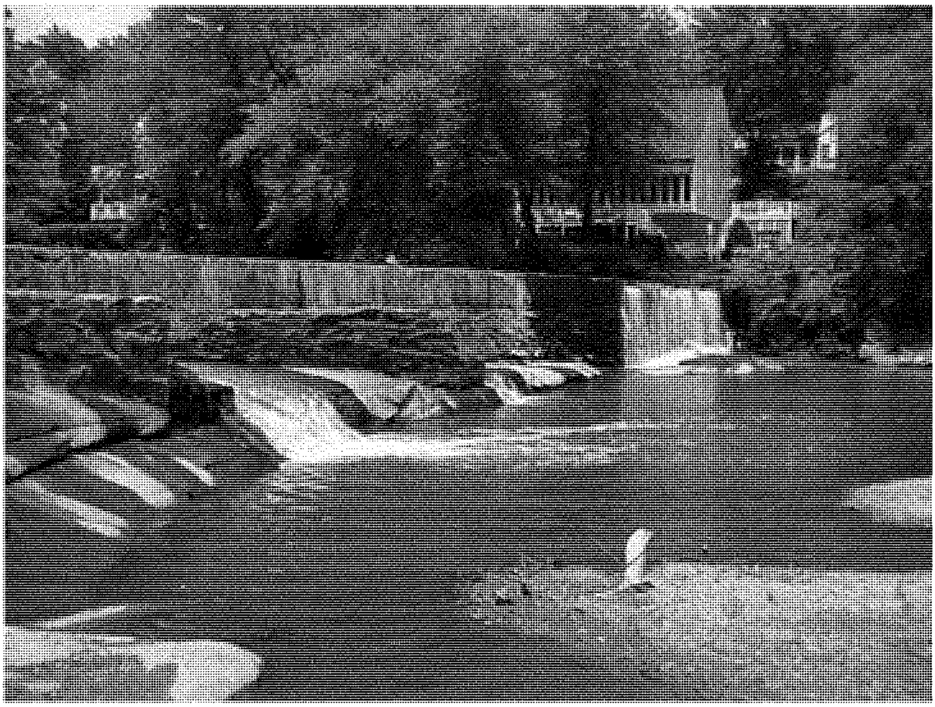
Recommendations: We propose to construct a fish ladder on Lassiter Dam to facilitate migration of shad and other anadromous species. Prior to the placement of this structure on Lassiter Dam, coordination with all interested parties will be completed.

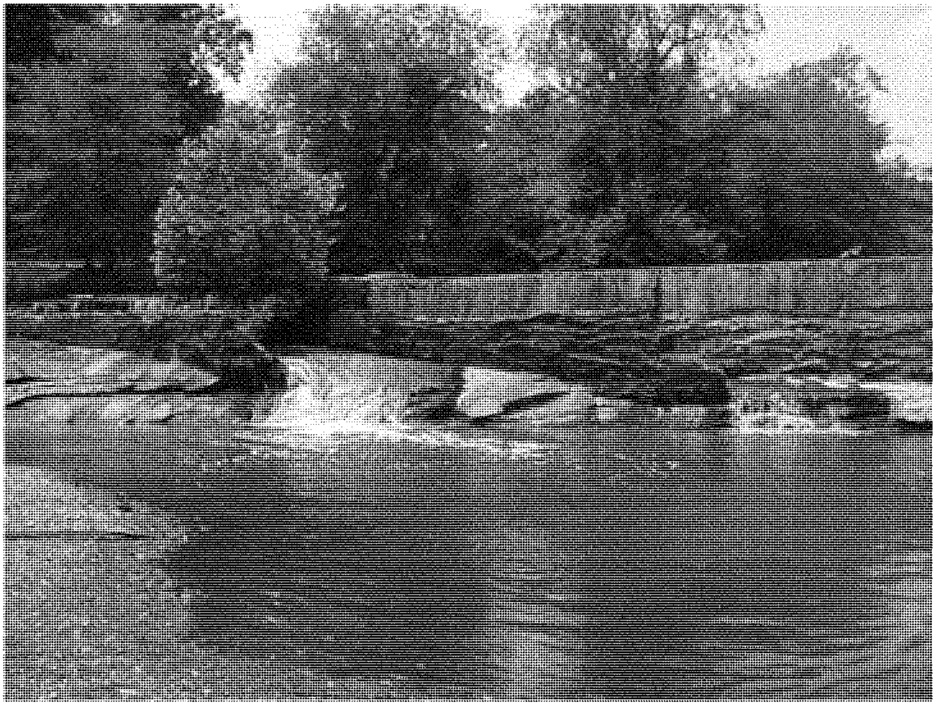
Proposed Denil Fishway for Lassiter Dam (Preliminary Design by Curt Orvis, USFWS).



Conceptual Design 4-foot wide Denil Fishway
for Lassiter Mill Dam, Crabtree Creek
Tributary to Neuse River near Raleigh, NC
by C. Orvis, U.S. Fish and Wildlife Service
June 21, 2007.

Photographs:





d. Breached Dam on Crabtree Creek. This structure is located in the William B. Umstead State Park, upstream of Lassiter Dam. About a third of the small concrete low head dam has collapsed. Water moving around the end of the collapsed dam has increased creek bank erosion.

Impacts. No adverse impacts to cultural resources, wetlands, HTRW, or the environment. Prior to any work being initiated, coordination with the NC Department of Parks and Recreation will be required.

Recommendations. Removal of the remaining concrete structure from the creek channel is recommended.

Photograph.

e. Breached Dam on Southwest Creek at Kelly Pond. Southwest Creek is a tributary of the Neuse River, near Kinston, in Lenior County. Southwest Creek has the capacity to provide habitat for anadromous species. Removal of the remainder of the structure would increase access upstream of the site.

Impacts. No adverse impacts to cultural resources, HTRW, or the environment since the structure is partially removed.

Recommendations. Removal of the remainder of the concrete structure from the stream channel would be the logical alternative. The adjacent mill house and upland portion of the property would not be impacted.

Photographs:

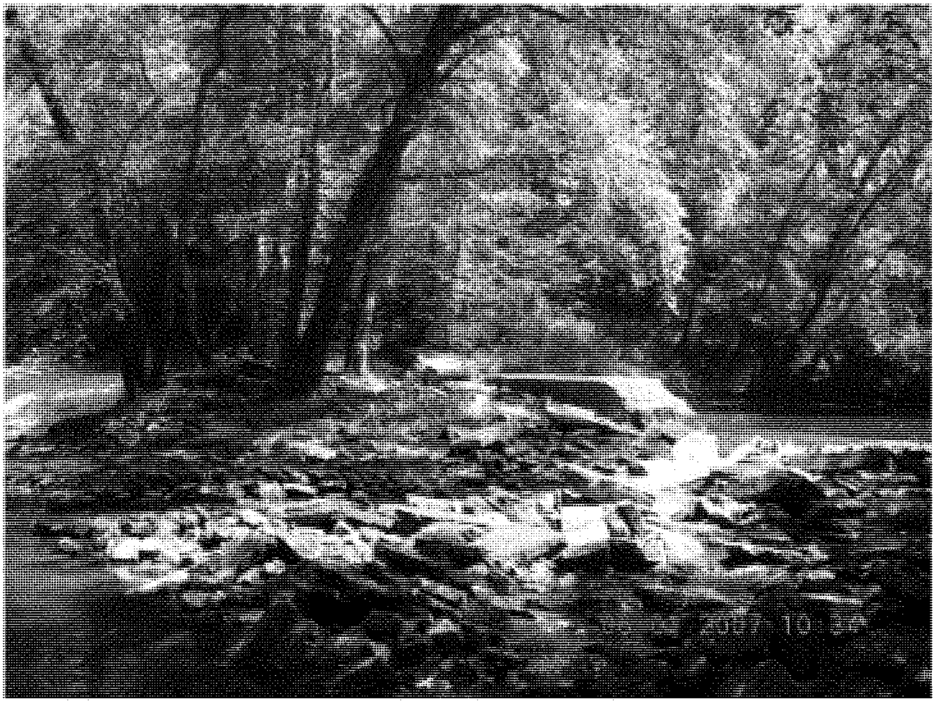
f. Low head dam on the Little River. This low head dam is located downstream of the City of Goldsboro's secondary water intake structure at the Water Treatment Plant. Goldsboro's primary water intake is located on the Neuse River. A portion of this structure has been removed or "notched" and under high flow conditions, some anadromous species are able to pass over this structure. However, under normal or low flow conditions, anadromous species and their eggs may not be able to pass this dam. Currently, two dams upstream (Raines Mill and Lowell Dams) have already been removed. If this dam in Goldsboro is removed up to 80 miles (to the Atkinson Mill Dam in Johnston County off NC Highway 42) of the main-stem of the Little River would be available for anadromous fish.

Impacts. No adverse impacts to cultural resources, HTRW, wetlands, or the environment. Will need to work with the City of Goldsboro regarding their upstream secondary water intake structure.

Recommendations. Removal of the remaining portion of the structure from the river channel.

Photographs.

1303

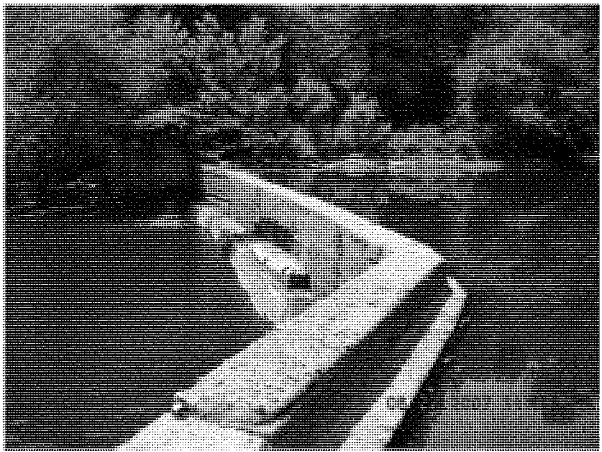


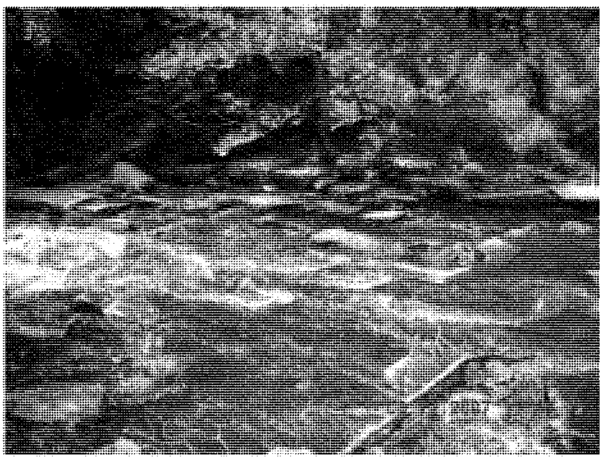
g. Partially Breached Dam on Contentnea Creek. The partially breached structure is located west of I-95 and off NC Highway 42 and SR 1142 in Wilson County. This dam is located upstream of Wiggins Mill Dam and Buckhorn Reservoir. Both Wiggins Mill and Buckhorn are water supply reservoirs for the City of Wilson.

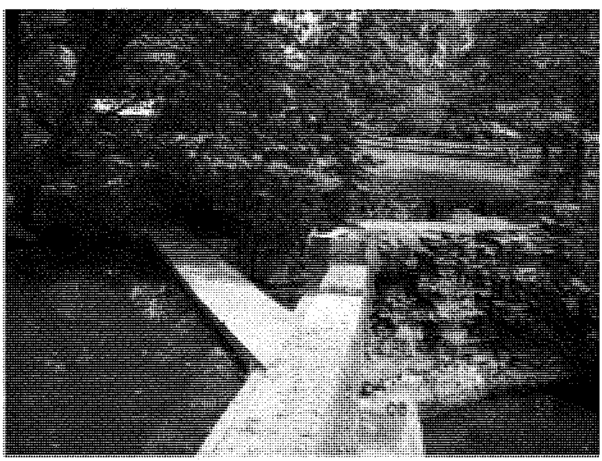
Impacts. Possible impacts to drinking water, cultural resources, HTRW, etc.

Recommendations. Need to discuss this matter with the PDT, since this site is located between two drinking water reservoirs.

Photographs.







Neuse River Basin Study, Anadromous Fish Habitat Restoration Group Dams That Have Been Removed Within the Project Area

1. Todate the following dams have been removed in the Neuse River Basin:

a. Quaker Neck Dam on the Neuse River. The Quaker Neck Dam was built in 1952 in order to provide cooling water for the CP&L steam generating plant. Removal of the dam in 1997 to 1998 reopened over 79 miles of the Neuse River to migratory fish habitat. The dam was removed voluntarily through a cooperative partnership of public and private stakeholders.

Demolition of the 260 - foot long Quaker Neck Dam will allow better passage for saltwater fish that spawn in rivers. Migratory fish that spawn in this freshwater system are already benefitting from the restored access to the upper Neuse. Specifically striped bass, American shad, hickory shad, and shortnose sturgeon are having better passage from their spawning grounds in the Neuse River between Goldsboro to Raleigh to the ocean.

Photographs: Not Available.

b. Cherry Hospital Dam on the Little River (tributary of the Neuse River). The small earthen - steel dam -- 135-feet wide and seven feet high -- is on the grounds of Cherry Hospital outside of Goldsboro, just off N.C. 581. The dam was built by the state about 50 years ago to impound water for use by nearby Cherry Hospital. A few years ago, the hospital began buying its water from the City of Goldsboro and the dam was no longer needed. Removal of the Cherry Hospital dam, according to DWR officials, will open 21 miles of the Little River and 33 miles of tributaries to the fish species that migrate from the ocean.

Photographs. Not Available.

c. Raines Mill Dam on the Little River (tributary of the Neuse River). In 1999, the 250-foot long, 12-foot high Rains Mill Dam and its attendant structures on the Little River, near Princeton, in Johnston County, North Carolina was demolished. Rains Mill Dam was located about 120 feet downstream of NC State Road 1002 and sometimes impounds up to a 28-acre lake.

Photographs.

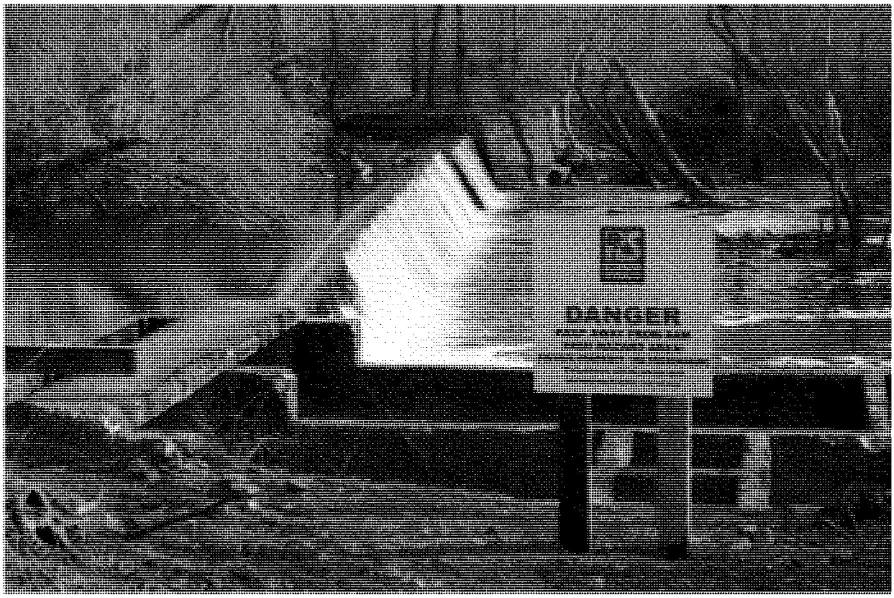
Before.

After.

d. Lowell Mill Dam on the Little River (tributary of the Neuse River). Lowell Mill Dam was about 200 feet long and less than 15-feet high. The dam was removed in 2005.

Photographs.

Before

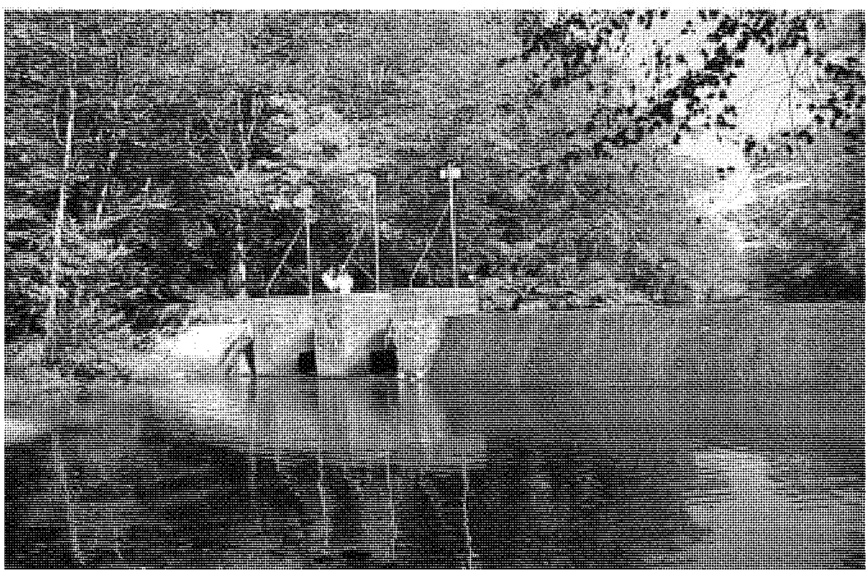


After.

e. Pleasant Green Road Dam on the Eno River. The Eno River begins in northwest Orange County, flowing eastward for approximately 33 miles where it converges with the Little and Flat Rivers to become the Neuse River which flows into Falls Lake. The Neuse River flows approximately 200 miles to its mouth at the Pamlico Sound. In 1915, the Pleasant Green Road Dam and the water intake canal, located about 200 feet upstream of the dam, were constructed on the Eno River by Duke Power Company to provide cooling water as well as a basin/reservoir, for the discharge of superheated water from the steam power generation plant (Hobbs, Upchurch, & Associates P.A. 2001). The Pleasant Green Road Dam is approximately 170 feet long and 10 to 12 feet-high, with two adjustable weirs on the south end (see Exhibit H, part 2). In 1958, Duke Power Company retired the power plant and removed all of its equipment but left the dam in place.

The dam is located in the Eno River State Park, about 270-feet upstream of the Pleasant Green Road (N.C. SR 1567) bridge, northwest of Durham, in Orange County, North Carolina. Because of the low height of the Pleasant Green Road Dam and incised piedmont riverbed, the impounded area is located entirely within the approximately 120-foot wide river channel. The structure was demolished in 2007.

Photographs.
Before



After

Freshwater fish species of recreational importance found in the Neuse River and tributaries are found in Table 2-4. The following information was taken from (NCDENR 2002):

> *Since 1998, the NCWRC has sampled the resident fish community using boat-mounted electrofishing gear at a number of locations in the Neuse River downstream of Goldsboro to New Bern as well as in its tributaries, Contentnea Creek and Trent River. Overall the number of species collected ranged from 11-29 with a mean of 20 species. At sites along the mainstem Neuse River, 16-26 species were collected, while at sites in Contentnea Creek and Trent River, 19-29 species and 11-26 species were collected, respectively.*

Common game and nongame species in the Neuse River Basin

Common name	Scientific name
Game	
largemouth bass	*Micropterus salmoides*
bluegill	*Lepomis macrochirus*
redear	*Lepomis microlophus*
redbreast sunfish	*Lepomis auritus*
pumpkinseed	*Lepomis gibbosus*
warmouth	*Lepomis gulosus*
black crappie	*Pomoxis nigromaculatus*
channel catfish	*Ictalurus punctatus (Rafinesque)*
white catfish	*Ameiurus catus*
blue catfish	*Ictalurus furcatus*
flathead catfish	*Pylodictis olivaris*
chain pickerel	*Esox niger*
redfin pickerel	*Esox americanus*
yellow perch	*Perca flavescens*
white perch	*Morone Americana*
Nongame	
bowfin	*Amia calva*
common carp	*Cyprinus carpio*
longnose gar	*Lepisosteus osseus* (Linnaeus)
pirate perch	*Aphredoderus sayanus*
satinfin shiner	*Cyprinella analostana*
v-lip redhorse	*Moxostoma pappillosum*
swallowtail shiner	*Notropis procne*
silvery	*Hybognathus regius*

Common name	Scientific name
minnow	
tessellated darter	*Etheostoma olmstedi*

NCWRC classifies all the species listed in the table above, except catfish, as inland game fish. Table 2-4 also lists nongame species commonly encountered. Largemouth bass and sunfish support popular fisheries year-round throughout the basin; however, peak fishing is in late spring and early summer. Anglers target black crappie in the late fall and early spring generally in the lower river and its tributaries. Yellow and white perch provide good fishing from late winter through the spring in the lower Neuse River, in particular the Trent River. Channel, blue, and flathead catfish provide additional angling opportunities throughout the year. Although large catfish (> 20 lbs) are common throughout the river and its major tributaries, much of the effort is concentrated from Goldsboro downstream to New Bern.

Anadromous species found within the Neuse River Basin include striped bass, American shad, hickory shad, blueback herring and alewife. Although striped bass are caught year-round in the Neuse and Trent rivers near New Bern, these species mainly support seasonal fisheries as they migrate into freshwater reaches of the Neuse River to spawn each spring. From 1952 to 1998, spawning migrations of anadromous fish were impeded by Quaker Neck Dam, a low-head dam near Goldsboro, and in most years spawning areas were limited to areas downstream of the dam. However, with the removal of Quaker Neck Dam in 1998, 79 miles of historical spawning habitat were restored. Anadromous species, in particular striped bass and American shad, now migrate upstream as far as Milburnie Dam near Raleigh, but the extent of upstream migration in a given year is highly dependent on river flows. Hickory shad, blueback herring and alewife are generally found from Goldsboro downstream to New Bern.

Appendix K: Streams and Wetlands Environmental Benefits Analysis

Introduction

This Appendix contains supplemental information and data regarding the Environmental Benefits Analysis (EBA) for streams and wetlands that was done for this study. A separate appendix (Appendix L) details the EBA that was done for oyster habitats. The information included in this Appendix consists of:

EBA calculation spreadsheets

This section contains: summary benefits and costs tables; calculation tables of AAFU benefits; and calculation tables for NC SHEM, including variable scores under different measures.

NC WAM data sheets

This section contains the data and output sheets that were used in the NC WAM analysis.

NC SHEM example data sheets

This section contains blank data sheets which show how variables are measured under NC SHEM. There are separate data sheets for Piedmont and for Coastal Plain streams.

The following sections provide a brief description of each the models used for wetland and stream assessment in this study. The models used were selected on the basis of their development within and applicability to North Carolina, and their sensitivity in being able to reflect changes to ecosystems on the basis of restoration activities. Applying the models in the field (determining variable scores under existing conditions) and in the office (predicting with and without project changes to variable scores over time) was done by a team of qualified biologists in the USACE Wilmington District with more than 70 years of combined experience. The models have been provided to the Ecosystem Restoration Planning Center of Expertise for an Agency Technical Review and have been requested to be approved for use on this study.

North Carolina Wetland Assessment Method (NC WAM)

Environmental benefits resulting from wetlands restoration opportunities were assessed using NC WAM Version 2.0, which is a rapid, reference-based functional assessment method. A state and Federal interagency team consisting of NCDOT, NCDENR, USEPA, USFWS, and the USACE developed NC WAM. The method provides functional ratings for up to 3 major functions and 10 sub-functions (Table 1), depending on the wetland type being assessed. Functions are evaluated using up to 22 field and GIS-based metrics, which include the soil, hydrologic, vegetative, and landscape characteristics of the assessment area. NC WAM data sheets are provided in Appendix K. Functional ratings are then determined on the basis of an iterative, Boolean logic process.

Table 1. Functions and sub-functions potentially measured in NC WAM

Function	Sub-function
Hydrology	Surface storage and retention
	Subsurface storage and retention
Water Quality	Pathogen change
	Particulate change
	Soluble change
	Physical change
	Pollution change
Habitat	Physical structure
	Landscape patch structure
	Vegetation composition

Three types of wetland are being assessed in this study—bottomland hardwood forest, estuarine woody wetland, and salt/brackish marsh. According to the assessment methodology, for bottomland hardwood forest sites, all functions and sub-functions (with the exception of the sub-function, pollution change) are measured by the assessment. For estuarine woody wetland, the hydrology main function and the habitat function and sub-functions are measured. For the salt/brackish marsh, only the hydrology and habitat main functions (no sub-functions) are measured.

The PDT made some modifications to the standard NC WAM outputs so that they could be useable in the EBA. The EBA requires that quality be measured numerically. NC WAM, however, does not provide numerical outputs; instead it gives each function and sub-function a rating of Low, Medium, or High. Therefore, the modification the PDT made was to assign each function or sub-function rating an index score of 0.1 (Low), 0.5 (Medium), or 1.0 (High). A sensitivity, or risk, analysis of assigning numbers to qualitative factors in this study is presented in section 6.4. For wetland classes that measure sub-functions, the sub-function scores are averaged to determine a score for the primary function. Because there was no clear scientific basis for differentially weighting sub-functions, each sub-function was given equal weight in determining the primary function score. For instance, the hydrology function consists of two sub-functions—surface storage and retention, and subsurface storage and retention. If, for instance, the scores for these sub-functions are 0.1 and 0.5, the score for the hydrology primary function will be 0.3. The primary functions scores are then averaged together to give a wetland functional index score for the site.

The entire NCWAM model documentation is available at:

http://portal.ncdenr.org/web/wq/swp/ws/pdu/ncwam

4.1.1.2 North Carolina Stream Habitat Evaluation Method (NC SHEM)
Stream restoration opportunities were assessed using the stream habitat evaluation procedure as outlined in the *Internal Technical Guide for Stream Work in North Carolina*, which was developed for NCDWQ by an interagency team including NCDWQ, North Carolina Division of Land Resources, and USACE. The method constitutes a functional assessment approach to stream habitat quality. Each stream segment is evaluated on the basis of seven or eight variables (depending on ecoregion location). The variables capture aspects of riparian condition, channel modification, and in-stream habitat. Each variable is assigned a numerical score on the basis of field observations and measurements, and some variables have higher maximum scores than others. An aggregate functional score for a stream segment is calculated by adding the individual variable scores, with the highest possible total score equaling 100. For the purpose of the EBA, the total score was divided by 100 to generate a stream functional index score. The *Internal Technical Guide for Stream Work in North Carolina* Document is available at:

http://h2o.enr.state.nc.us/ncwetlands/documents/streamgd-1.pdf

Average Annual Environmental Benefits and Total Primary Costs Spreadsheets

- Ellerbe Creek
- Adkin Branch
- Kinston East Wetland
- Gum Thicket / Cedar Creek
- Little River Dam

Ellerbe Creek Costs

			Unit Cost	Units	Cost	Conting.	E & D	Construction	O & PM	Total
Measure	A1	Real Estate	$10,000/acre	6.2	$62,000	$12,400	$7,440	$4,960	$3,100	**$89,900**
		Bottomland Hardwood Planting	$15,000/acre	6.2	$93,000	$18,600	$11,160	$7,440	$4,650	**$134,850**
		Excavate and Haul Offsite	$25/CY	5,000	$125,000	$25,000	$15,000	$10,000	$6,250	**$181,250**
										$406,000
	A2	Real Estate	$10,000/acre	5.3	$53,000	$10,600	$6,360	$4,240	$2,650	**$76,850**
		Bottomland Hardwood Planting	$15,000/acre	5.3	$53,000	$10,600	$6,360	$4,240	$2,650	**$76,850**
		Excavate and Haul Offsite	$25/CY	4,275	$106,875	$21,375	$12,825	$8,550	$5,344	**$154,969**
										$308,669
	A3	Real Estate	$10,000/acre	2.8	$28,000	$5,600	$3,360	$2,240	$1,400	**$40,600**
		Bottomland Hardwood Planting	$15,000/acre	2.8	$42,000	$8,400	$5,040	$3,360	$2,100	**$60,900**
		Excavate and Haul Offsite	$25/CY	2,259	$56,475	$11,295	$6,777	$4,518	$2,824	**$81,889**
										$183,389
	B	Step Pools - Rock	$94/ton	36	$3,384	$677	$406	$271	$169	**$4,907**
		Step Pools - Logs	$1,000/log	6	$6,000	$1,200	$720	$480	$300	**$8,700**
										$13,607
	B and C	Excavate and Haul Offsite	$25/CY	2420	$60,500	$12,100	$7,260	$4,840	$3,025	**$87,725**
		Step Pools - Rock	$94/ton	54	$5,076	$1,015	$609	$406	$254	**$7,360**
		Step Pools - Logs	$1,000/log	9	$9,000	$1,800	$1,080	$720	$450	**$13,050**
										$108,135
Site Prep.	A1				41145	$8,229	$4,937	$3,292	$2,057	**$59,660**
	A2				37003	$7,401	$4,440	$2,960	$1,850	**$53,654**
	A3				25495	$5,099	$3,059	$2,040	$1,275	**$36,968**
	B				1486	$297	$178	$119	$74	**$2,155**
										$152,437
General Markups		Contingencies	20%							
		Engineering & Design	12%							
		Construction	8%							
		Operations & PM	5%							

Ellerbe Creek Calculation of AAFU for streams

	Measure/Alternative Functional Index					
Year	A1	A2 or A3	A1A2A3C Reach 1	A1A2A3C Reach 2	A1A2A3BC Reach 1	A1A2A3BC Reach 2
1	0.4	0.34	0.41	0.39	0.66	0.64
2	0.40125	0.34333	0.41125	0.39333	0.66125	0.64333
3	0.4025	0.34666	0.4125	0.39666	0.6625	0.64666
4	0.40375	0.34999	0.41375	0.39999	0.66375	0.64999
5	0.405	0.35332	0.415	0.40332	0.665	0.65332
6	0.40625	0.35665	0.41625	0.40665	0.66625	0.65665
7	0.4075	0.35998	0.4175	0.40998	0.6675	0.65998
8	0.40875	0.36331	0.41875	0.41331	0.66875	0.66331
9	0.41	0.36664	0.42	0.41664	0.67	0.66664
10	0.41125	0.36997	0.42125	0.41997	0.67125	0.66997
11	0.4125	0.3733	0.4225	0.4233	0.6725	0.6733
12	0.41375	0.37663	0.42375	0.42663	0.67375	0.67663
13	0.415	0.37996	0.425	0.42996	0.675	0.67996
14	0.41625	0.38329	0.42625	0.43329	0.67625	0.68329
15	0.4175	0.38662	0.4275	0.43662	0.6775	0.68662
16	0.41875	0.38995	0.42875	0.43995	0.67875	0.68995
17	0.42	0.39328	0.43	0.44328	0.68	0.69328
18	0.42125	0.39661	0.43125	0.44661	0.68125	0.69661
19	0.4225	0.39994	0.4325	0.44994	0.6825	0.69994
20	0.42375	0.40327	0.43375	0.45327	0.68375	0.70327
21	0.425	0.4066	0.435	0.4566	0.685	0.7066
22	0.42625	0.40993	0.43625	0.45993	0.68625	0.70993
23	0.4275	0.41326	0.4375	0.46326	0.6875	0.71326
24	0.42875	0.41659	0.43875	0.46659	0.68875	0.71659
25	0.43	0.42	0.44	0.47	0.69	0.72
26	0.43	0.42	0.44	0.47	0.69	0.72
27	0.43	0.42	0.44	0.47	0.69	0.72
28	0.43	0.42	0.44	0.47	0.69	0.72
29	0.43	0.42	0.44	0.47	0.69	0.72
30	0.43	0.42	0.44	0.47	0.69	0.72
31	0.43	0.42	0.44	0.47	0.69	0.72
32	0.43	0.42	0.44	0.47	0.69	0.72
33	0.43	0.42	0.44	0.47	0.69	0.72
34	0.43	0.42	0.44	0.47	0.69	0.72
35	0.43	0.42	0.44	0.47	0.69	0.72
36	0.43	0.42	0.44	0.47	0.69	0.72
37	0.43	0.42	0.44	0.47	0.69	0.72
38	0.43	0.42	0.44	0.47	0.69	0.72
39	0.43	0.42	0.44	0.47	0.69	0.72
40	0.43	0.42	0.44	0.47	0.69	0.72
41	0.43	0.42	0.44	0.47	0.69	0.72
42	0.43	0.42	0.44	0.47	0.69	0.72
43	0.43	0.42	0.44	0.47	0.69	0.72
44	0.43	0.42	0.44	0.47	0.69	0.72
45	0.43	0.42	0.44	0.47	0.69	0.72
46	0.43	0.42	0.44	0.47	0.69	0.72
47	0.43	0.42	0.44	0.47	0.69	0.72
48	0.43	0.42	0.44	0.47	0.69	0.72
49	0.43	0.42	0.44	0.47	0.69	0.72
50	0.43	0.42	0.44	0.47	0.69	0.72
Acres	0.56	0.31	0.6	0.77	0.6	0.77
AAFI	0.42	0.40	0.43	0.45	0.68	0.70
AAFU	**0.24**	**0.12**	**0.26**	**0.35**	**0.41**	**0.54**

Ellerbe Creek NCSHEM Variable Scores for No Action (current condition) and With Project Measures and Alternatives

Measure / Alternative	Acres	Variable Scores * V1	V2	V3	V4	V5	V6	V7[1]	V8	Total[1,2]	AAFU	Benefit	Totals
No Action Reach 1	0.56	2	6	3	0	0	8	7	10	29	0.16	0	
No Action Reach 2	0.31	2	6	3	0	0	6	2	0	19	0.06	0	
A1	0.56	3	6	3	0	0	11	7 to 10	10	40 to 43	0.24	0.08	
A2 or A3, or A2 and A3	0.31	3	6	3	0	0	10	2 to 10	10	34 to 42	0.12	0.06	
B (Reach 1)	0.56	2	15	3	10	16	8	7	10	71	0.4	0.24	
B (Reach 2)	0.31	2	15	3	10	16	6	2	0	54	0.17	0.11	**0.35**
A1A2A3C (Reach 1)	0.6	4	6	3	0	0	11	7 to 10	10	41 to 44	0.26	0.1	
A1A2A3C (Reach 2)	0.77	4	6	3	0	0	14	2 to10	10	39 to 47	0.35	0.29	**0.39**
A1A2A3BC (Reach 1)	0.6	4	15	3	10	16	11	7 to 10	10	66 to 69	0.41	0.25	
A1A2A3BC (Reach 2)	0.77	4	15	3	10	16	14	2 to10	10	64 to 72	0.54	0.48	**0.73**

* V1 = Channel Modification
V2 = Instream Habitat
V3 = Bottom Substrate
V4 = Pool Variety
V5 = Riffle Habitats
V6 = Bank Stability and Vegetation
V7 = Light Penetration
V8 = Riparian Vegetation Zone Width

[1] There is an initial score at year 1 and increase linearly to a final score at year 25.
[2] Total NC SHEM score is divided by 100 to obtain Stream Functional Index score

Ellerbe Creek Calculation of AAFU for Wetlands

	NCWAM Sub-functions or Functions *													Effects of Measures A1, A2, or A3: Functional Index			Acres (No Meander)			Functional Units Benefit (No Meander)			AAFU Benefit (No Meander)			Acres (Meander)			Functional Units Benefit (Meander)			AAFU Benefit (Meander)		
Year	SF1	SF2	F1	SF3	SF4	SF5	SF6	F2	SF7	SF8	SF9	F3	Total	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3	A1	A2	A3
1	1	0.5	**0.75**	1	0.5	1	1	**0.875**	0.100	0.1	0.500	**0.233**	0.62	0.48	0.42	0	6.2	5.3	2.8	0.86	1.06	1.73	**1.78**	**1.84**	**2.15**	6.16	4.89	2.75	0.86	0.98	1.70	**1.77**	**1.70**	**2.11**
2	1	0.5	**0.75**	1	0.5208	1	1	**0.880**	0.138	0.1	0.521	**0.253**	0.63	0.48	0.42	0	6.2	5.3	2.8	0.92	1.10	1.76				6.16	4.89	2.76	0.91	1.02	1.73			
3	1	0.5	**0.75**	1	0.5416	1	1	**0.885**	0.175	0.1	0.542	**0.272**	0.64	0.48	0.42	0	6.2	5.3	2.8	0.97	1.14	1.78				6.16	4.89	2.75	0.96	1.08	1.75			
4	1	0.5	**0.75**	1	0.5624	1	1	**0.891**	0.213	0.1	0.562	**0.292**	0.64	0.48	0.42	0	6.2	5.3	2.8	1.02	1.19	1.80				6.16	4.89	2.75	1.01	1.10	1.77			
5	1	0.5	**0.75**	1	0.5832	1	1	**0.896**	0.250	0.1	0.583	**0.311**	0.65	0.48	0.42	0	6.2	5.3	2.8	1.07	1.23	1.83				6.16	4.89	2.75	1.06	1.14	1.79			
6	1	0.5	**0.75**	1	0.604	1	1	**0.901**	0.288	0.1	0.604	**0.331**	0.66	0.48	0.42	0	6.2	5.3	2.8	1.12	1.27	1.85				6.16	4.89	2.75	1.11	1.18	1.82			
7	1	0.5	**0.75**	1	0.6248	1	1	**0.906**	0.325	0.1	0.625	**0.350**	0.67	0.48	0.42	0	6.2	5.3	2.8	1.17	1.32	1.87				6.16	4.89	2.75	1.16	1.22	1.84			
8	1	0.5	**0.75**	1	0.6456	1	1	**0.911**	0.363	0.1	0.646	**0.369**	0.68	0.48	0.42	0	6.2	5.3	2.8	1.22	1.36	1.90				6.16	4.89	2.75	1.21	1.26	1.86			
9	1	0.5	**0.75**	1	0.6664	1	1	**0.917**	0.400	0.1	0.666	**0.389**	0.69	0.48	0.42	0	6.2	5.3	2.8	1.27	1.41	1.92				6.16	4.89	2.75	1.26	1.30	1.88			
10	1	0.5	**0.75**	1	0.6872	1	1	**0.922**	0.438	0.1	0.687	**0.408**	0.69	0.48	0.42	0	6.2	5.3	2.8	1.32	1.45	1.94				6.16	4.89	2.75	1.31	1.34	1.91			
11	1	0.5	**0.75**	1	0.708	1	1	**0.927**	0.475	0.1	0.708	**0.428**	0.70	0.48	0.42	0	6.2	5.3	2.8	1.37	1.49	1.96				6.16	4.89	2.75	1.36	1.38	1.93			
12	1	0.5	**0.75**	1	0.7288	1	1	**0.932**	0.513	0.1	0.729	**0.447**	0.71	0.48	0.42	0	6.2	5.3	2.8	1.42	1.54	1.99				6.16	4.89	2.75	1.42	1.42	1.95			
13	1	0.5	**0.75**	1	0.7496	1	1	**0.937**	0.550	0.1	0.750	**0.467**	0.72	0.48	0.42	0	6.2	5.3	2.8	1.48	1.58	2.01				6.16	4.89	2.75	1.47	1.46	1.97			
14	1	0.5	**0.75**	1	0.7704	1	1	**0.943**	0.588	0.1	0.770	**0.486**	0.73	0.48	0.42	0	6.2	5.3	2.8	1.53	1.62	2.03				6.16	4.89	2.75	1.52	1.50	2.00			
15	1	0.5	**0.75**	1	0.7912	1	1	**0.948**	0.625	0.1	0.791	**0.505**	0.73	0.48	0.42	0	6.2	5.3	2.8	1.58	1.67	2.06				6.16	4.89	2.75	1.57	1.54	2.02			
16	1	0.5	**0.75**	1	0.812	1	1	**0.953**	0.663	0.1	0.812	**0.525**	0.74	0.48	0.42	0	6.2	5.3	2.8	1.63	1.71	2.08				6.16	4.89	2.75	1.62	1.58	2.04			
17	1	0.5	**0.75**	1	0.8328	1	1	**0.958**	0.700	0.1	0.833	**0.544**	0.75	0.48	0.42	0	6.2	5.3	2.8	1.68	1.75	2.10				6.16	4.89	2.75	1.67	1.62	2.06			
18	1	0.5	**0.75**	1	0.8536	1	1	**0.963**	0.738	0.1	0.854	**0.564**	0.76	0.48	0.42	0	6.2	5.3	2.8	1.73	1.80	2.13				6.16	4.89	2.75	1.72	1.66	2.09			
19	1	0.5	**0.75**	1	0.8744	1	1	**0.969**	0.775	0.1	0.874	**0.583**	0.77	0.48	0.42	0	6.2	5.3	2.8	1.78	1.84	2.15				6.16	4.89	2.75	1.77	1.70	2.11			
20	1	0.5	**0.75**	1	0.8952	1	1	**0.974**	0.813	0.1	0.895	**0.603**	0.78	0.48	0.42	0	6.2	5.3	2.8	1.83	1.88	2.17				6.16	4.89	2.75	1.82	1.74	2.13			
21	1	0.5	**0.75**	1	0.916	1	1	**0.979**	0.850	0.1	0.916	**0.622**	0.78	0.48	0.42	0	6.2	5.3	2.8	1.88	1.93	2.19				6.16	4.89	2.75	1.87	1.78	2.16			
22	1	0.5	**0.75**	1	0.9368	1	1	**0.984**	0.888	0.1	0.937	**0.641**	0.79	0.48	0.42	0	6.2	5.3	2.8	1.93	1.97	2.22				6.16	4.89	2.75	1.92	1.82	2.18			
23	1	0.5	**0.75**	1	0.9576	1	1	**0.989**	0.925	0.1	0.958	**0.661**	0.80	0.48	0.42	0	6.2	5.3	2.8	1.98	2.01	2.24				6.16	4.89	2.75	1.97	1.86	2.20			
24	1	0.5	**0.75**	1	0.9784	1	1	**0.995**	0.963	0.1	0.978	**0.680**	0.81	0.48	0.42	0	6.2	5.3	2.8	2.04	2.06	2.26				6.16	4.89	2.75	2.02	1.90	2.22			
25	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
26	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
27	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
28	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
29	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
30	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
31	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
32	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
33	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
34	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
35	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
36	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
37	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
38	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
39	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
40	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
41	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
42	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
43	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
44	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
45	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
46	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
47	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
48	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
49	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
50	1	0.5	**0.75**	1	1	1	1	**1**	1	0.1	1	**0.7**	0.82	0.48	0.42	0	6.2	5.3	2.8	2.09	2.10	2.29				6.16	4.89	2.75	2.07	1.94	2.25			
													0.77																					

* SF1 = Hydrology subfunction - Surface Storage and Retention
SF2 = Hydrology subfunction - Sub-Surface Storage and Retention
F1 = Hydrology Primary Function
SF3 = Water Quality subfunction - Pathogen Change
SF4 = Water Quality subfunction - Particulate Change
SF5 = Water Quality subfunction - Soluble Change
SF6 = Water Quality subfunction - Physical Change
F2 = Water Quality Primary Function
SF7 = Habitat subfunction - Physical Structure
SF8 = Habitat subfunction - Landscape Patch Structure
SF9 = Habitat subfunction - Vegetation Composition
F3 = Habitat Primary Function

Adkin Branch Costs

		Quantity	Total 1	Contingencies	E&D	Construction	Operations & PM	Totals
Measure	A1							
	Plant riparian vegetation at $12,000 acres -	.33 acres	$3,960	$792	$475	$317	$198	**$5,742**
	A2							
	Plant riparian vegetation at $12,000 acres -	.65 acres	$7,800	$1,560	$936	$624	$390	**$11,310**
	B							
	Place Woody Debris - semi-buried, non-anchored logs w/root wads at $1,000 each - $9,000	9 logs	$9,000	$1,800	$1,080	$720	$450	**$13,050**
	Site Prep							
	$59,250 - identical for all alternatives		$59,250	$11,850	$7,110	$4,740	$2,963	**$85,913**

General Markups	Contingencies	20%
	Engineering & Design	12%
	Construction	8%
	Operations & PM	5%

Adkin Branch Calculation of AAFU for Streams

Year	[illegible]					
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	0.41	[illegible]	[illegible]	0.64
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	0.2816	0.4292	0.4125	0.39666	0.6625	0.64666
4	0.2924	0.4338	0.41375	0.39999	0.66375	0.64999
5	0.3032	0.4384	0.415	0.40332	0.665	0.65332
6	0.314	0.443	0.41625	0.40665	0.66625	0.65665
7	0.3248	0.4476	0.4175	0.40998	0.6675	0.65998
8	0.3356	0.4522	0.41875	0.41331	0.66875	0.66331
9	0.3464	0.4568	0.42	0.41664	0.67	0.66664
10	0.3572	0.4614	0.42125	0.41997	0.67125	0.66997
11	0.368	0.466	0.4225	0.4233	0.6725	0.6733
12	0.3788	0.4706	0.42375	0.42663	0.67375	0.67663
13	0.3896	0.4752	0.425	0.42996	0.675	0.67996
14	0.4004	0.4798	0.42625	0.43329	0.67625	0.68329
15	0.4112	0.4844	0.4275	0.43662	0.6775	0.68662
16	0.422	0.489	0.42875	0.43995	0.67875	0.68995
17	0.4328	0.4936	0.43	0.44328	0.68	0.69328
18	0.4436	0.4982	0.43125	0.44661	0.68125	0.69661
19	0.4544	0.5028	0.4325	0.44994	0.6825	0.69994
20	0.4652	0.5074	0.43375	0.45327	0.68375	0.70327
21	0.476	0.512	0.435	0.4566	0.685	0.7066
22	0.4868	0.5166	0.43625	0.45993	0.68625	0.70993
23	0.4976	0.5212	0.4375	0.46326	0.6875	0.71326
24	0.5084	0.5258	0.43875	0.46659	0.68875	0.71659
25	0.52	0.53	0.44	0.47	0.69	0.72
26	0.52	0.53	0.44	0.47	0.69	0.72
27	0.52	0.53	0.44	0.47	0.69	0.72
28	0.52	0.53	0.44	0.47	0.69	0.72
29	0.52	0.53	0.44	0.47	0.69	0.72
30	0.52	0.53	0.44	0.47	0.69	0.72
31	0.52	0.53	0.44	0.47	0.69	0.72
32	0.52	0.53	0.44	0.47	0.69	0.72
33	0.52	0.53	0.44	0.47	0.69	0.72
34	0.52	0.53	0.44	0.47	0.69	0.72
35	0.52	0.53	0.44	0.47	0.69	0.72
36	0.52	0.53	0.44	0.47	0.69	0.72
37	0.52	0.53	0.44	0.47	0.69	0.72
38	0.52	0.53	0.44	0.47	0.69	0.72
39	0.52	0.53	0.44	0.47	0.69	0.72
40	0.52	0.53	0.44	0.47	0.69	0.72
41	0.52	0.53	0.44	0.47	0.69	0.72
42	0.52	0.53	0.44	0.47	0.69	0.72
43	0.52	0.53	0.44	0.47	0.69	0.72
44	0.52	0.53	0.44	0.47	0.69	0.72
45	0.52	0.53	0.44	0.47	0.69	0.72
46	0.52	0.53	0.44	0.47	0.69	0.72
47	0.52	0.53	0.44	0.47	0.69	0.72
48	0.52	0.53	0.44	0.47	0.69	0.72
49	0.52	0.53	0.44	0.47	0.69	0.72
50	0.52	0.53	0.44	0.47	0.69	0.72
Acres	0.13	0.97	0.6	0.77	0.6	0.77
AAFI	0.45	0.50	0.43	0.45	0.68	0.70
AAFU	**0.06**	**0.49**	**0.26**	**0.35**	**0.41**	**0.54**

Adkin Branch NCSHEM Variable Scores for No Action (current condition) and With Project Measures

Measure / Alternative	Acres	Variable Scores V1	V2	V3	V4	V5[1]	V6[1]	V7	Total[1,2]	AAFU	Benefit	Total B
No Action Reach 1	0.13	5	0	7	0	4	0	6	0.22	0.03	0	
No Action Reach 2	1.05	5	5	7	0	17	10	10	0.54	0.57	0	
No Action Reach 3	0.97	5	5	7	0	9	7	7	0.4	0.39	0	
Measure A1	0.13	5	0	7	0	4 - 20	0 - 10	10	.26 - .52	0.06	0.03	
Measure A2	0.97	5	5	7	0	9 - 17	7 - 10	9	.42 - .53	0.49	0.1	
Measure B (Reach 1)	0.13	5	13	7	0	4	0	6	.35	0.05	0.02	
Measure B (Reach 2)	1.05	5	13	7	0	17	10	10	.62	0.65	0.08	
Measure B (Reach 3)	0.97	5	13	7	0	9	7	7	.48	0.47	0.08	0.18

V1 = Channel Modification
V2 = Instream Habitat
V3 = Bottom Substrate
V4 = Pool Variety
V5 = Bank Stability and Vegetation
V6 = Light Penetration
V7 = Riparian Vegetation Zone Width

[1] There is an initial score at year 1 and increase linearly to a final score at year 25.
[2] Total NC SHEM score is divided by 100 to obtain Stream Functional Index score

Kinston East Costs

				Total	Conting.	E&D	Constr.	Operations & PM	Total w/ GM
Measure	A	Excavate fill and haul offsite - $25.00 CY	14.5 acres x 4 ft depth = 93,570 CY	$2,339,250	$467,850.0	$280,710.00	$187,140.00	$116,962.50	$3,391,913
Measure	B	Plant Bottomland Vegetation - $15,000/acre	14.5 acres	$217,500	$43,500.0	$26,100.00	$17,400.00	$10,875.00	$315,375
Site Prep.		Identical for all alternatives		$436,400	$87,280.0	$52,368.00	$34,912.00	$21,820.00	$632,780

General Markups	Contingencies	20%
	Engineering & Design	12%
	Construction	8%
	Operations and PM	5%

Kinston East Calculation of AAFU for Wetlands

	Measure - No Planting													Measure - Planting												
	NCWAM Sub-functions or Functions *													NCWAM Sub-functions or Functions *												
Year	SF1	SF2	F1	SF3	SF4	SF5	SF6	F2	SF7	SF8	SF9	F3	Total	SF1	SF2	F1	SF3	SF4	SF5	SF6	F2	SF7	SF8	SF9	F3	Total
1	0.5	0.1	0.3	1	0.1	1	1	0.775	0.1	0.5	0.1	0.23	0.44	1	0.1	0.55	1	1	1	1	1	0.1	0.5	1	0.53	0.69
2	0.625	0.1	0.3625	1	0.325	1	1	0.8313	0.325	0.5	0.2	0.34	0.51	1	0.1	0.55	1	1	1	1	1	0.1375	0.5	1	0.55	0.70
3	0.75	0.1	0.425	1	0.55	1	1	0.8875	0.55	0.5	0.3	0.45	0.59	1	0.1	0.55	1	1	1	1	1	0.175	0.5	1	0.56	0.70
4	0.875	0.1	0.4875	1	0.775	1	1	0.9438	0.775	0.5	0.4	0.56	0.66	1	0.1	0.55	1	1	1	1	1	0.2125	0.5	1	0.57	0.71
5	1	0.1	0.55	1	1	1	1	1	1	0.5	0.5	0.67	0.74	1	0.1	0.55	1	1	1	1	1	0.25	0.5	1	0.58	0.71
6	1	0.1	0.55	1	1	1	1	1	1	0.5	0.52	0.67	0.74	1	0.1	0.55	1	1	1	1	1	0.2875	0.5	1	0.60	0.72
7	1	0.1	0.55	1	1	1	1	1	1	0.5	0.54	0.68	0.74	1	0.1	0.55	1	1	1	1	1	0.325	0.5	1	0.61	0.72
8	1	0.1	0.55	1	1	1	1	1	1	0.5	0.56	0.69	0.75	1	0.1	0.55	1	1	1	1	1	0.3625	0.5	1	0.62	0.72
9	1	0.1	0.55	1	1	1	1	1	1	0.5	0.58	0.69	0.75	1	0.1	0.55	1	1	1	1	1	0.4	0.5	1	0.63	0.73
10	1	0.1	0.55	1	1	1	1	1	1	0.5	0.6	0.70	0.75	1	0.1	0.55	1	1	1	1	1	0.4375	0.5	1	0.65	0.73
11	1	0.1	0.55	1	1	1	1	1	1	0.5	0.62	0.71	0.75	1	0.1	0.55	1	1	1	1	1	0.475	0.5	1	0.66	0.74
12	1	0.1	0.55	1	1	1	1	1	1	0.5	0.64	0.71	0.75	1	0.1	0.55	1	1	1	1	1	0.5125	0.5	1	0.67	0.74
13	1	0.1	0.55	1	1	1	1	1	1	0.5	0.66	0.72	0.76	1	0.1	0.55	1	1	1	1	1	0.55	0.5	1	0.68	0.74
14	1	0.1	0.55	1	1	1	1	1	1	0.5	0.68	0.73	0.76	1	0.1	0.55	1	1	1	1	1	0.5875	0.5	1	0.70	0.75
15	1	0.1	0.55	1	1	1	1	1	1	0.5	0.7	0.73	0.76	1	0.1	0.55	1	1	1	1	1	0.625	0.5	1	0.71	0.75
16	1	0.1	0.55	1	1	1	1	1	1	0.5	0.72	0.74	0.76	1	0.1	0.55	1	1	1	1	1	0.6625	0.5	1	0.72	0.76
17	1	0.1	0.55	1	1	1	1	1	1	0.5	0.74	0.75	0.77	1	0.1	0.55	1	1	1	1	1	0.7	0.5	1	0.73	0.76
18	1	0.1	0.55	1	1	1	1	1	1	0.5	0.76	0.75	0.77	1	0.1	0.55	1	1	1	1	1	0.7375	0.5	1	0.75	0.77
19	1	0.1	0.55	1	1	1	1	1	1	0.5	0.78	0.76	0.77	1	0.1	0.55	1	1	1	1	1	0.775	0.5	1	0.76	0.77
20	1	0.1	0.55	1	1	1	1	1	1	0.5	0.8	0.77	0.77	1	0.1	0.55	1	1	1	1	1	0.8125	0.5	1	0.77	0.77
21	1	0.1	0.55	1	1	1	1	1	1	0.5	0.82	0.77	0.77	1	0.1	0.55	1	1	1	1	1	0.85	0.5	1	0.78	0.78
22	1	0.1	0.55	1	1	1	1	1	1	0.5	0.84	0.78	0.78	1	0.1	0.55	1	1	1	1	1	0.8875	0.5	1	0.80	0.78
23	1	0.1	0.55	1	1	1	1	1	1	0.5	0.86	0.79	0.78	1	0.1	0.55	1	1	1	1	1	0.925	0.5	1	0.81	0.79
24	1	0.1	0.55	1	1	1	1	1	1	0.5	0.88	0.79	0.78	1	0.1	0.55	1	1	1	1	1	0.9625	0.5	1	0.82	0.79
25	1	0.1	0.55	1	1	1	1	1	1	0.5	0.9	0.80	0.78	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
26	1	0.1	0.55	1	1	1	1	1	1	0.5	0.92	0.81	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
27	1	0.1	0.55	1	1	1	1	1	1	0.5	0.94	0.81	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
28	1	0.1	0.55	1	1	1	1	1	1	0.5	0.96	0.82	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
29	1	0.1	0.55	1	1	1	1	1	1	0.5	0.98	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
30	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
31	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
32	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
33	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
34	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
35	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
36	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
37	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
38	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
39	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
40	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
41	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
42	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
43	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
44	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
45	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
46	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
47	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
48	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
49	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
50	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79	1	0.1	0.55	1	1	1	1	1	1	0.5	1	0.83	0.79
												AAFU	0.76												AAFU	0.77

* SF1 = Hydrology subfunction - Surface Storage and Retention
SF2 = Hydrology subfunction - Sub-Surface Storage and Retention
F1 = Hydrology Primary Function
SF3 = Water Quality subfunction - Pathogen Change
SF4 = Water Quality subfunction - Particulate Change
SF5 = Water Quality subfunction - Soluble Change
SF6 = Water Quality subfunction - Physical Change
F2 = Water Quality Primary Function
SF7 = Habitat subfunction - Physical Structure
SF8 = Habitat subfunction - Landscape Patch Structure
SF9 = Habitat subfunction - Vegetation Composition
F3 = Habitat Primary Function

Gum Thicket/Cedar Creek Costs for Alternatives

NEUSE RIVER BASIN (5-ft Total Height)				
Reach Meander - Gum Thicket				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	15,000	TON	$112.15	$1,682,250.00
Limestone	16,000	TON	$66.35	$1,061,600.00
Transfer Rock to Barge	22,000	CY	$7.00	$154,000.00
Placement of Rock	31,000	TON	$73.00	$2,263,000.00
Geotextile	15,000	SY	$4.50	$67,500.00
Oyster Habitat	1	LS	$1,477,755.00	$1,477,755.00
Place Sand Fill	25,000	CY	$28.25	$706,250.00
Plant Marsh Vegetation	3.1	AC	$24,075.00	$74,632.50
			Subtotal	$7,682,752.50
			Engineering & Design (@ 12%)	*$921,930.30*
			Construction (@8%)	*$614,620.20*
			Operations & PM (@5%)	*$384,137.63*
			Contingency (@ 20%)	*$1,920,688.13*
			Total	**$9,603,440.63**
Reach Parallel - Gum Thicket				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	12,000	TON	$112.15	$1,345,800.00
Limestone	12,000	TON	$66.35	$796,200.00
Transfer Rock to Barge	17,100	CY	$7.00	$119,700.00
Placement of Rock	24,000	TON	$73.00	$1,752,000.00
Geotextile	12,000	SY	$4.50	$54,000.00
Oyster Habitat	1	LS	$878,105.00	$878,105.00
Place Sand Fill	19,000	CY	$28.25	$536,750.00
Plant Marsh Vegetation	2.4	AC	$24,075.00	$57,780.00
			Subtotal	$5,736,100.00
			Engineering & Design (@ 12%)	*$688,332.00*
			Construction (@8%)	*$458,888.00*
			Operations & PM (@5%)	*$286,805.00*
			Contingency (@ 20%)	*$1,434,025.00*
			Total	**$8,604,150.00**
Reach Meander - Cedar Creek				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	22,000	TON	$112.15	$2,467,300.00
Limestone	24,000	TON	$66.35	$1,592,400.00
Transfer Rock to Barge	33,000	CY	$7.00	$231,000.00
Placement of Rock	46,000	TON	$73.00	$3,358,000.00
Geotextile	19,000	SY	$4.50	$85,500.00
Place Sand Fill	37,000	CY	$28.25	$1,045,250.00
Plant Marsh Vegetation	4.6	AC	$24,075.00	$110,745.00
			Subtotal	$9,085,960.00
			Engineering & Design (@ 12%)	*$1,090,315.20*
			Construction (@8%)	*$726,876.80*
			Operations & PM (@5%)	*$454,298.00*
			Contingency (@ 20%)	*$2,271,490.00*
			Total	**$13,628,940.00**
Reach Parallel - Cedar Creek				
Item Description	Quantity	UOM	Unit Price	Extended
Misc Site Work - Staging Area/ Mob/Demob	1	LS	$195,765.00	$195,765.00
Rock Sill Armor Stone (Granite)	17,000	TON	$112.15	$1,906,550.00
Limestone	18,000	TON	$66.35	$1,194,300.00
Transfer Rock to Barge	25,000	CY	$7.00	$175,000.00
Placement of Rock	35,000	TON	$73.00	$2,555,000.00
Geotextile	17,000	SY	$4.50	$76,500.00
Place Sand Fill	29,000	CY	$28.25	$819,250.00
Plant Marsh Vegetation	3.6	AC	$24,075.00	$86,670.00
			Subtotal	$7,009,035.00
			Engineering & Design (@ 12%)	*$841,084.20*
			Construction (@8%)	*$560,722.80*
			Operations & PM (@5%)	*$350,451.75*
			Contingency (@ 20%)	*$1,752,258.75*
			Total	**$10,513,552.50**

Gum Thicket/Cedar Creek Calculation of Wetland AAFU

Gum Thicket

Year	No Action	1A No Meander	1B Meander	Marsh FI	1A No Meander Benefit	1B Meander Benefit
	Acres	Acres	Acres	FI	FU	FU
1	99.116	104.8	106.2	1	5.684	7.084
2	98.232	104.8	106.2	1	6.568	7.968
3	97.348	104.8	106.2	1	7.452	8.852
4	96.464	104.8	106.2	1	8.336	9.736
5	95.58	104.8	106.2	1	9.22	10.62
6	94.696	104.8	106.2	1	10.104	11.504
7	93.812	104.8	106.2	1	10.988	12.388
8	92.928	104.8	106.2	1	11.872	13.272
9	92.044	104.8	106.2	1	12.756	14.156
10	91.16	104.8	106.2	1	13.64	15.04
11	90.276	104.8	106.2	1	14.524	15.924
12	89.392	104.8	106.2	1	15.408	16.808
13	88.508	104.8	106.2	1	16.292	17.692
14	87.624	104.8	106.2	1	17.176	18.576
15	86.74	104.8	106.2	1	18.06	19.46
16	85.856	104.8	106.2	1	18.944	20.344
17	84.972	104.8	106.2	1	19.828	21.228
18	84.088	104.8	106.2	1	20.712	22.112
19	83.204	104.8	106.2	1	21.596	22.996
20	82.32	104.8	106.2	1	22.48	23.88
21	81.436	104.8	106.2	1	23.364	24.764
22	80.552	104.8	106.2	1	24.248	25.648
23	79.668	104.8	106.2	1	25.132	26.532
24	78.784	104.8	106.2	1	26.016	27.416
25	77.9	104.8	106.2	1	26.9	28.3
26	77.016	104.8	106.2	1	27.784	29.184
27	76.132	104.8	106.2	1	28.668	30.068
28	75.248	104.8	106.2	1	29.552	30.952
29	74.364	104.8	106.2	1	30.436	31.836
30	73.48	104.8	106.2	1	31.32	32.72
31	72.596	104.8	106.2	1	32.204	33.604
32	71.712	104.8	106.2	1	33.088	34.488
33	70.828	104.8	106.2	1	33.972	35.372
34	69.944	104.8	106.2	1	34.856	36.256
35	69.06	104.8	106.2	1	35.74	37.14
36	68.176	104.8	106.2	1	36.624	38.024
37	67.292	104.8	106.2	1	37.508	38.908
38	66.408	104.8	106.2	1	38.392	39.792
39	65.524	104.8	106.2	1	39.276	40.676
40	64.64	104.8	106.2	1	40.16	41.56
41	63.756	104.8	106.2	1	41.044	42.444
42	62.872	104.8	106.2	1	41.928	43.328
43	61.988	104.8	106.2	1	42.812	44.212
44	61.104	104.8	106.2	1	43.696	45.096
45	60.22	104.8	106.2	1	44.58	45.98
46	59.336	104.8	106.2	1	45.464	46.864
47	58.452	104.8	106.2	1	46.348	47.748
48	57.568	104.8	106.2	1	47.232	48.632
49	56.684	104.8	106.2	1	48.116	49.516
50	55.8	104.8	106.2	1	49	50.4
AAFU					27.342	28.742

Cedar Creek

Year	No Action	2A No Meander	2B Meander	Marsh FI	2A No Meander Benefit	2B Meander Benefit
	Acres	Acres	Acres	FI	FU	FU
1	99.7	107.2	109.2	1	7.5	9.5
2	99.4	107.2	109.2	1	7.8	9.8
3	99.1	107.2	109.2	1	8.1	10.1
4	98.8	107.2	109.2	1	8.4	10.4
5	98.5	107.2	109.2	1	8.7	10.7
6	98.2	107.2	109.2	1	9	11
7	97.9	107.2	109.2	1	9.3	11.3
8	97.6	107.2	109.2	1	9.6	11.6
9	97.3	107.2	109.2	1	9.9	11.9
10	97	107.2	109.2	1	10.2	12.2
11	96.7	107.2	109.2	1	10.5	12.5
12	96.4	107.2	109.2	1	10.8	12.8
13	96.1	107.2	109.2	1	11.1	13.1
14	95.8	107.2	109.2	1	11.4	13.4
15	95.5	107.2	109.2	1	11.7	13.7
16	95.2	107.2	109.2	1	12	14
17	94.9	107.2	109.2	1	12.3	14.3
18	94.6	107.2	109.2	1	12.6	14.6
19	94.3	107.2	109.2	1	12.9	14.9
20	94	107.2	109.2	1	13.2	15.2
21	93.7	107.2	109.2	1	13.5	15.5
22	93.4	107.2	109.2	1	13.8	15.8
23	93.1	107.2	109.2	1	14.1	16.1
24	92.8	107.2	109.2	1	14.4	16.4
25	92.5	107.2	109.2	1	14.7	16.7
26	92.2	107.2	109.2	1	15	17
27	91.9	107.2	109.2	1	15.3	17.3
28	91.6	107.2	109.2	1	15.6	17.6
29	91.3	107.2	109.2	1	15.9	17.9
30	91	107.2	109.2	1	16.2	18.2
31	90.7	107.2	109.2	1	16.5	18.5
32	90.4	107.2	109.2	1	16.8	18.8
33	90.1	107.2	109.2	1	17.1	19.1
34	89.8	107.2	109.2	1	17.4	19.4
35	89.5	107.2	109.2	1	17.7	19.7
36	89.2	107.2	109.2	1	18	20
37	88.9	107.2	109.2	1	18.3	20.3
38	88.6	107.2	109.2	1	18.6	20.6
39	88.3	107.2	109.2	1	18.9	20.9
40	88	107.2	109.2	1	19.2	21.2
41	87.7	107.2	109.2	1	19.5	21.5
42	87.4	107.2	109.2	1	19.8	21.8
43	87.1	107.2	109.2	1	20.1	22.1
44	86.8	107.2	109.2	1	20.4	22.4
45	86.5	107.2	109.2	1	20.7	22.7
46	86.2	107.2	109.2	1	21	23
47	85.9	107.2	109.2	1	21.3	23.3
48	85.6	107.2	109.2	1	21.6	23.6
49	85.3	107.2	109.2	1	21.9	23.9
50	85	107.2	109.2	1	22.2	24.2
AAFU					14.85	16.85

Benefits based on sill 60 ft from shore

Calculation of Benefits for Gum Thicket/Cedar Creek TSP - SLR CURVE 1

Habitat Units			
Year	No Action	Alternative 1A2A*	
1	198.81	212.54	
2	197.60	212.54	
3	196.37	212.54	
4	195.11	212.54	
5	193.83	212.54	
6	192.52	212.54	
7	191.19	212.54	
8	189.84	212.54	
9	188.46	212.54	
10	187.06	212.54	
11	185.64	212.54	
12	184.19	212.54	
13	182.72	212.54	
14	181.22	212.54	
15	179.70	212.54	
16	178.16	212.54	
17	176.59	212.54	
18	175.00	212.54	
19	173.39	212.54	
20	171.75	212.54	
21	170.09	212.54	
22	168.41	212.54	
23	166.70	212.54	
24	164.96	212.54	
25	163.21	212.54	
26	161.43	212.54	
27	159.62	212.54	
28	157.79	212.54	
29	155.94	212.54	
30	154.07	212.54	
31	152.17	212.54	
32	150.25	212.54	
33	148.30	212.54	
34	146.33	212.54	
35	144.34	212.54	
36	142.32	212.54	
37	140.28	212.54	
38	138.21	212.54	
39	136.12	212.54	
40	134.01	212.54	
41	131.87	212.54	
42	129.71	212.54	
43	127.53	212.54	
44	125.32	212.54	
45	123.09	212.54	
46	120.84	212.54	
47	118.56	212.54	
48	116.25	212.54	
49	113.93	212.54	
50	111.58	212.54	Diff
AAHU	159.85	212.54	**52.69**

* Includes 0.54 HU benefits from oyster habitat

Total Erosion (ft)		
Year	Gum Thicket	Cedar Creek
1	9	2
2	18	4
3	28	6
4	37	8
5	47	10
6	57	13
7	67	15
8	77	17
9	87	19
10	98	22
11	109	24
12	120	27
13	131	29
14	142	32
15	154	34
16	166	37
17	177	39
18	190	42
19	202	45
20	214	48
21	227	50
22	240	53
23	253	56
24	266	59
25	279	62
26	293	65
27	306	68
28	320	71
29	334	74
30	348	77
31	363	81
32	377	84
33	392	87
34	407	90
35	422	94
36	437	97
37	453	101
38	469	104
39	484	108
40	500	111
41	517	115
42	533	118
43	550	122
44	566	126
45	583	130
46	600	133
47	618	137
48	635	141
49	653	145
50	671	149

Calculation of Benefits for Gum Thicket/Cedar Creek TSP - SLR CURVE 3

Habitat Units

Year	No Action	Alternative 1A2A	
1	248.81	262.54	
2	247.53	262.54	
3	246.14	262.54	
4	244.65	262.54	
5	243.06	262.54	
6	241.38	262.54	
7	239.59	262.54	
8	237.70	262.54	
9	235.71	262.54	
10	233.63	262.54	
11	231.44	262.54	
12	229.15	262.54	
13	226.76	262.54	
14	224.28	262.54	
15	221.69	262.54	
16	219.00	262.54	
17	216.21	262.54	
18	213.32	262.54	
19	210.33	262.54	
20	207.25	262.54	
21	204.06	262.54	
22	200.77	262.54	
23	197.38	262.54	
24	193.89	262.54	
25	190.30	258.95	
26	186.61	255.26	
27	182.82	251.47	
28	178.93	247.58	
29	174.94	243.59	
30	170.85	239.50	
31	166.66	235.31	
32	162.37	231.02	
33	157.98	226.64	
34	153.49	222.15	
35	148.90	217.56	
36	144.21	212.87	
37	139.42	208.07	
38	134.53	203.18	
39	129.54	198.19	
40	124.45	193.10	
41	119.26	187.91	
42	113.97	182.62	
43	108.58	177.23	
44	103.09	171.74	
45	97.50	166.15	
46	91.81	160.46	
47	86.02	154.67	
48	80.13	148.78	
49	74.14	142.79	
50	68.04	136.69	Diff
AAHU	178.05	231.49	**53.44**

* Includes 0.54 HU benefits from oyster habitat

Total Erosion (ft)

Year	Gum Thicket	Cedar Creek
1	9	2
2	19	4
3	29	7
4	41	9
5	53	12
6	65	15
7	79	18
8	93	21
9	108	24
10	124	28
11	141	31
12	158	35
13	176	39
14	195	43
15	215	48
16	235	52
17	256	57
18	278	62
19	301	67
20	324	72
21	349	77
22	374	83
23	399	89
24	426	94
25	453	100
26	481	107
27	510	113
28	539	120
29	570	126
30	601	133
31	632	140
32	665	147
33	698	155
34	732	162
35	767	170
36	803	178
37	839	186
38	876	194
39	914	202
40	953	211
41	992	220
42	1032	229
43	1073	238
44	1115	247
45	1157	256
46	1201	266
47	1245	276
48	1289	286
49	1335	296
50	1381	306

USFWS OYSTER HSI MODEL	V1 Substrate Index	V2 Mean Sum Salinity Index	V3, Gregarious Factor (density)	**CI_L Larvae HSI =(V_1 X V_2 X V_3)$^{1/3}$ if V_3=0 (V_1 x V_2) $^{1/2}$**	V4 Hist Mean Sal Index	V5 Mean-Kill Freq Index	V6 Substrate Firmness Project Condition Rock	**CI_A =(V_4 X V_5 X V_6)$^{1/3}$ if V_6=0 CI_A= 0**	**is<CI_L HSI=CI_A, if CI_A>CI_L HSI =(CI_A X CI_L)$^{1/2}$**
Gum Thicket Creek	1.0	1.0	0.0	*1.0*	1.0	0.7	1.0	*0.9*	**0.9**

The methods used to calculate these benefits are described in the Oyster Reef Appendix of the Feasiblity Report

Little River NCSHEM Variable Scores for Existing Condition of River

Assessment Zone	Sample Point	Reach	Miles	Acres	V1	V2	V3	V4	V5	V6	V7	V8	Total
Coastal Plain	1	1	1.8	22.9	15	14	7	3	20	9	7		0.75
	2	2			15	15	7	6	16	7	1		0.67
	3	2			15	19	7	10	20	10	10		0.91
	4	2	16	242.4	15	15	7	6	20	7	7		0.77
	5	3	2.3	31.8	15	15	13	6	20	5	10		0.84
	6	4			15	15	7	4	20	4	5		0.46
	7	4			15	19	13	4	20	10	10		0.61
	8	4			15	19	13	4	20	10	9		0.9
	9	4			15	15	13	4	20	7	5		0.79
	10	4			15	19	13	0	20	10	10		0.87
	11	4	23.7	195.3	15	14	13	4	20	4	9		0.55
Piedmont	12	5	2.1	16.8	4	15	3	4	3	3	14	8	0.54

(V1–V8: Variable Scores *)

* V1 = Channel Modification
V2 = Instream Habitat
V3 = Bottom Substrate
V4 = Pool Variety
V5 = Riffle Habitats
V6 = Bank Stability and Vegetation
V7 = Light Penetration
V8 = Riparian Vegetation Zone Width

	Functional Units				
Reach	100% FU	No-Action	Gate (A)	Ramp (B)	Removal (C)
1	17.2	12.0	17.0	13.7	17.2
2	189.9	132.9	188.0	151.9	189.9
3	26.7	18.7	26.4	21.4	26.7
4	136.1	95.2	134.7	108.8	136.1
5	9.1	6.4	9.0	7.3	9.1
Total	378.9	265.2	375.1	303.1	378.9

NC DWQ Stream Habitat Evaluation Forms

- Mountain / Piedmont Streams
- Coastal Plain Streams

Appendix E DWQ Stream Habitat Evaluation Form

5/99 Revision 4

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Directions for use of this Assessment: The observer is to survey a minimum of 100 meters of stream, preferably in an upstream direction starting above the bridge pool and the road right-of-way. The stream segment which is assessed should represent average stream conditions. In order to perform a proper habitat evaluation the observer needs to get into the stream. All meter readings need to be performed prior to walking the stream. When working the habitat index, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. There are eight different metrics in this index and a final habitat score is determined by adding the results from the different metrics.

Stream_________________________Location/Road____________________County____________________

Date________________CC#______________Basin____________________Subbasin_____________________

Observer(s)____________________Office Location_______________Agency ________________________

Type of Study: Fish Benthos Basinwide Special Study (Describe) ___________________________

Latitude __________Longitude ____________Ecoregion (circle one) MT P Distance Surveyed______meters

Physical Characterization: Land use refers to immediate area that you can see from sampling location - include what you see driving thru the watershed in the remarks section. Also use the remarks section for such descriptions as "deeply incised" or "exposed bedrock" or other unusual conditions.

Land use: Forest_____% Active Pasture_____% Active Crops_____% Fallow Fields____% Commercial____%
Industrial____% Residential_____% Other _____%-Describe:_______________________________________

Width: (meters) Stream________ Channel__________ Average Stream Depth: (m)_________ Velocity______m/sec

Flow conditions (circle one): High Normal Low

Manmade Stabilization: Y[ ] N[ ] Describe:____

Water Quality: Temperature____°C Dissolved Oxygen _______mg/l Conductivity ______µmhos/cm pH _______

Turbidity: (circle) Clear Slightly Turbid Turbid Tannic

Weather Conditions:_______________________________________**Photo #**_______________________

Remarks:____

____

I. Channel Modification (Use topo map as an additional aid for this parameter) Score

A. channel natural, frequent bends (good diversity of bends or falls).. 5
B. channel natural, infrequent bends... 4
C. some channelization present... 3
D. more extensive channelization, >40% of stream disrupted.. 2
E. no bends, completely channelized or rip rapped or gabioned, etc... 0

Remarks____Subtotal_____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover.
Circle the habitats which occur- **(Rocks) (Macrophytes) (sticks and leaf packs) (snags and logs) (undercut banks or root mats)** Definition: leafpacks consist of older leaves that are packed together and have begun to decay. Piles of leaves in pool areas are not considered leaf packs. EXAMPLE: If >70% of the reach is rocks, 1 type is present, circle the score of 17.

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70% Score	40-70% Score	20-40% Score	<20% Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

Remarks____Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) look at entire reach for substrate scoring, but only look at riffle for embeddedness.

	Score
A. substrate with good mix of gravel cobble and boulders	
1. embeddedness <20% (very little sand, usually only behind large boulders)	15
2. embeddedness 20-40%	12
3. embeddedness 40-80%	8
4. embeddedness >80%	3
B. substrate gravel and cobble	
1. embeddedness <20%	14
2. embeddedness 20-40%	11
3. embeddedness 40-80%	6
4. embeddedness >80%	2
C. substrate mostly gravel	
1. embeddedness <50%	8
2. embeddedness >50%	2
D. substrate homgeneous	
1. substrate nearly all bedrock	3
2. substrate nearly all sand	3
3. substrate nearly all detritus	2
4. substrate nearly all silt/ clay	1

Remarks____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m area surveyed)	
a. variety of pool sizes	10
b. pools same size	8
2. Pools Infrequent (<30% of the 100m area surveyed)	
a. variety of pool sizes	6
b.pools same size	4
B. Pools absent	
1. Runs present	3
2. Runs absent	0

Remarks____Page Total______

V. Riffle Habitats

	Riffles **Frequent** Score	Riffles **Infrequent** Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream	16	12

B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent	0	

Subtotal_____

VI. Bank Stability and Vegetation

	Left Bank <u>Score</u>	Rt. Bank <u>Score</u>
A. Banks stable		
1. no evidence of erosion or bank failure, little potential for erosion	7	7
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems	6	6
2. few trees or small trees and shrubs; vegetation appears generally healthy	5	5
3. sparse vegetation; plant types and conditions suggest poorer soil binding	3	3
4. mostly grasses, few if any trees and shrubs, high ersosion and failnre potential at high flow	2	2
5. no bank vegetation, mass erosion and bank failure evident	0	0

Total______

Remarks____

VII. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** shading with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent	8
C. Stream with **partial** shading - snnlight and shading are essentially equa	7
D. Stream with **minimal** shading - full sun in all but a few areas	2
E. **No shading**	0

Remarks____Subtotal____

VIII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollntants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters	5	5
2. zone width 12-18 meters	4	4
3. zone width 6-12 meters	3	3
4. zone width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters	4	4
b. zone width 12-18 meters	3	3
c. zone width 6-12 meters	2	2
d. zone width < 6 meters	1	1
2. breaks common		
a. zone width > 18 meters	3	3
b. zone width 12-18 meters	2	2
c. zone width 6-12 meters	1	1
d. zone width < 6 meters	0	0

Remarks____ Total_____

TOTAL SCORE ____________________

5/99 Revision 4

Habitat Assessment Field Data Sheet
Coastal Plain Streams

Directions for use of this Assessment: The observer is to survey a minimum of 100 meters of stream, preferably in an upstream direction starting above the bridge pool and the road right-of-way. The stream segment which is assessed should represent average stream conditions. In order to perform a proper habitat evaluation the observer needs to get into the stream. All meter readings need to be performed prior to walking the stream. When working the habitat index, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. There are seven different metrics in this index and a final habitat score is determined by adding the results from the different metrics.

Stream____________________ Location/Road____________________ County____________________

Date____________________ CC#____________ Subbasin______________ Basin_______________

Observer(s):_________________ Office Location________________ Agency ____________________

Type of Study: Fish Benthos Basinwide Special Study (Describe) ____________________

Latitude _______ Longitude ________ Ecoregion (circle one) CA CB Swamp Distance Surveyed____meters

Physical Characterization: Land use refers to immediate area that you can see from sampling location - include what you see driving thru the watershed in the remarks section.

Land use: Forest____% Active Pasture____% Active Crops____% Fallow Fields____% Commercial____%
Industrial____% Residential____% Other ____%. Describe:________________________________

Width: (meters) Stream_______ Channel________ Average Stream Depth: (m)_______ Velocity_____m/sec

Flow conditions (circle one): High Normal Low

Manmade Stabilization: Y[ ] N[ ] Describe:____

Water Quality: Temperature____°C Dissolved Oxygen ______mg/l Conductivity _____µmhos/cm pH ______

Turbidity: (circle) Clear Slightly Turbid Turbid Tannic

Weather Conditions:______________________________________ **Photo #**____________________

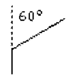
Remarks:____

____

I. Channel Modification (Use topo map as an additional aid for this parameter)

	Natural Channel	**Modified** Channel (channelized)
A. Frequent bends	Score	Score
1. bends > 60°	15	12
2. bends < 60°	13	10
B. Infreqnent bends		
1. bends > 60°	11	7
2. bends < 60°	8	5

Remarks____Subtotal____



II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. Circle the habitats which occur- **(Rocks) (Macrophytes) (sticks and leaf packs) (snags and logs) (undercut banks or root mats)** Definition: leafpacks consist of older leaves that are packed together and have begun to decay. Piles of leaves in pool areas are not considered leaf packs. EXAMPLE: If >70% of the reach is rocks, 1 type is present, circle the score of 17.

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>50%	30-50%	10-30%	<10%
	Score	Score	Score	Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

Remarks____Subtotal____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) look at entire reach for substrate scoring, but only look at riffle for embeddedness.

	Score
A. substrate types mixes	
1. gravel/rocks dominant)	15
2. sand dominant	13
3. detrirus dominant	7
4. silt/clay dominant	4
B. substrate homgeneous	
1. substrate nearly all gravel	12
2. substrate nearly all sand	7
3. substrate nearly all detritus	4
4. substrate nearly all silt/ clay	1

Remarks____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m area surveyed)	
a. variety of pool sizes	10
b.pools same size	8
2. Pools Infrequent (<30% of the 100m area surveyed)	
a. variety of pool sizes	6
b.pools same size	4
B. Pools absent	
1. Runs present	3
2. Runs absent	0

Remarks____Page Total_______

V. Bank Stability and Vegetation

	Lft. Bank Score	Rt. Bank Score
A. Banks stable		
1. no evidence of erosion or bank failure, little potential for erosion	10	10
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems	9	9
2. few trees or small trees and shrubs; vegetation appears generally healthy	7	7
3. sparse vegetation; plant types and conditions suggest poorer soil binding	4	4
4. mostly grasses, few if any trees and shrubs, high ersosion and failure potential at high flow	2	2
5. no bank vegetation, mass erosion and bank failure evident	0	0

Total_____

Remarks____

VI. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** shading with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent	8
C. Stream with **partial** shading - sunlight and shading are essentially equa	7
D. Stream with **minimal** shading - full sun in all but a few areas	2
E. No shading	0

Remarks____

VII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters	5	5
2. zone width 12-18 meters	4	4
3. zone width 6-12 meters	3	3
4. zone width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters	4	4
b. zone width 12-18 meters	3	3
c. zone width 6-12 meters	2	2
d. zone width < 6 meters	1	1
2. breaks common		
a. zone width > 18 meters	3	3
b. zone width 12-18 meters	2	2
c. zone width 6-12 meters	1	1
d. zone width < 6 meters	0	0

Total______

Remarks____

TOTAL SCORE ___________

NC Wetland Assessment Method Field Forms and Results

- Ellerbe Creek
- Kinston East Wetland
- Gum Thicket / Cedar Creek

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Ellerbe Creek -Measure 1, Year 1 **Date** 1/82010
Wetland Type Bottomland Hardwood Forest **Assessor Name/Organization** USACE
Level III Ecoregion Piedmont **Nearest Named Water Body**
River Basin Neuse **USGS 8-Digit Catalogue Unit**
☒ Yes ☐ No **Precipitation within 48 hrs?** **Latitude/Longitude (deci-degrees)**

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.
- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? ☐ Yes ☒ No

Describe effects of stressors that are present.
Stream has been channelized, mowed sewer right of way extends through wetland area

Regulatory Considerations
Select all that apply to the assessment area.
☐ Anadromous fish
☐ Federally protected species or State endangered or threatened species
☑ NCDWQ riparian buffer rule in effect
☐ Abuts a Primary Nursery Area (PNA)
☐ Publicly owned property
☐ N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
☐ Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
☐ Designated NCNHP reference community
☑ Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
☐ Blackwater
☒ Brownwater
☐ Tidal (if tidal, check one of the following boxes) ☐ Lunar ☐ Wind ☐ Both

Is the assessment area on a coastal island? ☐ Yes ☒ No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? ☐ Yes ☒ No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☒ A	☒ A	Not severely altered
☐ B	☐ B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☒ A	☒ A	Water storage capacity and duration are not altered.
☐ B	☐ B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐ C	☐ C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
☐ A	☐ A	Majority of wetland with depressions able to pond water > 1 foot deep
☐ B	☐ B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
☐ C	☐ C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
☒ D	☒ D	Depressions able to pond water < 3 inches deep

☐ A Evidence that maximum depth of inundation is greater than 2 feet
☐ B Evidence that maximum depth of inundation is between 1 and 2 feet
☒ C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- [ ] A Sandy soil
- [ ] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [x] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[x] ≤ 15-feet wide [ ] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[ ] Yes [x] No
Is stream or other open water sheltered or exposed?
- [x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
- [ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
[x] A	[x] A	≥ 100 feet
[ ] B	[ ] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)

RB	
[x] A	≥ 50 feet
[ ] B	From 30 to < 50 feet
[ ] C	From 15 to < 30 feet
[ ] D	From 5 to < 15 feet
[ ] E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. **Indicators of Deposition – assessment area condition metric**
Consider recent deposition only (no plant growth since deposition).
- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. **Wetland Size – wetland type/wetland complex condition metric**
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. **Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)**
- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. **Connectivity to Other Natural Areas – landscape condition metric**
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
	F	Wetland type has a poor or no connection to other natural habitats
Yes	No	Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. **Edge Effect – wetland type condition metric**
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. **Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)**
- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. **Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)**
- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

☒ **Vegetation present**

Evaluate percent coverage of vegetation for marshes only

- ☐ A ≥ 25% coverage of vegetation
- ☐ B < 25% coverage of vegetation

Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
☐ A	☒ A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
☐ B	☐ B	Canopy present, but opened more than natural gaps
☒ C	☐ C	Canopy sparse or absent
☐ A	☐ A	Dense mid-story/sapling layer
☒ B	☒ B	Moderate density mid-story/sapling layer
☐ C	☐ C	Mid-story/sapling layer sparse or absent
☐ A	☐ A	Dense shrub layer
☐ B	☒ B	Moderate density shrub layer
☒ C	☐ C	Shrub layer sparse or absent
☐ A	☐ A	Dense herb layer
☒ B	☒ B	Moderate density herb layer
☐ C	☐ C	Herb layer sparse or absent

☐ **Vegetation absent**

18. Snags – wetland type condition metric

- ☐ A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- ☒ B Not A

19. Diameter Class Distribution – wetland type condition metric

- ☐ A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- ☐ B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- ☒ C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

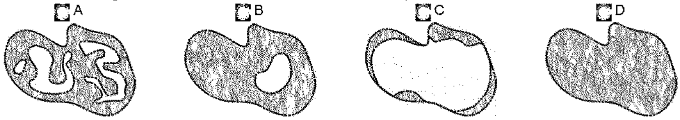
Include both natural debris and man-placed natural debris.

- ☐ A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- ☒ B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

☐ A ☐ B ☐ C ☐ D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

- ☒ A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- ☐ B Overbank flow is severely altered in the assessment area.
- ☐ C Overland flow is severely altered in the assessment area.
- ☐ D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Ellerbe Creek -Measure 1, Year 1	Date	1/82010
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	USACE

Presence of stressor affecting assessment area (Y/N)	YES
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**HIGH**
	Sub-Surface Storage and Retention	Condition	**MEDIUM**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**LOW**
	Landscape Patch Structure	Condition	**LOW**
	Vegetation Composition	Condition	**MEDIUM**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**LOW**

Overall Wetland Rating **HIGH**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Ellerbe Creek -Measure 1, Year 25 **Date** 1/8/2010
Wetland Type Bottomland Hardwood Forest **Assessor Name/Organization** USACE
Level III Ecoregion Piedmont **Nearest Named Water Body**
River Basin Neuse **USGS 8-Digit Catalogue Unit**
[x] Yes [ ] No **Precipitation within 48 hrs?** **Latitude/Longitude (deci-degrees)**

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.
- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.
Stream has been channelized, mowed sewer right of way extends through wetland area

Regulatory Considerations
Select all that apply to the assessment area.
- [ ] Anadromous fish
- [ ] Federally protected species or State endangered or threatened species
- [x] NCDWQ riparian buffer rule in effect
- [ ] Abuts a Primary Nursery Area (PNA)
- [ ] Publicly owned property
- [ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
- [ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
- [ ] Designated NCNHP reference community
- [x] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
- [ ] Blackwater
- [x] Brownwater
- [ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[x] A	[x] A	Not severely altered
[ ] B	[ ] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[x] A	[x] A	Water storage capacity and duration are not altered.
[ ] B	[ ] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[ ] C	[ ] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[ ] B	[ ] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[x] D	[x] D	Depressions able to pond water < 3 inches deep

- [ ] A Evidence that maximum depth of inundation is greater than 2 feet
- [ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
- [x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- [ ] A Sandy soil
- [ ] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [x] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[x] ≤ 15-feet wide [ ] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[ ] Yes [x] No
Is stream or other open water sheltered or exposed?
[x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
[ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
[x] A	[x] A	≥ 100 feet
[ ] B	[ ] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)

RB	
[x] A	≥ 50 feet
[ ] B	From 30 to < 50 feet
[ ] C	From 15 to < 30 feet
[ ] D	From 5 to < 15 feet
[ ] E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- ☒ A Sediment deposition is not excessive, but at approximately natural levels.
- ☐ B Sediment deposition is excessive, but not overwhelming the wetland.
- ☐ C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
☐ A	☐ A	☐ A	≥ 500 acres
☐ B	☐ B	☐ B	From 100 to < 500 acres
☐ C	☐ C	☐ C	From 50 to < 100 acres
☐ D	☐ D	☐ D	From 25 to < 50 acres
☐ E	☐ E	☐ E	From 10 to < 25 acres
☐ F	☐ F	☐ F	From 5 to < 10 acres
☒ G	☒ G	☒ G	From 1 to < 5 acres
☐ H	☐ H	☐ H	From 0.5 to < 1 acre
☐ I	☐ I	☐ I	From 0.1 to < 0.5 acre
☐ J	☐ J	☐ J	From 0.01 to < 0.1 acre
☐ K	☐ K	☐ K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- ☐ A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- ☐ B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
☐ A	☐ A	≥ 500 acres
☐ B	☐ B	From 100 to < 500 acres
☐ C	☐ C	From 50 to < 100 acres
☐ D	☒ D	From 10 to < 50 acres
☒ E	☐ E	< 10 acres
	☐ F	Wetland type has a poor or no connection to other natural habitats
☐ Yes	☐ No	Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- ☐ A No artificial edge within 150 feet in all directions
- ☒ B No artificial edge within 150 feet in four (4) to seven (7) directions
- ☐ C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- ☒ A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- ☐ B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- ☐ C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- ☒ A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- ☐ B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- ☐ C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

- **Vegetation present**

  Evaluate percent coverage of vegetation for marshes only
  - A ≥ 25% coverage of vegetation
  - B < 25% coverage of vegetation

  Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
C	C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
C	C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
C	C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
C	C	Herb layer sparse or absent

- **Vegetation absent**

18. Snags – wetland type condition metric

- A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- B Not A

19. Diameter Class Distribution – wetland type condition metric

- A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

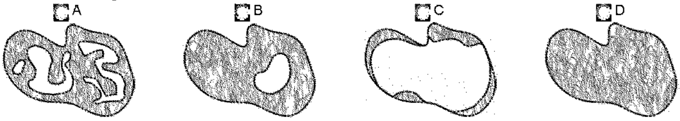
Include both natural debris and man-placed natural debris.

- A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

A B C D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

- A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- B Overbank flow is severely altered in the assessment area.
- C Overland flow is severely altered in the assessment area.
- D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Ellerbe Creek -Measure 1, Year 25	Date	1/8/2010
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	USACE

Presence of stressor affecting assessment area (Y/N)	YES
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**HIGH**
	Sub-Surface Storage and Retention	Condition	**MEDIUM**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**HIGH**
	Landscape Patch Structure	Condition	**LOW**
	Vegetation Composition	Condition	**HIGH**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**HIGH**

Overall Wetland Rating **HIGH**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Ellerbe Creek Reach 1 - No Action — **Date** 1/8/2010
Wetland Type Bottomland Hardwood Forest — **Assessor Name/Organization** USACE
Level III Ecoregion Piedmont — **Nearest Named Water Body**
River Basin Neuse — **USGS 8-Digit Catalogue Unit**
[x] Yes [ ] No **Precipitation within 48 hrs?** — **Latitude/Longitude (deci-degrees)**

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.
- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.
Stream has been channelized, mowed sewer right of way extends through wetland area

Regulatory Considerations
Select all that apply to the assessment area.
- [ ] Anadromous fish
- [ ] Federally protected species or State endangered or threatened species
- [x] NCDWQ riparian buffer rule in effect
- [ ] Abuts a Primary Nursery Area (PNA)
- [ ] Publicly owned property
- [ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
- [ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
- [ ] Designated NCNHP reference community
- [x] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
- [ ] Blackwater
- [x] Brownwater
- [ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[ ] A	[ ] A	Not severely altered
[x] B	[x] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[ ] A	[ ] A	Water storage capacity and duration are not altered.
[ ] B	[ ] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[x] C	[x] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[ ] B	[ ] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[x] D	[x] D	Depressions able to pond water < 3 inches deep

- [ ] A Evidence that maximum depth of inundation is greater than 2 feet
- [ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
- [x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- [ ] A Sandy soil
- [ ] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [x] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[x] ≤ 15-feet wide [ ] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[x] Yes [ ] No
Is stream or other open water sheltered or exposed?
[x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
[ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC		RB (applicable if assessment area is within 50 feet of a tributary)	
[x] A	[x] A	≥ 100 feet	[x] A	≥ 50 feet
[ ] B	[ ] B	From 80 to < 100 feet	[ ] B	From 30 to < 50 feet
[ ] C	[ ] C	From 50 to < 80 feet	[ ] C	From 15 to < 30 feet
[ ] D	[ ] D	From 40 to < 50 feet	[ ] D	From 5 to < 15 feet
[ ] E	[ ] E	From 30 to < 40 feet	[ ] E	< 5 feet
[ ] F	[ ] F	From 15 to < 30 feet		
[ ] G	[ ] G	From 5 to < 15 feet		
[ ] H	[ ] H	< 5 feet		

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. **Indicators of Deposition – assessment area condition metric**
Consider recent deposition only (no plant growth since deposition).
- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. **Wetland Size – wetland type/wetland complex condition metric**
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre or assessment area is clear-cut

12. **Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)**
- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. **Connectivity to Other Natural Areas – landscape condition metric**
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
	F	Wetland type has a poor or no connection to other natural habitats
Yes	No	Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. **Edge Effect – wetland type condition metric**
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions or assessment area is clear-cut

15. **Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)**
- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. **Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)**
- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

Vegetation present

Evaluate percent coverage of vegetation for marshes only

- A ≥ 25% coverage of vegetation
- B < 25% coverage of vegetation

Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
C	C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
C	C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
C	C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
C	C	Herb layer sparse or absent

Vegetation absent

18. Snags – wetland type condition metric

- A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- B Not A

19. Diameter Class Distribution – wetland type condition metric

- A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

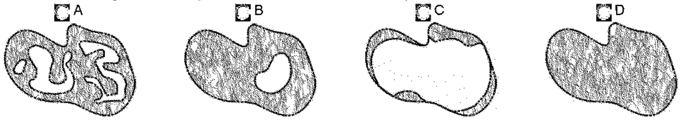
Include both natural debris and man-placed natural debris.

- A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

A B C D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

- A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- B Overbank flow is severely altered in the assessment area.
- C Overland flow is severely altered in the assessment area.
- D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Ellerbe Creek Reach 1 - No Action	Date	1/8/2010
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	USACE

Presence of stressor affecting assessment area (Y/N)	YES
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**MEDIUM**
	Sub-Surface Storage and Retention	Condition	**MEDIUM**
Water Quality	Pathogen Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Particulate Change	Condition	**LOW**
		Condition/Opportunity	**LOW**
		Opportunity Presence? (Y/N)	**NO**
	Soluble Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Physical Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**MEDIUM**
	Landscape Patch Structure	Condition	**LOW**
	Vegetation Composition	Condition	**HIGH**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**MEDIUM**
Water Quality	Condition	**MEDIUM**
	Condition/Opportunity	**MEDIUM**
	Opportunity Presence? (Y/N)	**NO**
Habitat	Conditon	**MEDIUM**

Overall Wetland Rating **MEDIUM**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Ellerbe Creek - Reach 2, No Action   **Date** 1/8/2010
Wetland Type Bottomland Hardwood Forest   **Assessor Name/Organization** USACE
Level III Ecoregion Piedmont   **Nearest Named Water Body**
River Basin Neuse   **USGS 8-Digit Catalogue Unit**
[x] Yes [ ] No **Precipitation within 48 hrs?**   **Latitude/Longitude (deci-degrees)**

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.
Stream has been channelized, mowed sewer right of way extends through wetland area

Regulatory Considerations
Select all that apply to the assessment area.
[ ] Anadromous fish
[ ] Federally protected species or State endangered or threatened species
[x] NCDWQ riparian buffer rule in effect
[ ] Abuts a Primary Nursery Area (PNA)
[ ] Publicly owned property
[ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
[ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
[ ] Designated NCNHP reference community
[x] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
[ ] Blackwater
[x] Brownwater
[ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[ ] A	[ ] A	Not severely altered
[x] B	[x] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[ ] A	[ ] A	Water storage capacity and duration are not altered.
[ ] B	[ ] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[x] C	[x] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[ ] B	[ ] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[x] D	[x] D	Depressions able to pond water < 3 inches deep

[ ] A Evidence that maximum depth of inundation is greater than 2 feet
[ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
[x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- [ ] A Sandy soil
- [ ] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [x] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[x] ≤ 15-feet wide [ ] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[ ] Yes [x] No
Is stream or other open water sheltered or exposed?
[x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
[ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
[x] A	[x] A	≥ 100 feet
[ ] B	[ ] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)	
[ ] A	≥ 50 feet
[ ] B	From 30 to < 50 feet
[ ] C	From 15 to < 30 feet
[ ] D	From 5 to < 15 feet
[x] E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- [x] A Sediment deposition is not excessive, but at approximately natural levels.
- [ ] B Sediment deposition is excessive, but not overwhelming the wetland.
- [ ] C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
[ ] A	[ ] A	[ ] A	≥ 500 acres
[ ] B	[ ] B	[ ] B	From 100 to < 500 acres
[ ] C	[ ] C	[ ] C	From 50 to < 100 acres
[ ] D	[ ] D	[ ] D	From 25 to < 50 acres
[ ] E	[ ] E	[ ] E	From 10 to < 25 acres
[ ] F	[ ] F	[ ] F	From 5 to < 10 acres
[x] G	[x] G	[x] G	From 1 to < 5 acres
[ ] H	[ ] H	[ ] H	From 0.5 to < 1 acre
[ ] I	[ ] I	[ ] I	From 0.1 to < 0.5 acre
[ ] J	[ ] J	[ ] J	From 0.01 to < 0.1 acre
[ ] K	[ ] K	[ ] K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- [ ] A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- [ ] B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
[ ] A	[ ] A	≥ 500 acres
[ ] B	[ ] B	From 100 to < 500 acres
[ ] C	[ ] C	From 50 to < 100 acres
[ ] D	[x] D	From 10 to < 50 acres
[x] E	[ ] E	< 10 acres
	[ ] F	Wetland type has a poor or no connection to other natural habitats
[ ] Yes	[ ] No	Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- [ ] A No artificial edge within 150 feet in all directions
- [ ] B No artificial edge within 150 feet in four (4) to seven (7) directions
- [x] C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- [ ] A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- [x] B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- [ ] C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- [x] A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- [ ] B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- [ ] C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

☒ **Vegetation present**

Evaluate percent coverage of vegetation for marshes only

☐ A ≥ 25% coverage of vegetation
☐ B < 25% coverage of vegetation

Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
☒ A	☒ A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
☐ B	☐ B	Canopy present, but opened more than natural gaps
☐ C	☐ C	Canopy sparse or absent
☐ A	☐ A	Dense mid-story/sapling layer
☒ B	☒ B	Moderate density mid-story/sapling layer
☐ C	☐ C	Mid-story/sapling layer sparse or absent
☐ A	☐ A	Dense shrub layer
☐ B	☒ B	Moderate density shrub layer
☒ C	☐ C	Shrub layer sparse or absent
☐ A	☐ A	Dense herb layer
☒ B	☒ B	Moderate density herb layer
☐ C	☐ C	Herb layer sparse or absent

☐ **Vegetation absent**

18. Snags – wetland type condition metric

☐ A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
☒ B Not A

19. Diameter Class Distribution – wetland type condition metric

☐ A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
☒ B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
☐ C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

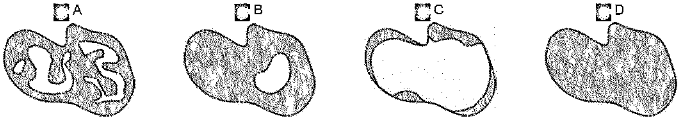
Include both natural debris and man-placed natural debris.

☐ A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
☒ B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

☐ A ☐ B ☐ C ☐ D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

☐ A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
☒ B Overbank flow is severely altered in the assessment area.
☐ C Overland flow is severely altered in the assessment area.
☐ D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Ellerbe Creek - Reach 2, No Action	Date	1/8/2010
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	USACE

Presence of stressor affecting assessment area (Y/N)	YES
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**MEDIUM**
	Sub-Surface Storage and Retention	Condition	**MEDIUM**
Water Quality	Pathogen Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Particulate Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Soluble Change	Condition	**MEDIUM**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**NO**
	Physical Change	Condition	**LOW**
		Condition/Opportunity	**LOW**
		Opportunity Presence? (Y/N)	**NO**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**MEDIUM**
	Landscape Patch Structure	Condition	**LOW**
	Vegetation Composition	Condition	**MEDIUM**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**MEDIUM**
Water Quality	Condition	**MEDIUM**
	Condition/Opportunity	**MEDIUM**
	Opportunity Presence? (Y/N)	**NO**
Habitat	Conditon	**LOW**

Overall Wetland Rating **MEDIUM**

NC WAM WETLAND ASSESSMENT FORM

Version 1.5 (November 2, 2009)

RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Kinston East Wetland Complex - Existing Bottomland | **Date** ______

Wetland Type Bottomland Hardwood Forest | **Assessor Name/Organization** ______

Level III Ecoregion Middle Atlantic Coastal Plain | **Nearest Named Water Body** ______

River Basin Neuse | **USGS 8-Digit Catalogue Unit** ______

☐ Yes ☒ No **Precipitation within 48 hrs?** | **Latitude/Longitude (deci-degrees)**

Evidence of stressors affecting the assessment area (may not be within the assessment area)

Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? ☐ Yes ☐ No

Describe effects of stressors that are present.

Regulatory Considerations

Select all that apply to the assessment area.

- ☐ Anadromous fish
- ☐ Federally protected species or State endangered or threatened species
- ☐ NCDWQ riparian buffer rule in effect
- ☐ Abuts a Primary Nursery Area (PNA)
- ☐ Publicly owned property
- ☐ N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
- ☐ Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
- ☐ Designated NCNHP reference community
- ☐ Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)

- ☒ Blackwater
- ☐ Brownwater
- ☐ Tidal (if tidal, check one of the following boxes) ☐ Lunar ☐ Wind ☐ Both

Is the assessment area on a coastal island? ☐ Yes ☒ No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? ☐ Yes ☒ No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
   Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☒ A	☒ A	Not severely altered
☐ B	☐ B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
   Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☐ A	☐ A	Water storage capacity and duration are not altered.
☒ B	☒ B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐ C	☐ C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
   Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
☐ A	☐ A	Majority of wetland with depressions able to pond water > 1 foot deep
☒ B	☒ B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
☐ C	☐ C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
☐ D	☐ D	Depressions able to pond water < 3 inches deep

- ☐ A Evidence that maximum depth of inundation is greater than 2 feet
- ☐ B Evidence that maximum depth of inundation is between 1 and 2 feet
- ☒ C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- [ ] A Sandy soil
- [x] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [ ] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [ ] A Soil ribbon < 1 inch
- [x] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[x] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[ ] ≤ 15-feet wide [x] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[x] Yes [ ] No
Is stream or other open water sheltered or exposed?
[x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
[ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC		RB (applicable if assessment area is within 50 feet of a tributary)	
[x] A	[x] A	≥ 100 feet	[x] A	≥ 50 feet
[ ] B	[ ] B	From 80 to < 100 feet	[ ] B	From 30 to < 50 feet
[ ] C	[ ] C	From 50 to < 80 feet	[ ] C	From 15 to < 30 feet
[ ] D	[ ] D	From 40 to < 50 feet	[ ] D	From 5 to < 15 feet
[ ] E	[ ] E	From 30 to < 40 feet	[ ] E	< 5 feet
[ ] F	[ ] F	From 15 to < 30 feet		
[ ] G	[ ] G	From 5 to < 15 feet		
[ ] H	[ ] H	< 5 feet		

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- [ ] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [x] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. **Indicators of Deposition – assessment area condition metric**
Consider recent deposition only (no plant growth since deposition).
- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. **Wetland Size – wetland type/wetland complex condition metric**
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. **Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)**
- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. **Connectivity to Other Natural Areas – landscape condition metric**
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
	F	Wetland type has a poor or no connection to other natural habitats
Yes	No	Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. **Edge Effect – wetland type condition metric**
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. **Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)**
- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. **Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)**
- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. **Vegetative Structure – assessment area/wetland type condition metric**

- **Vegetation present**
  - **Evaluate percent coverage of vegetation for marshes only**
    - A ≥ 25% coverage of vegetation
    - B < 25% coverage of vegetation
  - **Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.**

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
C	C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
C	C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
C	C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
C	C	Herb layer sparse or absent

- **Vegetation absent**

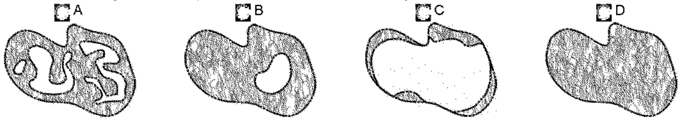
18. **Snags – wetland type condition metric**
- A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- B Not A

19. **Diameter Class Distribution – wetland type condition metric**
- A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- C Majority of canopy trees are < 6 inches DBH or no trees.

20. **Large Woody Debris – wetland type condition metric**
Include both natural debris and man-placed natural debris.
- A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- B Not A

21. **Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)**
Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

A B C D



22. **Hydrologic Connectivity – assessment area condition metric**
Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.
- A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- B Overbank flow is severely altered in the assessment area.
- C Overland flow is severely altered in the assessment area.
- D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name ıston East Wetland Complex - Existing Bottomla Date ____
Wetland Type Bottomland Hardwood Forest Assessor Name/Organization ____

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	NO
Wetland is intensively managed (Y/N)	
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**MEDIUM**
	Sub-Surface Storage and Retention	Condition	**LOW**
Water Quality	Pathogen Change	Condition	**LOW**
		Condition/Opportunity	**MEDIUM**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	
	Landscape Patch Structure	Condition	**MEDIUM**
	Vegetation Composition	Condition	**HIGH**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**MEDIUM**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	

Overall Wetland Rating ____

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Kinston No-Plant Restoration Year 0 **Date** ____________

Wetland Type Bottomland Hardwood Forest **Assessor Name/Organization** ____________

Level III Ecoregion Middle Atlantic Coastal Plain **Nearest Named Water Body** ____________

River Basin Neuse **USGS 8-Digit Catalogue Unit** ____________

[ ] Yes [x] No **Precipitation within 48 hrs?** **Latitude/Longitude (deci-degrees)** ____________

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.

Regulatory Considerations
Select all that apply to the assessment area.

[ ] Anadromous fish
[ ] Federally protected species or State endangered or threatened species
[ ] NCDWQ riparian buffer rule in effect
[ ] Abuts a Primary Nursery Area (PNA)
[ ] Publicly owned property
[ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
[ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
[ ] Designated NCNHP reference community
[ ] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)

[x] Blackwater
[ ] Brownwater
[ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[x] A	[x] A	Not severely altered
[ ] B	[ ] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[ ] A	[ ] A	Water storage capacity and duration are not altered.
[x] B	[x] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[ ] C	[ ] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[x] B	[x] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[ ] D	[ ] D	Depressions able to pond water < 3 inches deep

[ ] A Evidence that maximum depth of inundation is greater than 2 feet
[ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
[x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.

☐ A Sandy soil
☒ B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
☐ C Loamy or clayey soils not exhibiting redoxymorphic features
☐ D Loamy or clayey gleyed soil
☐ E Histosol or histic epipedon

☐ A Soil ribbon < 1 inch
☒ B Soil ribbon ≥ 1 inch

☒ A No peat or muck presence
☐ B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
☒ A	☒ A	Little or no evidence of pollutants or discharges entering the assessment area
☐ B	☐ B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
☐ C	☐ C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles and within the watershed draining to the assessment area (5M), and within 2 miles and within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
☒ A	☒ A	☒ A	≥ 10% impervious surfaces
☐ B	☐ B	☐ B	< 10% impervious surfaces
☐ C	☐ C	☐ C	Confined animal operations (or other local, concentrated source of pollutants)
☐ D	☒ D	☐ D	≥ 20% coverage of pasture
☐ E	☐ E	☐ E	≥ 20% coverage of agricultural land (regularly plowed land)
☐ F	☐ F	☐ F	≥ 20% coverage of maintained grass/herb
☐ G	☐ G	☐ G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
☐ H	☐ H	☐ H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
☒ Yes ☐ No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
☐ ≤ 15-feet wide ☒ > 15-feet wide ☐ Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
☒ Yes ☐ No
Is stream or other open water sheltered or exposed?
☒ Sheltered – adjacent open water with width < 2500 feet and no regular boat traffic.
☐ Exposed – adjacent open water with width ≥ 2500 feet or regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
☒ A	☒ A	≥ 100 feet
☐ B	☐ B	From 80 to < 100 feet
☐ C	☐ C	From 50 to < 80 feet
☐ D	☐ D	From 40 to < 50 feet
☐ E	☐ E	From 30 to < 40 feet
☐ F	☐ F	From 15 to < 30 feet
☐ G	☐ G	From 5 to < 15 feet
☐ H	☐ H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)

RB	
☒ A	≥ 50 feet
☐ B	From 30 to < 50 feet
☐ C	From 15 to < 30 feet
☐ D	From 5 to < 15 feet
☐ E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
☒ A Evidence of short-duration inundation (< 7 consecutive days)
☐ B Evidence of saturation, without evidence of inundation
☐ C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- [x] A Sediment deposition is not excessive, but at approximately natural levels.
- [ ] B Sediment deposition is excessive, but not overwhelming the wetland.
- [ ] C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
[ ] A	[ ] A	[ ] A	≥ 500 acres
[x] B	[x] B	[x] B	From 100 to < 500 acres
[ ] C	[ ] C	[ ] C	From 50 to < 100 acres
[ ] D	[ ] D	[ ] D	From 25 to < 50 acres
[ ] E	[ ] E	[ ] E	From 10 to < 25 acres
[ ] F	[ ] F	[ ] F	From 5 to < 10 acres
[ ] G	[ ] G	[ ] G	From 1 to < 5 acres
[ ] H	[ ] H	[ ] H	From 0.5 to < 1 acre
[ ] I	[ ] I	[ ] I	From 0.1 to < 0.5 acre
[ ] J	[ ] J	[ ] J	From 0.01 to < 0.1 acre
[ ] K	[ ] K	[ ] K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- [ ] A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- [ ] B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
[ ] A	[ ] A	≥ 500 acres
[x] B	[x] B	From 100 to < 500 acres
[ ] C	[ ] C	From 50 to < 100 acres
[ ] D	[ ] D	From 10 to < 50 acres
[ ] E	[ ] E	< 10 acres
	[ ] F	Wetland type has a poor or no connection to other natural habitats

[ ] Yes [ ] No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- [x] A No artificial edge within 150 feet in all directions
- [ ] B No artificial edge within 150 feet in four (4) to seven (7) directions
- [ ] C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- [ ] A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- [ ] B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- [x] C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- [x] A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- [ ] B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- [ ] C Vegetation is dominated by exotic species (>50% cover of exotics).

17. **Vegetative Structure – assessment area/wetland type condition metric**

- [ ] **Vegetation present**

  Evaluate percent coverage of vegetation for marshes only
  - [x] A ≥ 25% coverage of vegetation
  - [ ] B < 25% coverage of vegetation

  Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
[x] C	[x] C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
[x] C	[x] C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
[x] C	[x] C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
[x] C	[x] C	Herb layer sparse or absent

- [x] **Vegetation absent**

18. **Snags – wetland type condition metric**
- [ ] A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- [x] B Not A

19. **Diameter Class Distribution – wetland type condition metric**
- [ ] A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- [ ] B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- [x] C Majority of canopy trees are < 6 inches DBH or no trees.

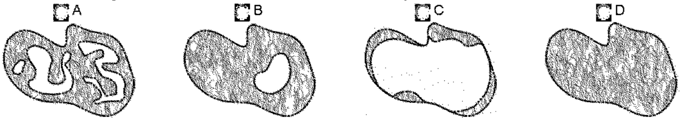
20. **Large Woody Debris – wetland type condition metric**

Include both natural debris and man-placed natural debris.
- [ ] A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- [x] B Not A

21. **Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)**

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

- [ ] A
- [ ] B
- [ ] C
- [ ] D



22. **Hydrologic Connectivity – assessment area condition metric**

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.
- [x] A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- [ ] B Overbank flow is severely altered in the assessment area.
- [ ] C Overland flow is severely altered in the assessment area.
- [ ] D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Kinston No-Plant Restoration Year 0	Date	
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	NO
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**MEDIUM**
	Sub-Surface Storage and Retention	Condition	**LOW**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**LOW**
		Condition/Opportunity	**LOW**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**LOW**
	Landscape Patch Structure	Condition	**MEDIUM**
	Vegetation Composition	Condition	**LOW**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**MEDIUM**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**LOW**

Overall Wetland Rating **MEDIUM**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name	Kinston Planting Restoration Year 0	**Date**	
Wetland Type	Bottomland Hardwood Forest	**Assessor Name/Organization**	
Level III Ecoregion	Middle Atlantic Coastal Plain	**Nearest Named Water Body**	
River Basin	Neuse	**USGS 8-Digit Catalogue Unit**	
[ ] Yes [x] No **Precipitation within 48 hrs?**		**Latitude/Longitude (deci-degrees)**	

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.
- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.

Regulatory Considerations
Select all that apply to the assessment area.
- [ ] Anadromous fish
- [ ] Federally protected species or State endangered or threatened species
- [ ] NCDWQ riparian buffer rule in effect
- [ ] Abuts a Primary Nursery Area (PNA)
- [ ] Publicly owned property
- [ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
- [ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
- [ ] Designated NCNHP reference community
- [ ] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
- [x] Blackwater
- [ ] Brownwater
- [ ] Tidal (if tidal, check one of the following boxes) [ ] Lunar [ ] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[x] A	[x] A	Not severely altered
[ ] B	[ ] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[ ] A	[ ] A	Water storage capacity and duration are not altered.
[x] B	[x] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[ ] C	[ ] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[x] B	[x] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[ ] D	[ ] D	Depressions able to pond water < 3 inches deep

- [ ] A Evidence that maximum depth of inundation is greater than 2 feet
- [ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
- [x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.

- [ ] A Sandy soil
- [x] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [ ] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [ ] A Soil ribbon < 1 inch
- [x] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[x] A	[x] A	[x] A	≥ 10% impervious surfaces
[ ] B	[ ] B	[ ] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[x] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[ ] ≤ 15-feet wide [x] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[x] Yes [ ] No
Is stream or other open water sheltered or exposed?
[x] Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
[ ] Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
[x] A	[x] A	≥ 100 feet
[ ] B	[ ] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)

RB	
[x] A	≥ 50 feet
[ ] B	From 30 to < 50 feet
[ ] C	From 15 to < 30 feet
[ ] D	From 5 to < 15 feet
[ ] E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.

- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre or assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
	F	Wetland type has a poor or no connection to other natural habitats

Yes No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions or assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

- [x] **Vegetation present**

  Evaluate percent coverage of vegetation for marshes only
  - [x] A ≥ 25% coverage of vegetation
  - [ ] B < 25% coverage of vegetation

  Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands.
  Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
[ ] A	[ ] A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
[ ] B	[ ] B	Canopy present, but opened more than natural gaps
[x] C	[x] C	Canopy sparse or absent
[ ] A	[ ] A	Dense mid-story/sapling layer
[x] B	[x] B	Moderate density mid-story/sapling layer
[ ] C	[ ] C	Mid-story/sapling layer sparse or absent
[ ] A	[ ] A	Dense shrub layer
[ ] B	[ ] B	Moderate density shrub layer
[x] C	[x] C	Shrub layer sparse or absent
[ ] A	[ ] A	Dense herb layer
[ ] B	[ ] B	Moderate density herb layer
[x] C	[x] C	Herb layer sparse or absent

- [ ] **Vegetation absent**

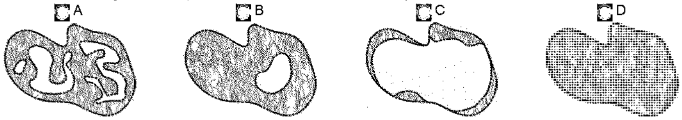
18. Snags – wetland type condition metric
- [ ] A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- [x] B Not A

19. Diameter Class Distribution – wetland type condition metric
- [ ] A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- [ ] B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- [x] C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric
Include both natural debris and man-placed natural debris.
- [ ] A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- [x] B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)
Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

[ ] A [ ] B [ ] C [ ] D



22. Hydrologic Connectivity – assessment area condition metric
Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.
- [x] A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- [ ] B Overbank flow is severely altered in the assessment area.
- [ ] C Overland flow is severely altered in the assessment area.
- [ ] D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Kinston Planting Restoration Year 0	Date	
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	NO
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**HIGH**
	Sub-Surface Storage and Retention	Condition	**LOW**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**LOW**
	Landscape Patch Structure	Condition	**MEDIUM**
	Vegetation Composition	Condition	**HIGH**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**MEDIUM**

Overall Wetland Rating **HIGH**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Kinston No-Plant Restoration Year 5 **Date** ____
Wetland Type Bottomland Hardwood Forest **Assessor Name/Organization** ____
Level III Ecoregion Middle Atlantic Coastal Plain **Nearest Named Water Body** ____
River Basin Neuse **USGS 8-Digit Catalogue Unit** ____
☐ Yes ☒ No **Precipitation within 48 hrs?** **Latitude/Longitude (deci-degrees)** ____

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? ☐ Yes ☒ No

Describe effects of stressors that are present.

Regulatory Considerations
Select all that apply to the assessment area.

☐ Anadromous fish
☐ Federally protected species or State endangered or threatened species
☐ NCDWQ riparian buffer rule in effect
☐ Abuts a Primary Nursery Area (PNA)
☐ Publicly owned property
☐ N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
☐ Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
☐ Designated NCNHP reference community
☐ Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
☒ Blackwater
☐ Brownwater
☐ Tidal (if tidal, check one of the following boxes) ☐ Lunar ☐ Wind ☐ Both

Is the assessment area on a coastal island? ☐ Yes ☒ No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? ☐ Yes ☒ No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☒ A	☒ A	Not severely altered
☐ B	☐ B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☐ A	☐ A	Water storage capacity and duration are not altered.
☒ B	☒ B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐ C	☐ C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
☐ A	☐ A	Majority of wetland with depressions able to pond water > 1 foot deep
☒ B	☒ B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
☐ C	☐ C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
☐ D	☐ D	Depressions able to pond water < 3 inches deep

☐ A Evidence that maximum depth of inundation is greater than 2 feet
☐ B Evidence that maximum depth of inundation is between 1 and 2 feet
☒ C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- ☐ A Sandy soil
- ☒ B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- ☐ C Loamy or clayey soils not exhibiting redoxymorphic features
- ☐ D Loamy or clayey gleyed soil
- ☐ E Histosol or histic epipedon

- ☐ A Soil ribbon < 1 inch
- ☒ B Soil ribbon ≥ 1 inch

- ☒ A No peat or muck presence
- ☐ B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
☒ A	☒ A	Little or no evidence of pollutants or discharges entering the assessment area
☐ B	☐ B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
☐ C	☐ C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
☒ A	☒ A	☒ A	≥ 10% impervious surfaces
☐ B	☐ B	☐ B	< 10% impervious surfaces
☐ C	☐ C	☐ C	Confined animal operations (or other local, concentrated source of pollutants)
☐ D	☒ D	☐ D	≥ 20% coverage of pasture
☐ E	☐ E	☐ E	≥ 20% coverage of agricultural land (regularly plowed land)
☐ F	☐ F	☐ F	≥ 20% coverage of maintained grass/herb
☐ G	☐ G	☐ G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
☐ H	☐ H	☐ H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
☒ Yes ☐ No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
☐ ≤ 15-feet wide ☒ > 15-feet wide ☐ Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
☒ Yes ☐ No
Is stream or other open water sheltered or exposed?
☒ Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
☐ Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
☒ A	☒ A	≥ 100 feet
☐ B	☐ B	From 80 to < 100 feet
☐ C	☐ C	From 50 to < 80 feet
☐ D	☐ D	From 40 to < 50 feet
☐ E	☐ E	From 30 to < 40 feet
☐ F	☐ F	From 15 to < 30 feet
☐ G	☐ G	From 5 to < 15 feet
☐ H	☐ H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)	
☒ A	≥ 50 feet
☐ B	From 30 to < 50 feet
☐ C	From 15 to < 30 feet
☐ D	From 5 to < 15 feet
☐ E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- ☒ A Evidence of short-duration inundation (< 7 consecutive days)
- ☐ B Evidence of saturation, without evidence of inundation
- ☐ C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- ☒ A Sediment deposition is not excessive, but at approximately natural levels.
- ☐ B Sediment deposition is excessive, but not overwhelming the wetland.
- ☐ C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
☐ A	☐ A	☐ A	≥ 500 acres
☒ B	☒ B	☒ B	From 100 to < 500 acres
☐ C	☐ C	☐ C	From 50 to < 100 acres
☐ D	☐ D	☐ D	From 25 to < 50 acres
☐ E	☐ E	☐ E	From 10 to < 25 acres
☐ F	☐ F	☐ F	From 5 to < 10 acres
☐ G	☐ G	☐ G	From 1 to < 5 acres
☐ H	☐ H	☐ H	From 0.5 to < 1 acre
☐ I	☐ I	☐ I	From 0.1 to < 0.5 acre
☐ J	☐ J	☐ J	From 0.01 to < 0.1 acre
☐ K	☐ K	☐ K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- ☐ A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- ☐ B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
☐ A	☐ A	≥ 500 acres
☒ B	☒ B	From 100 to < 500 acres
☐ C	☐ C	From 50 to < 100 acres
☐ D	☐ D	From 10 to < 50 acres
☐ E	☐ E	< 10 acres
	☐ F	Wetland type has a poor or no connection to other natural habitats

☐ Yes ☐ No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- ☒ A No artificial edge within 150 feet in all directions
- ☐ B No artificial edge within 150 feet in four (4) to seven (7) directions
- ☐ C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- ☐ A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- ☒ B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- ☐ C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- ☒ A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- ☐ B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- ☐ C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

- Vegetation present
  - **Evaluate percent coverage of vegetation for marshes only**
    - A ≥ 25% coverage of vegetation
    - B < 25% coverage of vegetation
  - **Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.**

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
C	C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
C	C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
C	C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
C	C	Herb layer sparse or absent

- Vegetation absent

18. Snags – wetland type condition metric

- A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- B Not A

19. Diameter Class Distribution – wetland type condition metric

- A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

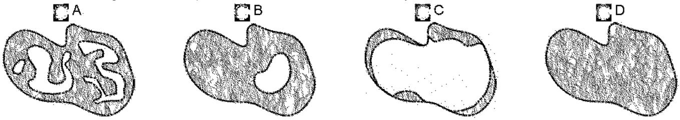
Include both natural debris and man-placed natural debris.

- A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

A B C D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

- A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- B Overbank flow is severely altered in the assessment area.
- C Overland flow is severely altered in the assessment area.
- D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Kinston No-Plant Restoration Year 5	Date	
Wetland Type	Bottomland Hardwood Forest	Assessor Name/Organization	

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	NO
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**HIGH**
	Sub-Surface Storage and Retention	Condition	**LOW**
Water Quality	Pathogen Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Particulate Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Soluble Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Physical Change	Condition	**HIGH**
		Condition/Opportunity	**HIGH**
		Opportunity Presence? (Y/N)	**YES**
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	**LOW**
	Landscape Patch Structure	Condition	**MEDIUM**
	Vegetation Composition	Condition	**MEDIUM**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	**HIGH**
	Condition/Opportunity	**HIGH**
	Opportunity Presence? (Y/N)	**YES**
Habitat	Conditon	**LOW**

Overall Wetland Rating **HIGH**

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Gum Thicket **Date** ______
Wetland Type Estuarine Woody Wetland **Assessor Name/Organization** ______
Level III Ecoregion Middle Atlantic Coastal Plain **Nearest Named Water Body** ______
River Basin Neuse **USGS 8-Digit Catalogue Unit** ______
☐ Yes ☒ No **Precipitation within 48 hrs?** **Latitude/Longitude (deci-degrees)** ______

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.
- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? ☐ Yes ☒ No

Describe effects of stressors that are present.

Regulatory Considerations
Select all that apply to the assessment area.
☐ Anadromous fish
☐ Federally protected species or State endangered or threatened species
☐ NCDWQ riparian buffer rule in effect
☐ Abuts a Primary Nursery Area (PNA)
☑ Publicly owned property
☐ N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
☐ Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
☐ Designated NCNHP reference community
☐ Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
☐ Blackwater
☐ Brownwater
☑ Tidal (if tidal, check one of the following boxes) ☐ Lunar ☒ Wind ☐ Both

Is the assessment area on a coastal island? ☐ Yes ☒ No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? ☐ Yes ☒ No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☒ A	☒ A	Not severely altered
☐ B	☐ B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☒ A	☒ A	Water storage capacity and duration are not altered.
☐ B	☐ B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐ C	☐ C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
☐ A	☐ A	Majority of wetland with depressions able to pond water > 1 foot deep
☐ B	☐ B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
☐ C	☐ C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
☒ D	☒ D	Depressions able to pond water < 3 inches deep

☐ A Evidence that maximum depth of inundation is greater than 2 feet
☐ B Evidence that maximum depth of inundation is between 1 and 2 feet
☒ C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.

- [ ] A Sandy soil
- [x] B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- [ ] C Loamy or clayey soils not exhibiting redoxymorphic features
- [ ] D Loamy or clayey gleyed soil
- [ ] E Histosol or histic epipedon

- [x] A Soil ribbon < 1 inch
- [ ] B Soil ribbon ≥ 1 inch

- [x] A No peat or muck presence
- [ ] B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
[x] A	[x] A	Little or no evidence of pollutants or discharges entering the assessment area
[ ] B	[ ] B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
[ ] C	[ ] C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles and within the watershed draining to the assessment area (5M), and within 2 miles and within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
[ ] A	[ ] A	[ ] A	≥ 10% impervious surfaces
[x] B	[x] B	[x] B	< 10% impervious surfaces
[ ] C	[ ] C	[ ] C	Confined animal operations (or other local, concentrated source of pollutants)
[ ] D	[ ] D	[ ] D	≥ 20% coverage of pasture
[ ] E	[ ] E	[ ] E	≥ 20% coverage of agricultural land (regularly plowed land)
[ ] F	[ ] F	[ ] F	≥ 20% coverage of maintained grass/herb
[ ] G	[ ] G	[ ] G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
[ ] H	[ ] H	[ ] H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
[x] Yes [ ] No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
[ ] ≤ 15-feet wide [x] > 15-feet wide [ ] Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
[ ] Yes [x] No
Is stream or other open water sheltered or exposed?
[ ] Sheltered – adjacent open water with width < 2500 feet and no regular boat traffic.
[x] Exposed – adjacent open water with width ≥ 2500 feet or regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
[ ] A	[ ] A	≥ 100 feet
[ ] B	[ ] B	From 80 to < 100 feet
[ ] C	[ ] C	From 50 to < 80 feet
[ ] D	[ ] D	From 40 to < 50 feet
[ ] E	[ ] E	From 30 to < 40 feet
[ ] F	[ ] F	From 15 to < 30 feet
[ ] G	[ ] G	From 5 to < 15 feet
[ ] H	[ ] H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)	
[ ] A	≥ 50 feet
[ ] B	From 30 to < 50 feet
[ ] C	From 15 to < 30 feet
[ ] D	From 5 to < 15 feet
[ ] E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.

- [x] A Evidence of short-duration inundation (< 7 consecutive days)
- [ ] B Evidence of saturation, without evidence of inundation
- [ ] C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric
Consider recent deposition only (no plant growth since deposition).
- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric
Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)
- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric
Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
F		Wetland type has a poor or no connection to other natural habitats

Yes No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric
May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.
- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)
- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)
- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

- [x] **Vegetation present**

  Evaluate percent coverage of vegetation for marshes only
  - [ ] A ≥ 25% coverage of vegetation
  - [ ] B < 25% coverage of vegetation

  Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands.
  Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
[x] A	[x] A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
[ ] B	[ ] B	Canopy present, but opened more than natural gaps
[ ] C	[ ] C	Canopy sparse or absent
[ ] A	[ ] A	Dense mid-story/sapling layer
[x] B	[x] B	Moderate density mid-story/sapling layer
[ ] C	[ ] C	Mid-story/sapling layer sparse or absent
[ ] A	[ ] A	Dense shrub layer
[x] B	[x] B	Moderate density shrub layer
[ ] C	[ ] C	Shrub layer sparse or absent
[x] A	[x] A	Dense herb layer
[ ] B	[ ] B	Moderate density herb layer
[ ] C	[ ] C	Herb layer sparse or absent

- [ ] **Vegetation absent**

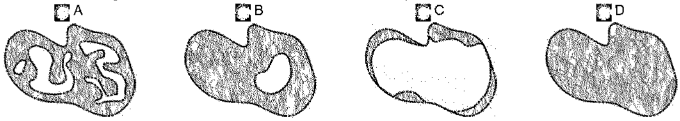
18. Snags – wetland type condition metric
- [ ] A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- [x] B Not A

19. Diameter Class Distribution – wetland type condition metric
- [ ] A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- [ ] B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- [x] C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric
Include both natural debris and man-placed natural debris.
- [ ] A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- [x] B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)
Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

[ ] A [ ] B [ ] C [ ] D



22. Hydrologic Connectivity – assessment area condition metric
Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.
- [ ] A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
- [ ] B Overbank flow is severely altered in the assessment area.
- [ ] C Overland flow is severely altered in the assessment area.
- [ ] D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name: Gum Thicket
Date:
Wetland Type: Estuarine Woody Wetland
Assessor Name/Organization:

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	**HIGH**
	Sub-Surface Storage and Retention	Condition	NA
Water Quality	Pathogen Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Particulate Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Soluble Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Physical Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Pollution Change	Condition	
		Condition/Opportunity	
		Opportunity Presence? (Y/N)	
Habitat	Physical Structure	Condition	**HIGH**
	Landscape Patch Structure	Condition	**HIGH**
	Vegetation Composition	Condition	**HIGH**

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	
	Condition/Opportunity	
	Opportunity Presence? (Y/N)	
Habitat	Conditon	**HIGH**

Overall Wetland Rating ____________

NC WAM WETLAND ASSESSMENT FORM
Version 1.5 (November 2, 2009)
RATING CALCULATOR VERSION 1.10 (November 23, 2009)

Wetland Site Name Gum Thicket
Date ____________
Wetland Type Brackish/Salt Marsh
Assessor Name/Organization ____________
Level III Ecoregion Middle Atlantic Coastal Plain
Nearest Named Water Body ____________
River Basin Neuse
USGS 8-Digit Catalogue Unit ____________
[ ] Yes [x] No **Precipitation within 48 hrs?**
Latitude/Longitude (deci-degrees) ____________

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note below if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, approximately within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? [ ] Yes [x] No

Describe effects of stressors that are present.

Regulatory Considerations
Select all that apply to the assessment area.
[ ] Anadromous fish
[ ] Federally protected species or State endangered or threatened species
[ ] NCDWQ riparian buffer rule in effect
[ ] Abuts a Primary Nursery Area (PNA)
[x] Publicly owned property
[ ] N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
[ ] Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
[ ] Designated NCNHP reference community
[ ] Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (Check all that apply)
[ ] Blackwater
[ ] Brownwater
[x] Tidal (if tidal, check one of the following boxes) [ ] Lunar [x] Wind [ ] Both

Is the assessment area on a coastal island? [ ] Yes [x] No

Is the assessment area's surface water storage capacity or duration substantially altered by beaver? [ ] Yes [x] No

1. **Ground Surface Condition/Vegetation Condition – assessment area condition metric**
Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
[x] A	[x] A	Not severely altered
[ ] B	[ ] B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, less diversity [if appropriate], artificial hydrologic alteration)

2. **Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric**
Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and ditch sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
[x] A	[x] A	Water storage capacity and duration are not altered.
[ ] B	[ ] B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
[ ] C	[ ] C	Water storage capacity or duration are substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. **Water Storage/Surface Relief – assessment area/wetland type condition metric**
Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

AA	WT	
[ ] A	[ ] A	Majority of wetland with depressions able to pond water > 1 foot deep
[ ] B	[ ] B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
[ ] C	[ ] C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
[x] D	[x] D	Depressions able to pond water < 3 inches deep

[ ] A Evidence that maximum depth of inundation is greater than 2 feet
[ ] B Evidence that maximum depth of inundation is between 1 and 2 feet
[x] C Evidence that maximum depth of inundation is less than 1 foot

4. **Soil Texture/Structure – assessment area condition metric**
Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the 12 inches. Use most recent National Technical Committee for Hydric Soils guidance for regional indicators.
- ☐ A Sandy soil
- ☐ B Loamy or clayey soils exhibiting redoxymorphic features (concentrations, depletions, or rhizospheres)
- ☐ C Loamy or clayey soils not exhibiting redoxymorphic features
- ☒ D Loamy or clayey gleyed soil
- ☐ E Histosol or histic epipedon

- ☐ A Soil ribbon < 1 inch
- ☒ B Soil ribbon ≥ 1 inch

- ☐ A No peat or muck presence
- ☒ B A peat or muck presence

5. **Discharge into Wetland – opportunity metric**
Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
☒ A	☒ A	Little or no evidence of pollutants or discharges entering the assessment area
☐ B	☐ B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
☐ C	☐ C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. **Land Use – opportunity metric**
Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles <u>and</u> within the watershed draining to the assessment area (5M), and within 2 miles <u>and</u> within the watershed draining to the assessment area (2M). Effective riparian buffers are considered to be 50 feet wide in the Coastal Plain and Piedmont ecoregions and 30 feet wide in the Blue Ridge Mountains ecoregion.

WS	5M	2M	
☐ A	☐ A	☐ A	≥ 10% impervious surfaces
☒ B	☒ B	☒ B	< 10% impervious surfaces
☐ C	☐ C	☐ C	Confined animal operations (or other local, concentrated source of pollutants)
☐ D	☐ D	☐ D	≥ 20% coverage of pasture
☐ E	☐ E	☐ E	≥ 20% coverage of agricultural land (regularly plowed land)
☐ F	☐ F	☐ F	≥ 20% coverage of maintained grass/herb
☐ G	☐ G	☐ G	≥ 20% coverage of silvicultural land characterized by a clear-cut < 5 years old
☐ H	☐ H	☐ H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic modifications that prevent drainage or overbank flow from affecting the assessment area.

7. **Wetland Acting as Vegetated Buffer – assessment area condition metric**
Is assessment area within 50 feet of a stream or other open water? (open water does not typically include man-made ditches or canals)
☒ Yes ☐ No If No, skip to next metric.
Stream width (Stream width is normal flow width [ordinary high water to ordinary high water]). If the stream is anastomosed, combine widths of channels/braids for a total stream width.
☐ ≤ 15-feet wide ☒ > 15-feet wide ☐ Not applicable (no stream within 50 feet of the assessment area)
Do roots of assessment area vegetation extend into the bank of the adjacent stream/open water?
☐ Yes ☒ No
Is stream or other open water sheltered or exposed?
☐ Sheltered – adjacent open water with width < 2500 feet <u>and</u> no regular boat traffic.
☒ Exposed – adjacent open water with width ≥ 2500 feet <u>or</u> regular boat traffic.

8. **Wetland/Riparian Buffer Width – assessment area/wetland type/wetland complex metric**
Check a box in each column for riverine wetlands only. Select the appropriate width for the wetland type at the assessment area (WT), the wetland complex at the assessment areas (WC), and the riparian buffer at the assessment area (RB) (if applicable). See User Manual for WT and WC boundaries. Riparian buffer need only be present on one side of the water body. Make buffer judgment based on dominant landscape feature. Record a note if a portion of the buffer has been removed or disturbed. Under RB, description E should be selected if ditches effectively bypass the buffer.

WT	WC	
☐ A	☐ A	≥ 100 feet
☐ B	☐ B	From 80 to < 100 feet
☐ C	☐ C	From 50 to < 80 feet
☐ D	☐ D	From 40 to < 50 feet
☐ E	☐ E	From 30 to < 40 feet
☐ F	☐ F	From 15 to < 30 feet
☐ G	☐ G	From 5 to < 15 feet
☐ H	☐ H	< 5 feet

RB (applicable if assessment area is within 50 feet of a tributary)	
☐ A	≥ 50 feet
☐ B	From 30 to < 50 feet
☐ C	From 15 to < 30 feet
☐ D	From 5 to < 15 feet
☐ E	< 5 feet

9. **Inundation Duration – assessment area condition metric**
Answer for assessment area dominant landform.
- ☒ A Evidence of short-duration inundation (< 7 consecutive days)
- ☐ B Evidence of saturation, without evidence of inundation
- ☐ C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. Indicators of Deposition – assessment area condition metric

Consider recent deposition only (no plant growth since deposition).

- A Sediment deposition is not excessive, but at approximately natural levels.
- B Sediment deposition is excessive, but not overwhelming the wetland.
- C Sediment deposition is excessive and is overwhelming the wetland.

11. Wetland Size – wetland type/wetland complex condition metric

Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the contiguous wetland complex (WC), and the size of the contiguous, forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
A	A	A	≥ 500 acres
B	B	B	From 100 to < 500 acres
C	C	C	From 50 to < 100 acres
D	D	D	From 25 to < 50 acres
E	E	E	From 10 to < 25 acres
F	F	F	From 5 to < 10 acres
G	G	G	From 1 to < 5 acres
H	H	H	From 0.5 to < 1 acre
I	I	I	From 0.1 to < 0.5 acre
J	J	J	From 0.01 to < 0.1 acre
K	K	K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)

- A Pocosin is the full extent (≥ 90%) of its natural landscape size.
- B Pocosin is < 90% of the full extent of its natural landscape size.

13. Connectivity to Other Natural Areas – landscape condition metric

Check appropriate box(es) (a box may be checked in each column). Involves a GIS effort with field adjustment. This metric well evaluates whether the wetland is connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, urban landscapes, maintained fields (pasture open and agriculture), or water > 300 feet wide.

Well	Loosely	
A	A	≥ 500 acres
B	B	From 100 to < 500 acres
C	C	From 50 to < 100 acres
D	D	From 10 to < 50 acres
E	E	< 10 acres
F		Wetland type has a poor or no connection to other natural habitats

Yes No Wetland type has a surface hydrology connection to open waters/stream or tidal wetlands. **(evaluate for marshes only)**

14. Edge Effect – wetland type condition metric

May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include permanent features such as fields, development, two-lane or larger roads (≥ 40-feet wide), utility line corridors wider than a two-lane road, and clear-cuts < 10 years old. Consider the eight main points of the compass.

- A No artificial edge within 150 feet in all directions
- B No artificial edge within 150 feet in four (4) to seven (7) directions
- C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)

- A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- C Vegetation severely altered from reference in composition. Expected strata are unnaturally absent or dominated by exotic species or composed of planted stands of non-characteristic species or inappropriately composed of a single species.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)

- A Vegetation diversity is high and is composed primarily of native species (<10% cover of exotics).
- B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- C Vegetation is dominated by exotic species (>50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

Vegetation present

Evaluate percent coverage of vegetation for marshes only

- A ≥ 25% coverage of vegetation
- B < 25% coverage of vegetation

Check a box in each column for each stratum. Evaluate this portion of the metric for non-marsh wetlands.
Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

AA	WT	
A	A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
B	B	Canopy present, but opened more than natural gaps
C	C	Canopy sparse or absent
A	A	Dense mid-story/sapling layer
B	B	Moderate density mid-story/sapling layer
C	C	Mid-story/sapling layer sparse or absent
A	A	Dense shrub layer
B	B	Moderate density shrub layer
C	C	Shrub layer sparse or absent
A	A	Dense herb layer
B	B	Moderate density herb layer
C	C	Herb layer sparse or absent

Vegetation absent

18. Snags – wetland type condition metric

- A Large snags (more than one) are visible (> 12-inches DBH, or large relative to species present and landscape stability).
- B Not A

19. Diameter Class Distribution – wetland type condition metric

- A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12-inch DBH.
- C Majority of canopy trees are < 6 inches DBH or no trees.

20. Large Woody Debris – wetland type condition metric

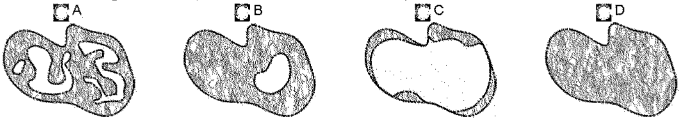
Include both natural debris and man-placed natural debris.

- A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

A B C D



22. Hydrologic Connectivity – assessment area condition metric

Evaluate for riverine wetlands only. Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

- A Overbank and overland flow are not severely altered in the assessment area.
- B Overbank flow is severely altered in the assessment area.
- C Overland flow is severely altered in the assessment area.
- D Both overbank and overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet

Wetland Site Name	Gum Thicket	Date	
Wetland Type	Brackish/Salt Marsh	Assessor Name/Organization	

Presence of stressor affecting assessment area (Y/N)	NO
Notes on Field Assessment Form (Y/N)	NO
Presence of regulatory considerations (Y/N)	YES
Wetland is intensively managed (Y/N)	NO
Wetland may be a high-quality riverine wetland (Y/N)	NA
Assessment area's surface water storage capacity or duration substantially altered by beaver (Y/N)	NO

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	NA
	Sub-Surface Storage and Retention	Condition	NA
Water Quality	Pathogen Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Particulate Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Soluble Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Physical Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
	Pollution Change	Condition	NA
		Condition/Opportunity	NA
		Opportunity Presence? (Y/N)	NA
Habitat	Physical Structure	Condition	NA
	Landscape Patch Structure	Condition	NA
	Vegetation Composition	Condition	NA

Function Rating Summary

Function	Metrics/Notes	Rating
Hydrology	Condition	**HIGH**
Water Quality	Condition	
	Condition/Opportunity	
	Opportunity Presence? (Y/N)	
Habitat	Conditon	**HIGH**

Overall Wetland Rating ____________

Attachment 1 – Memorandum – Neuse River Basin Feasibility Study, Summary of Model Review Results and Recommendation for Approval for Single Use

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

REPLY TO
ATTENTION OF:

CEMVD-PD-N *11 July 2011*

MEMORANDUM FOR CECW-SAD (Schwichtenberg)

SUBJECT: Neuse River Basin Feasibility Study, Summary of Model Review Results and Recommendation for Approval for Single Use

1. References:
a. Engineering Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2010.
b. CESAW-TS-P Memorandum to ECO-PCX dated 19 January 2011, Subject: Neuse River Basin Feasibility Study Model Approval for Use Request.
c. Agency Technical Review DrChecks Output (Enclosure 2)
d. Model Documentation, North Carolina Wetland Assessment Method (NC WAM)
e. North Carolina Wetland Assessment Method User Manual Version 2.0
f. Model Documentation, North Caroline Stream Habitat Evaluation Method (NC SHEM)
g. Internal Technical Guide for Stream Work in North Carolina. 2001
h. The Qualitative Habitat Evaluation Index (QHEI): Rationale, methods, and application. Rankin, 1989, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.
i. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI), Ohio Environmental Protection Agency, Division of Surface Water.

2. The Ecosystem Restoration Planning Center of recommends the following models for approval for use on the Neuse River Basin Feasibility Study: 1) North Carolina Wetlands Assessment Method (NC WAM) and 2) North Carolina Stream Habitat Evaluation Method (NC SHEM). Please log in this recommendation with the Office of Water Project Review for consideration by the Model Certification Team.

3. The Neuse River Basin Feasibility Study used the following models for evaluation and comparison of aquatic ecosystem restoration alternatives: 1) North Carolina Wetlands Assessment Method (NC WAM) and 2) North Carolina Stream Habitat Evaluation Method (NC SHEM). The Wilmington District submitted model documentation to the ECO-PCX, requesting model approval for single use on the subject study (Enclosures 1-5). The model documentation includes manuals and guides from the North Carolina Department of the Environment and Natural Resources (NCDENR) and supplemental required by Reference 1.a. Appendix A.

4. The Ecosystem Restoration Planning Center of Expertise (ECO-PCX) reviewed the models in accordance with Reference 1.a. A sub-set of the Agency Technical Review (ATR) team reviewed the technical and system quality and usability of the models. Tim Wilder (ERDC-EL-MS) reviewed the NC WAM and Dr. Craig Fischenich (ERDC-EL-MS) reviewed the NC SHEM. Documentation of ATR comments and responses is included in Enclosure 6. The ECO-PCX reviewed the model documentation and ATR comments.

5. NC WAM is a rapid, reference-based functional assessment method. NC WAM was developed by a state and federal interagency team consisting of the NC Department of Transportation, NC Department of Environment and Natural Resources, US Environmental Protection Agency, US Fish and Wildlife Service, and USACE. The method provides functional ratings for up to 3 major functions and 10 sub-functions, depending on the wetland type being assessed. Functions are evaluated using up to 22 field and GIS-based metrics, which include soil, hydrologic, vegetative, and landscape characteristics of the assessment area. Functional ratings are then determined based on an iterative, Boolean logic process. Model output consists of function and sub-function ratings of low, medium and high which were converted to a Suitability Index score. Sub-function scores were averaged to calculate function scores. Model documentation is included in Enclosures 2 and 3. Model Version 2.0 was used in the evaluation. This model was used to evaluate the following 3 communities in the study: bottomland hardwood forest, estuarine woody wetland, and salt/brackish marsh.

6. The ECO-PCX recommends single-use approval of NC WAM on the subject study. The model has sufficient technical quality. It is based on accepted theory, using reference wetlands and assessing widely accepted wetland functions. The technical quality of the model is supported by data and literature citations in the model documentation. The model complies with USACE policies in that it does not include non-ecosystem or non-wetland variables. The model and associated spreadsheets have undergone peer review and testing by NCDENR. As the underlying Boolean logic chain is not documented in the user's manual nor is viewable in the spreadsheet, USACE must rely on peer review conducted by NC DENR to ensure that the spreadsheet follows current theory as outlined in the model documentation and that the programming is correct. The user's manual is clear and the spreadsheet is locked. The Project Development Team (PDT) has clearly outlined assumptions associated with model application. In response to ATR comments associated with translation of NC WAM qualitative rankings into numeric quality scores, SAW conducted sensitivity analyses to see how fluctuations in the model output affected identification of NER and found that minor fluctuations would not affect the identification of NER. A member of the PDT has taken a training course on application of the NC WAM model.

7. NC SHEM is a stream habitat evaluation procedure outlined in the "Internal Technical Guide for Stream Work in North Carolina" (NCDENR 2001), which was developed by the NC Division of Water Quality, NC Division of Land Resources, and the US Army Corps of Engineers. The method evaluates streams on 7 or 8 variables (depending on ecoregion location). The variables measure aspects of riparian condition, channel modification, and in-stream habitat. Each variable is assigned a numerical score based on field observations and measurements; some variables have higher maximum scores then others. A total functional score for the stream segment is calculated by adding together the individual variable scores, with the highest possible total score equaling 100. For the purpose of the EBA, the total score will be divided by 100 to generate a stream functional index score. Model documentation is included as Enclosure 4 and 5. This model was used to evaluate streams for the study.

8. The ECO-PCX recommends single-use approval of NC SHEM on the subject study. The model has sufficient technical quality. It is a variation of the Ohio Environmental Protection Agency's Qualitative Habitat Evaluation Index (References 1.h and 1.i.) which is a widely accepted method for assessing stream habitat quality. The model complies with USACE policies in that it does not include non-ecosystem or non-wetland variables. There is not a spreadsheet associated with the model documentation. The simple spreadsheets used by the PDT in application were checked for computation correctness during ATR and identified errors were corrected.

9. In summary, the ECO-PCX finds that the models have sufficient technical and system quality and the ECO-PCX recommends single-use approval of these models on the Neuse River Basin Feasibility Study. Please notify the ECO-PCX of the findings of the Model Certification Panel.

Enclosures (6)

Jodi Staebell
Operating Director, Ecosystem Restoration
Planning Center of Expertise

CF (without enclosures):
CECW-PC (Coleman, Matusiak)
CECW-CP (Kitch, Hughes)
CECW-PB (Carlson)
CEMVD-PD-N (Wilbanks, Smith, Staebell)
CEMVR-PD-E (Theiling)
CESAD-PDS-P (Lampley)
CESAW-PM-C (Castens)
CESAW-TSD-PL (Barnes)
CESAW-TS-PF (Lin)
CESAW-TS-PE (Wilson)

Appendix L: Oyster Reef Environmental Benefits Analysis

Contents

1.0 Introduction

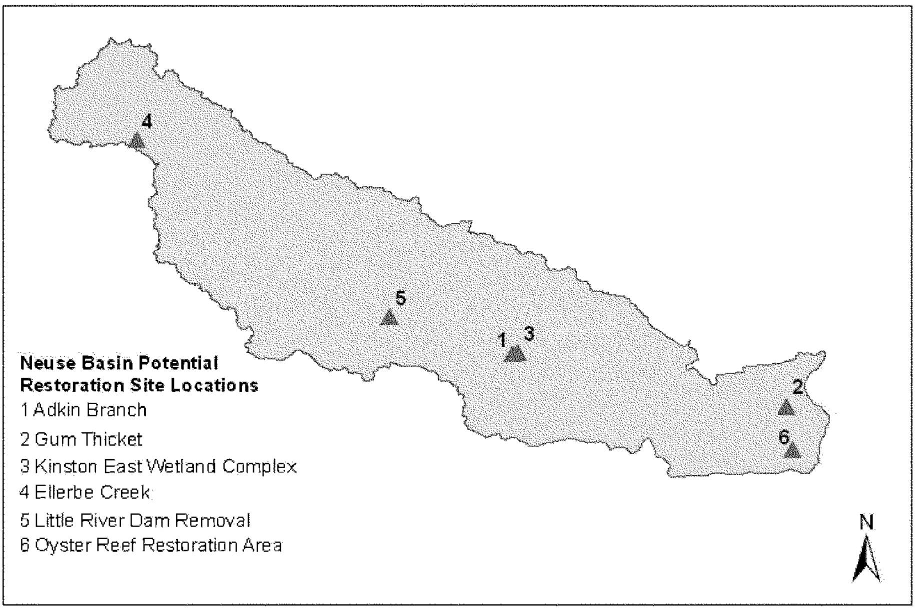
Environmental benefits assessment (EBA) is used to measure the increase in both the quality and quantity of a targeted ecosystem due to various proposed restoration measures and alternatives at a site. For the Neuse River study, quality was measured in terms of a functional index. The functional index is multiplied by the number of acres being restored in order to generate a "functional unit (FU)" output.

The Neuse River study evaluated environmental benefits in three broad ecosystem categories – wetland, stream, and oyster reef. Because there was no existing single index model which could be used to evaluate all three ecosystems, three different models were used, one for each ecosystem. These models were:

1) **Wetlands:** North Carolina Wetland Assessment Method
2) **Streams:** North Carolina Stream Habitat Evaluation Method
3) **Oyster Reef:** Habitat Evaluation Procedure (HEP) for oysters

Potential project locations are shown of Figure I-1. Potential oyster projects are located at areas 2 and 6 (see Figure I-1).

Figure L-1 Neuse Basin Potential Restoration Locations



The following sections contain detailed description of the application of the Oyster HEP model.

2.0 Habitat Evaluation Procedure (HEP)

Estuarine reefs were evaluated using a USFWS Habitat Evaluation Procedure (HEP). The American Oyster was the target species since a healthy oyster population is considered a keystone indicator of the ecological health of the estuary (NCDMF 2001, Frankenberg, 1995). Oysters are ecosystem engineers (Jones et. al 1994) where oyster growth and recruitment is required for reef sustainability and expansion.

Habitat Suitability Index (HSI) Model: The Habitat Suitability Index (HSI) Model: Gulf of Mexico American Oyster developed by the US Fish and Wildlife Service (Cake 1983) was applied. This model was developed for the Gulf of Mexico; however, it can be applied in specific Atlantic coast habitats. The Neuse Estuary Oyster Growing Area (OGA) is similar to the Gulf of Mexico, supporting subtidal oysters *Crassostrea virginica* in waters that are less than 33 feet deep and experience a small mean diurnal tidal variation. All oyster life requisites measured by model variables were confirmed as appropriate for this analysis by review of literature regarding Atlantic coast oyster populations (Kennedy et. al 1996) and biological and physical data available for the Neuse River OGA.

Variables and Formulas. This HSI model has a larval and an adult component and assesses 6 variables. The variables measure reef structure, water column conditions, and oyster abundance to determine site suitability for both larvae (Table I1, Variables 1-3) and adult oysters (Table I1, Variables 4-6). Variable V5, killing events, considered four types. Killing events as described below were defined by the Corps based on oyster life requisites from Cake (1983) and Kennedy et al. (1996).

1. Dissolved oxygen: less than 1 mg/L for 3 days.
2. Dissolved oxygen: less than 2 mg/L for 5 days.
3. Salinity: less than 2 ppt for 30 days.
4. Salinity: less than 1 ppt for 5 days.

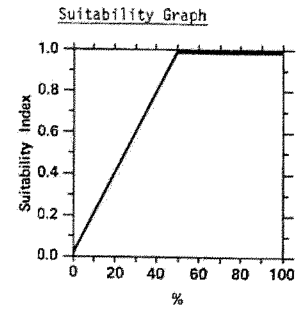
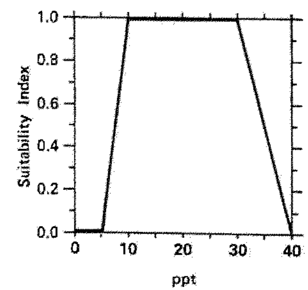
The following formulas (Cake 1983) were used to calculate habitat suitability.

CIL Larvae HSI = $(V1 \times V2 \times V3)^{1/3}$ if V3 = 0 $(V1 \times V2)^{1/2}$
CIA (Adult HSI) = $(V4 \times V5 \times V6)^{1/3}$ if V6 =0 CIA = 0
Oyster HSI If CIA is $<$ CIL his = CIA, if CIA $>$ CIL HSI = $(CIA \times CIL)^{1/2}$

The standard application was selected for simplicity. Optional variables related to disease and predators were not included since disease was present on all reefs with the exception of those with low oyster populations (>4 oyster/m2). However this factor will be considered the future in selection of reef sites within a given evaluation cell. No oyster drills, the identified indicator species for predators, were observed in any biological samples.

This model specifically measures habitat suitability for oysters; however, for this application oysters are considered a keystone species supporting, and therefore serving as an indicator of, the wide array of estuarine functions described below. Therefore for the purpose of this assessment Habitat Suitability Index (HSI) and Habitat Units (HUs) as described in the HEP model will be referred to as “Functional Index” and “Functional Units” respectively.

Table L1. HSI Variables to assess suitability for oyster larvae.

FUNCTION	VARIABLE	DATA SOURCE	HSI Graph
Support larval attachment	V1 Percent suitable cultch	Versar - Neuse OGA reef sampling July 2008 and proposed design criteria.	
Water quality support for oyster larvae	V2 Mean summer salinity (ppt)	Tetra Tech - WASP Lower Neuse estuary, period of record 1998-2006	

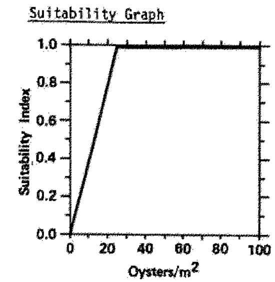
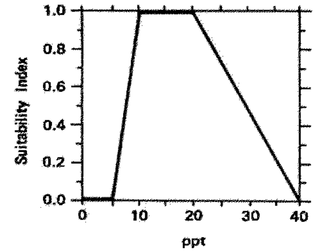
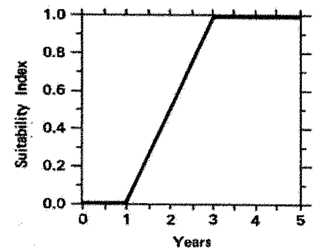
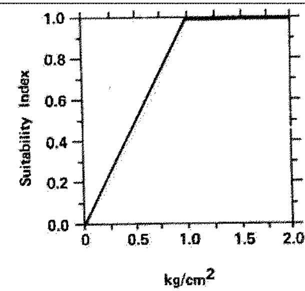
Biological support for larvae	V3 Mean abundance of living oysters /M^2	Versar - Neuse OGA reef sampling July 2008 and NCDMF State Sanctuary monitoring	

Table I2. HSI Variables to assess suitability for adult oysters.

FUNCTION	VARIABLE	DATA SOURCE	HSI Graph
Water column support adult oysters	V4 Historic mean salinity (ppt)	Tetra Tech WASP Lower Neuse estuary, period of record 1998-2006	 mean salinity
Avoidance of killing conditions	V5 Frequency of low salinity (ppt) and low DO (mgl) events (killing events/period of record)	Tetra Tech WASP Lower Neuse estuary period of record 1998-2006	 interval between killing events

Structural support for adult oysters	V6 Substrate firmness (hard or soft)	Geodynamics - Neuse OGA sidescan survey Aug 2006 and proposed design criteria	

The FI, representing habitat quality was multiplied by the available habitat quantity, or reef service area to determine output measured in Functional Units. Reef service area is = reef top acres/0.13, consistent with conditions measured at the existing NCDMF Neuse River Sanctuary.

3.0 Existing and Future Without Project Conditions

Existing Conditions. In 2007, The National Oceanic and Atmospheric Administration's (NOAA) Eastern Oyster Biological Review Team (EOBRT 2007) conducted a status review of *Crassostrea virginica*. The review determined that the oyster harvest along the East Coast of the United States is only 2% of peak historical harvest and oyster restoration and enhancement efforts are "necessary to sustain populations" in about half of the estuaries in the Middle and South Atlantic. Historic oyster degradation in Neuse River estuary is particularly apparent. The NCDMF (Street 2005) reports that viable oyster beds in the Neuse River have been "displaced downstream roughly 10-15 miles" since the late 1940s (Jones and Sholar 1981; Steel 1991). This was confirmed by US Army Corps of Engineers biological sampling (USACE 2008) that found average oyster populations (counting only oysters larger than 1 inch) of 4 or less oysters/meter^2 on reefs located in the upstream 14 miles of the Neuse River Estuary oyster growing area (OGA). This is a stark contrast to the productive downstream reefs that averaged about 50 oysters/meter^2. These counts were from reefs open to dredging and may underestimate potential for proposed sanctuary reefs. These counts also did not include spat however; Lenihan and Peterson (1998) sampled spat set on newly constructed reefs in the lower Neuse River estuary. They found heavy larval settlement in August through early September of 1993. By May 1994 spat grew to an average length of 39 mm and a density per 0.16 square meter that varied with depth from 106 spat at 3 m, to 58 spat at 4 m, and 146 at 6 m.

Figure L-2 presents the location of the OGA and relative productivity of known deepwater oyster reef habitat in the Neuse River Estuary.

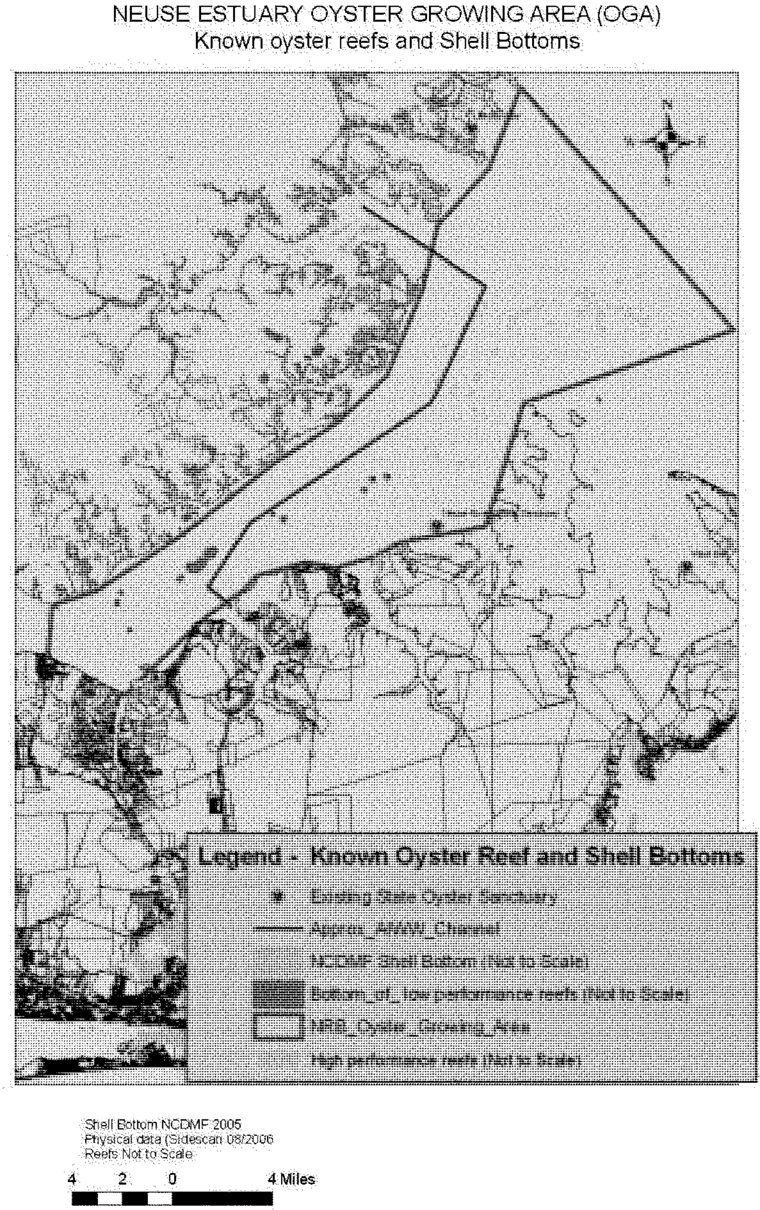


Figure L-2 Existing Oyster Reef Habitat in the Neuse River Estuary

The primary causes of the historic oyster decline in the Neuse Estuary are the cumulative effects of pollution (Cooper et al., 2004, Pinckney et al., 1998), disease, and depletion of habitat from historic overfishing using destructive oyster dredges (Lenihan and Peterson, 1998). To combat this decline, the State of North Carolina has implemented "the Neuse River Rules" (NCEMC 1997) to control pollution from upstream waters, and current harvest limits imposed by NCDMF prevent overfishing.

Future Without Condition. The EOBRT (2007) determined overharvesting to be only a minor threat to current oyster populations nationwide and efforts by the Corps, the State of North Carolina, NOAA, and non-government organizations have implemented several successful oyster restoration projects. The NCDMF Oyster Sanctuary Program is a comprehensive effort to cover the entire APNE oyster growing area.

The North Carolina Oyster Restoration Steering Committee Northern Work Group developed a Conservation Action Plan (CAP) identifying how much in-the-water restoration is needed to promote the recovery of native oysters in the APNE. The CAP concluded that the efforts to restore oysters must be ambitious and aggressive, in the water and on land, with 500 acres of new rock reef constructed and designated as sanctuary by 2018 (NCCF 2008). Oyster Sanctuaries are distinguished by a series of buoys and managed by the NCDMF to preclude oyster harvest. Since 2008 one new 30 acre sanctuary site, Gibbs shoal, has been designated in the APNE and about 45,000 tons of limestone rock has been distributed over several sanctuaries for reef construction (Reference Attachment 1). NCDMF estimates their maximum annual production rate of the state's sanctuary program without assistance at about 18,000 tons/year. Historic production over the last 14 year has been about 5,800 tons. Assuming maximum NCDMF production, by 2018 less than ½ of the plan's goal will have been met. At the historic rate the 500 acre goal will not be met within the project 50 year period of analysis.

In the Neuse Estuary, reefs continue to be stressed by disease and fishing pressure. However, the presence of large oysters (> 100mm or about 4 inches) in high output cells is an indicator of natural disease resistance. Dremo disease causes delayed mortality generally by two growing seasons or when oysters are about ~75mm or 3 inches in height and therefore oysters that survive beyond those limits are potentially resistant to Dermo (V.G. Encomio et.al, 2005). NCDMF considers the status of the Oyster Stock as "Concern", due to historic decline. However, sampling data shows "Dermo has declined in recent years and commercial landings have shown improvement" (NCMDF 2009). While reversal of displaced reefs is not expected as a result of the aforementioned regulatory controls, no additional downstream displacement is expected over the 50 year period with these controls in place. It is also expected that with the aforementioned pollution and harvest controls, ecological output of downstream reefs will be maintained at current rates.

The ORSC has identified a 100 ac sanctuary goal for the Neuse River Sub Region. Current sanctuary area in this sub region includes ~6 acres at the Neuse site and ~7 (4 developed) acres in West Bay (~13 acres total). One new 10 acre sanctuary, the Little Creek Oyster Sanctuary, is proposed for construction in 2012 as an Estuary Restoration

Act Project. No additional sites are currently proposed for the Neuse River OGA by others.

4.0 Screening

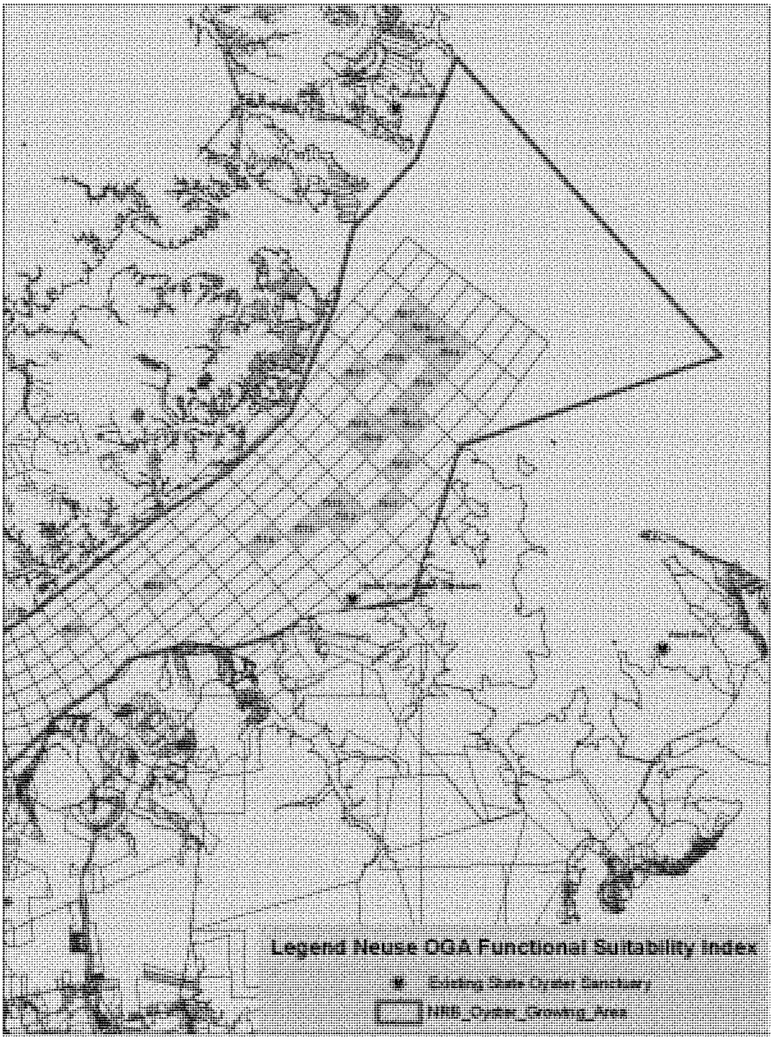
Screening of Measures. Only one restoration measure for the OGA was found to technically and environmentally feasible for implementation; Building new sanctuary reefs.

New high output reef areas would be constructed and identified by a series of buoys for designation as a sanctuary. As sanctuary, these sites would be managed by NCDMF to preclude oyster harvest. Recreational fin-fishing is allowed. This measure would expand on an existing successful practice in the Neuse River Estuary and the Pamlico Sound. The proposed materials have been proven by extensive field application. The proposed reef architecture has been modified to more closely match the form of nearby reference reefs. A recently approved Estuary Restoration Act Project, known as Little Creek Oyster Sanctuary, is to be located in the lower Neuse River in Pamlico Sound, NC. Approximately 10 miles east of the town of Oriental and 1.8 miles north west of Little Creek. (N35° 02.616' W76° 30.889'). This 10 acre site is proposed for construction and monitoring beginning early in 2012 and include alternate materials in addition to conventional stone design. If monitoring shows alternate materials are as productive and less costly that conventional methods they will be incorporated into the TSP during PED.

Other alternatives considered included (1) Restoring existing low output reefs by addition of new cultch and (2) Designating existing high output reefs as sanctuaries to preclude impacts associated with harvest. For alternative 1, This alternative is not considered technically feasible since the reef would not be sustainable and quickly revert to the previous degraded condition. For Alternative 2, existing State sanctuary regulation only allow "Oyster Sanctuary" designation at previously low value bottoms where new reefs have been constructed. These two options were eliminated from detailed evaluation.

Screening of evaluation cells. A theoretical grid comprised of evaluation cells covering the lower Neuse Estuary was drawn to support the water quality modeling of the estuary. These cells were also used as a boundary to identify sites with potential for oyster growth. Existing oyster reefs were sampled to determine the health of existing oyster populations and to validate the modeled results. Modeled cells outside the OGA were eliminated since these areas do not have historic or future potential to support oyster reefs. All cells (20) that contained reference reefs (sampled by Versar, where water quality was modeled by Tetra Tech were initially selected for HEP evaluation (see Reference Attachment 2- Screening, see Round 1and Figure L-2).

NEUSE ESTUARY OYSTER EBA
ROUND 1 SCREENING IDENTIFY POTENTIAL CELLS FOR EVALUATION



Water quality data (Modeled 01/1998 -12/2006)
Biological data (reef sampling 07/2008)
Physical data (Sidescan 08/2006 Multibeam 05/207
FSI =HSI computed from USFWS Oyster HEP model (Cake 1983)

Figure L-3. Modeled Cells with sampled Reference Reefs

The selected cells illustrated in Figure L-3 were evaluated for low oyster populations (less than 4 Oysters /m$^{2)}$ and annual killing events. Water quality Modeled output predicted that three (2) cells are subjected to annual killing events (V5 index= .1 or less. These cells were eliminated from further evaluation (Reference Attachment 2-Screening, see Round 2). Six cells that were not initially selected because no biological data was collected, were added to the evaluation; State Neuse Sanctuary (South Shore 1 cell), and a second site (4 cells) located, on the Neuse Estuary Northern shoreline. These sites were identified for evaluation with the understanding that they could only be tentatively scored and that additional survey and/or biological sampling would be required to confirm oyster growth potential. Assuming oyster potential is confirmed, inclusion of these sites allows the new reefs to be more widely spread across the river and to include sites expected to be less obtrusive to shrimp fishermen than middle river sites.

Computation of Functional Index All potential development sites have or will be confirmed by side scan survey to be existing mud or sand bottoms that lack suitable attachment substrate for oyster reef development under the existing and future without project condition. These site would have an existing and future functional index of 0 without the addition of reef structure.

The future with Functional Index (FI) were computed for all cells remaining after Round 2 Screening as shown in Table L-3.

Full data sets were available for mid river cells. For V1 substrate and V6 firmness all reefs would be constructed of rock that will provide permanent cultch across the reef top and have a firmness of greater than 1kg/cm^2. These sites have natural shell reference reefs. Long term suitability was measured based on the % of sample tows that contained no to few degraded shell fragments. Variable V3 used direct population measurements and Variables V2,V4, and V5 used or were derived from modeled water quality data.

Data was limited for some variables for the North and South shore and Gum thicket creek and required profession judgment for tentative selection as discussed below. Data will be collected in these sites and scores calculated and confirmed prior to their use.

No reference reef has been identified for the North near shore cells. Preliminary evaluation was based on modeled water quality data that predicts high site potential. For V1 substrate and V6 firmness all reefs would be constructed of rock that will provide permanent cultch across the reef top and an estimate of 50 % of suitable cultch was made being the lowest percentage identified in the vicinity. Oyster population was not predicted and scored as 0. If a productive reference reef is not found in the North near shore area, this reef development site would be selected from nearby cells with confirmed HSI Scores of 1.0. State sanctuary monitoring data and modeled water quality data was available to evaluate the potential for site expansion on the south shore. Percent suitable cultch was estimated to be at least 50% since the site will be constructed of rock that will provide permanent cultch across the reef top and adequate oyster growth has been documented by monitoring to provide a predictable renewable shell cultch surface.

For V1 substrate and V6 firmness, all reefs would be constructed of rock that will provide permanent cultch across the reef top and an estimate of 50 % of suitable cultch was made being the lowest percentage identified for productive reefs. Oyster have been observed to be abundant on existing sill sections; however the population was not predicted and scored as 0. Oyster populations would be confirmed prior to implementation of oyster features at this site.

Table L3 FI computations based on HEP for future with project conditions. (Table references to I and J represent modeled cells.)

USFWS OYSTER HSI MODEL (CAKE 1983)	I (Grid Stationing)	J (Grid Stationing)	V1 Substrate Index	V2 Mean Sum Salinity Index	V3, Gregarious Factor (density)	CI_L Larvae HSI $=(V_1 X V_2 X V_3)^{1/3}$ if $V_3=0$ $(V_1 \times V_2)^{1/2}$	V4 Hist Mean Sal Index	V5 Mean-Kill Freq Index	V6 Substrate Firmness Project Condition Rock	$CI_A=(V_4 X V_5 X V_6)^{1/3}$ if $V_6=0$ $CI_A=0$	If CI_A is<CI_L HSI=CI_A, if CI_A>CI_L HSI $=(CI_A X CI_L)^{1/2}$
Potential Mid-river Reefs	78	14	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
	78	16	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
	77	14	1.0	1.0	0.7	0.9	1.0	1.0	1.0	1.0	**0.9**
	77	16	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
	76	13	1.0	1.0	1.0	1.0	1.0	0.8	1.0	0.9	**0.9**
	76	14	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
	75	12	1.0	1.0	1.0	1.0	1.0	0.4	1.0	0.7	**0.7**
	75	14	1.0	1.0	1.0	1.0	1.0	0.8	1.0	0.9	**0.9**
	75	15	1.0	1.0	1.0	1.0	1.0	0.4	1.0	0.7	**0.7**
	74	11	1.0	1.0	0.6	0.8	1.0	0.4	1.0	0.7	**0.7**
	73	12	1.0	1.0	1.0	1.0	1.0	0.1	1.0	0.5	**0.5**
	73	13	1.0	1.0	1.0	1.0	1.0	0.1	1.0	0.5	**0.5**
	78	15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
North Bank Vicinity											
	76	17	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0	**1.0**
	78	17	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
	77	17	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
Tentatively selected	76	18	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	**1.0**
Tentatively selected	77	18	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	**1.0**
South Shore Sanctuary	72	8	1.0	1.0	1.0	1.0	1.0	0.8	1.0	0.9	**0.9**
Gum thicket Reef	72	18	1.0	1.0	0.0	1.0	1.0	0.7	1.0	0.9	**0.9**

Construction of new sanctuary reefs would add suitable cultch (V1), provide firm substrate where soft bottom currently exists (V6). Variable V3, oyster density, will be assumed to be equal to nearby reference reefs by year 3. Benefits realized by construction of new sanctuary reefs will not be fully realized until year 3 at which time oyster recruitment and growth is expected to equal that of natural reefs located in the same cell. FIs were annualized as shown in Reference Attachment 3. For simplicity, benefits are assumed to increase linearly until year 3.

Benthic Conditions Evaluated. Two potential bottom conditions were evaluated to determine existing suitability for oyster growth including (1) soft bottom and (2) oyster reef. Future without project conditions over the 50 year period of analysis is status quo, where soft bottom would persist. Under with project conditions soft bottoms would be converted to functioning reefs with FI equal to individual cell potential at year 3.

Soft Bottom. OGA deep water soft bottoms lack substrate firmness and suitable cultch and cannot support oyster reefs without the addition of structure and cultch and therefore existing and future without FI for all evaluation cells is 0.0. These soft bottom habitats, lack hard structure and are remote to existing reefs so they do not currently provide reef service area. However they are subjected to reoccurring impacts to benthic resources from summer hypoxia and shrimp trawling (Street et al. 1995).

Oyster Reefs. FIs for reef habitat varied for reef containing cells ranging from 0.5 to 1.0. Variables that reduced index scores were suitable cultch (V1), mean abundance of living oysters (V3), and frequency of low salinity and low dissolved oxygen (V5). Even low scoring sites s have a hard structure that elevates the reef tops reducing exposure to hypoxia. Their structural relief and associated current upwelling attracts pelagic forage fish, and shell covered surface provides habitat for resident species such as crabs, gobies, blennies and toad fish. This provides a food source for anadromous fish, including striped bass, and also important estuarine spawning sport fish, like red drum, as they congregate in preparation for spawning. Juvenile sea bass, grouper and other ocean spawning estuarine dependent species, also use these reefs as essential habitat during their exodus from estuarine nursery areas to the ocean (Posey et al. 1999, Mann 2001, Peterson et al. 2003, Soniat et al. 2004). Reefs with scores of 0.5 or less are considered degraded. Degradation is confirmed low oyster production high presence of shell hash as determined by biological sampling (Versar 2008). Low oyster numbers limit the food production potential and filtering capacity of the reef. A low ratio of erect live oysters to flat shell, results in a smoother surface texture, a less desirable habitat for resident species. Reef sustainability, supported by the continual production of new clean attachment surfaces by individual oysters, is also reduced where oyster populations are low. Only cells with FI 0.7 and above were considered for reef construction. In reference standard (FI 1.0) conditions high productivity improves ability to renew and sustain the reef structure above hypoxic bottom waters despite reoccurring harvest. Abundant oysters support improved water quality by providing substantial filtering (Cresman et.al 2003), and provide improved habitat conditions supporting higher fish and fish food production. All of the evaluation cells with the exception of the existing NCDMF sanctuary site are subjected to harvest pressures under existing conditions.

5.0 Functional Output

Round 3 Screening. Reefs with FI scores of 0.5 or less are considered degraded and were eliminated as potential restoration sites leaving 15 remaining evaluation cells (Reference Attachment 2-Screening, see Round 3) as shown on Figure I-4. Three development levels representing small, standard, and large sanctuary development, were evaluated at each selected evaluation cell including: (a) 20 acre sanctuary, (b) 30 acre sanctuary and (c) 40 acre sanctuary located. Each of the development levels were applied in 3 river locations: Mid River, North Bank and South Bank. FUs and project costs were calculated for 7 scenario, or alternatives, including:

(1) No Action,

(2) Mid River Reef Cells with FIs 1.0,

(3) Mid River Reef Cells with FIs 0.9

(4) Mid River Reef Cells with FIs 0.8

(5) Mid River Reef Cells with FIs 0.7

(6) North Shore Reef Cell with FI 1.0, and

(7) South Shore Sanctuary FI 0.9

Each alternative is defined by their FUs and project costs in Table I4.

For each alternative, a total Average Annual Functional Unit (AAFU) was calculated. The total AAFU is calculated as the sum of AAFU for wetland, stream, and oyster components. Since the identified oyster projects did not generate benefits in other categories oyster AAFUs and total AFFUs were equal. AAFU are calculated by determining functional index at each project year, adding these together, and dividing by the project life (50 years). (Reference 4) The total AAFU *benefit* for oysters is the difference between the AAFU calculated for that alternative (with project) and the AAFU calculated for the no action alternative (without project). In all the alternatives evaluated, the without project condition was 0.

NEUSE ESTUARY OYSTER GROWING AREA (OGA)
Round 3 Evaluation Areas for IWR Plan

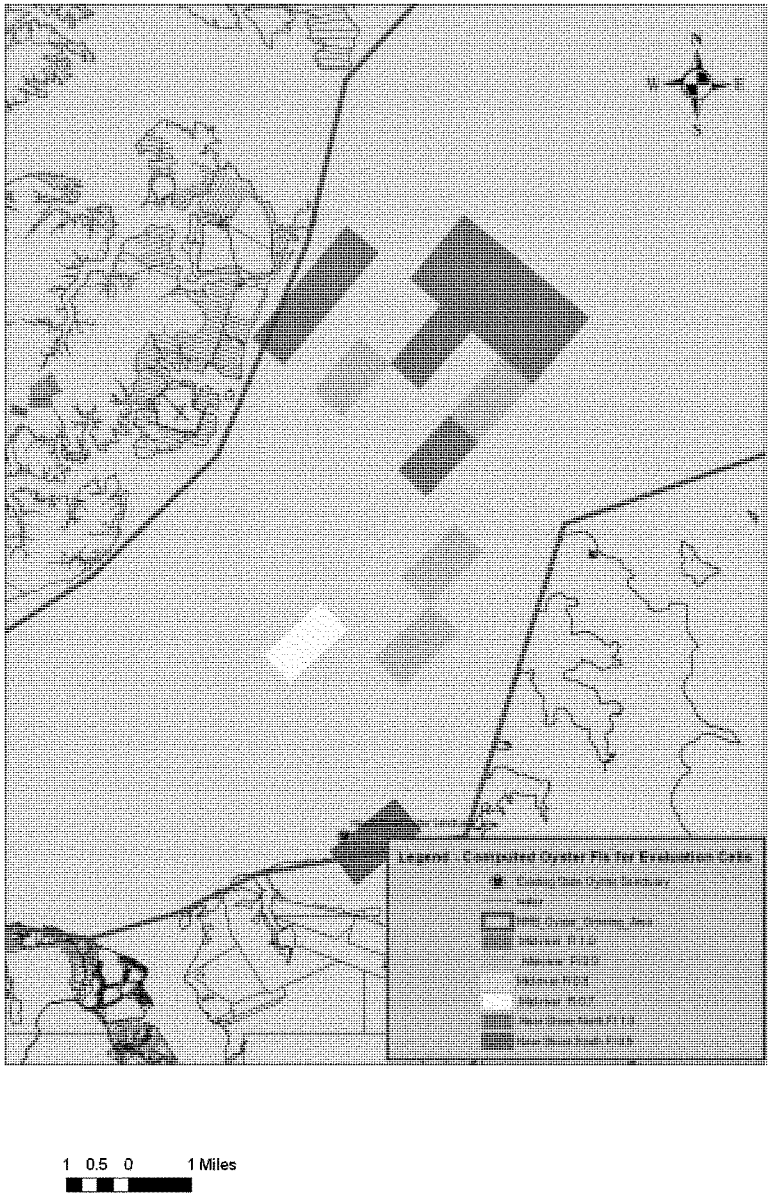


Figure I-4 FI for Evaluated Potential New Oyster Reefs

Table I4 Benefits for Oyster Sanctuaries.

Alternatives & Measures				Wetland acres	Stream acres	Oyster acres	Wetland AAFU benefit	Stream AAFU benefit	Oyster AAFU benefit	Total acres	Total AAFU benefit
1) No Action				0	0	0	0	0	0	0	0
2) FSI =	1										
	a	20	Sanctuary Ac.	0	0	20	0	0	19.4	20	20
	b	30	Sanctuary Ac.	0	0	30	0	0	3029.1	30	30
	c	40	Sanctuary Ac.	0	0	40	0	0	38.8	40	40
3) FSI =	0.9										
	a	20	Sanctuary Ac.	0	0	20	0	0	17.5	20	18
	b	30	Sanctuary Ac.	0	0	30	0	0	26.2	30	27
	c	40	Sanctuary Ac.	0	0	40	0	0	34.9	40	36
4) FSI =	0.7										
	a	20	Sanctuary Ac.	0	0	20	0	0	13.6	20	14
	b	30	Sanctuary Ac.	0	0	30	0	0	20.4	30	21
	c	40	Sanctuary Ac.	0	0	40	0	0	27.2	40	28
1) No Action				0	0	0	0	0	0	0	0
2) FSI =	1										
	a	20	Sanctuary Ac.	0	0	20	0	0	19.4	20	20
	b	30	Sanctuary Ac.	0	0	30	0	0	29.1	30	30
	c	40	Sanctuary Ac.	0	0	40	0	0	38.8	40	40
1) No Action		6	Sanctuary Ac.	0	0	6	0	0	5.2	6	5
3) FSI =	0.9										
	a	14	Sanctuary Ac.	0	0	14	0	0	12.2	14	13
	b	24	Sanctuary Ac.	0	0	24	0	0	20.9	24	22

	c	3 4	Sanctuary Ac.	0	0	34	0	0	29.5	34	31

6.0 Incremental Analysis and Selection of Proposed Alternatives

The identified scenarios were evaluated using IWR Plan as described in Appendix K tentatively selected sites are shown on Figure I-5, including 3,600 acres in the Mid River area where a potential 40 acre sanctuary site would be located, a 1,000 acre North Shore site were an additional potential 40 acre sanctuary would be located.

For a complete list of references, see main report

NEUSE ESTUARY OYSTER GROWING AREA (OGA)
Tenativily Selected Sites

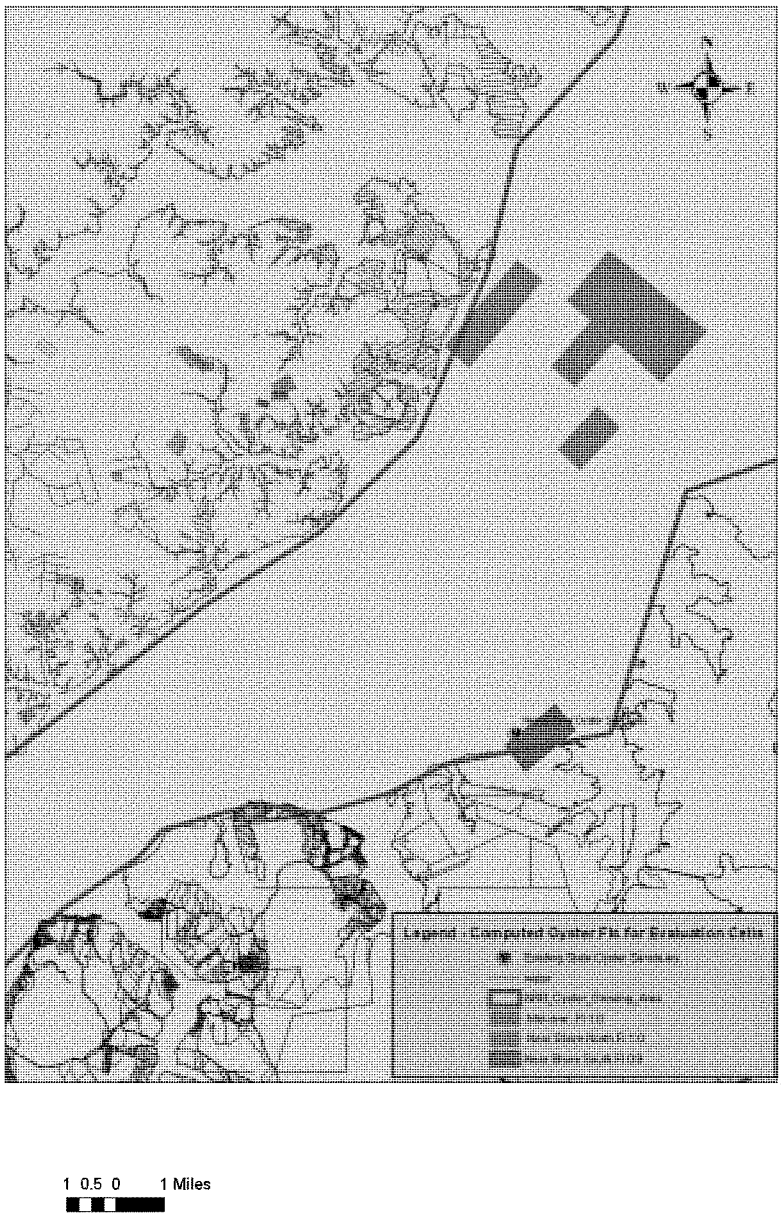


Figure L-5 *Tentatively* Selected Sites

Attachment 1 – NCDMF Oyster Sanctuary Program Accomplishments 1996-2010

Reference 1 **Table provided by NCDMF**

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010

			Oyster Sanctuary					**Calculation By Corps**						
Sanc. No.	**LOCATION**	**YEAR**	**MATERIAL**	**AMOUNT**	**# of Mounds**	**Size of sanctuary (acres)**	**% developed**	Current Acres	Proposed Acres	Tons since 1996	Tons Since 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
1	Croatan Sd.	1996	Class B rip rap	600 tons	1 leg	7.7	50.1	3.9	3.8	1800	0	466.6	5790.9	4.8
		1998	Class B rip rap	600 tons	1 leg									
		2003	Class B rip rap	600 tons	1 leg									
		2003	Oyster Shells	4,000 bus.	Overplanting									
		2003	Surf Clam Shells	2,640 bus.	Overplanting									
		2003	#4 Limesto	4,000 bus.	Overplanting									

Reference 1 **Table provided by NCDMF**

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010

			Oyster Sanctuary					**Calculation By Corps**						
Sanc. No.	**LOCATION**	**YEAR**	**MATERIAL**	**AMOUNT**	**# of Mounds**	**Size of sanctuary (acres)**	**% developed**	Current Acres	Proposed Acres	Tons since 1996	Tons Since 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
			ne Marl											
2	Deep Bay	1996	Class B rip rap	700 tons	1 leg	17.2	23.3	4.0	13.2	1300	0	324.4		
		2003	Class B rip rap	600 tons	1 leg									
		2003	Oyster Shells	4,620 bus.	Overplanting									
		2003	Surf Clam Shells	3,600 bus.	Overplanting									
		2003	#4 Lime stone Marl	4,000 bus.	Overplanting									
3	West Bay	1996	Class B rip rap	700 tons	1 leg	6.6	59.1	3.9	2.7	2000	0	512.7		
		1998	Class B rip rap	700 tons	1 leg									
		2003	Class B	600 tons	1 leg									

Reference 1 **Table provided by NCDMF**

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010

		Oyster Sanctuary						**Calculation By Corps**						
Sanc. No.	**LOCATION**	**YEAR**	**MATERIAL**	**AMOUNT**	**# of Mounds**	**Size of sanctuary (acres)**	**% developed**	Current Acres	Proposed Acres	Tons since 1996	Since Tons 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
			rip rap											
		2003	Oyster Shells	3,380 bus.	Overplanting									
		2003	Surf Clam Shells	5,760 bus.	Overplanting									
		2003	#4 Limestone Marl	4,000 bus.	Overplanting									
4	Clam Shoal (AR-296)	1996	Class B rip rap	600 tons	1 leg	47.7	21.9	10.4	37.3	12358	8267	1183		
		2002	Class B rip rap	600 tons	6									
		2004	Class B rip rap	600 tons	6									
		2005	Class B rip rap	2,300 tons	14									
		2009[a]	Class B	4,056 tons	27									

Reference 1 **Table provided by NCDMF**

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010 **Oyster Sanctuary** **Calculation By Corps**

Sanc. No.	LOCATION	YEAR	MATERIAL	AMOUNT	# of Mounds	Size of sanctuary (acres)	% developed	Current Acres	Proposed Acres	Tons since 1996	Tons Since 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
			rip rap											
		2010[a]	Class B rip rap	4,202 tons	28									
5	Crab Hole	2003	Class B rip rap	3,000 tons	21	30.5	100	30.5	0	3785	26188	1241.2		
		2004	Class B rip rap	600 tons	4									
		2006	Class B rip rap	8,070 tons	55									
		2008	Class B rip rap	4,500 tons	26									
		2009[a]	Class B rip rap	21,688	144									
6	Ocracoke (AR 298)	2004	Class B rip rap	600 tons	4	28	32.3	9	19	11412	1462	1261.8		
		2004-05	Class B rip rap	2,300 tons	13									

Reference 1 Table provided by NCDMF

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010

				Oyster Sanctuary				Calculation By Corps						
Sanc. No.	**LOCATION**	**YEAR**	**MATERIAL**	**AMOUNT**	**# of Mounds**	**Size of sanctuary (acres)**	**% developed**	Current Acres	Proposed Acres	Tons since 1996	Since Tons 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
		2006	Class B rip rap	3,816 tons	23									
		2008	Class B rip rap	1,096 tons	6									
		2009	Class B rip rap	3,600 tons	24									
7	Middle Bay	2004	Class B rip rap	900 tons	45	4.6	8.7	0.4	4.2	900.0	0.0			
8	Neuse River	2005	Class B rip rap	2,300 tons	15	5.7	94.2	5.4						
		2006	Class B rip rap	3,062 tons	21									
		2008	Class B rip rap	1,900 tons	13				0.3	7262	1900	1352.5		
9	West Bluff Pt.	2005	Class B rip rap	3,000 tons	22	19.9	42.2							
		2005	Class B rip rap	440 tons	3			8.4	11.5	9636	1096	1147.4		

Reference 1 **Table provided by NCDMF**

NCDMF Oyster Sanctuary Program Accomplishments 1996 -2010

Oyster Sanctuary **Calculation By Corps**

Sanc. No.	LOCATION	YEAR	MATERIAL	AMOUNT	# of Mounds	Size of sanctuary (acres)	% developed	Current Acres	Proposed Acres	Tons since 1996	Tons Since 2008	Tons/acre	Average annual Production Rate (Total Tons/14 years)	Average sanctuary acres / year
		2006	Class B rip rap	1,650 tons	11									
		2008	Class B rip rap	1,096 tons	6									
		2009	Class B rip rap	3,450 tons	23									
10	Gibbs Shoal	2009	Class B rip rap	296 tons	4	30	5.6	1.7	28.3	1646.0	1646.0	979.8		
		2010	Class B rip rap	1,350 tons	9			Total (acres)	Total (acres)	Total (tons)	Total (tons)	Avg (tons/ acre)		
	Updated 1/22/10		Totals	75,768 tons	573*	197.9	Total	78	120	81072	40559	1194		
				36,000 bus**										

Attachment 2 - Screening Process - Rounds 1-3 and Areas Selected for IWR Analysis

Reference 2 – Screening Process Rounds 1-3 and Areas Selected for IWR Analysis

Round 1 Screening		Round 2 Screening					Round 3 Screening		Selected for IWR Plan Analysis
Ij of included cells		Compute FSI		FSI	Compute service existing	FCU area	Run IWR Plan		
78	14	78	14	1	7.4		78	14	Potential Mid-River Restoration
78	14	78	14	1	10.4		78	14	Potential Mid-River Restoration
78	14	78	14	1	24.9		78	14	Potential Mid-River Restoration
78	14	78	14	1	28.6		78	14	Potential Mid-River Restoration
78	15	78	15	1	32.6		78	15	Potential Mid-River Restoration
78	16	78	16	1	4.4		78	16	Potential Mid-River Restoration
78	16	78	16	1	10.2		78	16	Potential Mid-River Restoration
78	16	78	16	1	7.8		78	16	Potential Mid-River Restoration
78	16	78	16	1	8.0		78	16	Potential Mid-River Restoration
78	17	78	17	1	7.0		78	17	Potential Mid-River Restoration
78	17	78	17	1	1.9		78	17	Potential Mid-River Restoration
77	14	77	14	0.9	17.6		77	14	
77	16	77	16	1	7.2		77	16	Potential Mid-River Restoration
77	16	77	16	1	37.7		77	16	Potential Mid-River Restoration

Round 1 Screening		Round 2 Screening					Round 3 Screening		Selected for IWR Plan Analysis
Ij of included cells		Compute FSI		FSI	Compute service existing	FCU area	Run IWR Plan		
77	16	77	16	1	2.8		77	16	Potential Mid-River Restoration
76	13	Annual Hypoxia Screened Out							
76	14	76	14	1	23.5		76	14	Potential Mid-River Restoration
76	17	76	17	0.9	6.6		76	17	Potential Mid-River Restoration
75	12	75	12	0.9	4.1		75	12	Potential Mid-River Restoration
75	14	75	14	0.8	9.7		75	14	Potential Mid-River Restoration
75	14	75	14	0.8	15.0		75	14	Potential Mid-River Restoration
75	15	Annual Hypoxia Screened Out							
75	15	Annual Hypoxia Screened Out							
74	11	74	11	0.9	19.5		74	11	Potential Mid-River Restoration
73	12	Annual Hypoxia Screened Out							
73	13	73	13	0.7	6.9		73	13	Potential Mid-River Restoration
72	13	72	13	0.5	3.2		Screened out oyster Density <4 & FSI $\leq$0.5		
71	14	71	14	0.5	3.8		Screened out oyster Density <4 & FSI $\leq$0.5		
71	14	71	14	0.5	2.5		Screened out oyster Density <4 & FSI $\leq$0.5		
68	16	68	16	0.5	2.4		Screened out oyster Density <4 & FSI $\leq$0.5		
65	17	65	17	0.5	1.7		Screened out oyster Density <4 & FSI $\leq$0.5		
65	17	65	17	0.5	1.5		Screened out oyster Density <4 & FSI $\leq$0.5		
65	17	65	17	0.5	2.6		Screened out oyster Density <4 & FSI $\leq$0.5		

Round 1 Screening		Round 2 Screening					Round 3 Screening		Selected for IWR Plan Analysis
Ij of included cells		Compute FSI		FSI	Compute service existing	FCU area	Run IWR Plan		
65	17	65	17	0.5	1.9		Screened out oyster Density <4 & FSI ≤ 0.5		
		76	19	1	0.0		76	19	Potential North Shore Slte
		77	19	1	0.0		77	19	Potential North Shore Slte
		72	8	0.9	6.0		72	8	Potential South Shore Slte

		Reef Number	Sample Area #	Demo_M_Quant	Hopkins-index	Oyster_mean_density	LVO_L_Smp	LVO_L_Smp index	V_gt_summ	# size classes	# size classes index	largest class present	P_to_A	Roughness	Foot_Print_Ac	Sample_area_acres	Reef_height_F	Reef_height_F index	*	Average B depth (F)	Average T Depth (F)	Dist_Frm_thalweg_M	Influence present	% hatch free tows
78	14	ERHA-00088	FHSA-00113	24.413	6.7	78.2	30.6	1.0	0	16	0.8	100	0.02	0.37	2.82	0.96	4.2	1.0	0	-24.2	-20.1	862	1	0.33
78	14	ERHA-00085	FHSA-00112	26.649	6.6	22.0	19.7	0.6	5	16	0.8	100	0.02	0.33	3.63	1.36	4.3	1.0	0	-24.5	-20.2	623	1	1
78	14	ERHA-00084	FHSA-00111	42.137	6.5	105.5	24.2	0.6	0	14	0.7	90	0.01	0.49	8.43	3.24	6.1	1.0	0	-25.9	-19.7	404	1	0.33
78	14	ERHA-00082	FHSA-00109	84.088	6.8	63.2	23.9	0.6	0	17	0.8	105	0.01	0.38	11.3	3.72	6.2	1.0	0	-26.1	-19.9	234	1	0.66
78	15	ERHA-00083	FHSA-00110	25.768	6.8	28.8	22.4	0.7	0	14	0.7	95	0.01	0.67	8.62	4.24	4.3	1.0	0	-25.0	-20.7	557	1	1
78	16	ERHA-00081	FHSA-00106	46.538	6.5	37.2	17.3	0.6	2	16	0.8	100	0.03	0.15	1.43	0.57	2.2	0.8	0	-21.7	-19.5	2027	1	1
78	16	ERHA-00078	FHSA-00103	52.318	5.4	37.9	16.1	0.5	2	16	0.8	100	0.02	0.25	2.7	1.32	2.3	0.8	0	-22.0	-19.7	1672	1	1
78	16	ERHA-00077	FHSA-00102	82.185	6.6	81.8	20.9	0.7	1	16	0.8	100	0.03	0.45	2.55	1.02	2.3	0.8	0	-22.1	-19.8	1775	1	0.33
78	16	ERHA-00076	FHSA-00101	2.284	6.7	67.1	17.7	0.6	1	16	0.8	100	0.02	0.28	2.37	1.04	2.7	0.7	0	-22.1	-19.4	1893	1	0.33
78	17	ERHA-00080	FHSA-00105	19.469	6.3	28.7	15.1	0.5	4	16	0.8	100	0.03	0.28	1.96	0.81	1.3	0.3	0	-21.3	-20.0	2318	1	1
78	17	ERHA-00079	FHSA-00104	17.471	6.2	45.8	11.9	0.4	1	16	0.8	105	0.04	0.21	0.73	0.28	1.6	0.4	0	-21.2	-19.7	2408	1	1
77	14	ERHA-00070	FHSA-00094	80.964	6.4	16.1	15.3	0.5	4	17	0.9	110	0.01	0.23	6.85	2.54	3.0	0.8	0	-21.9	-18.8	585	1	1
77	16	ERHA-00074	FHSA-00098	31.755	6.1	43.5	16.1	0.5	5	18	0.9	120	0.02	0.26	2.11	0.94	1.9	0.5	0	-21.8	-19.9	1880	1	1
77	16	ERHA-00072	FHSA-00096	284.666	7.0	103.1	21.1	0.7	2	16	0.8	100	0.02	0.30	8.83	4.9	1.6	0.5	0	-21.6	-19.7	1881	1	0.66

		Reef Number	Sample Area #	Dermo_M_Quant	Hopkins-Index	Oyster_mean_density	LvO_L_Smp	LvO_L_Smp index	L_SF_numm	# size classes	# size classes index	largest class present	P_to_A	Roughness	Foot_Print_Ac	Sample_area_acres	Reef_height_F	Reef_height_F index	*	Average B depth (F)	Average T Depth (F)	Dist_Fm_thalveg_M	infauna present	% harsh free tows[1]
7 7	1 6	ERHA-00071	FHSA-00095	29,728	6.5	67.9	17.8	0.6	4	17	0.9	115	0.04	0.45	1	0.36	1.5	0.4	0	-21.4	-19.8	1520	1	1
7 8	1 2	ERHA-00048	FHSA-00092	214,152	7.4	98.2	18.0	0.6	5	16	0.8	100	0.02	0.17	5.18	1.73	5.5	1.0	0	-24.4	-18.9	245	1	1
7 8	1 4	ERHA-00131	FHSA-00093	207,606	6.7	90.3	19.1	0.3	1	15	0.8	100	0.01	0.22	15.83	3.05	4.5	1.0	0	-23.9	-19.3	537	1	0.66
7 8	1 7	ERHA-00069	FHSA-00195	151,561	7.0	21.1	12.4	0.4	7	18	0.5	110	0.02	0.34	2.12	0.95	1.3	0.3	0	-20.1	-18.5	2287	1	1
7 5	1 2	ERHA-00063	FHSA-00080	5,815	8.2	54.7	20.5	0.7	1	16	0.9	100	0.02	0.09	2.54	0.59	6.5	1.0	0	-24.3	-17.7	1535	1	0.66
7 5	1 4	ERHA-00067	FHSA-00087	22,936	7.7	56.2	19.8	0.6	9	19	1.0	125	0.02	0.19	4.71	1.58	4.5	1.0	0	-23.8	-19.1	277	1	0.66
7 5	1 4	ERHA-00065	FHSA-00085	245,121	8.4	109.6	23.3	0.8	1	16	0.8	100	0.02	0.29	8.61	2.44	4.4	1.0	0	-23.7	-19.3	367	1	1
7 5	1 5	ERHA-00065	FHSA-00085	296,788	8.2	100.7	21.8	0.7	4	17	0.8	100	0.02	0.34	10.74	2.48	3.7	0.8	0	-22.4	-19.3	1302	1	0.33
7 5	1 6	ERHA-00064	FHSA-00085	282,230	6.0	55.0	22.4	0.7	1	16	0.8	100	0.01	0.40	8.59	2.91	3.7	0.9	0	-22.7	-19.0	1303	1	1
7 4	1 1	ERHA-00061	FHSA-00061	8,635	5.1	15.6	10.2	0.3	5	15	1.0	115	0.01	0.57	7.33	2.82	3.2	0.8	0	-21.6	-19.5	3245	1	1
7 3	1 2	ERHA-00060	FHSA-00080	13,836	7.1	32.7	18.4	0.6	1	16	0.8	100	0.02	0.21	3.48	0.9	4.5	1.0	0	-22.5	-19.1	1636	1	0.66
7 3	1 3	ERHA-00059	FHSA-00079	8,096	6.0	47.3	7.8	0.3	1	16	0.8	110	0.02	0.15	4.28	1.28	4.8	1.0	0	-22.7	-18.1	846	1	0.66
7 2	1 3	ERHA-00056	FHSA-00078	686	7.1	4.0	7.3	0.2	3	11	0.6	75	0.02	0.34	3.41	0.82	4.1	1.0	0	-22.8	-19.7	594	1	0.3
7 1	1 4	ERHA-00057	FHSA-00077	26	6.7	2.4	4.0	0.1	0	11	0.6	75	0.02	0.22	3.5	0.90	4.2	1.0	0	-23.0	-18.8	123	1	0.1
7 1	1 4	ERHA-00055	FHSA-00075	229	6.0	3.6	1.9	0.0	3	10	0.5	75	0.02	0.29	2.7	0.64	4.7	1.0	0	-22.8	-19.2	298	1	0.1

		Reef Number	Sample Area #	Dermo_M_Quant	Hopkins-Index	Oyster_mean_density	LvO_L_Smp	LvO_L_Smp index	L_gt_numm	# size classes	# size classes index	largest class present	P_to_A	Roughness	Foot_Print_Ac	Sample_area_acres	Reef_height_F	Reef_height_F index		Average B depth (F)	Average T Depth (F)	Dist_Frm_thalweg_M	infauna present	% hash free tows[1]
8 8	1 6	ESHA-03064	FHSA-03075	77	7.8	3.3	1.6	0.9	0	10	0.5	75	0.02	0.25	3.52	0.63	3.0	1.0	0	-20.0	-16.1	1100	1	0.1
8 5	1 7	ESHA-03259	FHSA-03085	54	7.8	1.0	1.0	0.9	0	9	0.5	60	0.05	0.26	2.4	0.49	4.7	1.0	0	-20.2	-15.5	550	1	0.39
8 5	1 7	ESHA-00548	FHSA-03505	65	7.1	0.7	1.2	0.9	0	10	0.5	70	0.04	0.31	2.76	0.30	3.7	0.8	0	-20.1	-16.4	663	1	0.1
8 5	1 7	ESHA-00548	FHSA-03004	55	7.8	2.7	1.9	0.9	0	9	0.5	65	0.03	0.29	2	0.08	4.0	1.0	0	-19.9	-16.6	815	1	0.1
8 5	1 7	ESHA-03545	FHSA-03169	97	7.4	2.7	1.2	0.9	0	12	0.8	75	0.03	0.25	3.04	0.5	4.1	1.0	0	-20.1	-16.0	654	1	0.1

Note 1 Minimum score for sites where all tows contained shell hash was 0.1 since all sites contained some live oysters indicating some suitable cultch

Attachment 3 –Annualized FCIs

ANNULIZED FCIs

YEAR	RANGE of CALCULATED FCIs				
	1.0	0.9	0.8	0.7	0.5
1	0.0	0.0	0.0	0.0	0.0
2	0.5	0.5	0.4	0.4	0.3
3	1.0	0.9	0.8	0.7	0.5
4	1.0	0.9	0.8	0.7	0.5
5	1.0	0.9	0.8	0.7	0.5
6	1.0	0.9	0.8	0.7	0.5
7	1.0	0.9	0.8	0.7	0.5
8	1.0	0.9	0.8	0.7	0.5
9	1.0	0.9	0.8	0.7	0.5
10	1.0	0.9	0.8	0.7	0.5
11	1.0	0.9	0.8	0.7	0.5
12	1.0	0.9	0.8	0.7	0.5
13	1.0	0.9	0.8	0.7	0.5
14	1.0	0.9	0.8	0.7	0.5
15	1.0	0.9	0.8	0.7	0.5
16	1.0	0.9	0.8	0.7	0.5
17	1.0	0.9	0.8	0.7	0.5
18	1.0	0.9	0.8	0.7	0.5
19	1.0	0.9	0.8	0.7	0.5
20	1.0	0.9	0.8	0.7	0.5
21	1.0	0.9	0.8	0.7	0.5
22	1.0	0.9	0.8	0.7	0.5
23	1.0	0.9	0.8	0.7	0.5
24	1.0	0.9	0.8	0.7	0.5
25	1.0	0.9	0.8	0.7	0.5
26	1.0	0.9	0.8	0.7	0.5
27	1.0	0.9	0.8	0.7	0.5
28	1.0	0.9	0.8	0.7	0.5

ANNULIZED FCIs

YEAR	RANGE of CALCULATED FCIs				
	1.0	0.9	0.8	0.7	0.5
29	1.0	0.9	0.8	0.7	0.5
30	1.0	0.9	0.8	0.7	0.5
31	1.0	0.9	0.8	0.7	0.5
32	1.0	0.9	0.8	0.7	0.5
33	1.0	0.9	0.8	0.7	0.5
34	1.0	0.9	0.8	0.7	0.5
35	1.0	0.9	0.8	0.7	0.5
36	1.0	0.9	0.8	0.7	0.5
37	1.0	0.9	0.8	0.7	0.5
38	1.0	0.9	0.8	0.7	0.5
39	1.0	0.9	0.8	0.7	0.5
40	1.0	0.9	0.8	0.7	0.5
41	1.0	0.9	0.8	0.7	0.5
42	1.0	0.9	0.8	0.7	0.5
43	1.0	0.9	0.8	0.7	0.5
44	1.0	0.9	0.8	0.7	0.5
45	1.0	0.9	0.8	0.7	0.5
46	1.0	0.9	0.8	0.7	0.5
47	1.0	0.9	0.8	0.7	0.5
48	1.0	0.9	0.8	0.7	0.5
49	1.0	0.9	0.8	0.7	0.5
50	1.0	0.9	0.8	0.7	0.5
AAFCI	1.0	0.9	0.8	0.7	0.5

APPENDIX M: REAL ESTATE

REAL ESTATE APPENDIX

(Neuse River Basin Feasibility Report)

Contents

SECTION 1. THE REAL ESTATE REPORT

1.1 Statement of Purpose

This report is tentative in nature, focuses on the Tentatively Selected Plan, and is to be used for planning purposes only. Valuation of lands was determined by a gross appraisal. There may be modifications to the plans that occur during Planning, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and/or administrative and land cost. The Real Estate Appendix is intended to support the Neuse River Basin Feasibility Study which is a General Investigative (GI) study, and is written to the same level of detail as the main report. The author of this report has viewed the general project areas. The North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Resources (NCDWR) is the non-Federal sponsor for the project. Date of this report is September 2012.

1.2 Study Authority

This Interim Integrated Feasibility Report and Environmental Assessment (EA) are being prepared in response to the following resolution adopted July 23, 1997:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control, environmental protection and restoration, and related purposes.*

1.3 Project Location

The Neuse River Basin is the third largest river basin in North Carolina. The basin encompasses a total area of 6,234 square miles (Figure 1.3-1), and is one of only four basins that are entirely within the state. The Neuse River originates in north-central North Carolina in Person and Orange counties and flows southeasterly until it reaches tidal waters near Streets Ferry upstream of New Bem. The river broadens dramatically at New Bem and changes from a free-flowing river to a tidal estuary known as the Neuse River Estuary, which eventually flows into Pamlico Sound. The upper one-third of the basin lies in the Piedmont Physiographic Province, while the lower two-thirds lie in the Mid-Atlantic Coastal Plain Physiographic Province. Elevations in the Neuse River Basin range from 905 feet in the western part of the basin to sea level where the Neuse River Estuary joins Pamlico Sound.

The Eno and Flat rivers converge to form the Neuse River near Durham, North Carolina. The first 22 miles of the river immediately downstream of this confluence are impounded by Falls Lake, a multipurpose reservoir completed in 1983 and managed by the US Army Corps of Engineers. Falls Lake provides flood control storage, water quality releases, water supply storage, and recreation. It is the primary drinking water source for the city of Raleigh. Below Falls Lake the river flows southeasterly for about 180 miles, past Smithfield, Goldsboro, Kinston, and New Bem.

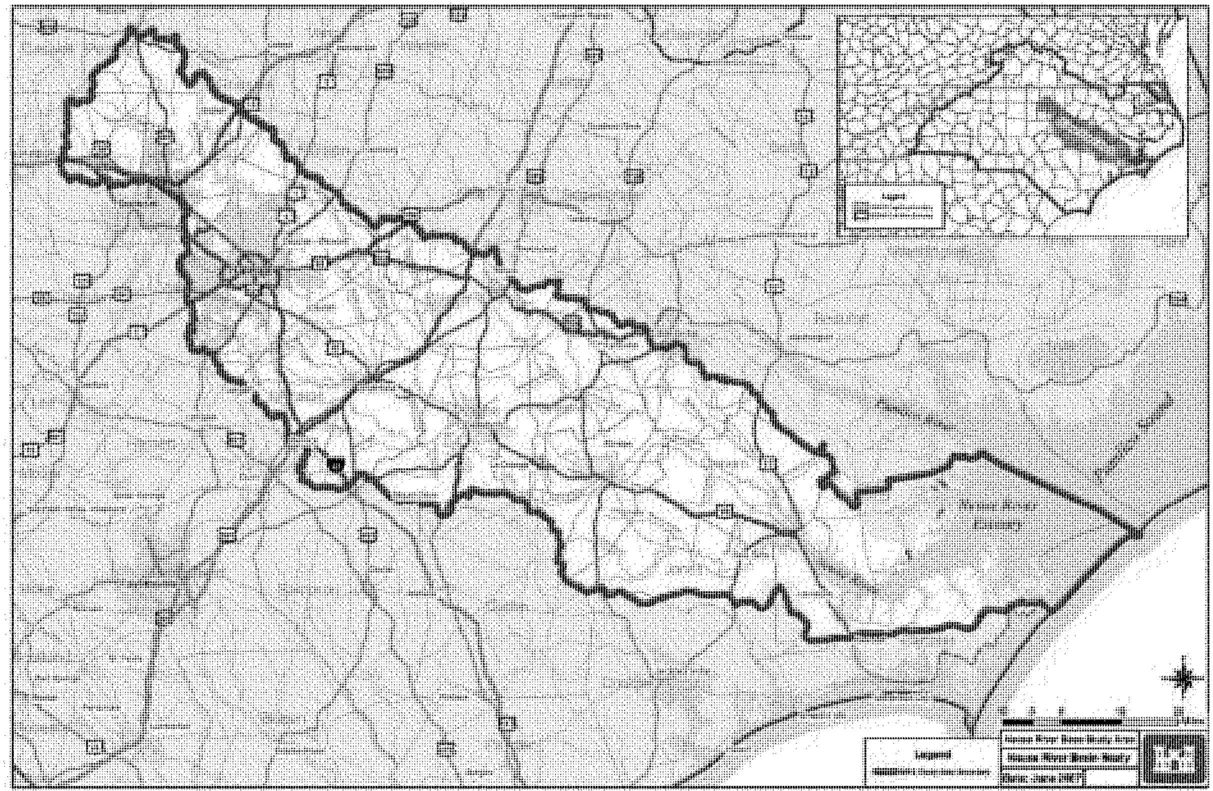


Figure 1.3-1. Project Vicinity/Location Map

There are 19 major reservoirs in the Neuse River Basin, most in the upper portion of the basin. Eighteen are non-Federal. Falls Lake is the largest and only Federal reservoir. Several significant reservoirs serving as water supply and flood control structures, along with old millponds and beaver impoundments, characterize the Piedmont region of the Upper Neuse River Basin. Reservoirs are few in number in the Coastal Plain physiographic province of the basin because of inhibitive factors such as highly pervious sands and flat topography.

1.4 Project Description

The National Ecosystem Restoration Plan (NER) is the plan that reasonably maximizes net ecosystem restoration benefits by having the maximum beneficial ecosystem effects for the costs. Small projects throughout the watershed would provide a cascade effect that contributes to the health of the overall watershed. Success in providing suitable aquatic habitat conditions in the overall watershed would begin by improving riverine and riparian habitat conditions, then removing obstructions and creating connectivity to once-unavailable habitat, and finally providing habitat in the estuary for species to begin their journey upstream. The NER Plan, the Tentatively Selected Plan, (TSP) is at Table 1.4-1. Each plan component along with real estate requirements will be discussed below in Section 1.5. The locations of the components of the TSP are shown at Figure 1.4-1.

Table 1.4-1. NER Plan

Modification of Low-head Dam on Little River near Goldsboro
Kinston East Wetland Restoration Complex
Stabilization of Gum Thicket Creek and Cedar Creek
Construction of New Reef Habitat

Objectives of the project are to:

- Improve the quality of instream and riparian habitat
- Increase the quantity and quality of estuarine shoreline habitat
- Improve the connectivity between the aquatic estuary and riverine habitats
- Increase the quantity and quality of oyster reef habitat.

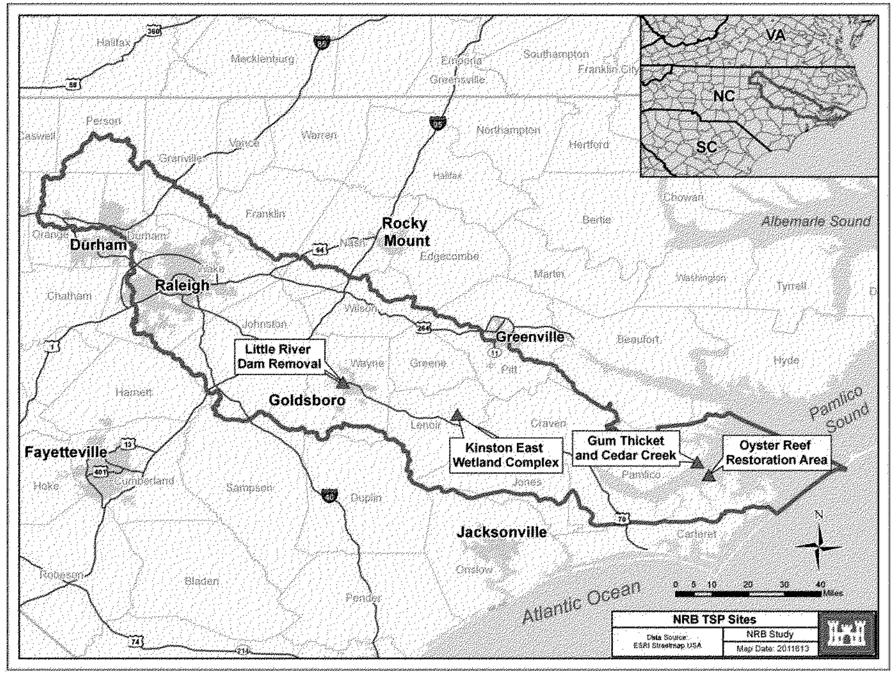


Figure 1.4-1. Locations of Components of TSP

1.5 Real Estate Requirements

The requirements for lands, easements, rights-of-way and relocations, and disposal/borrow areas (LERR) should include the rights to construct, maintain, and repair bank protection works and the right to construct new reef habitat in the Neuse River estuary. Components of the project can be constructed under the standard Fee estate, Temporary Work Area Easement and the standard Bank Protection Easement and a non standard Dam Modification Easement. Real Estate requirements for each of the proposed plan components are discussed in this section.

Modification of Low-head Dam on Little River near Goldsboro: An approximately 20-ft section of the existing 100-ft-wide, 4-ft-high concrete dam would be removed. A hydraulic gate or a stop log structure would be installed within this 20-ft opening. The gate within the existing dam would remain open during the anadromous fish migration season (i.e., about January to May of any year). During low-flow conditions (i.e., July to September of any year), the City of Goldsboro would close the gate in order to use the upstream secondary water intake structure. The low-head dam can be seen in Figure 1.5-1 and the location is illustrated at Figure 1.5-2.

The Un-named Dam on the Little River is bounded by private land on the north side and by land owned by the City of Goldsboro on the south side. The City of Goldsboro built the dam in 1914 and owns and operates the dam. A title search will be performed during PED to determine if any real estate interest will be required from the landowner on the north side of the dam. All work can be performed from the city owned land which is utilized as a Water Treatment Plant and has sufficient area for a staging area. The Temporary Work Area Easement will be used for the staging area and access is by public road. Approximately 0.90 acres will be required in temporary work area easement. A non standard Dam Modification Easement will be used to remove a portion of the dam and install a stop log, gate or other appropriate structure. Approval of this non-standard estate is requested with this report. Figure 1.5-3 shows the approximate area that will be used for the staging area during construction.

Figure 1.5-1. Low-head Un-named Dam at Goldsboro.

Un-named Dam, Wayne County

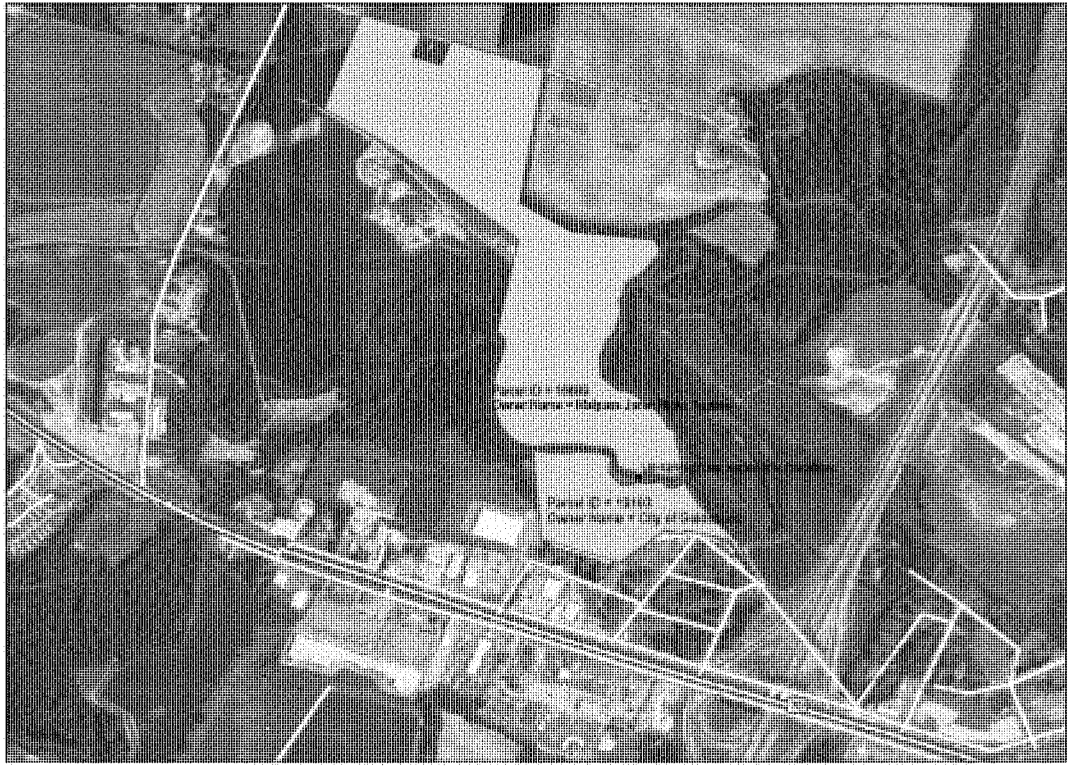


Figure 1.5-2 Un-named Dam

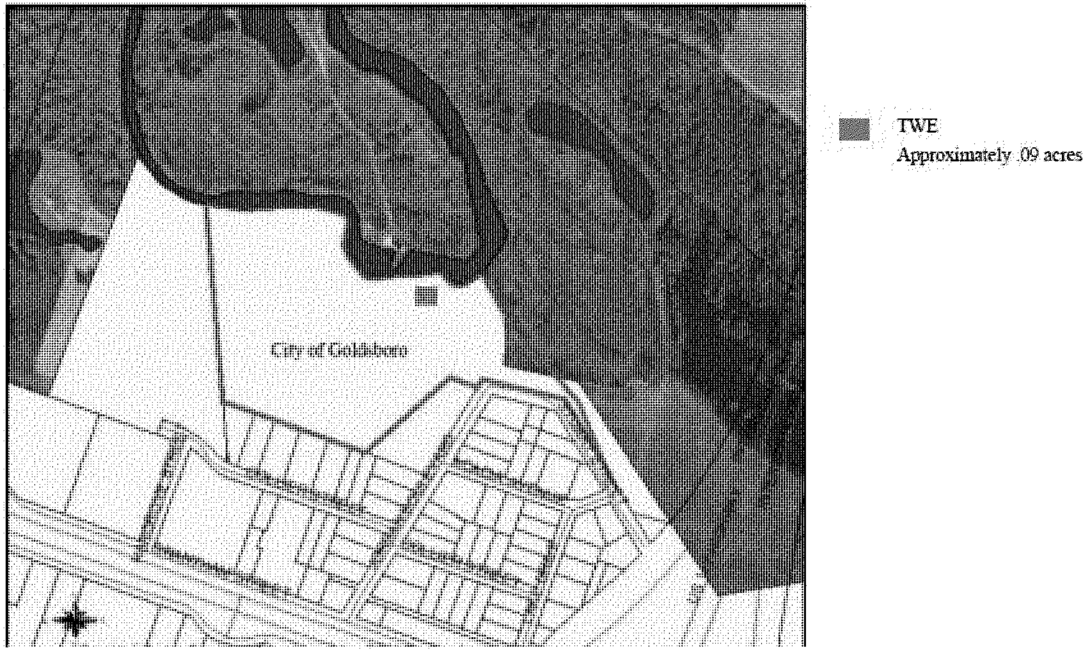


Figure 1.5-3 Staging Area for Un-named Dam.

Kinston East Wetland Restoration Alternative: The Kinston East Wetland Complex consists of about 30 acres in Kinston and it is located within the Neuse River floodplain. About 14.5 acres of this 30 acres property has been previously filled and is no longer functioning as a bottomland hardwood wetland area and no longer provides flood storage capacity. Based on aerial photography it is confirmed that the fill and clearing activity on the property occurred prior to the Clean Water Act. The proposed action consists of re-grading the site to the approximate elevation of the adjacent bottomland hardwood forest and both allowing natural revegetation of the site by bottomland hardwood species and limited planting. The construction contract would be set up in sections. The contractor would be allowed to have limited portions of the site disturbed at any one time. Starting nearest the river and working north toward Lincoln Street, each area would be cleared, grubbed, and brought to final grade, and seeded with either permanent or temporary grass varieties depending on the time of year. During the re-grading process and until stabilization with a permanent cover of grass is achieved, sediment control devices will be used to prevent sediment from leaving the site.

Approximately 14.15 acres of land on one parcel, owned by a private landowner, will be directly impacted by construction of the above measure. It is currently proposed to acquire the entire 30 acre parcel in fee. While the excavation could possibly be accomplished with a temporary estate, acquiring this fee estate will best ensure project benefits, including connectivity, and is economically justified given the construction cost of this feature.

A disposal site is considered part of the LERRD and therefore a real estate requirement to be provided by the sponsor. During PED a site for disposal will be identified and an analysis will be performed comparing the cost of acquiring a site for disposal to the cost of using a landfill to clearly demonstrate the least cost alternative. For cost purposes it was projected that excavated material would be disposed of in an offsite landfill as a least cost alternative. If acquisition of real estate is determined to be the least cost alternative, a site will be identified and the Temporary Work Area Easement will be used. A Temporary Work Area Easement will be used for a staging area of approximately 2.4 acres that will be provided on City owned lands that are adjacent to the proposed restoration site. The 30 acre Kinston site is shown at Figure 1.5-4 along with a potential area for staging on city owned land. The restoration is to provide connectivity to the river rather than for recreation activity and public access to the site is not necessary.

Figure 1.5-4. Kinston East Wetland Complex Site is outlined in Red. Staging Area Will Be Within the Yellow Area

Stabilization of Gum Thicket and Cedar Creek: This component includes measures at both Gum Thicket Creek and Cedar Creek. Meandering rock sills approximately 4,500 ft long at Gum Thicket Creek and 6,700 ft long at Cedar Creek would be built at distances of about 150 ft offshore. Construction of the rock sill would create new marsh after initial planting with *Spartina* species to create a "living shoreline" consisting of planted and open-water areas. In the Gum Thicket Creek reach, rock cultch would be added for additional oyster habitat. These components are illustrated at Figure 1.5-5 and Figure 1.5-6. The Borrow Area Location is shown at Figure 1.5-7.

Construction of the rock sills and marsh benches in the above plan components will be below mean high water. Therefore a permit from the State of North Carolina Division of Water Resources will be required. Construction of the rock sill will be done from a barge in the water. Borrow material will be required for the fill needed that will be placed behind the rock sill. An area that is owned by Four Pamlico Partners LLC that is suitable for borrow has been identified. A temporary staging area will be required for stone materials that will be used for construction of the sill. An area under the Hoboken Bridge is being considered as a staging area, but a final decision has not yet been made. A Bank Protection Easement along the shoreline is recommended for marsh plantings accomplished from the shoreline side. Four parcels will be impacted by marsh planting. According to Pamlico County public records the parcels are three separate ownerships. The standard Borrow Easement and Temporary Work Area Easement can be used for the borrow area, staging area and temporary work areas. It is estimated that approximately 23.70 acres will be required for bank protection, 1.5 acres will be required for temporary work area (staging) and approximately 6 acres will be required for the borrow area.

Construction of New Reef Habitat: This component, shown at Figure 1.5-8, includes expanding the existing Neuse Sanctuary located on the Neuse Southern Shore, constructing four new reef tops in the new Mid-river site, and constructing a new reef top in the Neuse North Shore site, totaling 92 acres of new oyster reef habitat in the Neuse River Estuary. The new reef would be constructed as elevated 4-ft-high flat plateau mounds with a minimum size of 1 ac.

A permit from the State of North Carolina would be required for construction of the oyster reefs. It is probable that fill can be acquired from the same area proposed for fill for the Gum Thicket and Cedar Creek Components which is owned by Four Pamlico Partners LLC. Possible Staging areas have been identified as per Figure 1.5-9 and 1.5-10, but specific requirements have not been identified. For planning purposes 1.5 acres is estimated for a staging area. The Borrow Easement and Temporary Work Area Easement will be used for staging, borrow and access areas.

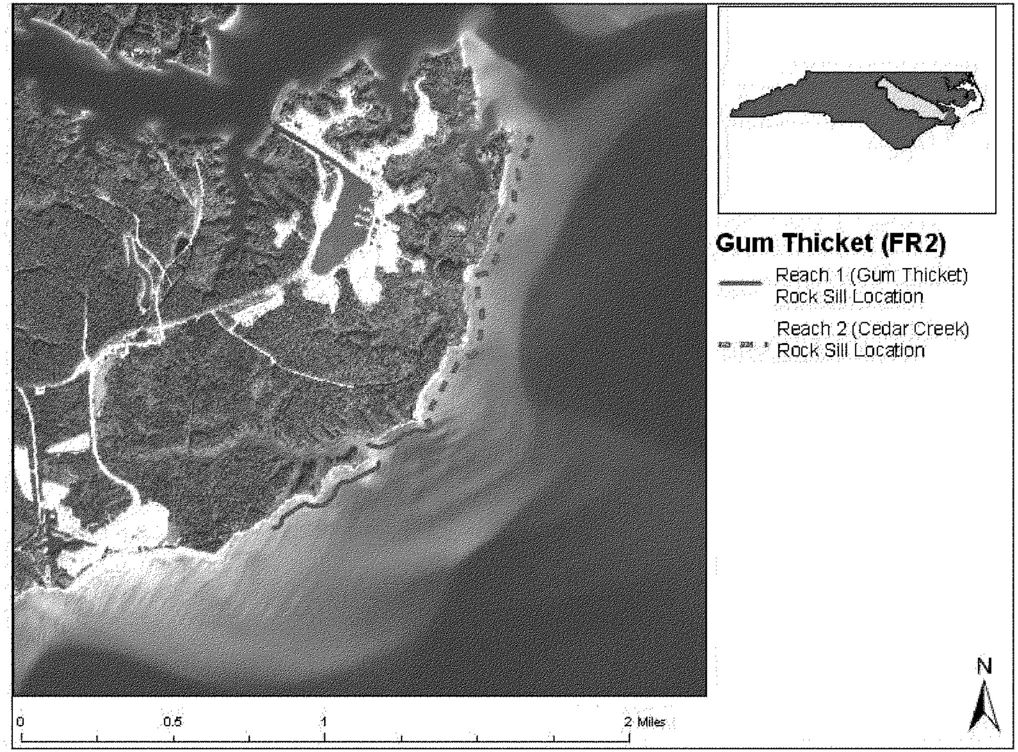


Figure 1.5-5 Location of Restoration for Gum Thicket Creek and Cedar Creek

Figure 1.5-6 Easement Areas for Gum Thicket and Cedar Creek Restoration

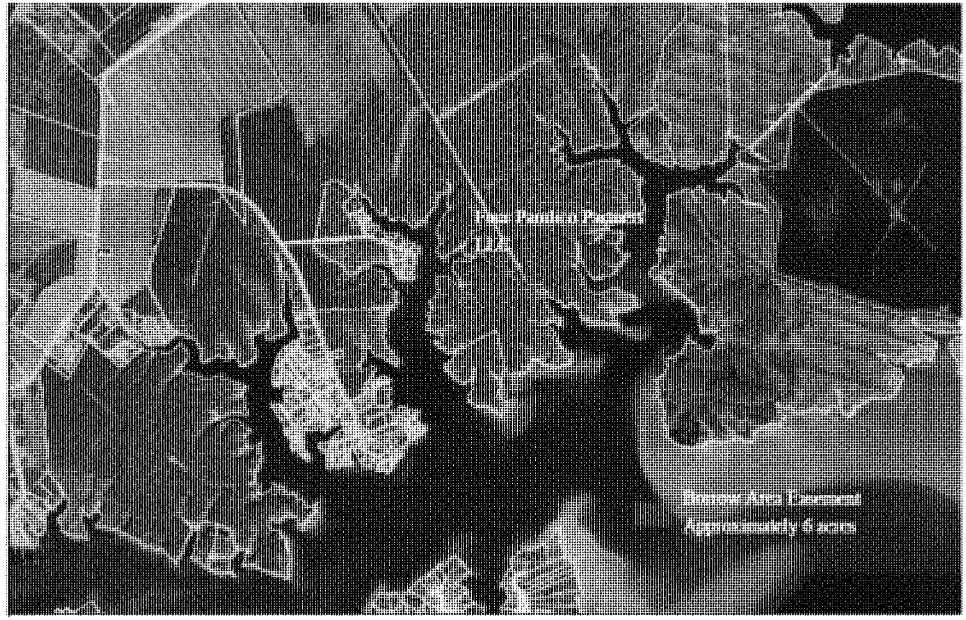


Figure 1.5-7 Borrow Easement Area for Gum Thicket and Cedar Creek Restoration

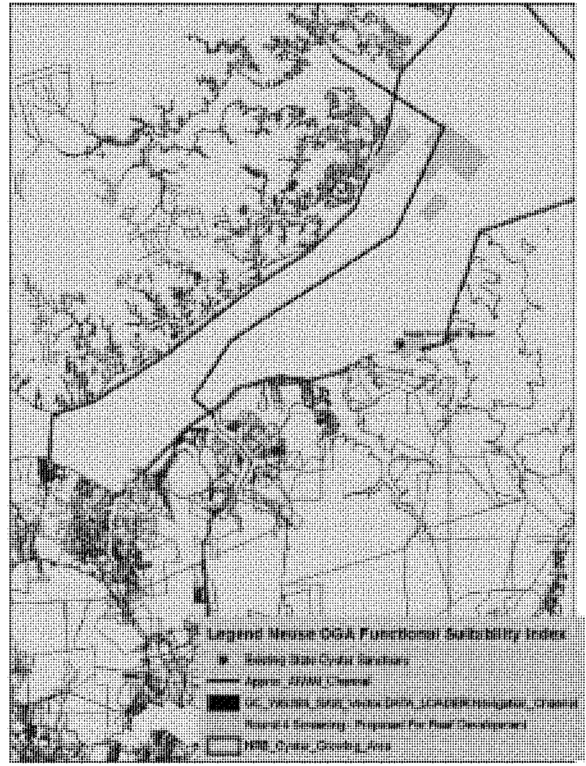


Figure 1.5-8 - Construction of New Reef Habitat

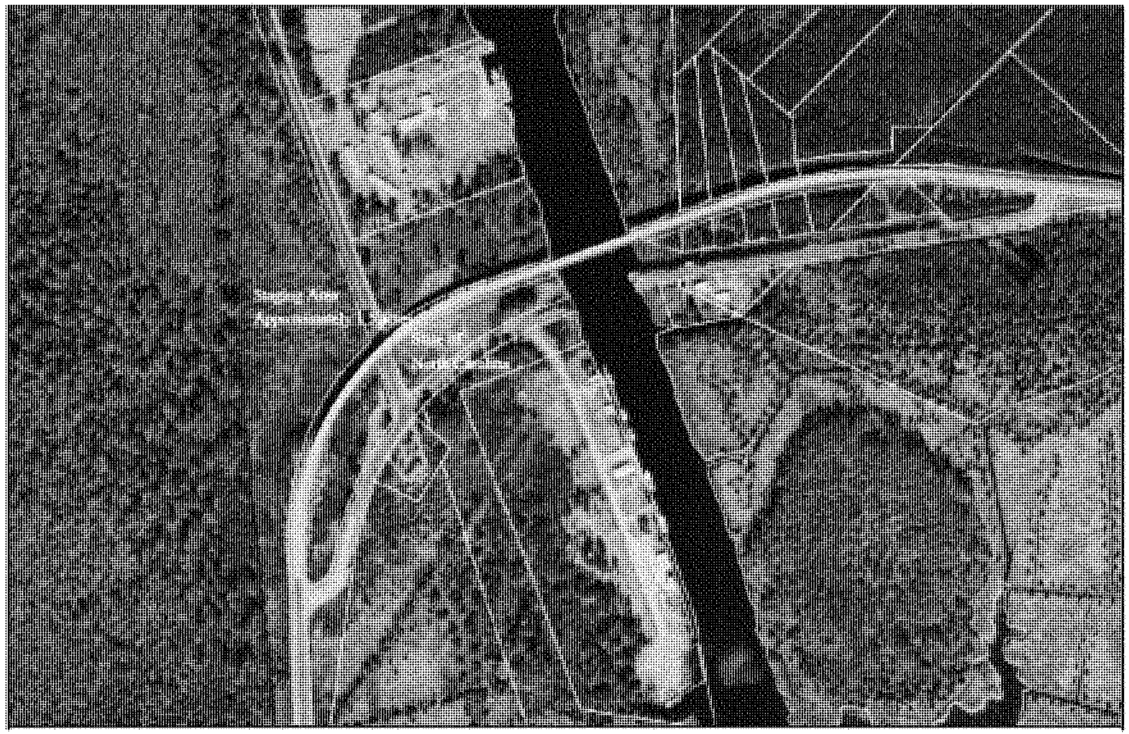


Figure 1.5-9 Potential Staging Site at Hobucken Bridge for Materials for North Shore Oyster Reef Construction and Gum Thicket

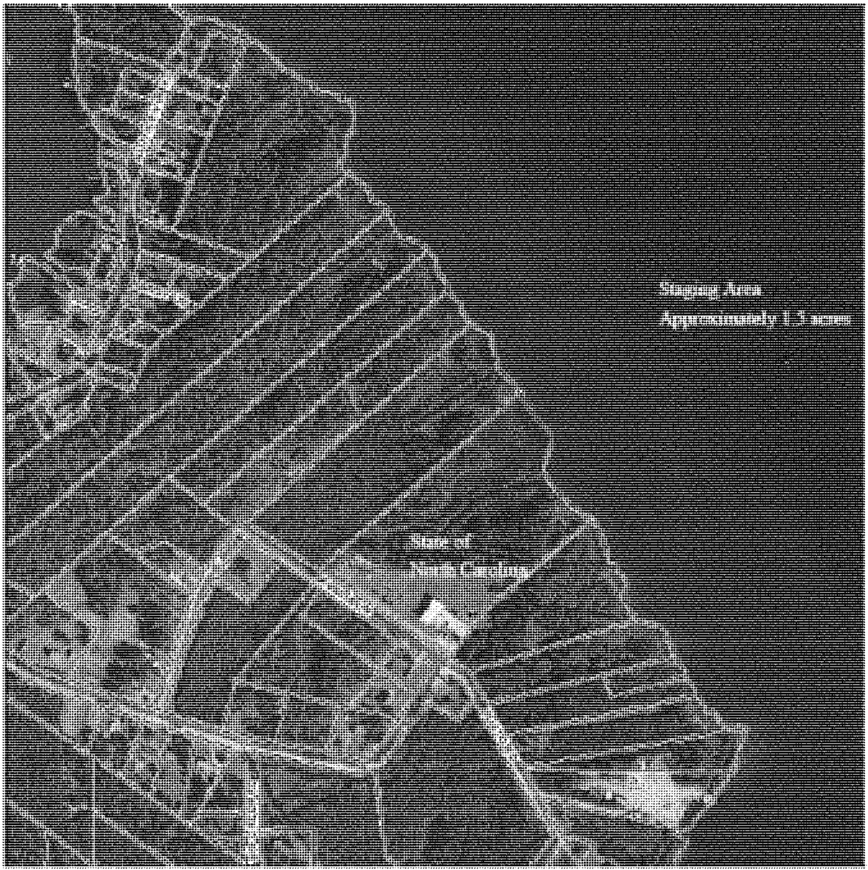


Figure 1.5-10 Potential Staging Site for Materials for Southern and Mid Reefs.

Table 1.5 - 1

Land Requirements for the NER Components

Alternative Description	Impacted Parcels	Dam Modification Easement	Fee Acres	Bank Protection Easement Acres	Temp Work Area Easement Acres	Borrow Area Easement Acres	Land Cost	Land Owners
Low Head (Un-named) Dam Modification	1	Dam area			0.9		1,929	City of Goldsboro
Kinston East Wetland Complex	2		30.00		2.40		30,567	Perry Grandchildren LLC City of Kinston
Stabilization of Gum Thicket Creek and Cedar Creek	5			23.7	1.5	6.0	10,235	Four Pamlico Partners LLC River Dunes Corporation J.E. Peagram State of North Carolina Preservation Associates
New Reef Habitat	Permit				1.5			State of North Carolina
TOTALS	8		30.00	23.7	6.3	6.0	42,731	
ROUNDED							**$42,730**	

1.6 Utility/Facility Relocation

The term "relocation" shall mean providing a functionally equivalent facility to the owner of an existing utility, cemetery, highway or other public facility or town when such action is authorized in accordance with applicable legal principles of just compensation or as otherwise provided by Federal statute or any project report or House or Senate document referenced therein. Providing a functionally equivalent facility may take the form of adjusting, altering, lowering, raising, or replacement and attendant removal of the affected facility or part thereof. It is important to note that relocation assistance under Public Law 91-646 relates specifically to displaced persons, and should be distinguished from the separate concept of facility or utility relocations.

There are no known utility/facility relocations required for implementation of the project.

1.7 Existing Projects

A full discussion of related studies, reports, water resource projects and initiatives is at Section 1.6 of the Feasibility Report and Environmental Impact Statement for the Neuse River Basin.

1.8 Environmental Impacts

The goals of the study are to benefit fish and wildlife resources and adverse environmental impacts to the project area are not expected

1.9 Project Sponsor Responsibilities and Capabilities

The North Carolina Division of Water Resources (NCDWR) is the non-Federal sponsor for the project (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. The sponsor will have operation and maintenance responsibility for the project after construction is completed.

Title to any acquired real estate will be retained by the Project Sponsor and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). A form for the Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix.

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the lands, easements and rights-of-way (LER) is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the

Government. The NFS will not receive credit for lands used that were previously provided as an item of cooperation.

The NFS should not acquire lands required for the project prior to execution of the Project Partnership Agreement (PPA). Should the NFS proceed with acquisition of lands prior to execution of the PPA, it is at the risk of not receiving credit or reimbursement for any costs incurred in the connection with the acquisition process should the PPA not be signed. There is also risk in acquiring lands either not needed for the project or not acquired in compliance with requirements for crediting purposes in accordance with 49 CFR Part 24, dated March 2, 1989. A letter dated April 6, 2011 was sent to the NFS to notify the NFS of the risks associated with early acquisition. The letter is included in the Real Estate Appendix as Exhibit 'C".

1.10 Government Owned Property

There is no Federally owned land within the areas proposed for construction of the components of the tentatively selected plan.

1.11 Historical Significance

The Neuse River Basin contains a wealth of prehistoric and historic period sites that reflect more than 12,000 years of human discovery and settlement. See section 2.4 Cultural Resources for a full discussion. There are no known historic sites in the areas proposed for project construction.

1.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

1.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

Before any dam removals, the sediment upstream and downstream of the structure would be tested for contaminants to ensure that contaminants of concem are not present at levels that would cause unacceptable effects on aquatic resources if mobilized downstream. Proposed project locations were evaluated, or will be evaluated after approval of the selected plan, using standard American Society for Testing and Materials (ASTM) Phase I and Phase II assessments to determine whether the locations have materials that could affect the plans for that location or require management modifications to accommodate the materials or conditions. USEPA and state-managed lists were reviewed and did not find a presence of hazardous materials in the project area.

1.14 Public Law-646, Relocation Assistance Benefits

Public Law 91-646, Uniform Relocation Assistance provides entitlement for various payments associated with federal participation in acquisition of real property. Title II makes provision for relocation expenses for displaced persons, and Title III provides for reimbursement of certain expenses incidental to transfer of property. There are no relocations of displaced persons or businesses required for implementation of the project.

1.15 Attitude of Property Owners

The project is fully supported. There are no known objections to the project from landowners within the project area.

1.16 Navigation Servitude

Navigation Servitude is not applicable to this project.

1.17 Acquisition Schedule

The project sponsor is responsible for acquiring real estate interests required for the project. It is projected that acquisitions will take approximately 12 months, and can begin when final plans and specs have been completed and the PPA has been executed. The Project Sponsor, Project Manager and Real Estate Technical Manager will formulate the milestone schedule upon project approval to meet dates for advertisement and award of a construction contract. A sample milestone schedule which shows the steps in the process is at Exhibit "D".

1.18 Estates for Proposed Project

The standard Bank Protection Easement is recommended along with the standard Borrow Easement and standard Temporary Work Area Easement for borrow, staging and access areas. A permit from the State will be required for construction of the oyster reefs and rock sills. Fee estate is recommended for the Kinston Site. A non-standard Dam Modification Easement is recommended for the un-named dam in Goldsboro. The non standard estate must be approved prior to executing the Project Partnership Agreement.

Dam Modification Easement

A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to modify the dam as required for said project including all appurtenances thereto, and to construct, maintain, repair, replace, operate, and patrol a stop log, a gate or other appropriate structure; reserving, however, to the owners, their heirs, successors and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Borrow Easement

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired. (this easement can be limited to time)

Bank Protection Easement

A perpetual and assignable easement and right-of-way in, on, over and across the land hereinafter described for the location, construction, operation, maintenance, alteration, repair, rehabilitation and replacement of a bank protection works, and for the placement of stone, riprap and other materials for the protection of the bank; together with the continuing right to trim, cut, fell, remove and dispose therefrom all trees, underbrush, obstructions, and other vegetation; and to remove and dispose of structures or obstructions within the limits of the right-of-way; and to place thereon dredged, excavated or other fill material, to shape and grade said land to desired slopes and contour; and to use vegetative methods to increase habitat and prevent erosion and to do any other work necessary and incident to the project; together with the right of ingress and egress for such work; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

Temporary Work Area Easement

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the Sponsor for use by the Sponsor, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Neuse River Basin Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

1.19 Zoning Ordinances

Zoning ordinances are not of issue with this project. Application or enactment of zoning ordinances is not to be used in lieu of acquisition.

1.20 Real Estate Estimate

A gross appraisal was performed on 23 June 2009 to determine land values for the project. The estimated real estate costs include the land cost for acquisition of land, relocation costs, and federal and non-federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary during Planning, Engineering and Design (PED). A 25% contingency is applied to the estimated total for these items. Table 1.20-1 is a summary of the real estate cost for the project.

Table 1.20-1

Real Estate Estimate

a. Lands		42,730
1 Parcel – Flowage Easement		
4 Parcels - Bank Restoration		
3 Parcels - TWA, Staging, Access, Borrow, Dam Modification Easements		
b. Improvements		-
(Residential)		-
(Commercial)		-
c. Mineral Rights		-
d. Damages		-
e. P.L. 91-646 Relocation costs		-
f. Acquisition Cost - Admin (7 ownerships)		151,200
Federal	18,200	
Non-federal	133,000	
	151,200	
1 Permit	5,000	5,000
Sub-Total		198,930
Contingencies (25%)		49,733
TOTAL		**248,663**
ROUNDED		**$ 249,000**

1.21 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERR, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES). The Chart of Accounts is at Table 1.21-1.

Table 1.21-1.

Chart of Accounts

01A	PROJECT PLANNING	FEDERAL	NON-FEDERAL	TOTALS
	Other			
	Project Cooperation Agreement	$	$	$
01AX	Contingencies (25%)	$	$	$
	Subtotal	$	$	$
01B	LANDS AND DAMAGES			
01B40	Acq/Review of PS	$ 18,200	$	$ 18,200
01B20	Acquisition by PS	$	$ 133,000	$ 133,000
01BX	Contingencies (25%)	$ 4,550	$ 33,250	$ 37,800
	Subtotal	$ 22,750	$ 166,250	$ 189,000
01G	TEMPORARY PERMITS			
01G10	By Government	$	$	$
01G20	By PS	$	$ 5,000	$ 5,000
01G30	By Government on Behalf of PS	$	$	$
01GX	Contingencies (25%)	$	$ 1,250	$ 1,250
	Subtotal	$	$ 6,250	$ 6,250
01H	AUDIT			
01H10	Real Estate Audit	$	$	$
01HX	Contingencies (25%)	$	$	$
	Subtotal	$	$	$
01R	REAL ESTATE LAND PAYMENTS			
01R1B	Land Payments by PS	$	$ 42,730	$ 42,730
01R2B	PL91-646 Relocation Payment by PS	$	$	$
01R2D	Review of PS	$	$	$
01RX	Contingencies (25%)	$	$ 10,683	$ 10,683
	Subtotal	$	$ 53,413	$ 53,413
	TOTALS	$ 22,750	$ 225,913	$ 248,663
	ROUNDED TO			**$ 249,000**

Exhibits

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I ______________________________, ________________________ for the
(Name of accountable official) (Title)

(Sponsor Name) ______, do hereby certify that the ___(Sponsor Name) has acquired the real property interest required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction for (Project Name, Specifically identified project features, etc.). Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon ______________________
(identify tracts)

to construct (Project Name, Specifically identified project features, etc.) as set forth in the plans and specifications held in the U. S. Army Corps of Engineers' (district, city, state)

WITNESS my signature as ____________________________ for the
(Title)

(Sponsor Name) this __ day of ____________, 20_________.

BY: ______________________
(Name)

____
(Title)

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, ______________________ , ______________________________ for the
(Name) (Title of legal officer)

(Sponsor Name), certify that ___________________________ has
(Name of accountable official)

authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as _____________________ for the
(Title)

(Sponsor Name), this________day of_____________, 20____.

BY: ______________________
(Name)

____
(Title)

Exhibit A

Assessment of Non-Federal Sponsor's
Real Estate Acquisition Capability
Neuse River Basin GI Study

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **YES**

b. Does the sponsor have the power to eminent domain for this project? **YES**

c. Does the sponsor have "quick-take" authority for this project? **YES**

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **NO**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? **NO**

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **YES**

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? **YES**

e. Can the sponsor obtain contractor support, if required in a timely fashion? **YES**

f. Will the sponsor likely request USACE assistance in acquiring real estate? **YES – Only in an advisory capacity**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **YES**

b. Has the sponsor approved the project/real estate schedule/milestones? **NO – Project milestone will be developed during PED and will be a joint effort between PM, Realty Specialist and NF Sponsor**

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects? **YES**

b. With regard to the project, the sponsor is anticipated to be: **Highly Capable/.**

Exhibit B
1st Page

V. Coordination:

a. Has this assessment been coordinated with the sponsor? **YES**

b. Does the sponsor concur with this assessment? **YES**

Prepared by:

Belinda S. Estabrook
Realty Specialist

Reviewed and approved by:

Cindy B. Turner
Acting Chief, Real Estate Division

Exhibit B
2nd Page

DEPARTMENT OF THE ARMY
SAVANNAH DISTRICT, CORPS OF ENGINEERS
100 W. OGLETHORPE AVENUE
SAVANNAH, GEORGIA 31401-3640

April 6, 2011

Real Estate Division

Subject: Neuse River Basin Project – Real Estate Acquisition

Mr. Tom Reeder, Director
North Carolina Division of Water Resources
1611 Mail Service Center
Raleigh, North Carolina 27699-1611

Dear Mr. Reeder:

The intent of this letter is to formally advise the State of North Carolina, as the potential non-Federal sponsor for the proposed project, of the risks associated with land acquisition prior to the execution of the Project Partnership Agreement (PPA) or prior to the Government's formal notice to proceed with acquisition. If a non-Federal sponsor deems it necessary to commence acquisition prior to an executed PPA for whatever reason, the non-Federal sponsor assumes full and sole responsibility for any and all costs, responsibility, or liability arising out of the acquisition effort.

Generally, these risks include, but may not be limited to, the following:

(1) Congress may not appropriate funds to construct the proposed project;

(2) The proposed project may otherwise not be funded or approved for construction;

(3) A PPA mutually agreeable to the non-Federal sponsor and the Government may not be executed and implemented;

(4) The non-Federal sponsor may incur liability and expense by virtue of its ownership of contaminated lands, or interests therein, whether such liability should arise out of local, state, or Federal laws or regulations including liability arising out of CERCLA, as amended;

(5) The non-Federal sponsor may acquire interests or estates that are later determined by the Government to be inappropriate, insufficient, or otherwise not required for the project;

(6) The non-Federal sponsor may initially acquire insufficient or excessive real property acreage which may result in additional negotiations and/or benefit payments under P.L. 91-646 as well as the payment of additional fair market value to affected landowners which could have been avoided by delaying acquisition until after PPA execution and the Government's notice to commence acquisition and performance of LERRD; and

Exhibit "C"

(7) The non-Federal sponsor may incur costs or expenses in connection with its decision to acquire or perform LERRD in advance of the executed PPA and the Government's notice to proceed which may not be creditable under the provisions of Public Law 99-662 or the PPA.

We appreciate the State's participation in this project. Should you have questions or concerns pertaining to this letter please feel free to contact Ms. Belinda Estabrook at (912) 652-5667.

Sincerely,

Ralph J. Werthmann,
Savannah District
Chief, Real Estate Division
Real Estate Contracting Officer

Real Estate Milestones

____________________, 2012

PROJECT: Neuse River Basin Project

REQUIREMENTS: Acquisition of 6 parcels in easement for bank protection, temporary work area, staging area and borrow areas.

DATE Projected / Actual	REQUIREMENT	RESPONSIBLE PARTY
	Plans & Specs Provided to Sponsor	CESAS-PM
	Sponsor Notified of Risks for RE Acquisition Prior to Execution of PPA	CESAS-RE
	PPA Executed	CESAS & Sponsor
	Final ROW drawings to Sponsor	CESAS-PM
	Estates provided to Sponsor	CESAS-RE
	Surveys Initiated	Sponsor
	Surveys Complete	Sponsor
	Survey Maps Submitted to SAS-RE for Review and Approval	Sponsor
	Maps Reviewed and Approved	CESAS-RE
	Title Evidence Initiated	Sponsor
	Title Evidence Complete	Sponsor
	Title Evidence Submitted to CESAS-RE for Review	Sponsor
	Title Evidence Reviewed	CESAS-RE

Exhibit D
First Page

	Appraiser's Resume' Submitted for Approval	Sponsor
	Appraiser Approved	CESAS-RE
	Appraisals Initiated	Sponsor
	Appraisals Submitted to CESAS-RE for Review and Approval	Sponsor
	Appraisals Approved	CESAS-RE
	Initiate Negotiations for Acquisition	Sponsor
	Complete Acquisitions	Sponsor
	Submit LERR for Review	Sponsor
	Review LERR	CESAS-RE
	Initiate Condemnations if Required	Sponsor
	Review Condemnations	CESAS-RE
	Complete Condemnations (Obtain Possession)	Sponsor
	Complete PL 91-646 Assistance	Sponsor
	Review PL 91-646 Payments	CESAS-RE
	Review & Certify Real Estate	CESAS-RE
	Advertise for Construction	CESAS-PM
	Submit Credit Request	Sponsor
	Review Credit Request	CESAS-RE
	Approve Crediting	CESAS-RE

Schedule will be completed as soon as PPA is executed. Realty Specialist, Project Manager and Sponsor will develop schedule in conjunction with other project milestones, to allow adequate time to obtain real estate and to meet schedule set for advertisement for construction.

Exhibit D
Second Page

Appendix N: Cost

EXECUTIVE SUMMARY

The Cost Engineering narrative was prepared to describe the Current Working Estimate (CWE) for the Draft Neuse River Basin Feasibility Report and Environmental Assessment. This narrative provides details of costs for the Tentative Selected Plan (TSP) also identified as the National Ecosystem Restoration Plan (NERP). The plan would improve biological integrity, improve freshwater mussel population, improve anadromous fish populations, restore emergent wetland, and increase the quantity and quality of oyster reef habitat.

A CWE for construction and non-construction features was developed for the Tentative Selected Plan (TSP). A summary of costs for the TSP is shown below and in the Total Project Cost Summary (TPCS) as fully funded to the midpoint of construction. The costs are summarized and listed below in the Code of Accounts format and are based upon October 2011 price levels.

Evaluations of alternatives determined the TSP to provide the best environmental effective plan/output based on positive and negative environmental effects. A final recommended plan will be included in the final Feasibility Report.

The CWE OCTOBER 2011 for the TSP includes:

	$ 1,000's	with CONTINGENCY
-ACCOUNT 06 FISH and WILDLIFE FACILITIES		
-Modify Low Head Dam on Little River (Goldsboro, NC)	$ 427	$ 521
-Cedar Creek & Gum Thicket - Rock Sill & Marsh - 8,700 LF- - - - - - - - - - - -	$ 11,275	$ 13,755
-Kinston, NC Wetland Restoration 14.5 acres	$ 3,144	$ 3,836
-Oyster Reef Habitat Creation – 80 acres -	$ 9,080	$ 11,078
-ACCOUNT 01 - LANDS AND DAMAGES	$ 199	$ 249
-ACCOUNT 30 - PLANNING, ENGINEERING & DESIGN - - - - - - - - - - - - - - - - -	$ 2,393	$ 2,919
-ACCOUNT 31 – SUPERVISION, ASSURANCE, & ADAPTIVE MGT	$ 2,426	$ 2,960
TOTALS	$ 28,944	$ 35,318

The CWE and Code of Account features are further broken down into more detail in the Microcomputer Aided Cost Estimating System (MCACES) MII estimate discussed below and shown in Section 6 of this Appendix.

A Total Project Cost Summary (TPCS), Section 5 of this Appendix, identifies the CWE for the October 2011 as $ 28,944,000 ($ 35,318,000 with contingency) and fully funded to midpoint of construction as $ 38,156,000 with contingency.

The TPCS estimate certification by the Cost Center DX is included in Section 5 of this Appendix.

Based on a 2014 Program Year Budget, overall construction is estimated to be approximately 2.5 years. The midpoint of construction is estimated to be JANUARY 2016. Construction completion is estimated to be APRIL 2017 with post construction monitoring and adaptive management to follow construction completion.

SECTION 1. GENERAL

1.1 Guidance

1. ER 1110-2-1302, CIVIL WORKS COST ENGINEERING
2. ER 1110-2-1150, ENGINEERING AND DESIGN FOR CIVIL WORKS PROJECTS
3. ETL 1110-2-573, CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS
4. ECB 2007-17, APPLICATION OF COST RISK ANALYSIS TO DEVELOP CONTINGENCIES FOR CIVIL WORKS TOTAL PROJECT COSTS

1.2 Computer Aided Software

1. Micro-Computer Aided cost Estimating System (MCACES), Second Generation (MII). MII 4.1
2. Abbreviated Risk Analysis Spreadsheet maintained by USACE Cost Center of Expertise, Walla Walla, WA.

SECTION 2. THE COST ESTIMATE REPORT

2.1 Report Description

This report is intended to be used for planning purposes.

The estimate reflects a feasibility level design stage. This civil works project includes restoration of Kinston East Wetlands, modifying the low-head dam on the Little River near Goldsboro, NC, stabilizing Gum Thicket Creek and Cedar Creek shorelines, and constructing new oyster reef habitats. The construction measures primarily include the construction of rock sills, vegetation establishment, earthwork activities, and oyster reef construction.

The Tentatively Selected Plan (TSP) was chosen based on economic factors indicating the greatest effectiveness. The Cost Estimate supporting the TSP is prepared using the MCACES, Second Generation (MII 4.1).

- MCACES references the MII English Cost Book 2010 as the source library for all construction based activities unless otherwise adjusted by the user.
- Equipment cost is referenced through the MII Equipment Region III – 2009 based on the EP 1110-1-8, Construction Equipment and Operation Expense Schedule 2009 version.
- MCACES Labor has been adjusted by the User to reflect the region and North Carolina labor rates as illustrated in the Department of Labor Wage Rates with a reasonable markup for payroll taxes, insurance, fringes and burdens.

There may be modifications to the plans that occur during Planning, Engineering and Design (PED) phase, thus changing the scope or assumptions provided in developing the Cost Estimate. In addition, a contingency of 22% (except Real Estate 25%) was developed to allow for risk and uncertainty which may impact costs.

The Current Working Estimate (CWE) for Construction of the TSP is $28,944,000($35,318,000 with contingency). These costs have been established to be the Baseline Cost Estimate for OCTOBER 2011 price levels (effective pricing levels of OCTOBER 2011 based on MII Libraries).

2.2 Estimate Qualifications

- The project construction cost estimate is prepared as though the Government were a prudent and well-equipped contractor estimating the proposed measures based on the current feasibility level design. The estimates are developed in as much detail as can be assumed based on the best information available at this time.

- The estimate adheres to the civil works, work breakdown structure, and was internally verified for quality control addressing cost, schedule and risk issues as practical. The estimate was developed based on a scope of work with recorded notes of assumptions, construction methods, concerns, and unknowns maintained within the MII estimate for each construction task.

- Parametric estimating techniques were also used to develop the estimate. They are based on engineering parameters, historical information, practical construction practices and engineering principles. Project definition characteristics to include physical properties of the project site, functional purpose of the project and methods of construction were considered when developing the estimate.

- The estimated time to construct the project was developed based on the production rates of the largest and most significant features of the project. The project construction schedule was developed using Microsoft Project to substantiate the construction duration assumptions. Often a disconnect with probable durations was noticed when compared to MII durations that don't normally account for multiple crews working jointly. MII durations assume one crew completing a specific construction task, which can lead to large, unrealistic durations. Therefore, the construction schedule shows a realistic duration to reflect the work of a suitable number of crews based on site conditions and practical industry standards. Generally, one crew was assumed for each major feature of work location such as Gum Thicket, Cedar Creek, Kinston Wetland, Low Head Dam repair, Mid-River Oyster Sanctuary, and North Oyster Sanctuary.

- The structure of the cost estimate is planned so that all tasks are logical and are in accordance with appropriate plan of construction and good understanding of the project scope. A unit cost for each task is developed in an effort to increase the accuracy of the estimate and includes consideration given to site specific conditions as they pertain to constructability, biddability, and operability issues. The assumptions for allowances are documented in the estimates and are based on experience and consultation with project teammates. As design scope evolves, it is anticipated that these costs will be better defined.

- The district developed a baseline cost estimate within which the project can be designed and constructed. The proposed project features are comprised largely of stone sill construction. To compute accurate stone quantities, the district obtained recent contour data from topographic mapping at the proposed project location. This mapping was used for determining proposed project features and computing stone sill quantities.

- The estimated costs developed for this project are fair and reasonable to a well-equipped contractor and include overhead costs and profit. Actual crew sizes, equipment and production rates that contractors have achieved previously on similar types of projects were used in developing the unit costs for the work items contained in this project.

- Unit prices for construction features and lump sum costs for structures were developed using parametric estimated from the MII Costbook database and drew from expertise maintained within the Wilmington District.

2.3 Estimate Assumptions

- Bid Items and Tasks are based on the English 2010 MII Costbook.
- Fuel rates were set at October 2011 pricing of $3.45 for unleaded gasoline, $3.50 for Off-Road diesel, and $3.70 for on-road diesel.
- Prime Contractor and subcontractor's job office overhead, home office overhead, and profit vary.
- It is anticipated that the prime contractor will be a marine construction contractor. The following is a list of anticipated subcontractors used for the estimate: Hauling subcontractor, Earthwork subcontractor, Landscaping subcontractor, Sheetpile subcontractor, and Concrete Subcontractor.
- At this time, site specific utility information is unknown yet not anticipated. Therefore, costs for relocation or design for this infrastructure is not included in the estimate. The unknown nature of the existing utilities introduces some risk and potential cost increase that may be mitigated with further investigation and design.
- Construction Staging Areas have not yet been completely finalized for the various phases of the project. Included in the estimate are equipment and temporary erosion control measures required as well as mob/demob. Primary erosion control feature is silt fencing.
- Items that may be encountered but are not yet completely defined until further site investigation and planning include: demolition of drainage appurtenances, fencing, sidewalk, pavement or curb.

SECTION 3. CODE OF ACCOUNTS

3.1 Current Working Estimate (CWE)

The detailed CWE's are shown in the attached MCACES (Microcomputer Aided Cost Engineering System) files. The estimates are formatted into a Code of Accounts framework in compliance with Civil Works Breakdown Structure. The costs included under each Code of Accounts are described below.

3.2 Account 01: Lands and Damages

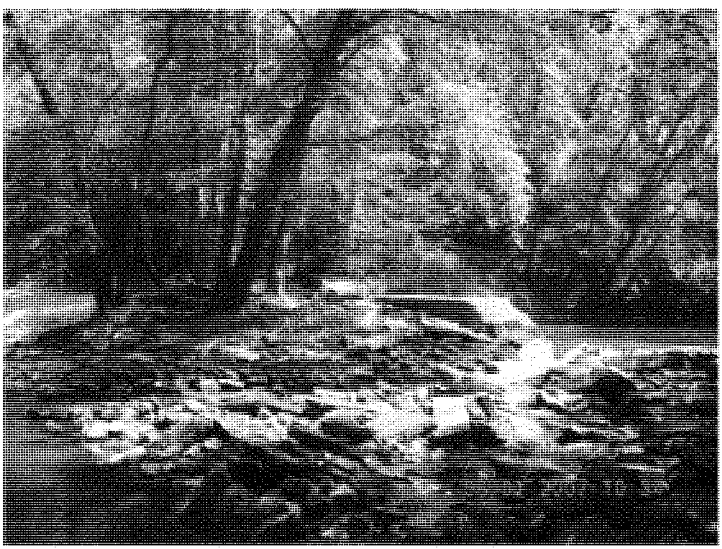
The estimated costs were furnished by the Real Estate Division, Savannah District and are discussed in the Real Estate Appendix. The estimated real estate costs include the land cost for acquisition of land, relocation costs, and federal and non-federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinion, analysis or other requirements that may be necessary during Planning, Engineering and Design (PED). A 25% contingency is applied to the estimated costs for these items, separate of the analysis for construction contingencies.

3.3 Account 06: Fish and Wildlife Facilities

This account includes the costs for mobilization and demobilization, staging and construction of the TSP.

A. Low-head (Unnamed) Dam on Little River near Goldsboro:

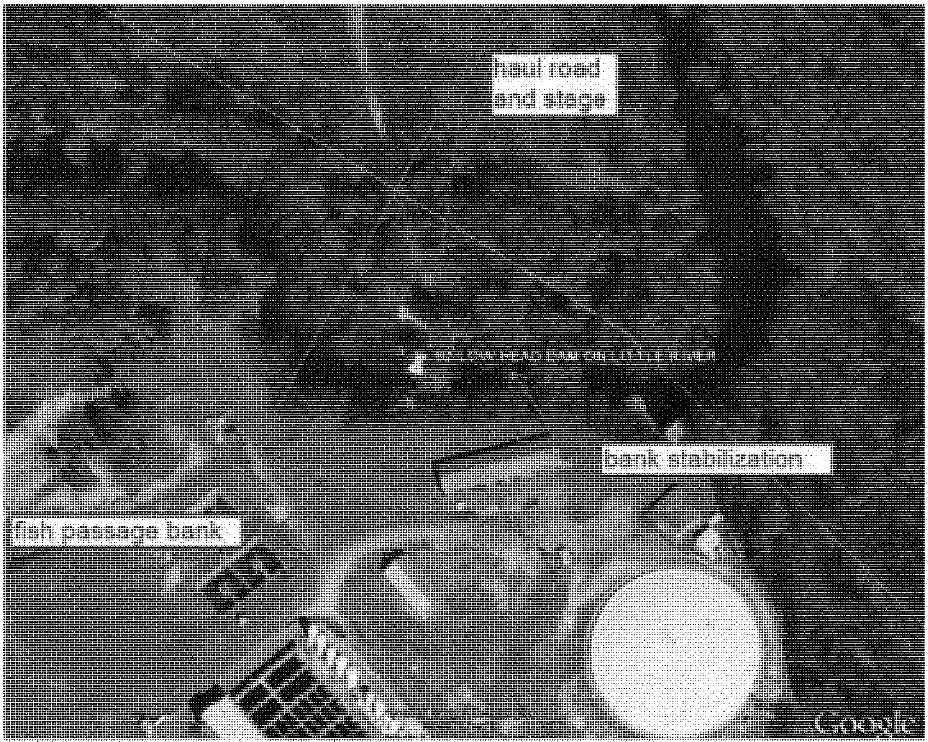
This low head dam is located downstream of the City of Goldsboro's secondary water intake structure at the Water Treatment Plant. Goldsboro's primary water intake is located on the Neuse River. A portiou of this structure has been removed or 'notched' and under high flow conditions, some anadromous species are able to pass over this structure. Modification of the low-head dam includes approximately 20' section of the existing 100' wide, 4' high concrete dam to be restored. A stop log structure or operational weir gates would be installed within the refurbished 20' opening. This work also includes removal of the 30' wide notch down to the river bed, temporary dewatering structure is necessary to reduce environmental impacts of equipment and debris in the river. Incidental work will include cleaning and selective removal of rock rubble to use for bank stabilization. Construction time is anticipated to be approximately 120 to 150 calendar days.



Photograph 1: showing upstream location with existing weir cut out and rubble to be removed

Activities include site access, clear-n-grub, seeding & mulch, stop log/weir gates installation.

1. Cofferdam Construction: Temporary Sheetpile for temporary dewatering, includes BMP for Turbidity Control.
2. Install Weir structures to the Existing dam.
3. Restore Banks and armor riparian edges. Includes seeding, planting, removal of obstructions.



Google Map showing approximate location of dam site.

B. New Oyster Reef Sanctuary Habitat

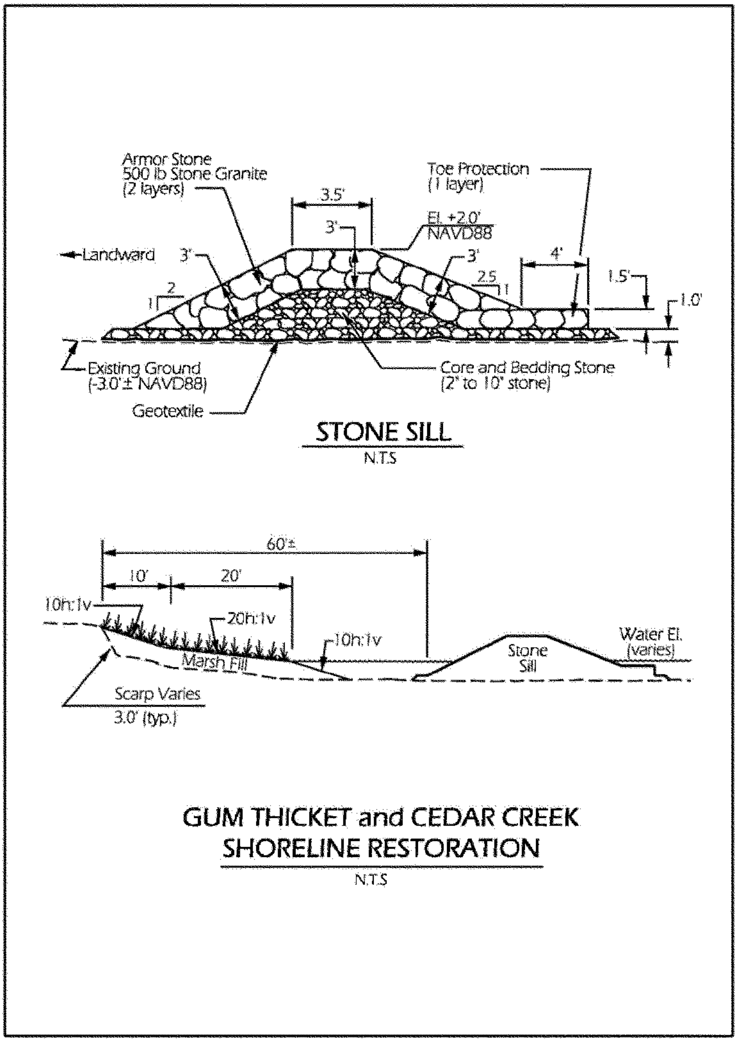
This part of the TSP includes construction of a new oyster reef habitat as shown in Engineering Appendix O, Figure 16. This will expand the existing Neuse Oyster Sanctuary through the construction of new reef top oysters at a Mid-river site, and construction of new reef top oysters in the Neuse North Shore site.

A total of 80 acres of new estuarine reef habitat, 10.4 acres of oyster reef top, will restore historic reef loss in the Neuse River Estuary. These areas will be managed as sanctuaries by the state of North Carolina. These reefs would each be constructed as an elevated 4-ft-high plateau mounds, under water, with a minimum size of 1.3 acre oyster reef top. A typical 40 acre sanctuary is shown in Engineering Appendix O, Figure 17. Quantities include 112,000 tons of limestone (NCDOT Class B stone) and 30,000 bushels of oyster shells over 10.4 acres of reef top.

The new reef sites will be located in areas adjacent to the existing reef where larvae can be transported from the existing reefs. New reefs will be designed and constructed as flat-top features to maximize the surface area of the management measures. During Planning, Engineering and Design phase of this project, the project delivery team will optimize the shape of the reef units. Construction time is anticipated to be approximately 1.5 years.

C.Gum Thicket Creek & Cedar Creek Rock Sills and Marsh Restoration:

The stabilization of Gum Thicket and Cedar Creeks include measures to reduce erosion along the shoreline. The tentatively selected plan for this area consists of constructing a rock sill parallel to the shoreline alignment and with high marsh buffer. Construction time is anticipated to be approximately 2.5 years concurrently. A preliminary design of sill and marsh for Gum Thicket and Cedar Creek is shown below:



A conceptual layout location is shown below including quantities for each location.

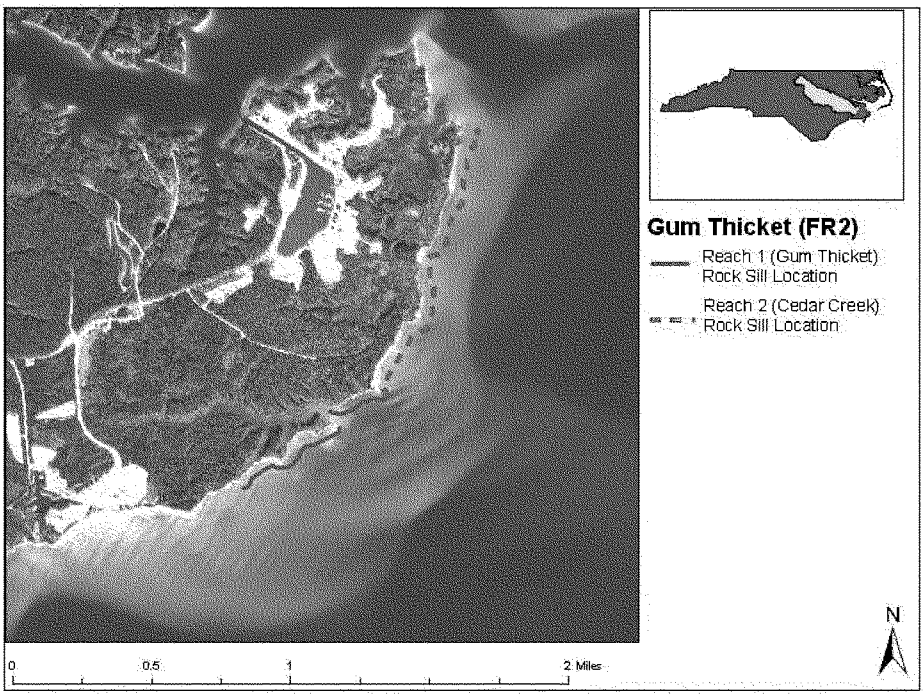


Table 3- Gum Thicket Quantities – 3,500 lf			
Description	Quantity	Unit	Comments
Rock sill armor stone	8,200	cy	Granite, average weight 500 lbs, range from 200 to 1,000 lbs (12,000 tons)
Rock sill core/bedding stone	5,400	cy	Limestone, 2 in to 10 in
Rock sill additional core/bedding stone for settlement	3,500	cy	Limestone, 2 in to 10 in
Fill for marsh buffer	19,000	cy	Based on 2 ft scarp, 10H:1V slope, flattened to 20H:1V in the intertidal zone
Plantings for marsh buffer	2.4	ac	Based on 30 ft planting width
Geotextile	12,000	sy	

Table 4 - Cedar Creek Quantities – 5,200 lf			
Description	Quantity	Unit	Comments
Rock sill armor stone	12,000	cy	Granite, average weight 500 lbs, range from 200 to 1,000 lbs (17,000 tons)
Rock sill core/bedding stone	8,000	cy	Limestone, 2 in to 10 in
Rock sill additional core/bedding stone for settlement	5,000	cy	Limestone, 2 in to 10 in
Fill for marsh buffer	29,000	cy	Based on 2 ft scarp, 10H:1V slope, flattened to 20H:1V in the intertidal zone
Plantings for marsh buffer	3.6	ac	Based on 30 ft planting width
Geotextile	17,000	sy	

B. Kinston East Wetland Complex

This element would restore approximately 14.5 ac of damaged or eliminated riparian buffer where a former bottomland hardwood forest adjacent to the Neuse River was filled. Restoration of this area would result in a reconnection to the floodplain. Construction would require clearing and grubbing of approximately 14.5 acres, then excavation/grading and removal of 94,000 cubic yards of soil to restore the floodplain. Construction is anticipated to be approximately 8 to 12 months.

Project Cost and Schedule Risk Analysis: Contingency -An overall project contingency of 22% (except Real Estate 25%) was developed during a cost/risk analysis conducted with the Project Delivery Team (PDT). A summary of the development for the contingency is included in Section 7 of this Appendix.

3.4 Account 30: Planning, Engineering, and Design

The costs included in this account were based on discussions with Planning, Engineering, Contracting, Operations and Construction to determine a reasonable percentage of project costs based on similar historic performance. The costs were based on 10% of the construction cost for this project. This account includes plans, specifications, cost estimates, field investigations, surveys, engineering during construction, and project management.

3.5 Account 31: Construction Management

The costs included in this account were based on discussions with Planning, Engineering, Contracting, Operations and Construction to determine a reasonable percentage of project costs based on similar historic performance. The costs were based on 10% of the construction cost for this project, plus 1% of construction costs for monitoring the project features after construction, and 3% of the Oyster Sanctuary costs for potential adaptive management. This account includes supervision and administration of the contracts by construction management and includes hydrologic surveys during construction and necessary contracting personnel during construction, environmental/physical monitoring after construction, and adaptive management.

SECTION 4. CONSTRUCTION SCHEDULE

The construction schedule shows each feature of the selected plan constructed concurrently. This is necessary to establish an entire system improvement for the ecosystem restoration project to function properly.

ID		Task Name	Duration	Start	Finish	Predecessors
1		NEUSE RIVER BASIN - CONSTRUCTION SCHE	0 days	Mon 10/6/14	Mon 10/6/14	
2		NTP	1 day	Mon 10/6/14	Mon 10/6/14	1
3		Submittals	60 days	Tue 10/7/14	Mon 12/29/14	2
4		Mobilization	10 days	Tue 12/30/14	Mon 1/12/15	3
5		**Cedar Creek Parallel Restoration**	0 days	Mon 1/12/15	Mon 1/12/15	4
6		Site Preparation	20 days	Tue 1/13/15	Mon 2/9/15	4
7		Rock Sill Placement	550 days	Tue 2/10/15	Mon 3/20/17	6
8		Place Sand	15 days	Tue 2/10/15	Mon 3/2/15	6
9		Plant Marsh Vegetation	20 days	Tue 3/3/15	Mon 3/30/15	8
10		**Gum Thicket Parallel Restoration**	1 day?	Tue 1/13/15	Tue 1/13/15	4
11		Site Preparation	20 days	Tue 1/13/15	Mon 2/9/15	4
12		Rock Sill Placement	355 days	Tue 2/10/15	Mon 6/20/16	11
13		Place Sand	20 days	Tue 2/10/15	Mon 3/9/15	11
14		Plant Marsh Vegetation	20 days	Tue 3/10/15	Mon 4/6/15	13
15		**Little River Dam**	0 days	Mon 1/12/15	Mon 1/12/15	4
16		Site Access & Preparation	5 days	Tue 1/13/15	Mon 1/19/15	4
17		Clear & Grub	10 days	Tue 1/20/15	Mon 2/2/15	16
18		Snagging & Bank Clearing	15 days	Tue 2/3/15	Mon 2/23/15	17
19		Dam Removal/Spillway Installation	35 days	Tue 2/24/15	Mon 4/13/15	18
20		**Kinston East Wetland Restoration**	0 days	Mon 1/12/15	Mon 1/12/15	4
21		Site Preparation	15 days	Tue 1/13/15	Mon 2/2/15	4
22		Clearing & Grubbing	15 days	Tue 2/3/15	Mon 2/23/15	21
23		Excavation & Grading	80 days	Tue 2/24/15	Mon 6/15/15	22
24		Temporary Seeding	20 days	Tue 6/16/15	Mon 7/13/15	23
25		Permanent Seeding.	20 days	Tue 7/14/15	Mon 8/10/15	24
26		**Mid River Site - Oyster Reef Habitat**	0 days	Mon 1/12/15	Mon 1/12/15	4
27		Staging	15 days	Tue 1/13/15	Mon 2/2/15	4
28		Limestone - Purchased end Delivered to Site	30 days	Tue 2/3/15	Mon 3/16/15	27
29		Transfer Rock to Scow	30 days	Tue 3/17/15	Mon 4/27/15	28
30		Placement of Rock	262 days	Tue 4/28/15	Wed 4/27/16	29
31		Oyster Cultch Placement	14 days	Thu 4/28/16	Tue 5/17/16	30
32		**Northern Shores - Oyster Reef Habitat**	0 days	Tue 1/13/15	Tue 1/13/15	4
33		Staging	15 days	Tue 1/13/15	Mon 2/2/15	4
34		Limestone - Purchased and Delivered to Site	30 days	Tue 2/3/15	Mon 3/16/15	33
35		Transfer Rock to Scow	30 days	Tue 3/17/15	Mon 4/27/15	34
36		Placement of Rock	262 days	Tue 4/28/15	Wed 4/27/16	35
37		Oyster Cultch Placement	14 days	Thu 4/28/16	Tue 5/17/16	36
38		Project Closeout	10 days	Tue 3/21/17	Mon 4/3/17	7
39		Demobilization	5 days	Tue 3/21/17	Mon 3/27/17	7
40		Project Duration	651 days	Mon 10/6/14	Mon 4/3/17	

'11 | Aug 7, '11 | Aug 14, '11 | Aug 21, '11 | Aug 28, '11 | Sep 4, '11 | Sep 11, '11

T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F S S M T W T F

Project: NEUSE RIVER Construction S
Date: Thu 8/4/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

SECTION 5. TOTAL PROJECT COST SUMMARY (TPCS)

NEUSE RIVER BASIN FEASIBILITY REPORT
USACE – WILMINGTON DISTRICT

COST ENGINEERING DX - TPCS ATR CERTIFICATION

The Neuse River Basin Feasibility Report for Wilmington District has undergone a successful Cost Agency Technical Review (ATR), performed by the Walla Walla Cost DX representatives. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies in accordance with ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of 2 October 2011, the Walla Walla District, Cost Engineering Directory of Expertise (DX) for Civil Works, certifies the estimated total project cost of Neuse River Basin Feasibility Report estimated values of:

FY 2014 Price Level:	$36,659,000
Fully Funded Amount:	$38,156,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project controls and implementation procedures.

11-2-2011
Date

Kim C. Callan, PE, CCE, PM1
Chief, Cost Engineering
Walla Walla District

Printed:11/2/2011
Page 1 of 2

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: NEUSE RIVER BASIN FEASIBILITY REPORT
LOCATION: NORTH CAROLINA

DISTRICT: WILMINGTON
POC: CHIEF, COST ENGINEERING,

PREPARED: 10/29/2011

This Estimate reflects the scope and schedule in report; NEUSE RIVER BASIN FEASIBILITY REPORT

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

		ESTIMATED COST				PROJECT FIRST COST				TOTAL PROJECT COST (FULLY FUNDED)				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 1-Oct-11 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
06	FISH & WILDLIFE FACILITIES	$23,926	$5,264	22%	$29,190	3.2%	$24,704	$5,435	$30,138	NA		$25,660	$5,645	$31,305
	CONSTRUCTION ESTIMATE TOTALS:	$23,926	$5,264		$29,190	3.2%	$24,704	$5,435	$30,138			$25,660	$5,645	$31,305
01	LANDS AND DAMAGES	$199	$50	25%	$249	3.2%	$205	$51	$257			$206	$52	$258
30	PLANNING, ENGINEERING & DESIGN	$2,393	$526	22%	$2,919	6.5%	$2,550	$561	$3,111			$2,577	$567	$3,143
31	CONSTRUCTION MANAGEMENT	$2,426	$534	22%	$2,960	6.5%	$2,585	$569	$3,153			$2,828	$622	$3,450
	PROJECT COST TOTALS:	$28,944	$6,374	22%	$35,318	3.8%	$30,043	$6,616	$36,659			$31,270	$6,886	$38,156

_______________ CHIEF, COST ENGINEERING,

_______________ PROJECT MANAGER,

_______________ CHIEF, REAL ESTATE,

_______________ CHIEF, PLANNING,

_______________ CHIEF, ENGINEERING,

_______________ CHIEF, OPERATIONS,

_______________ CHIEF, CONSTRUCTION,

_______________ CHIEF, CONTRACTING,

_______________ CHIEF, PM-PB

_______________ CHIEF, DPM,

ESTIMATED FEDERAL COST:	65%	**$24,801**
ESTIMATED NON-FEDERAL COST:	35%	**$13,355**
ESTIMATED TOTAL PROJECT COST:		**$38,156**

O&M OUTSIDE OF TOTAL PROJECT COST: NA

Filename: TPCS_Oct_29_2011_FINAL.xlsx
TPCS

**** TOTAL PROJECT COST SUMMARY ****

Printed:11/2/2011
Page 2 of 2

**** CONTRACT COST SUMMARY ****

PROJECT: NEUSE RIVER BASIN FEASIBILITY REPORT
LOCATION: NORTH CAROLINA
This Estimate reflects the scope and schedule in report; NEUSE RIVER BASIN FEASIBILITY REPORT

DISTRICT: WILMINGTON
POC: CHIEF, COST ENGINEERING,
PREPARED: 10/29/2011

Estimate Prepared: 1-Oct-11
Effective Price Level: 1-Oct-11

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
06	FISH & WILDLIFE FACILITIES	$23,926	$5,264	22%	$29,190	3.2%	$24,704	$5,435	$30,138	2016Q2	3.9%	$25,660	$5,645	$31,305
	CONSTRUCTION ESTIMATE TOTALS:	$23,926	$5,264	22%	$29,190		$24,704	$5,435	$30,138			$25,660	$5,645	$31,305
01	LANDS AND DAMAGES	$199	$50	25%	$249	3.2%	$205	$51	$257	2014Q2	0.4%	$206	$52	$258
30	PLANNING, ENGINEERING & DESIGN													
	Planning, Egineering & Design	$2,393	$526	22%	$2,919	6.5%	$2,550	$561	$3,111	2014Q2	1.1%	$2,577	$567	$3,143
31	CONSTRUCTION MANAGEMENT													
	Construction Management	$2,426	$534	22%	$2,960	6.5%	$2,585	$569	$3,153	2016Q2	9.4%	$2,828	$622	$3,450
	CONTRACT COST TOTALS:	$28,944	$6,374		$35,318		$30,043	$6,616	$36,659			$31,270	$6,886	**$38,156**

Filename: TPCS_Oct_29_2011_FINAL.xlsx
TPCS

NEUSE RIVER BASIN FEASIBILITY REPORT
USACE – WILMINGTON DISTRICT

COST ENGINEERING DX - TPCS ATR CERTIFICATION

The Neuse River Basin Feasibility Report for Wilmington District has undergone a successful Cost Agency Technical Review (ATR), performed by the Walla Walla Cost DX representatives. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies in accordance with ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of 2 October 2011, the Walla Walla District, Cost Engineering Directory of Expertise (DX) for Civil Works, certifies the estimated total project cost of Neuse River Basin Feasibility Report estimated values of:

FY 2013 Price Level:	$35,774,000
Fully Funded Amount:	$37,962,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project controls and implementation procedures.

CALLAN.KIM.C.1231558221 Digitally signed by CALLAN.KIM.C.1231558221 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=CALLAN.KIM.C.1231558221 Date: 2013.02.08 12:09:59 -08'00'

08 Feb 2013

Date

Kim C. Callan, PE, CCE, PM1
Chief, Cost Engineering
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

Printed:2/8/2013
Page 1 of 2

PROJECT: NEUSE RIVER BASIN FEASIBILITY REPORT
LOCATION: NORTH CAROLINA

DISTRICT: WILMINGTON
POC: CHIEF, COST ENGINEERING.
PREPARED: 10/29/2011

This Estimate reflects the scope and schedule in report; NEUSE RIVER BASIN FEASIBILITY REPORT

						Program Year (Budget EC): 2013	Effective Price Level Date: 1 OCT 12			TOTAL PROJECT COST (FULLY FUNDED)				
		ESTIMATED COST				PROJECT FIRST COST				Spent Thru:				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	1-Oct-11 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
06	FISH & WILDLIFE FACILITIES	$23,926	$5,264	22%	$29,190	1.3%	$24,229	$5,330	**$29,560**	NA		$25,629	$5,638	$31,267
	CONSTRUCTION ESTIMATE TOTALS:	$23,926	$5,264		**$29,190**	1.3%	$24,229	$5,330	**$29,560**			$25,629	$5,638	$31,267
01	LANDS AND DAMAGES	$199	$50	25%	$249	1.9%	$203	$51	**$254**			$207	$52	$259
30	PLANNING, ENGINEERING & DESIGN	$2,393	$526	22%	$2,919	1.4%	$2,426	$534	**$2,960**			$2,518	$554	$3,072
31	CONSTRUCTION MANAGEMENT	$2,426	$534	22%	$2,960	1.4%	$2,460	$541	**$3,001**			$2,757	$607	$3,364
	PROJECT COST TOTALS:	$28,944	$6,374	22%	**$35,318**	1.3%	$29,318	$6,456	**$35,774**			$31,112	$6,851	$37,962

________________ CHIEF, COST ENGINEERING,

________________ PROJECT MANAGER,

________________ CHIEF, REAL ESTATE,

________________ CHIEF, PLANNING,

________________ CHIEF, ENGINEERING,

________________ CHIEF, OPERATIONS,

________________ CHIEF, CONSTRUCTION,

________________ CHIEF, CONTRACTING,

________________ CHIEF, PM-PB,

________________ CHIEF, DPM,

ESTIMATED FEDERAL COST:	65%	**$24,675**
ESTIMATED NON-FEDERAL COST:	35%	**$13,287**
ESTIMATED TOTAL PROJECT COST:		**$37,962**

O&M OUTSIDE OF TOTAL PROJECT COST: NA

Filename: TPCS_Oct_29_2011_FINAL revised to new budget year FY13.xlsx
TPCS

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: NEUSE RIVER BASIN FEASIBILITY REPORT
LOCATION: NORTH CAROLINA
This Estimate reflects the scope and schedule in report; NEUSE RIVER BASIN FEASIBILITY REPORT

DISTRICT: WILMINGTON
POC: CHIEF, COST ENGINEERING,
PREPARED: 10/29/2011

	Estimate Prepared: 1-Oct-11 Effective Price Level: 1-Oct-11			RISK BASED		Program Year (Budget EC): 2013 Effective Price Level Date: 1 OCT 12				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
06	FISH & WILDLIFE FACILITIES	$23,926	$5,264	22%	$29,190	1.3%	$24,229	$5,330	$29,560	2016Q2	5.8%	$25,629	$5,638	$31,267
	CONSTRUCTION ESTIMATE TOTALS:	$23,926	$5,264	22%	**$29,190**		$24,229	$5,330	$29,560			$25,629	$5,638	$31,267
01	LANDS AND DAMAGES	$199	$50	25%	$249	1.9%	$203	$51	$254	2014Q2	2.1%	$207	$52	$259
30-Jan-00	PLANNING, ENGINEERING & DESIGN													
	Planning, Egineering & Design	$2,393	$526	22%	$2,919	1.4%	$2,426	$534	$2,960	2014Q2	3.8%	$2,518	$554	$3,072
31-Jan-00	CONSTRUCTION MANAGEMENT													
	Construction Management	$2,426	$534	22%	$2,960	1.4%	$2,460	$541	$3,001	2016Q2	12.1%	$2,757	$607	$3,364
	CONTRACT COST TOTALS:	$28,944	$6,374		**$35,318**		$29,318	$6,456	$35,774			$31,112	$6,851	**$37,962**

SECTION 6. TSP DETAILED ESTIMATE - MCACES

U.S. Army Corps of Engineers
Project 16: NEUSE RIVER BASIN - TENTATIVELY SELECTED PLAN
Neuse River Basin ATR

NEUSE RIVER BASIN - TENTATIVELY SELECTED PLAN
Neuse River Basin Feasibility Report and Environmental Impact Statement

Estimated by	OLSEN
Designed by	Wilmington District PDT
Prepared by	Kristin S Olsen
Preparation Date	10/10/2011
Effective Date of Pricing	10/1/2011
Estimated Construction Time	651 Days

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Owner Page			**28,943,885**	**0**	**28,943,885**
01__Lands and Damages	**1.0**	**LS**	**199,000**	**0**	**199,000**
01_01_Real Estate Analysis Documents	**1.0**	**LS**	**199,000**	**0**	**199,000**
06__Fish and Wildlife Facilities	**1.0**	**LS**	**23,926,010**	**0**	**23,926,010**
06_01_Wildlife Facilities & Sanctuary	**1.0**	**LS**	**23,926,010**	**0**	**23,926,010**
06_01_01_Cedar Creek - Parallel Shoreline, Stone Sill and Marsh	**1.0**	**LS**	**6,633,135**	**0**	**6,633,135**
			216,815.6		*216,815.6*
06_01_02_Kinston East Wetland	**14.5**	**ACR**	**3,143,826**	**0**	**3,143,826**
06_01_03_Gum Thicket - Parallel Shoreline, Stone Sill and Marsh	**1.0**	**LS**	**4,641,828**	**0**	**4,641,828**
06_01_04_Low head dam on the Little River Near Goldsboro - Weir Improvements	**1.0**	**LS**	**426,872**	**0**	**426,872**
			873,110.5		*873,110.5*
06_01_05_ NEW SANCTUARY Oyster Reef Habitat	**10.4**	**ACR**	**9,080,349**	**0**	**9,080,349**
30__Planning, Engineering, and Design	**1.0**	**LS**	**2,392,480**	**0**	**2,392,480**
31__Construction Management, Monitoring & Adaptive Mgt.	**1.0**	**LS**	**2,426,395**	**0**	**2,426,395**

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
Contract Cost			**28,943,885**	**0**	**28,943,885**
01__Lands and Damages	**1.0**	**LS**	**199,000**	**0**	**199,000**
01_01_Real Estate Analysis Documents	**1.0**	**LS**	**199,000**	**0**	**199,000**
06__Fish and Wildlife Facilities	**1.0**	**LS**	**23,926,010**	**0**	**23,926,010**
06_01_Wildlife Facilities & Sanctuary	**1.0**	**LS**	**23,926,010**	**0**	**23,926,010**
06_01_01_Cedar Creek - Parallel Shoreline, Stone Sill and Marsh	**1.0**	**LS**	**6,633,135**	**0**	**6,633,135**
			1,275.60		*1,275.60*
PARALLEL REACH	**5,200.0**	**LF**	**6,633,135**	**0**	**6,633,135**
a-Site Preparations	**1.0**	**LS**	**198,361**	**0**	**198,361**
			4,861.08		*4,861.08*
Mob & Demob	**1.0**	**EA**	**4,861**	**0**	**4,861**
			193,499.61		*193,499.61*
Access Site Road and staging	**1.0**	**EA**	**193,500**	**0**	**193,500**
			217.57		*217.57*
b-Rock Sill	**25,000.0**	**CY**	**5,439,238**	**0**	**5,439,238**
			111.91		*111.91*
1-Rock Sill Armor Stone	**17,000.0**	**TON**	**1,902,400**	**0**	**1,902,400**
			59.43		*59.43*
2- Limestone	**18,200.0**	**TON**	**1,081,706**	**0**	**1,081,706**
			6.67		*6.67*
3- Transfer Rock to Barge	**25,000.0**	**CY**	**166,738**	**0**	**166,738**
			62.78		*62.78*
4- Scow Placement of Rock	**35,200.0**	**TON**	**2,210,016**	**0**	**2,210,016**
			4.61		*4.61*
5-Geotextile	**17,000.0**	**SY**	**78,378**	**0**	**78,378**
			23,635.61		*23,635.61*
c-Plant Marsh Vegetation	**3.6**	**ACR**	**85,088**	**0**	**85,088**
			31.03		*31.03*
d-Place Sand	**29,000.0**	**CY**	**899,998**	**0**	**899,998**
			5.65		*5.65*
e-Grade Scarp	**1,850.0**	**CY**	**10,450**	**0**	**10,450**
			216,815.60		*216,815.60*
06_01_02_Kinston East Wetland	**14.5**	**ACR**	**3,143,826**	**0**	**3,143,826**
a-Mob & Demob	**1.0**	**LS**	**23,681**	**0**	**23,681**

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
			147.85		*147.85*
b-Haul Road and staging	1,000.0	LF	147,853	0	147,853
			5.44		*5.44*
c-Silt Fencing	10,000.0	LF	54,390	0	54,390
			9,270.69		*9,270.69*
d-Clearing & Grubbing - sitework	14.5	ACR	134,425	0	134,425
			5.56		*5.56*
e-Excavation & Grading	94,000.0	CY	522,992	0	522,992
			22.54		*22.54*
f-Hauling & Disposal	94,000.0	CY	2,118,563	0	2,118,563
			4,893.86		*4,893.86*
g-Temporary Seeding	14.5	ACR	70,961	0	70,961
			4,893.86		*4,893.86*
h-Permanent Seeding	14.5	ACR	70,961	0	70,961
06_01_03_Gum Thicket - Parallel Shoreline, Stone Sill and Marsh	1.0	LS	4,641,828	0	4,641,828
			1,326.24		*1,326.24*
PARALLEL REACH	3,500.0	LF	4,641,828	0	4,641,828
a-Site Preparations	1.0	LS	198,361	0	198,361
			4,861.08		*4,861.08*
Mob & Demob	1.0	EA	4,861	0	4,861
			193,499.61		*193,499.61*
Access Site Road and staging	1.0	EA	193,500	0	193,500
			221.62		*221.62*
b-Rock Sill	17,100.0	CY	3,789,763	0	3,789,763
			111.91		*111.91*
1-Rock Sill Armor Stone	12,000.0	TON	1,342,870	0	1,342,870
			59.43		*59.43*
2- Limestone	12,460.0	TON	740,553	0	740,553
			6.67		*6.67*
3- Transfer Rock to Barge	17,100.0	CY	114,049	0	114,049
			62.84		*62.84*
4- Scow Placement of Rock	24,460.0	TON	1,536,966	0	1,536,966
			4.61		*4.61*
5-Geotextile	12,000.0	SY	55,326	0	55,326
			31.03		*31.03*
c-Place Sand	19,000.0	CY	589,636	0	589,636

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
			23,635.61		*23,635.61*
d-Plant Marsh Vegetation	**2.4**	**ACR**	**56,725**	**0**	**56,725**
			5.65		*5.65*
e-Grade Scarp	**1,300.0**	**CY**	**7,343**	**0**	**7,343**
06_01_04_Low head dam on the Little River Near Goldsboro - Weir Improvements	**1.0**	**LS**	**426,872**	**0**	**426,872**
a Mob and Demob	**1.0**	**LS**	**5,995**	**0**	**5,995**
			28.44		*28.44*
b SITE ACCESS	**200.0**	**LF**	**5,687**	**0**	**5,687**
			12,078.42		*12,078.42*
c Clear/Grub - sitework	**5.0**	**ACR**	**60,392**	**0**	**60,392**
d Snagging and Bank Clear	**1.0**	**LS**	**72,120**	**0**	**72,120**
-Debris/Snag	**1.0**	**LS**	**64,865**	**0**	**64,865**
-Riparian Edge - Riprap	**1.0**	**LS**	**7,255**	**0**	**7,255**
e Dam Removal and Spillway installed	**1.0**	**LS**	**282,678**	**0**	**282,678**
-Temp dewater structures	**1.0**	**LS**	**134,996**	**0**	**134,996**
			29,192.85		*29,192.85*
-Weir Construction	**4.0**	**EA**	**116,771**	**0**	**116,771**
			5,151.80		*5,151.80*
-Partial Dam Removal - Weir Preparations	**6.0**	**CY**	**30,911**	**0**	**30,911**
			873,110.52		*873,110.52*
06_01_05_ NEW SANCTUARY Oyster Reef Habitat	**10.4**	**ACR**	**9,080,349**	**0**	**9,080,349**
			873,110.52		*873,110.52*
a-MID RIVER SITES	**5.2**	**ACR**	**4,540,175**	**0**	**4,540,175**
			73,059.43		*73,059.43*
-Misc Site Work - Staging Area	**1.0**	**EA**	**73,059**	**0**	**73,059**
Set-Up	**1.0**	**LS**	**73,059**	**0**	**73,059**
			4,117.53		*4,117.53*
1 - Mob & Demob	**1.0**	**EA**	**4,118**	**0**	**4,118**
			1,660.38		*1,660.38*
2 - Survey	**20.0**	**ACR**	**33,208**	**0**	**33,208**
			35,734.26		*35,734.26*
3 - Site Work - Construct Stage Facility	**1.0**	**EA**	**35,734**	**0**	**35,734**
			859,060.63		*859,060.63*
-MID RIVER SITES	**5.2**	**ACR**	**4,467,115**	**0**	**4,467,115**

Description	Quantity	UOM	ContractCost	Contingency	ProjectCost
			79.77		*79.77*
Installation	56,000.0	TON	4,467,115	0	4,467,115
			60.50		*60.50*
1- Limestone	56,000.0	TON	3,387,892	0	3,387,892
			5.87		*5.87*
2- Transfer Rock to Scow	40,000.0	CY	234,773	0	234,773
			12.91		*12.91*
3- Scow Placement of Rock	56,000.0	TON	722,844	0	722,844
			8.11		*8.11*
4- Oyster Transfer - Bushels	15,000.0	EA	121,607	0	121,607
			873,110.52		*873,110.52*
b-NORTHERN SHORES	5.2	ACR	4,540,175	0	4,540,175
			73,059.43		*73,059.43*
-Misc Site Work - Staging Area	1.0	EA	73,059	0	73,059
Set-Up	1.0	LS	73,059	0	73,059
			4,117.53		*4,117.53*
1 - Mob & Demob	1.0	EA	4,118	0	4,118
			1,660.38		*1,660.38*
2 - Survey	20.0	ACR	33,208	0	33,208
			35,734.26		*35,734.26*
3 - Site Work - Construct Stage Facility	1.0	EA	35,734	0	35,734
			859,060.63		*859,060.63*
-NORTH SHORES SITES	5.2	ACR	4,467,115	0	4,467,115
			79.77		*79.77*
Installation	56,000.0	TON	4,467,115	0	4,467,115
			60.50		*60.50*
1- Limestone	56,000.0	TON	3,387,892	0	3,387,892
			5.87		*5.87*
2- Transfer Rock to Scow	40,000.0	CY	234,773	0	234,773
			12.91		*12.91*
3- Scow Placement of Rock	56,000.0	TON	722,844	0	722,844
			8.11		*8.11*
4- Oyster Transfer - Bushels	15,000.0	EA	121,607	0	121,607
30__Planning, Engineering, and Design	1.0	LS	2,392,480	0	2,392,480
31__Construction Management, Monitoring & Adaptive Mgt.	1.0	LS	2,426,395	0	2,426,395

SECTION 7. COST AND SCHEDULE RISK ANALYSIS (Contingency)

An overall project contingency of 22% (except Real Estate 25%) was developed during a cost/risk analysis conducted with the Project Delivery Team (PDT). A summary of the contingency development is described below. The development of 25% contingency for Real Estate (ACCOUNT 01) is contained within the Real Estate Appendix.

Contingency percentage is the amount added to an estimate to allow for uncertainty of items, conditions, or events that impact a project. Many items are known to effect costs but how much these items will vary depends on many factors.

Examples of risks/uncertainties known to effect costs are fluctuations of fuel prices, labor, material prices or availability, how work will be performed, competitive bid environment, multiple year contracts and schedules, funding constraints, site condition material factors, variation in quantities, etc.

Experience shows that many items of the construction first costs will vary during the life of a project and likely result in additional costs. The question is how to account for the likelihood and impact of these variables changing the project costs and what confidence level (likelihood or certainty) costs will be exceeded.

Questions of risk and uncertainty were addressed by a problematic risk analysis. A risk analysis is a systematic method to evaluate uncertainty and risks.

The information in this section includes the Abbreviated Risk Analysis – SUMMARY PAGE; RISK REGISTER; AND WBS RISK MATRIX WGT%.

First, the major potential risk areas (with associated Contract Costs) were identified such as 1. ROCK SILL stone/placement; 2.Marsh Vegetation; 3.Sand placement at Rock Sill; 4.Oyster Reef Habitat – stone placement; etc. These areas are listed with contract costs and shown in the **ABBREVIATED RISK ANALYSIS - SUMMARY PAGE**.

Next, a RISK REGISTER was developed for these risk areas to evaluate potential concerns for Project Scope, Acquisition Strategy, Construction Complexity, Volatile Commodities, Quantities, Fabrication Project Equipment, Estimating Methods, and External Project Risks. Risks were characterized by the magnitude of possible uncertainties and the probability of occurrence for each item or event. Any concerns were identified, discussed, and assigned a likelihood and impact to the project risk areas. This generated a Risk Level of 1 thru 5 as shown in the **RISK REGISTER** far right hand column.

The **WBS RISK MATRIX WGT%** was populated based on the choices identified in the Risk Register. Subsequently, the ABBREVIATED RISK ANALYSIS – SUMMARY PAGE applied the weighted risk percentages to all potential risk areas. The overall project contingency of 22% resulted from this systematic method of evaluating uncertainty and risk.

Abbreviated Risk Analysis - SUMMARY PAGE

Project (less than $40M): Neuse River Basin POTENTIAL RISK AREAS
Project Development Stage: ATR of Selected Plan

OCT 1, 2011 effective price level
Total Construction Contract Costs = $ 23,926,010

	WBS	Potential Risk Areas	Contract Cost		RISK MATRIX WEIGHTED % % Contingency	$ Contingency	Total
1	06 FISH AND WILDLIFE FACILITIES	Rock Sill -stone/placement	$ 9,229,001		22.92%	$ 2,114,979	$ 11,343,980
2	06 FISH AND WILDLIFE FACILITIES	Marsh Vegetation at Rock Sill	$ 141,813		8.33%	$ 11,818	$ 153,631
3	06 FISH AND WILDLIFE FACILITIES	Sand Placement at Rock Sill	$ 1,489,634		20.83%	$ 310,340	$ 1,799,974
4	06 FISH AND WILDLIFE FACILITIES	Oyster Reef Habitat - Stone Placement	$ 8,691,016		22.92%	$ 1,991,691	$ 10,682,707
5	06 FISH AND WILDLIFE FACILITIES	Oyster Reef Habitat - Oyster Shell	$ 243,214		20.83%	$ 50,670	$ 293,884
6	06 FISH AND WILDLIFE FACILITIES	Low Head Dam - Goldsboro	$ 426,872		25.00%	$ 106,718	$ 533,590
7	06 FISH AND WILDLIFE FACILITIES	Kinston Excavation & Disposal	$ 3,143,826		31.25%	$ 982,446	$ 4,126,272
8		Item Name	$ -		0.00%	$ -	$ -
9		Item Name	$ -		0.00%	$ -	$ -
10		Item Name	$ -		0.00%	$ -	$ -
11		Item Name	$ -		0.00%	$ -	$ -
12		**Remaining Construction Items**	$ 560,634	2.4%	14.58%	$ 81,759	$ 642,393
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 2,392,480		14.58%	$ 348,903	$ 2,741,383
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 2,426,395		14.58%	$ 353,849	$ 2,780,244

Totals	Contract Cost	% Contingency	$ Contingency	Total
Total Construction Estimate	$ 23,926,010	23.62%	$ 5,650,421	$ 29,576,431
Total Planning, Engineering & Design	$ 2,392,480	14.58%	$ 348,903	$ 2,741,383
Total Construction Management	$ 2,426,395	14.58%	$ 353,849	$ 2,780,244
Total	$ 28,744,885	22.10%	$ 6,353,174	$ 35,098,059
TOTAL PROJECT COST + REAL ESTATE	$ 28,943,885		$6,374,000	$35,317,885

Neuse River Basin **POTENTIAL RISK AREAS**

ATR of Selected Plan

Abbreviated Risk Analysis - SUMMARY PAGE

Meeting Date: 1-Jul-11

RISK REGISTER for LIKELIHOOD AND IMPACT

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Rock Sill -stone/placement	Design could change and vary type stone and quantity.	The design of the sill is based on historical use of similar designs that have proven successful.	Unlikely	Marginal	1
PS-2	Marsh Vegetation at Rock Sill	Variations of plantings could change but have not historically.	Project scope is well defined for marsh vegetation.	Unlikely	Marginal	1
PS-3	Sand Placement at Rock Sill	Variations in design could change based on surveys.	Scope is similar to past projects need but need ground contours.	Unlikely	Marginal	1
PS-4	Oyster Reef Habitat - Stone Placement	Design could change and vary type stone and quantity.	Project scope is well defined for stone placement for oyster habitat and similar to previious structures constructed.	Unlikely	Marginal	1
PS-5	Oyster Reef Habitat - Oyster Shell	Design could change as project is developed.	Project scope is similar to prveviously constructed oyster habitats and adaptive mgt provisions are included.	Unlikely	Marginal	1
PS-6	Low Head Dam - Goldsboro	Project scope for removal of the low head dam seems simplistic and well defined but details/design may change.	While PDT and local sponsor is aware of what needs to be done, the existing conditions aren't well known. We don't know the width of the existing notch in the dam, and therefore the closure structure may need to be wider. Utilities are not expected but also not confirmed.	Unlikely	Marginal	1
PS-7	Kinston Excavation & Disposal	Design could change based on surveys and requirements to grade as project is developed.	Project includes excavation and grading, it is very likely that the scope could creep into additional grading or excavation or other land based civil works. Utilities are not expected but also not confirmed.	LIKELY	Significant	4
PS-8	Item Name			Very Unlikely	Negligible	0
PS-9	Item Name			Very Unlikely	Negligible	0
PS-10	Item Name			Very Unlikely	Negligible	0
PS-11	Item Name			Very Unlikely	Negligible	0
PS-12	Remaining Construction Items			Very Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design	Specification requirements are not all typical of what standard specs in tack, especially oyster requirements and may require more than average cut/paste specs	Multiple sets of plans and specs could likely occur given the current climate of project funding both federal and state budgets.	LIKELY	Marginal	2
PS-14	Construction Management	Because of multiple sites and 5 mobs/demobs, there could be more than standard percentage of typical construction projects		Unlikely	Marginal	1

Acquisition Strategy

AS-1	Rock Sill -stone/placement	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Procurement-funding variations and multiple year contracts, including small business or 8A could cause marginal cost impacts	Unlikely	Marginal	1
AS-2	Marsh Vegetation at Rock Sill	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Site conditions and type of vegetation require that the landscape subcontractor is experienced and well equiped.	Unlikely	Marginal	1
AS-3	Sand Placement at Rock Sill	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Procurement-funding variations and multiple year contracts, including small business or 8A could cause marginal cost impacts	Unlikely	Marginal	1
AS-4	Oyster Reef Habitat - Stone Placement	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Procurement-funding variations and multiple year contracts, including small business or 8A could cause marginal cost impacts	Unlikely	Marginal	1
AS-5	Oyster Reef Habitat - Oyster Shell	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Abundant suppliers in the area but procurement may be limited	Unlikely	Marginal	1
AS-6	Low Head Dam - Goldsboro	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Procurement-funding variations and multiple year contracts, including small business or 8A could cause marginal cost impacts	Unlikely	Marginal	1
AS-7	Kinston Excavation & Disposal	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Site may be considered for 8(a), Hub Zone or other disadvantaged contractor.	LIKELY	Marginal	2
AS-8	Item Name			Very Unlikely	Negligible	0
AS-9	Item Name			Very Unlikely	Negligible	0
AS-10	Item Name			Very Unlikely	Negligible	0
AS-11	Item Name			Very Unlikely	Negligible	0
AS-12	Remaining Construction Items	Procurement-funding variations and multiple year contracts could cause marginal cost impacts	Procurement-funding variations and multiple year contracts, including small business or 8A could cause marginal cost impacts	Unlikely	Marginal	1
AS-13	Planning, Engineering, & Design	Multiple sets of plans and specs could likely occur given the current climate of project funding both federal and state budgets.	Concern may be likely but overall marginal for multiple acquisitions.	LIKELY	Marginal	2
AS-14	Construction Management	Because of multiple sites and 5 mobs/demobs, there could be more than standard percentage of typical construction projects	Question as to whether or not these will be separate contracts or solicited as one large contract may impact construction mgt, contracting, processing submittals, etc.	LIKELY	Marginal	2

Construction Complexity						
CC-1	Rock Sill -stone/placement	Various construction sequencing has been discussed due to the relatively shallow depth of water, limited site access, and length of rock sill. Impact will be a slowing in productivity of the stone placement crew.	Construction techniques have been similar for most historic projects and with tidal effects some constraints could impact costs above average historic costs.	LIKELY	Marginal	2
CC-2	Marsh Vegetation at Rock Sill	Experienced Subcontractor will be required to perform restoration in the area - limited site access will require proper construction sequencing with prime contractor and other subs.	Although limited access the complexity is unlikely and could cause marginal cost increase.	Unlikely	Marginal	1
CC-3	Sand Placement at Rock Sill	Sand source from Corps disposal area may require separation of sand from any silty material	Separation of material is unlikely based on known characteristics of material placed into the disposal areas.	Unlikely	Marginal	1
CC-4	Oyster Reef Habitat - Stone Placement	Unique construction techniques in open water could cause variation in methods for placement.	Construction techniques have been similar for most historic projects and with tidal effects some constraints could impact costs above average historic costs.	LIKELY	Marginal	2
CC-5	Oyster Reef Habitat - Oyster Shell	Unique construction techniques in open water could cause variation in methods for placement.	Construction techniques have been similar for most historic projects and with tidal effects some constraints could impact costs above average historic costs.	LIKELY	Marginal	2
CC-6	Low Head Dam - Goldsboro	Site location and conditions make construction difficult. Decrease in productivity is likely.	Although typical construction techniques are expected there may be conditions not known at this point of feasibility.	LIKELY	Significant	4
CC-7	Kinston Excavation & Disposal	Although excavated material is suitable fill (marketable) disposal locations will be left to the contractor.	This estimate may not have considered all the uncertainties associated with disposal/hauling material of this quantity.	LIKELY	Marginal	2
CC-8	Item Name			Very Unlikely	Negligible	0
CC-9	Item Name			Very Unlikely	Negligible	0
CC-10	Item Name			Very Unlikely	Negligible	0
CC-11	Item Name			Very Unlikely	Negligible	0
CC-12	Remaining Construction Items	Staging locations have preliminarily been identified, however, it still remains to be seen if existing soils in the area will be sufficient for temporary staging - especially if access will be through a marsh area - it might require the addition of temporary ramps and platform for construction staging.	The need for additional staging could cause significant cost increase for project areas not highlighted as major cost drivers.	LIKELY	Significant	4
CC-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
CC-14	Construction Management	While 1' of settlement is accounted for in the estimated quantities. The long lapse between receipt of survey data and actual construction raises the risk of potential in differing site conditions and therefore future modifications.	Conditions of quantity variations could cause marginal cost changes for construction personnel	LIKELY	Marginal	2

Volatile Commodities

VC-1	Rock Sill -stone/placement	Various quarries and suppliers in the area have been identified. Fuel fluctuations likely to cause cost increases based on heavy equipment usage	Fuel fluctuations are likely to cause cost increases but expected to be marginal based on fuel used in this estimate of $3.50/gallon which has been stable for last 6 months and heading lower. This is the highest price over last 3 years since 2008 futures speculation.	LIKELY	Marginal	2
VC-2	Marsh Vegetation at Rock Sill	Requirements for marsh plantings maintains flexibility - therefore minimizing risk to availability of species.	Marsh plantings not likely to be susceptable to volatile commodities.	Unlikely	Negligible	0
VC-3	Sand Placement at Rock Sill	Fuel fluctuations likely to cause cost increases based on heavy equipment usage.	Fuel fluctuations are likely to cause cost increases see VC-1 above.	LIKELY	Marginal	2
VC-4	Oyster Reef Habitat - Stone Placement	Various quarries and suppliers in the area have been identified. Fuel fluctuations likely to cause cost increases based on heavy equipment usage.	Fuel fluctuations are likely to cause cost increases see VC-1 above.	LIKELY	Marginal	2
VC-5	Oyster Reef Habitat - Oyster Shell	Fuel fluctuations likely to cause cost increases based on heavy equipment usage.	Fuel fluctuations are likely to cause cost increases see VC-1 above.	LIKELY	Marginal	2
VC-6	Low Head Dam - Goldsboro	Fuel fluctuations are likely to cause cost increases.	Fuel fluctuations could cause negligible cost variations based on equipment mix is not as fuel dependent.	LIKELY	Negligible	1
VC-7	Kinston Excavation & Disposal	Fuel fluctuations likely to cause cost increases based on heavy equipment usage.	Fuel fluctuations are likely to cause cost increases see VC-1 above.	LIKELY	Marginal	2
VC-8	Item Name			Very Unlikely	Negligible	0
VC-9	Item Name			Very Unlikely	Negligible	0
VC-10	Item Name			Very Unlikely	Negligible	0
VC-11	Item Name			Very Unlikely	Negligible	0
VC-12	Remaining Construction Items	No Concerns.		LIKELY	Negligible	1
VC-13	Planning, Engineering, & Design	No Concerns.		Very Unlikely	Negligible	0
VC-14	Construction Management	No Concerns.		Very Unlikely	Negligible	0

Quantities

Q-1	Rock Sill -stone/placement	As detailed survey of the area becomes available, the risk can be reduced for the calculated quantities. At this time, the design is based on the available soundings and added 1' for loss and settlement. Therefore, there is already some measure of contingency included.	Until additional surveys are acquired the risk is significant for quantity changes and costs.	Unlikely	Significant	3
Q-2	Marsh Vegetation at Rock Sill	Quantities required have been consistent with histoircal per acre	Quantities required have been consistent with histoircal per acre	Unlikely	Negligible	0
Q-3	Sand Placement at Rock Sill	As detailed survey of the area becomes available, the risk can be reduced for the calculated quantities. At this time, the design is based on the available soundings.	Until additional surveys are acquired the risk is significant for quantity changes and costs.	Unlikely	Significant	3
Q-4	Oyster Reef Habitat - Stone Placement	Additional Survey data - as it becomes available - will help reduce the uncertainty of the quantities. Impact is expected to be marginal.	Until additional surveys are acquired the risk is significant for quantity changes and costs.	Unlikely	Significant	3
Q-5	Oyster Reef Habitat - Oyster Shell	Additional Survey data - as it becomes available - will help reduce the uncertainty of the quantities. Impact is expected to be marginal.	Historical data for top reef quantities are typical and could likely change but should be marginal cost change.	LIKELY	Marginal	2
Q-6	Low Head Dam - Goldsboro	Additional Survey data - as it becomes available - will help reduce the uncertainty of the quantities. Impact is expected to be marginal.	Quantities and construction activities for retrofit will be better identified when survey and specific site info becomes available.	LIKELY	Marginal	2
Q-7	Kinston Excavation & Disposal	Additional Survey data - as it becomes available - will help reduce the uncertainty of the quantities. Impact is expected to be marginal.	Although likely quantities may change, initial estimate of quantities has been conservative and should only marginally effect costs.	LIKELY	Marginal	2
Q-8	Item Name			Very Unlikely	Negligible	0
Q-9	Item Name			Very Unlikely	Negligible	0
Q-10	Item Name			Very Unlikely	Negligible	0
Q-11	Item Name			Very Unlikely	Negligible	0
Q-12	Remaining Construction Items	No Concerns.		LIKELY	Negligible	1
Q-13	Planning, Engineering, & Design	No Concerns.		Unlikely	Marginal	1
Q-14	Construction Management	Adaptive mgt quantities have not been established.	Historic percentages for adaptive mgt costs are likely to increase costs but should be negligible increase.	LIKELY	Negligible	1

Fabrication & Project Installed Equipment

FI-1	Rock Sill -stone/placement	Quarries and suppliers are readily available in the area.	No concerns	Very Unlikely	Negligible	0
FI-2	Marsh Vegetation at Rock Sill	Suppliers are readily available in the area.	No concerns	Very Unlikely	Negligible	0
FI-3	Sand Placement at Rock Sill	Suppliers are readily available in the area.	No concerns	Very Unlikely	Negligible	0
FI-4	Oyster Reef Habitat - Stone Placement	Suppliers are readily available in the area.	No concerns	Very Unlikely	Negligible	0
FI-5	Oyster Reef Habitat - Oyster Shell	Suppliers are readily available in the area.	No concerns	Unlikely	Negligible	0
FI-6	Low Head Dam - Goldsboro	Fabrication of stop log structure or gate is easy to obtain.	No concerns	Very Unlikely	Negligible	0
FI-7	Kinston Excavation & Disposal	Construction is not dependent on any fabrication or installed equipment.	No concerns	Very Unlikely	Negligible	0
FI-8	Item Name			Very Unlikely	Negligible	0
FI-9	Item Name			Very Unlikely	Negligible	0
FI-10	Item Name			Very Unlikely	Negligible	0
FI-11	Item Name			Very Unlikely	Negligible	0
FI-12	Remaining Construction Items	No Concerns.		Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design	No Concerns.		Very Unlikely	Negligible	0
FI-14	Construction Management	No Concerns.		Very Unlikely	Negligible	0

Cost Estimating Method

CE-1	Rock Sill -stone/placement	Estimating of rock sill structure is based on successful historic projects and data.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Negligible	1
CE-2	Marsh Vegetation at Rock Sill	Water work makes constructon complex. The tidal effects may effect equipment mix and production but should still approximate historic pricing, and may affect construction with shut downs.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Negligible	1
CE-3	Sand Placement at Rock Sill	Estimating of the sand placement is based on successful historic projects and data in the region.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Negligible	1
CE-4	Oyster Reef Habitat - Stone Placement	Estimating of the stone sill for oyster habitat is based on recent succesful historic projects and data in the region.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Negligible	1
CE-5	Oyster Reef Habitat - Oyster Shell	Various suppliers were called to be sure that the cultch is readily available, can be placed as anticipated and crew rates, productivity were based on recent projects completed in the area.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Negligible	1
CE-6	Low Head Dam - Goldsboro	Updates/Modifications to the dam are straight forward civil works based construction.	Although estimate based on historic projects and pricing, variations are likely but should neglible cost variances.	LIKELY	Marginal	2
CE-7	Kinston Excavation & Disposal	No Concerns.		LIKELY	Marginal	2
CE-8	Item Name			Very Unlikely	Negligible	0
CE-9	Item Name			Very Unlikely	Negligible	0
CE-10	Item Name			Very Unlikely	Negligible	0
CE-11	Item Name			Very Unlikely	Negligible	0
CE-12	Remaining Construction Items	No Concerns.		Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design	Estimate based on historical percentage versus actual calculations	Although PDT and PM were engaged in developing this part of the estimate actuals could change but should be negligible.	LIKELY	Negligible	1
CE-14	Construction Management	Estimate based on historical percentage versus actual calculations	Construction PM's were engaged in developing this part of the estimate; however, adaptive mgt quantities have not been established.	LIKELY	Negligible	1

External Project Risks

EX-1	Rock Sill -stone/placement	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-2	Marsh Vegetation at Rock Sill	Should not be concerns due to adverse weather for this item	Should not be concerns due to adverse weather for this item	Unlikely	Negligible	0
EX-3	Sand Placement at Rock Sill	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-4	Oyster Reef Habitat - Stone Placement	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-5	Oyster Reef Habitat - Oyster Shell	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-6	Low Head Dam - Goldsboro	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-7	Kinston Excavation & Disposal	Adverse weather, acquisition, and changes to schedule have been considered elsewhere in the risk analysis; but there is likely other external risks beyond what was considered and not identifiable that can occur.	Unkown external risks could be likely but should have negligible impact based on considerations identified elsewhere in the risk anallysis.	LIKELY	Negligible	1
EX-8	Item Name			Very Unlikely	Negligible	0
EX-9	Item Name			Very Unlikely	Negligible	0
EX-10	Item Name			Very Unlikely	Negligible	0
EX-11	Item Name			Very Unlikely	Negligible	0
EX-12	Remaining Construction Items	No Concerns.		Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design	Local sponsors may provide additional input that requries additional rework during design.	Sponors and environmental regualtors will be engaged throughout the feasibility report and design.	Unlikely	Marginal	1
EX-14	Construction Management	No Concerns.		Very Unlikely	Negligible	0

Neuse River Basin **POTENTIAL RISK AREAS**

ATR of Selected Plan

Abbreviated Risk Analysis - SUMMARY PAGE

WBS RISK MATRIX SHOWING WGT %

Typical Risk Elements	Rock Sill - stone/placem	Marsh Vegetation at Rock Sill	Sand Placement at R Sill	Oyster Reef Habitat - Stone Placem	Oyster Reef Habitat - Oyster Shell	Low Head Dam - Goldsboro	Kinston Excavation & Disposal	Remaining Construction Items	Planning, Engineering & Design	Construction Management
Project Scope	1	1	1	1	1	1	4	-	2	1
Acquisition Strategy	1	1	1	1	1	1	2	1	2	2
Construction Complexity	2	1	1	2	2	4	2	4	-	2
Volatile Commodities	2	-	2	2	2	1	2	1	-	-
Quantities	3	-	3	3	2	2	2	1	1	1
Fabrication & Project Installed Equipment	-	-	-	-	-	-	-	-	-	-
Cost Estimating Method	1	1	1	1	1	2	2	-	1	1
External Project Risks	1	-	1	1	1	1	1	-	1	-
Weighted %	22.9%	8.3%	20.8%	22.9%	20.8%	25.0%	31.3%	14.6%	14.6%	14.6%

Appendix O: Review Plan and IERP Waiver

ROUTED: 5 Jun 2012 7496
ACTION: Elden Gatwood
SUSPENSE: Information Memo(note para 5)
CF: Cdr, DCdr,DPM,CoS, ,TSD

DEPARTMENT OF THE /
US ARMY CORPS OF ENGINEERS
SOUTH ATLANTIC DIVISION
60 FORSYTH ST, SW, ROOM 10M15
ATLANTA, GEORGIA 30303-3490

REPLY TO
ATTENTION OF:

CESAD-PDP

3 1 MAY 2012

MEMORANDUM FOR Commander, Wilmington District (CESAW-TS-P/Elden Gatwood)

SUBJECT: Review Plan Approval for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment

1. References:

a. Memorandum, 28 November 2011, CESAW-TS-P

b. Memorandum, 1 September 2011, CEMVD-PD-N

c. EC 1165-2-209, 31 January 2010, Civil Works Review Policy

2. The attached Review Plan for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment (enclosure) has been prepared in accordance with EC 1165-2-209.

3. The Review Plan has been coordinated with the National Ecosystem Planning Center of Expertise (ECO-PCX) of the Mississippi Valley Division (MVD), which is the lead office to execute this plan. For further information, please contact the ECO-PCX at (309) 794-5448. The Review Plan does not include independent external peer review.

4. I hereby approve this Review Plan, which is subject to change as circumstances require, consistent with study development under the Project Management Business Process. Subsequent revisions to this Review Plan or its execution will require new written approval from this office.

5. The District should take steps to post the approved Review Plan and a copy of this approval memorandum to the SAW District public internet website and provide a link to the ECO-PCX for their use. Before posting to the website, the names of Corps/Army employees should be removed.

CESAD-PDP
Subject: Review Plan Approval for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment

6. The SAD point of contact for this action is Ms. Karen Dove-Jackson, CESAD-PDP, (404) 562-5225.

FOR THE COMMANDER:

Encl

WILBERT V. PAYNES
Chief, Planning and Policy
Community of Practice

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
69 DARLINGTON AVENUE
WILMINGTON, NORTH CAROLINA 28403-1343

REPLY TO
ATTENTION OF:

CESAW-TS-P

28 November 2011

MEMORANDUM FOR Commander, South Atlantic Division (CESAD-PDS-P ATTN: Wilbert Paynes)

SUBJECT: Revised of Review Plan for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment

1. References.

   a. EC 1165-2-209, Civil Works Review Policy, 31 Jan 2010
   b. Decision Document Review Plan Template 15 June 2011

2. I hereby request approval of the enclosed Review Plan for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment. The Review Plan complies with applicable policy and includes our DQC, and ATR plans for this project.

3. A risk informed decision was made by CESAW to request an exclusion from IEPR as the project does not meet the conditions that warrant IEPR. A waiver request will be submitted upon approval of the Review Plan.

4. The National Planning Center of Expertise for Ecosystem Restoration (ECO-PCX) has reviewed the review plan and has no objections. A memo from the ECO-PCX, endorsing the Review Plan, was sent to CESAD on 9/1/2011. A copy of that memo is enclosed.

5. The District has responded to SAD comments and modified the Review Plan accordingly.

6. The District will post the CESAD approved Review Plan to its website and provide a link to the CESAD for its use. Names of Corps/Army employees are withheld from the posted version, in accordance with guidance.

FOR THE COMMANDER:

Encl

Elden Gatwood
Chief, Planning and Environmental Branch

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
69 DARLINGTON AVENUE
WILMINGTON, NORTH CAROLINA 28403-1343

REPLY TO
ATTENTION OF:

CESAW-TS-P

12 September 2011

MEMORANDUM FOR Commander, South Atlantic Division (CESAD-PDS-P ATTN: Wilbert Paynes)

SUBJECT: Approval of Review Plan for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment

1. References.

   a. EC 1165-2-209, Civil Works Review Policy, 31 Jan 2010

2. I hereby request approval of the enclosed Review Plan for Neuse River Basin, North Carolina, Integrated Feasibility Report and Environmental Assessment. The Review Plan complies with applicable policy and includes our DQC, and ATR plans for this project.

3. A risk informed decision was made by CESAW to request an exclusion from IEPR as the project does not meet the conditions that warrant IEPR.

4. The National Planning Center of Expertise for Ecosystem Restoration (ECO-PCX) has reviewed the review plan and has no objections. A memo from the ECO-PCX, endorsing the Review Plan, was sent to CESAD on 9/1/2011. A copy of that memo is enclosed.

5. The district will post the CESAD approved Review Plan to its website and provide a link to the CESAD for its use. Names of Corps/Army employees are withheld from the posted version, in accordance with guidance.

FOR THE COMMANDER:

Encl

Elden Gatwood
Chief, Planning and Environmental Branch

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

REPLY TO
ATTENTION OF:

CEMVD-PD-N

01 September 2011

MEMORANDUM FOR Commander, South Atlantic Division
ATTN: (Wilbert Paynes, SAD-PDS-P)

SUBJECT: Neuse River Basin, North Carolina Feasibility Report and Environmental Impact Statement, Wilmington District, Ecosystem Planning Center of Expertise Recommendation for Review Plan Approval

1. References:
   a. Engineering Circular (EC) 1165-2-209, Water Resources Policies and Authorities, CIVIL WORKS REVIEW POLICY, 31 Jan 2010
   b. EC 1105-2-412, Assuring Quality of Planning Models, 31 March 2011
   c. Engineering Regulation (ER) 1110-2-12, Quality Management, 30 Sep 2006

2. The enclosed Review Plan (RP) complies with all applicable policy and provides an adequate agency technical review of the plan formulation, engineering, and environmental analyses, and other aspects of plan development. The Ecosystem Restoration Planning Center of Expertise (ECO-PCX) has reviewed the RP.

3. The RP includes a risk informed decision for exclusion from Type I Independent External Peer Review (IEPR) for this study. The exclusion request has not been made yet. The ECO-PCX should be included on the coordination of this request. Final approval for exclusion must be obtained from the Director of Civil Works (DCW).

4. The Habitat Evaluation Procedures for Oyster Reef Habitat and the Habitat Suitability Index for the American Oyster used in this study were approved for use by HQ Memorandum Policy Guidance on Certification of Ecosystem Output Models (Aug 2008). The North Carolina Stream Habitat Evaluation Method (NC SHEM) and the North Carolina Wetland Assessment Method (NC WAM) used in this study were approved for use by the Headquarters' Model Certification Team on 09 August 2011.

5. The ECO-PCX concurs with the attached RP. Upon approval by the MSC Commander, please provide the approved RP, the MSC Commander's approval memorandum, and the link to the District posting of the RP to Jodi Staebell. When substantive revisions are made to the RP, such as approval of the IEPR exclusion request, changes in project scope, or Corps policy, a revised RP should be provided to the ECO-PCX for review. Non-substantive changes do not require further PCX review.

6. Thank you for the opportunity to assist in the preparation of the Review Plan. We look forward to reviewing the IEPR exclusion request when available.

Enclosures (1)

Jodi Staebell
Operational Director,
National Ecosystem Planning
Center of Expertise

CF:
CEMVD-PD-N (Wilbanks, Smith, Staebell)
CESAD-PDS (Stratton)
CESAW-TSD-PL (Barnes)
CESAW-PM-C (Castens)
CEMVR-PD-F (Knollenberg)

REVIEW PLAN

Neuse River Basin, North Carolina

Integrated Interim Feasibility Report and Environmental Assessment

Wilmington District

SAD Approval Date: May 2012

US Army Corps
of Engineers ®

REVIEW PLAN

Neuse River Basin, North Carolina
Integrated Feasibility Report and Environmental Assessment

TABLE OF CONTENTS

1. PURPOSE AND REQUIREMENTS

A. Purpose. This Review Plan defines the scope and level of review for the Neuse River Basin, North Carolina Integrated Interim Feasibility Report and Environmental Assessment.

B. References

1) Engineering Circular (EC) 1165-2-209, Civil Works Review Policy, 31 Jan 2010
2) EC 1105-2-410, Assuring Quality of Planning Models, 31 Mar 2011
3) Engineering Regulation (ER) 1110-1-12, Quality Management, 30 Sep 2006
4) ER 1105-2-100, Planning Guidance Notebook, Appendix H, Policy Compliance Review and Approval of Decision Documents, Amendment #1, 20 Nov 2007
5) CESAD Civil Works Planning and Policy Division Quality Management Sub-plan. CESAD R 110-1-8, App C. 28 Feb 2003.

C. Requirements. This review plan was developed in accordance with EC 1165-2-209, which establishes an accountable, comprehensive, life-cycle review strategy for Civil Works products by providing a seamless process for review of all Civil Works projects from initial planning through design, construction, and operation, maintenance, repair, replacement and rehabilitation (OMRR&R). The EC outlines four general levels of review: District Quality Control/Quality Assurance (DQC), Agency Technical Review (ATR), Independent External Peer Review (IEPR), and Policy and Legal Compliance Review. In addition to these levels of review, decision documents are subject to cost engineering review and certification by the Cost Planning Center of Expertise (PCX) (per EC 1165-2-209) and planning model certification/approval (per EC 1105-2-412).

2. REVIEW MANAGEMENT ORGANIZATION (RMO) COORDINATION

The RMO is responsible for managing the overall peer review effort described in this Review Plan. The RMO for decision documents is typically either a Planning Center of Expertise (PCX) or the Risk Management Center (RMC), depending on the primary purpose of the decision document. The RMO for the review effort described in this Review Plan is the Ecosystem Planning Center of Expertise (ECOPCX).

RMO will coordinate with the Cost Engineering Directory of Expertise (DX) to ensure the appropriate expertise is included on the review teams to assess the adequacy of cost estimates, construction schedules and contingencies.

3. STUDY INFORMATION

a. Decision Document. The Integrated Feasibility Report and Environmental Assessment for the Neuse River Basin, NC shall be the decision document. The Neuse River Basin Study is being pursued under the Corps of Engineers' General Investigation (GI) Program. The integrated Feasibility Report and Environmental Assessment (EA) are being conducted in response to a resolution adopted July 23, 1997:

"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on the Neuse River Basin, North Carolina, published as House Document 175, 89th Congress, 1st Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of flood control, environmental protection and restoration, and related purposes."

b. Study/Project Description. The Neuse River Basin is the third largest basin in North Carolina, encompassing a total area of 6,235 square miles. The river basin is one of only four basins located entirely within the state and incorporates parts or all of 18 counties. The Neuse River originates in north central North Carolina in Person and Orange Counties and flows southeasterly until it reaches tidal waters near Streets Ferry upstream of New Bern. The river broadens dramatically at New Bern and changes from a free-flowing river to a tidal estuary known as the Neuse River Estuary, which eventually flows into Pamlico Sound. The upper one-third of the basin lies in the Piedmont physiographic province while the lower two-thirds of the basin lie in the Coastal Plain physiographic province.

The Neuse River Feasibility Study is investigating stream restoration (reestablishing stream sinuosity, restoring wetlands and riparian buffers, preservation, etc.), anadromous fish habitat restoration (removal of dams and culverts), and estuarine restoration (reestablishing oyster reef habitat).The Neuse River, once thriving with abundant species in diverse habitats, has experienced detrimental impacts in water quality. Approximately 555 miles and 3,569 acres within the Neuse River are listed on the 2004 North Carolina 303(d) Impaired Waters List.

In addition to considerable water quality degradation, alteration and destruction of the estuary's habitats, alteration of river flow, and declines in aquatic populations has occurred. The study will address basin-wide improvements to water quality, environmental restoration, and related purposes. The State of North Carolina, Division of Water Resources is the non-federal sponsor for this study. (In-kind contributions are currently not provided by the non-federal sponsor.)

Recommended plans will be formulated to address the needs of the Neuse River Basin at the basin-wide scale. Plan components will be developed by the workgroups to address needs (study objectives) identified above for the individual focus areas. All Alternative Ecosystem Restoration Plans will be evaluated using a variety of habitat or functional assessment models, which are described in section 9 of this review plan. Cost will estimated for each plan and IWR Plan will be used evaluate alternatives for inclusion in the recommended plan.

c. Factors Affecting the Scope and Level of Review.

Study Challenges: The complexity of the possible problems in the watershed and the appearance that there is no single problem is a challenge.

Technical Challenges: Availability of suitable and acceptable models for use in analysis and the ability to compare outputs in a meaningful way because of the diversity of habitat types in the study area poses challenges for Environmental Benefits Analysis. Additionally, making a connection between possible measures across the very large watershed may also be a challenge.

Social Challenges: No Social Challenges are anticipated.

Institutional Challenges: Time and cost requirements for implementation of the Study, including the level of necessary review poses a challenge with the local sponsor. The sponsor suggests a more focused study approach but USACE policy and process requires a watershed approach.

Risk: The PDT worked to manage risk in developing measures. It developed measures by expanding on and referencing successful similar work completed by the USACE Wilmington District and others, including the State of North Carolina, on adjacent/nearby stream or shoreline segments or oyster reefs. The team used the experience from previous projects to identify possible risks and decrease uncertainty in plan formulation. No measures in the Tentatively Selected Plan are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed habitats. Significant risk would be avoided by proper design, appropriate site selection, and correct seasonal timing of biotic applications. Unforeseen temporary perturbations during habitat establishment would be addressed by making allowances for replanting during the biotic establishment period. The dynamic and complex nature of coastal environmental processes is a principal source of uncertainty. Post-construction monitoring and adaptive management plans would be used to address 20 unplanned outcomes in all Tentatively Selected Plan components.

Threat to human life/safety: There are no anticipated threats to human life or safety.

Governor request for review: The Governor of North Carolina has not requested a peer review by independent experts.

Public Dispute: The project is not expected to involve significant public dispute as to the size, nature, or effects of the project, or to the economic or environmental cost or benefit of the project.

Project Design: The information in the decision document or anticipated project design is not based on novel methods, involve the use of innovative materials or techniques, present complex challenges for interpretation, contain precedent-setting methods or models, or present conclusions that are likely to change prevailing practices. The project design does not require redundancy, resiliency, and/or robustness, unique construction sequencing, or a reduced or overlapping design construction schedule.

d. In-Kind Contributions.

Products and analyses provided by non-Federal sponsors as in-kind services are subject to DQC, ATR, and IEPR. For the Neuse River Basin, The local sponsor has provided $78,000 in in-kind contributions.

4. **DISTRICT QUALITY CONTROL (DQC)** All decision documents (including supporting data, analyses, environmental compliance documents, etc.) shall undergo DQC. DQC is an internal review process of basic science and engineering work products focused on fulfilling the project quality requirements defined in the Project Management Plan (PMP). The DQC Team will be comprised of management or staff that has not been directly involved in the day to day conduct of the study effort. The home district shall manage DQC. Documentation of DQC activities is

required and should be in accordance with the Quality Manual of the District and the home MSC.

The Wilmington District is responsible for controlling quality for all work that they accomplish. The SAW Quality Management Plan establishes district roles, responsibilities and processes consistent with the South Atlantic Division's Quality Management Plan (28 Feb 2003).The PDT is responsible for a complete reading of the report to assure the overall integrity of the report, technical appendices, and the recommendations before approval by the District Commander.

In general, the USACE Civil Works regulations, policy letters, technical manuals, and pertinent federal laws will serve as the basis of the technical review. Checklists developed by each functional area organization on the PDT may be used during the review process.

a. **Documentation of DQC.** Documentation of the technical and policy review of a specific product will be sufficient to allow both planning management and QC reviewers to feel confident that a comprehensive review was conducted in accordance with principles and guidelines established. All in-progress review actions, review team meetings, and other significant technical review related actions will be documented in the form of a written memorandum prepared by the review leader

b. **Products to Undergo DQC.** All documents will be submitted for DQC prior to Agency Technical Review.

5. AGENCY TECHNICAL REVIEW (ATR)

ATR is mandatory for all decision documents (including supporting data, analyses, environmental compliance documents, etc.). The objective of ATR is to ensure consistency with established criteria, guidance, procedures, and policy. The ATR will assess whether the analyses presented are technically correct and comply with published USACE guidance, and that the document explains the analyses and results in a reasonably clear manner for the public and decision makers. ATR is managed within USACE by the designated RMO (ECOPCX) and is conducted by a qualified team from outside the home district that is not involved in the day-to-day production of the project/product. ATR teams will be comprised of senior USACE personnel and may be supplemented by outside experts as appropriate. The ATR team lead will be from outside the home MSC.

a) Products to Undergo ATR.

ATR was performed for the Feasibility Scoping Meeting (FSM) documentation, August 2007. ATR was performed on the Alternative Formulation Briefing (AFB) package in accordance with EC 1105-2-410 (8/2008), June 2009, and again April 2010 with EC 1165-2-209. During this ATR, compliance with established policy, principles, and procedures utilizing justified and valid assumptions were verified. This included review of:

- Assumptions
- Methods, procedures, and material used in analyses
- Alternatives evaluated
- The appropriateness of data used and the level of data obtained

- Reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing USACE policy.

ATR was performed on the Environment Benefit Models April 2010. This review was performed by the USACE Environmental Research and Development Center (ERDC).

ATR will also be performed on the Final Report (including NEPA and supporting documentation).

b) **Required ATR Team Expertise.** The following table provides list of ATR Team disciplines and expertise required for the Neuse River Basin ATR team. The expertise represented on the ATR team reflects the significant expertise involved in the work effort, and in general, mirrors the expertise on the PDT. ATR Team members were determined by the RMO, in cooperation with the PDT, vertical team, and other centers of expertise, The names, organizations, contact information, credentials, and years of experience of the ATR members are included in Attachment 1.

ATR Team Members/Disciplines	**Expertise Required**
ATR Lead	The ATR lead should be a senior professional with extensive experience in preparing Civil Works decision documents and conducting ATR. The lead should also have the necessary skills and experience to lead a virtual team through the ATR process. The ATR lead may also serve as a reviewer for a specific discipline (such as planning, economics, environmental resources, etc).
Planning	The Planning reviewer should be a senior water resources planner with experience in Ecosystem Restoration Planning and familiar with applicable USACE plan formulation standards and procedures. Additionally, the team member will be experienced in Environmental Benefits Analysis modeling as it relates to the proposed measures for this study.
Cost Engineering	Team member will be an expert in Cost Engineering analyses for Ecosystem Restoration studies and have a thorough understanding of requirements based on study objectives and proposed measures.
Environmental Resources	Team member will be experienced in the field of estuarine, freshwater, and barrier island ecosystems as they relate to the proposed study measures. Specifically, the team member should be knowledgeable of salt marsh and submerged aquatic vegetation communities, as well as be familiar with all National Environmental Policy Act (NEPA) requirements.

Real Estate	The RE team member must be able to review the real estate plan and the real estate aspects of the planning documents, being familiar with and having expertise in the real estate planning process for cost shared and federal civil works projects, relocations, navigational servitude issues, report preparation and the reviewing and acquisition of real estate interests.
Hydrology & Hydraulics	Team member will be an expert in the field of hydrology & hydraulics and have a thorough understanding of specific requirements based on study objectives and proposed measures – for example, knowledge of watershed hydrology, channel dynamics, enclosed sound systems, and application of measures for fetch reduction within the Sound, etc. Additionally, the team member will be experienced in computer modeling techniques that will be used such as ADCIRC, CH3D, CE-QUAL-ICM, etc.

c) Documentation of ATR. DrChecks review software has been used to document all ATR comments, responses and associated resolutions accomplished throughout the review process. Comments should be limited to those that are required to ensure adequacy of the product. The four key parts of a quality review comment will normally include:

(1) The review concern – identify the product's information deficiency or incorrect application of policy, guidance, or procedures;

(2) The basis for the concern – cite the appropriate law, policy, guidance, or procedure that has not be properly followed;

(3) The significance of the concern – indicate the importance of the concern with regard to its potential impact on the plan selection, recommended plan components, efficiency (cost), effectiveness (function/outputs), implementation responsibilities, safety, Federal interest, or public acceptability; and

(4) The probable specific action needed to resolve the concern – identify the action(s) that the reporting officers must take to resolve the concern.

In some situations, especially addressing incomplete or unclear information, comments may seek clarification in order to then assess whether further specific concerns may exist.

The ATR documentation in DrChecks includes the text of each ATR concern, the PDT response, a brief summary of the pertinent points in any discussion, including any vertical team coordination (the vertical team includes the district, RMO, MSC, and HQUSACE), and the agreed upon resolution. If an ATR concern cannot be satisfactorily resolved between the ATR team and the PDT, it will be elevated to the vertical team for further resolution in accordance with the policy issue resolution process described in either ER 1110-1-12 or ER 1105-2-100, Appendix H, as appropriate. Unresolved concerns can be closed in DrChecks with a notation that the concern has been elevated to the vertical team for resolution.

At the conclusion of each ATR effort, the ATR team will prepare a Review Report summarizing the review. Review Reports will be considered an integral part of the ATR documentation and shall:

- Identify the document(s) reviewed and the purpose of the review;
- Disclose the names of the reviewers, their organizational affiliations, and include a short paragraph on both the credentials and relevant experiences of each reviewer;
- Include the charge to the reviewers;
- Describe the nature of their review and their findings and conclusions;
- Identify and summarize each unresolved issue (if any); and
- Include a verbatim copy of each reviewer's comments (either with or without specific attributions), or represent the views of the group as a whole, including any disparate and dissenting views.

ATR may be certified when all ATR concerns are either resolved or referred to the vertical team for resolution and the ATR documentation is complete. The ATR Lead will prepare a Statement of Technical Review certifying that the issues raised by the ATR team have been resolved (or elevated to the vertical team). A Statement of Technical Review should be completed, based on work reviewed to date, for the AFB, and final report. A sample Statement of Technical Review is included in Attachment 2.

6. INDEPENDENT EXTERNAL PEER REVIEW (IEPR)

IEPR may be required for decision documents under certain circumstances. IEPR is the most independent level of review, and is applied in cases that meet certain criteria where the risk and magnitude of the proposed project are such that a critical examination by a qualified team outside of USACE is warranted. A risk-informed decision, as described in EC 1165-2-209, is made as to whether IEPR is appropriate. IEPR panels will consist of independent, recognized experts from outside of the USACE in the appropriate disciplines, representing a balance of areas of expertise suitable for the review being conducted. There are two types of IEPR:

- Type I IEPR. Type I IEPR reviews are managed outside the USACE and are conducted on project studies. Type I IEPR panels assess the adequacy and acceptability of the economic and environmental assumptions and projections, project evaluation data, economic analysis, environmental analyses, engineering analyses, formulation of alternative plans, methods for integrating risk and uncertainty, models used in the evaluation of environmental impacts of proposed projects, and biological opinions of the project study. Type I IEPR will cover the entire decision document or action and will address all underlying engineering, economics, and environmental work, not just one aspect of the study. For decision documents where a Type II IEPR (Safety Assurance Review) is anticipated during project implementation, safety assurance shall also be addressed during the Type I IEPR per EC 1165-2-209.
- Type II IEPR. Type II IEPR, or Safety Assurance Review (SAR), are managed outside the USACE and are conducted on design and construction activities for hurricane, storm,

and flood risk management projects or other projects where existing and potential hazards pose a significant threat to human life. Type II IEPR panels will conduct reviews of the design and construction activities prior to initiation of physical construction and, until construction activities are completed, periodically thereafter on a regular schedule. The reviews shall consider the adequacy, appropriateness, and acceptability of the design and construction activities in assuring public health safety and welfare.

a. **Decision on IEPR.** A final risk informed decision analysis has been performed and a decision has been made by the District that performance of IEPR is not necessary based on criteria in EC 1165-2-209 and the information provided in section 3 (above). No significant threat to human life is anticipated, and current expectations are that Type II IEPR will not be required. A final determination concerning the requirement/need for a Type II IEPR will be made and documented in the Review Plan that addresses the project design/construction phase. An exclusion from Type I IEPR has been granted for this study for reasons documented below:

1. Implementation Guidance: The implementation guidance states that activities shall include preparation of a decision document which will contain at a minimum: Plan Formulation Analysis, an Incremental Analysis/Cost Effectiveness Analysis, the Appropriate National Environmental Policy Act Documentation, and the Results of Agency Technical Review and Independent External Peer Review to justify proceeding with the Selected Plan. All of these elements have been addressed except the Independent External Peer Review which is discussed below.

2. Draft Engineer Circular 1165-2-209 Requirements: Prior to issuance of this Engineering Circular this study was given a waiver from external peer review (Neuse River Basin Restoration Feasibility Study Peer Review Plan 11 October 2007). At the time it was determined that (1) no influential scientific information will be produced by the study and (2) the risk was assessed as low. Since that time, these factors are still relevant. Factors that trigger an Independent External Peer Review described in the Engineer Circular and their relevance to this project are discussed below.

3. According to Engineer Circular 1165-2-209, Appendix D, any of the following factors trigger the requirement for a Type I Independent External Peer Review:

   a) Significant threat to human life. None of the various components recommended for restoration in the Neuse River Basin present a risk to human life. Modification to an existing weir on Little River, stabilization of shoreline in the Neuse River Estuary, and construction of oyster reef habitat in the Neuse River Estuary do not present a risk to human life.

   b) Total project cost greater than $45 million. The current cost estimate is less than $45 million. Final cost estimates will be reviewed by the Cost Estimating Center of Expertise at Walla Walla District.

   c) Request by the State Governor. There has been no request for Independent External Peer by the Governor of North Carolina.

   d) Request by a State or Federal Agency. There has been no request for Independent External Peer Review by any State or Federal Agency.

e) Significant public dispute. There is no significant public dispute. Based on public scoping, the U.S. Army Corps of Engineers (Corps) determined that an Environmental Impact Statement is not necessary and are preparing a draft Environmental Assessment.

f) Methods are novel or complex. Modifying the existing weir to improve fish passage is not novel. Shoreline stabilization in the estuary is not novel. Finally, construction of oyster reef habitat is also not novel. Similar projects have been implemented by the Corps and other agencies.

g) Chief of Engineers determines Independent External Peer Review is necessary. To date, the Chief of Engineers has not determined that Independent External Peer Review is necessary.

The proposed project does not meet the criteria for conducting Type I IEPR as described in Paragraph 2 of Appendix D of EC 1165-2-209.

7. POLICY AND LEGAL COMPLIANCE REVIEW

All decision documents will be reviewed throughout the study process for their compliance with law and policy. Guidance for policy and legal compliance reviews is addressed in Appendix H, ER 1105-2-100. These reviews culminate in determinations that the recommendations in the reports and the supporting analyses and coordination comply with law and policy, and warrant approval or further recommendation to higher authority by the South Atlantic Division Commander. DQC and ATR augment and complement the policy review processes by addressing compliance with pertinent published Army policies, particularly policies on analytical methods and the presentation of findings in decision documents.

8. COST ENGINEERING DIRECTORY OF EXPERTISE (DX) REVIEW AND CERTIFICATION

All decision documents shall be coordinated with the Cost Engineering DX, located in the Walla Walla District. The Cost Engineering DX will assist in determining the expertise needed on the ATR team and Type I IEPR team (if required) and in the development of the review charge(s). The DX will also provide the Cost Engineering DX certification. The ECO PCX is responsible for coordination with the Cost Engineering DX.

9. MODEL CERTIFICATION AND APPROVAL

EC 1105-2-412 mandates the use of certified or approved models for all planning activities to ensure the models are technically and theoretically sound, compliant with USACE policy, computationally accurate, and based on reasonable assumptions. Planning models, for the purposes of the EC, are defined as any models and analytical tools that planners use to define water resources management problems and opportunities, to formulate potential alternatives to address the problems and take advantage of the opportunities, to evaluate potential effects of alternatives and to support decision making. The use of a certified/approved planning model does not constitute technical review of the planning product. The selection and application of the model and the input and output data is still the responsibility of the users and is subject to DQC, ATR, and IEPR (if required).

EC 1105-2-412 does not cover engineering models used in planning. The responsible use of well-known and proven USACE developed and commercial engineering software will continue and the professional practice of documenting the application of the software and modeling results will be followed. As part of the USACE Scientific and Engineering Technology (SET) Initiative, many engineering models have been identified as preferred or acceptable for use on Corps studies and these models should be used whenever appropriate. The selection and application of the model and the input and output data is still the responsibility of the users and is subject to DQC, ATR, and IEPR (if required).

Planning Models. The following planning models are anticipated to be used in the development of the decision document: A series of planning and biological models were used in this study. In accordance with EC 1105-2-412, IWR Plan was used to establish cost effective alternatives and compare the incremental cost benefits of alternatives. The planning and biological models used to quantify environmental benefits have completed ATR as recommended by the Ecosystem (ECO) PCX. The District is coordinating with the ECO PCX to determine what needs to be done to complete model approval. The information presented in this section will be presented at the Alternative Formulation Briefing for discussion and support in granting approval of these models for use in this study.

A description of each of the models and the results of technical review follow. Application of these models in the field and in the office was done by a team of qualified biologists in the USACE Wilmington District with more than 70 years of combined experience.

North Carolina Wetland Assessment Method (NC WAM). Environmental benefits resulting from wetlands restoration opportunities were assessed using NC WAM Version 2.0 (NCDENR 2009), which is a rapid, reference-based functional assessment method. NC WAM was developed by a state and federal interagency team consisting of NCDOT, NCDENR, USEPA, USFWS, and the USACE. The method provides functional ratings for up to 3 major functions and 10 subfunctions, depending on the wetland type being assessed. Functions are evaluated using up to 22 field and GIS-based metrics, which include the soil, hydrologic, vegetative, and landscape characteristics of the assessment area. Functional ratings are then determined based on an iterative, Boolean logic process.

Three types of wetland are being assessed in this study—bottomland hardwood forest, estuarine woody wetland, and salt/brackish marsh. As per the assessment methodology, for bottomland hardwood forest sites, all functions and subfunctions (with the exception of the subfunction "pollution change") are measured by the assessment. For estuarine woody wetland, the hydrology main function and the habitat function and subfunctions are measured. For the salt/brackish marsh, only the hydrology and habitat main functions (no subfunctions) are measured.

The PDT made some modifications to the standard NC WAM outputs so that they could be useable in this study. This analysis requires that quality be measured numerically. NC WAM, however, does not provide numerical outputs; instead it gives each function and subfunction a rating of Low, Medium, or High. Therefore, the PDT assigned each function or subfunction rating an index score of 0.1 (Low), 0.5 (Medium), or 1.0 (High). For wetland classes that measure subfunctions, the subfunction scores are averaged to determine a score for the primary function. Because there was no clear scientific basis for differentially weighting subfunctions, each subfunction was given equal weight in determining the primary function score. For instance, the hydrology function consists of two subfunctions—surface storage and retention, and subsurface storage and retention. If, for instance, the scores for these subfunctions are 0.1 and 0.5, the score for the hydrology primary function will be 0.3. The primary functions scores are then averaged together to give a wetland functional index score for the site.

In an April 2010 ATR, Tim Wilder of the Engineer Research Development Center (ERDC) reviewed the model to determine if it was appropriate for use in this study. The reviewer determined that it was inappropriate to use the qualitative model in a quantitative way. Unfortunately, other models of wetland function and habitat developed specifically for North Carolina are currently not available. This model is currently being used by various Federal, State and local agencies (including the US Fish and Wildlife Service and USACE Regulatory Division) on decisions regarding wetland activities. The District would like to maintain use of this model for this application and will provide further documentation regarding the potential range of environmental outcomes that exist based on the way the model was applied. A sensitivity of the results is discussed in the Feasibility Report to support use of this model application. At the Alternative Formulation Briefing, the District will present the results of the sensitivity analysis and describe the pros- and cons- of using this tool versus other regional models. In the interim, further discussions will be coordinated with ERDC and the ECO PCX to present the sensitivity analysis.

North Carolina Stream Habitat Evaluation Method (NC SHEM). Stream restoration opportunities were assessed using the stream habitat evaluation procedure as outlined in the Internal Technical Guide for Stream Work in North Carolina (NCDENR 2001), which was developed by the NCDWQ, the North Carolina Division of Land Resources, and the USACE. The method evaluates streams based on seven or eight variables (depending on ecoregion location). The variables measure aspects of riparian condition, channel modification, and instream habitat. Each variable is assigned a numerical score based on field observations and measurements, and some variables have higher maximum scores than others. A total functional score for the stream segment is calculated by adding together the individual variable scores, with the highest possible total score equaling 100. For the purpose of the EBA, the total score was divided by 100 to generate a stream functional index score.

Craig Fischenich of ERDC conducted ATR of this model to determine if it was appropriate for use in this study in April 2010. The review determined that this model was generally appropriate for use in this study. The description of this model application was updated in the report to discuss risk and uncertainty in the environmental benefits analysis. The model shortcomings and areas of uncertainty in the model and analysis were described and a sensitivity analysis was conducted to show a potential range of environmental outputs. This information will be described during the Alternative Formulation Briefing.

Habitat Evaluation Procedure for Oyster Reef Habitat. Estuarine reef restoration opportunities were evaluated using a USFWS HEP in which the quality of habitat is multiplied by the quantity of habitat to establish environmental benefit. The quality of habitat is defined by a Habitat Suitability Index (HSI) for a target species. The American oyster was the target species because a healthy oyster population is considered a keystone indicator of the ecological health of the estuary (NCDMF 2001). Ecological health is dependent on oysters because they are the ecosystem's "engineers" that build reefs (Jones et al. 1994). For the purpose of this assessment, HSI and Habitat Units (HUs) as described in the HEP model will be referred to as the "Functional Index" and "Functional Units," respectively. The HSI model Gulf of Mexico American Oyster, developed by the USFWS (Cake 1983), was applied. Although this model was developed for the Gulf of Mexico, it can be applied in specific Atlantic coast habitats. The Neuse Estuary OGA is similar to the Gulf of Mexico; it supports subtidal American oysters Crassostrea virginica in waters that are less than 33 ft deep and experiences a small mean diurnal tidal variation. All oyster life requisites were confirmed as appropriate through a review of literature regarding Atlantic coast oyster populations (Kennedy et. al 1996).

This HSI model has a larval and adult component and assesses six variables. The variables measure reef structure, water column conditions, and oyster abundance to determine site suitability for both adult oysters and larvae. Killing events (V5) were defined to address issues in the Basin—low salinity and low dissolved oxygen events (Burkholder et al. 2004, Lenihan et al. 1998).

David Schulte of the Norfolk District conducted an ATR on the Habitat Evaluation Procedure for Oyster Reef Habitat. He concluded that the application of this certified model was appropriate for use and conservative in its definition of killing events caused by low dissolved oxygen. This application errs on the conservative, thus increasing the likelihood for oyster recruitment.

Total Benefits Output. For each alternative at each site, a total Average Annual Functional Unit (AAFU) was calculated. The total AAFU was calculated as the sum of the AAFUs for the wetland, stream, and oyster components at each site. The different ecosystem components are given equal weight in this calculation, so as to not give "preference" for one type over another. AAFUs are calculated by determining the functional units at each project year, adding these together, and dividing by the project life (50 years). For alternatives or sites where benefits are not expected to change over the project life, the AAFU is the same as the benefits measured for year 0 (immediately following construction). The total AAFU benefit for an alternative is the difference between the AAFU calculated for that alternative (with project) and the AAFU calculated for the no-action plan (without project).

Model Name and Version	Brief Description of the Model and How It Will Be Applied in the Study	Certification / Approval Status
NC WAM Version 2.0	Environmental benefits resulting from wetlands restoration opportunities were assessed using NC WAM Version 2.0 (NCDENR 2009), which is a rapid, reference-based functional assessment method. NC WAM was developed by a state and federal interagency team. The method provides functional ratings for up to 3 major functions and 10	Approved *for Single Use* by HQ Model Certification Team on 8/9/11

	subfunctions, depending on the wetland type being assessed. Functions are evaluated using up to 22 field and GIS-based metrics, which include the soil, hydrologic, vegetative, and landscape characteristics of the assessment area. Functional ratings are then determined based on an iterative, Boolean logic process.	
NC SHEM	Stream restoration opportunities were assessed using the stream habitat evaluation procedure as outlined in the Internal Technical Guide for Stream Work in North Carolina (NCDENR 2001). The method evaluates streams based on seven or eight variables (depending on ecoregion location). The variables measure aspects of riparian condition, channel modification, and instream habitat. A total functional score for the stream segment is calculated by adding together the individual variable scores.	Approved *for Single Use* by HQ Model Certification Team on 8/9/11
HEP Procedure for Oyster HSI	Estuarine reef restoration opportunities were evaluated using a USFWS HEP in which the quality of habitat is multiplied by the quantity of habitat to establish environmental benefit. The quality of habitat was defined by a Habitat Suitability Index (HSI) for the eastern oyster.	Certified

Engineering Models. No Engineering models were used for this study.

10. REVIEW SCHEDULES AND COSTS

I. ATR Schedule and Cost.

REVIEW PHASE	COMPLETION DATE	COST
ATR of FSM Documentation	8/22/07	$18,200
ATR of Models Package (w/ AFB ATR)	3/24/09	$20,000
ATR of AFB Documentation (w/ model ATR)	3/24/09	$20,000
ATR of Draft Feasibility Report	9/27/11	$25,000*
ATR of Final Report	6/18/12	$15,000*

* Estimated costs are based on the actual cost of the ATR for the FSM and AFB Documentation, as well as communication with the PCX Guild.

II. Type I IEPR Schedule and Cost. Not Applicable

III. Model Certification/Approval Schedule and Cost.

The NC WAM and NC SHEM models were approved *for Single Use* by HQ Model Certification Team on 8/9/11 for the Neuse Study. These models are considered "Class 1" models and are not expected to be used in future studies and therefore certification of the models was not requested. At the request of the ECO-PCX, these models underwent review as part of the normal Agency Technical Review of the Alternative Formulation Briefing Report in April 2010. ATR costs for the model review were approximately $20,000.

The USFWS Eastern Oyster Habitat Suitability Index (HSI) Model being utilized for the Habitat Evaluation Procedures (HEP) was approved for use August 13, 2008 (Policy Guidance on Certification of Ecosystem Output Models).

11. PUBLIC PARTICIPATION

Public comments are solicited for the duration of the Study through initiatives such as the initial public scoping meeting, interagency coordination meetings, and the posting of study products and documents on the District website for public access and review. Once completed, the Neuse River Basin feasibility report will be disseminated to resource agencies, interest groups, and the public as part of the National Environmental Policy Act (NEPA) environmental compliance review. The report will include an Environmental Assessment (EA). Public entities and private individuals may also review and comment on draft documents as members of the PDT. All significant and relevant public comments will be provided as part of the review package to Peer Reviewers as they are available and may include but not be limited to: scoping letters, meeting minutes, other received letters, and emails.

12. REVIEW PLAN APPROVAL AND UPDATES

The South Atlantic Division that oversees the home district is responsible for approving the review plan. Approval is provided by the South Atlantic Division Commander. The commander's approval should reflect vertical team input (involving district, MSC, PCX, and HQUSACE members) as to the appropriate scope and level of review for the decision document. Like the Project Management Plan, the Review Plan is a living document and may change as the study progresses. Changes to the review plan should be approved by following the process used for initially approving the plan. In all cases the MSCs will review the decision on the level of review and any changes made in updates to the project.

13. REVIEW PLAN POINTS OF CONTACT

Public questions and/or comments on this review plan can be directed to the following points of contact:

- **Ben Lane** – Project Manager

US Army Corps of Engineers – Wilmington District
CESAW-PM-C
69 Darlington Avenue
Wilmington, NC 28403
Phone: (910) 251-4831 **Fax:** (910) 251-4965
Email: Ben.Lane@usace.army.mil

- **Tomma Barnes** – Lead Planner
  US Army Corps of Engineers – Wilmington District
  CESAW-TS-PE
  69 Darlington Avenue
  Wilmington, NC 28403
  Phone: (910) 251-4728 **Fax:** (910) 251-4965
  Email: Tomma.K.Barnes@usace.army.mil

- **Terry Stratton** – SAD Point of Contact
  US Army Corps of Engineers – South Atlantic Division
  CESAD-PDS
  60 Forsyth Street, Rm. 10M15
  Atlanta, GA 30303
  Phone: (404) 562-5228
  Email: Terry.D.Stratton@usace.army.mil

- **Greg Steele** – ECO PCX Point of Contact
  US Army Corps of Engineers – Eco PCX
  CENAO-WR-PF
  803 Front Street
  Norfolk, VA 23510
  Phone: (757)201-7779
  Email: Gregory.C.Steele@usace.army.mil

ATTACHMENT 1: TEAM ROSTERS

Project Delivery Team

Role	Team Member	Organization
Project Manager	Ben Lane	SAW-PM-C
Lead Planner	Tomma Barnes	SAW-TS-PL
Biologist, Anadromous Fish & NEPA	Hugh Heine	SAW-TS-PE
Biologist, Estuarine Resources	Chuck Wilson	SAW-TS-PE
Cultural Resources	Richard Kimmel	SAW-TS-PE
Coastal/H&H	John Hazelton	SAW-TS-EC
Cost Engineering	Kristin Olsen and John Caldwell	SAW-TS-EE
Geographic Information Specialist	Jim Jacaruso	SAW-TS-EE
Real Estate	Belinda Estabrook	SAS-RE-RP

ATR Team

Role	Team Member
ATR Lead	Michele Gomez
Plan Formulation	Michele L. Gomez GS-12, Biologist/NEPA Baltimore District, Planning Division (CENAB-PL-P)
Environmental	Christopher Spaur GS-12, Ecologist Baltimore District, Planning Division (CENAB-PL-P)
Cost Estimating	James G. Neubauer GS-12, Hydraulic Engineer Walla Walla District, Cost DX (CENWW-EC-X)
Hydrology and Hydraulics	Carey Nagoda GS-12, Hydraulic Engineer Baltimore District, Water Resources Section (CENAB-EN-WW)

Real Estate	Adam L. Oestreich GS-12, Realty Specialist Baltimore District, Real Estate (CENAB-RE-C)

Vertical Team

Wilbert Paynes
USACE South Atlantic Division- Planning Dvision
Atlanta, GA
404-562-5220
Wilbert.v.paynes@usace.army.mil

Bradd Schwictenberg
USACE South Atlantic Division – Regional Integration Team
Washington, DC
202-761-4552
Bradd.r.schwichtenberg@usace.army.mil

ATTACHMENT 2: SAMPLE STATEMENT OF TECHNICAL REVIEW FOR DECSION DOCUMENTS

COMPLETION OF AGENCY TECHNICAL REVIEW

The Agency Technical Review (ATR) has been completed for the Integrated Feasibility Study and Environmental Assessment for Neuse River Basin. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-209. During the ATR, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The ATR also assessed the District Quality Control (DQC) documentation and made the determination that the DQC activities employed appear to be appropriate and effective. All comments resulting from the ATR have been resolved and the comments have been closed in DrChecks^{sm}.

SIGNATURE

Michelle Gomez — Date

ATR Team Leader

CENAB-PL-P

SIGNATURE

Christopher Spaur — Date

Environmental Review Lead

CENAB-PL-P

SIGNATURE

James Neubauer — Date

Cost Estimating Review Lead

CENWW-EC-X

SIGNATURE

Carey Nagoda — Date

Hydrology and Hydraulics Review Lead

CENAB-EN-WW

SIGNATURE

Adam Oestreich

Real Estate Review Lead

CENAB-RE-C

Date

CERTIFICATION OF AGENCY TECHNICAL REVIEW

Significant concerns and the explanation of the resolution are as follows:

As noted above, all concerns resulting from the ATR of the project have been fully resolved.

SIGNATURE

Greg Williams

Chief, Engineering Division

CESAW-TS-EC

Date

SIGNATURE

Elden Gatwood

Chief, Planning and Environmental Branch

CESAW-TSD-PL

Date

ATTACHMENT 3: REVIEW PLAN REVISIONS

Revision Date	**Description of Change**	**Page / Paragraph Number**
1/25/2011	Review Plan revised based on updated guidance; EC 1105-2-410, EC 1165-2-209, and EC 1105-2-412.	Entire report

ATTACHMENT 4. MEMORANDUM FOR REVIEW PLAN APPROVAL, 11 OCT 2007

DEPARTMENT OF THE ARMY
SOUTH ATLANTIC DIVISION, CORPS OF ENGINEERS
60 FORSYTH STREET
RM: 9M15
ATLANTA, GEORGIA 30303

REPLY TO
ATTENTION OF:

CESAD-PDS-P

11 October 2007

MEMORANDUM FOR Wilmington District Commander (CESAW-TS-PF)

SUBJECT: Neuse River Basin Restoration Feasibility Study Peer Review Plan (PRP)

1. References:

a. Memorandum, 5 October 2007, subject: Neuse River Basin Restoration Feasibility Study, National Ecosystem Restoration Center of Expertise (ECO-PCX) Recommendation for Approval of PRP and US Army Corps of Engineers, Wilmington District, Technical Services and Plan Formulation.

b. EC 1105-2-408, "Peer Review of Decision Documents," 31 May 2005.

c. CECW-CP memorandum, 30 March 2007, subject: Peer Review Process.

d. Supplemental information for the "Peer Review Process" memorandum, March 2007 from CECW-P.

2. In accordance with EC 1105-2-408, "Peer Review of Decision Documents," the PRP for the Neuse River Basin Restoration Feasibility Study has been coordinated and developed with the ECO-PCX. The plan as prepared has been reviewed by this office and is approved.

3. We concur with the conclusion that external peer review of this project is not necessary for the following reasons: (1) no influential scientific information will be produced by the study and (2) the risk was assessed as low. The PRP complies with all applicable policy and provides an adequate independent technical review of the plan formulation, engineering, and environmental analyses, and other aspects of the plan development. Non-substantive changes to this PRP do not require further approval.

4. The district should take steps to post the PRP to its web site and to provide a link to the ECO-PCX for their use. Before posting to the web site the names of Corps/Army employees should be removed in accordance with reference 1.d. above.

Appendix P: Engineering Design

Appendix P: Preliminary Design

This appendix will focus on the engineering aspects of the components of the Tentatively Selected Plan, which include restoring the Kinston East Wetland Complex, modifying the low-head dam on the Little River near Goldsboro, stabilizing Gum Thicket Creek and Cedar Creek estuarine shorelines, and constructing new oyster reef habitat.

Restoring the Kinston East Wetland Complex. The general location of this 14.5 acre site is shown in Figure 1. Figure 2 shows an on-ground photo showing current conditions. The grade of the site was apparently raised with hauled-in fill material in preparation for development, but the project did not go forward. The proposed measures consist of regrading the site to the approximate elevation of the adjacent bottomland hardwood forest, and allowing natural revegetation of the site by bottomland hardwood species without replanting trees.

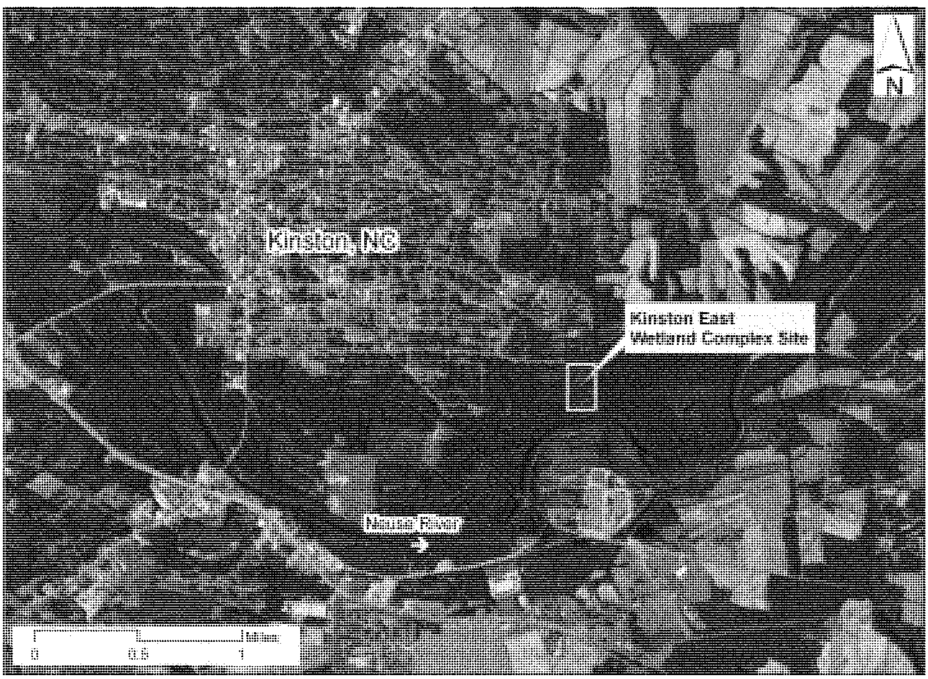


Figure 1. General location map of Kinston East Wetland Complex Site.

Figure 2. Filled area in Kinston; current condition.

The construction contract would be set up in sections. The contractor would be allowed to have limited portions of the site disturbed at any one time. Starting nearest the river and working north toward Lincoln Street, each area would be cleared, grubbed, and brought to final grade, and seeded with either permanent or temporary grass varieties depending on the time of year. During the regrading process and until stabilization with a permanent cover of grass is achieved, sediment control devices will be used to prevent sediment from leaving the site.

Table 1 - Kinston East Wetland Quantities			
Description	Quantity	Unit	Comments
Haul road to site	1,000	lf	24 ft wide, 6 in ABC
Silt fence	10,000	lf	
Clearing and grubbing upland areas	14.5	ac	Entire site
Grade upland to match grade of bottomland hardwood forest	94,000	cy	
Haul away excess material and dispose off-site	94,000	cy	
Temporary seeding	14.5	ac	
Seeding and mulching	14.5	ac	

During Preconstruction Engineering and Design (PED), a topographic survey of the proposed restoration area should be accomplished. While there is no indication of any soil contamination, additional investigations will be conducted to determine the historical usage of the site and surrounding areas.

Modifying the Low-head Dam at the Little River near Goldsboro. The general location of the dam is shown in Figure 3. Figure 4 shows a closer view of the relationship between the dam and intake. A ground level photograph is shown in Figure 5. The photograph was taken during the summer, when flow in the Little River is low. The left of the photograph is downstream. The City of Goldsboro seasonally operates a raw water intake upstream of the dam, i.e., to the right of this photograph (see Figure 4).

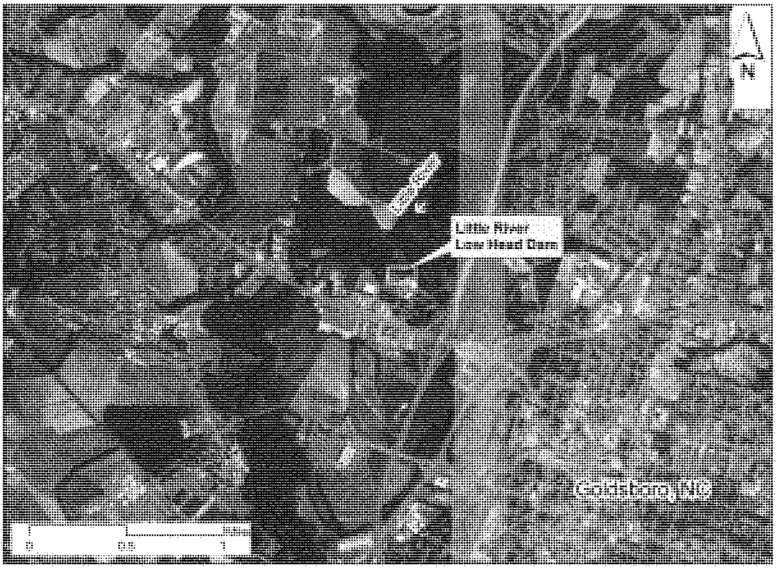


Figure 3. General Vicinity Map of the Little River Low-Head Dam.

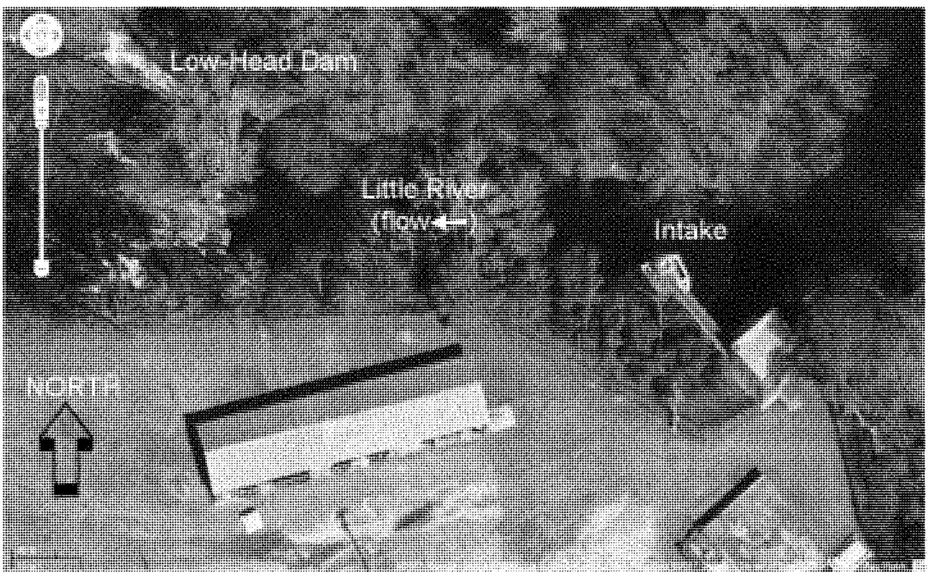


Figure 4. Closer view of current dam and intake configuration.

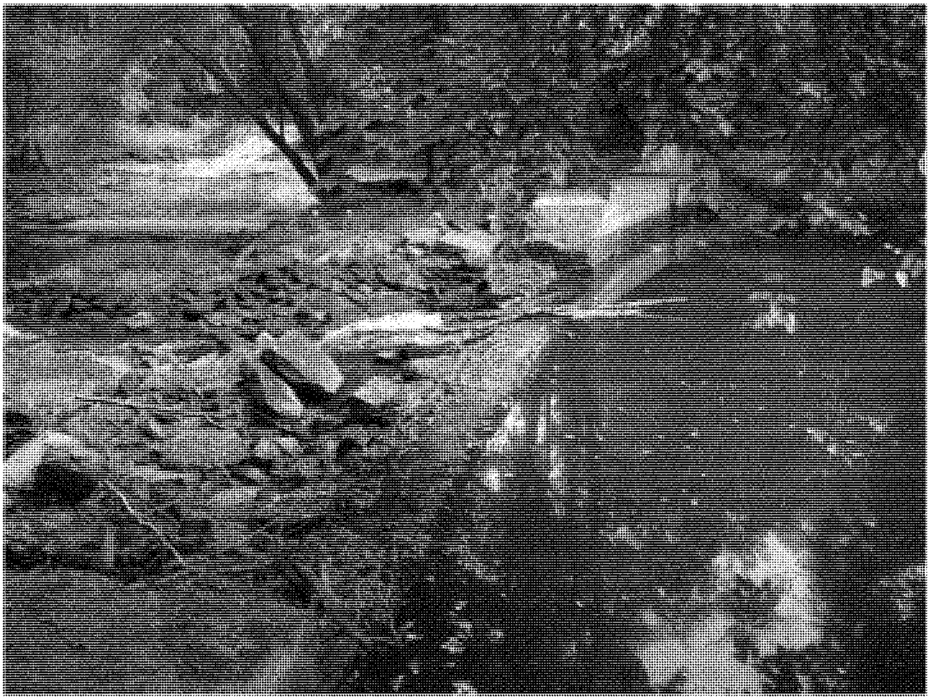


Figure 5. Low head dam on the Little River

The dam is approximately 100 feet long, 4 feet high. A notch approximately 20 feet wide was created earlier. The tentatively selected plan would involve removing an additional portion of the dam to lower the invert of the notch, which may facilitate fish migration. A water control structure will be needed in order to provide sufficient water depth for the operation of the water treatment plant intake structure during the low flow periods in the summer. The water control structure could be a stoplog type closure structure with aluminum stoplogs. An access walkway for workers with safety rails and a toeboard will be provided across the gap with the walking surface at an elevation close to the top of the dam to facilitate the safe installation and removal of the stoplogs. Guides for the stoplogs will be extended to the elevation of the top rail so that the stoplogs can be placed without the necessity for workers to lean over the river. Three to four openings will be provided so that the stoplogs can be placed by two workers. In addition, the photograph shows a considerable amount of debris around the existing notch, probably material that was broken up in creating the original notch, but not removed from the site. The plan would include removal of this debris and erosion control measures to reduce deterioration of the river banks and hydraulic scour at the toe of the dam. A survey of the work area has not been completed; therefore, quantities have been estimated rather than measured.

Table 2 - Little River Dam Quantities			
Description	Quantity	Unit	Comments
Remove concrete from notch	8	cy	Based on 5ft wide x 20 ft long x 2 ft high
Remove broken concrete and debris	16	cy	Based on existing notch appearing to be around 4 ft high in photos
Erosion control for river bottom at notch	600	sf	Preformed concrete blanket product
H-Piles	120	lf	Total of 5 piles to create 4 openings
Aluminum Stoplogs	16	ea	Each 6 ft long x 8 in wide
Access Walkway	1	ls	20 ft long

During the next phase of this project, a survey of the work site, along with subsurface investigations to support alternatives under consideration, should be performed. Also, alternative water control structures should be evaluated to optimize the selection. An inflatable dam is one alternative that could be investigated, others may be stoplog structures of varying opening size and height, gate systems, and still others may be brainstormed during PED. The requirements of the existing water intake structure, along with the effects of the various alternatives on the ponded area, should be analyzed.

A private environmental group has expressed interest in modifying or removing this low-head dam to restore natural flows in this section of Little River. At this point, these interests are in the very preliminary stages of planning, but have potential for further development. We will continue to coordinate with this group as we proceed, but because of their interest, our detailed engineering analysis and design has been minimal to this point.

Stabilizing Gum Thicket Creek and Cedar Creek. The site of the work is shown in Figure 6.

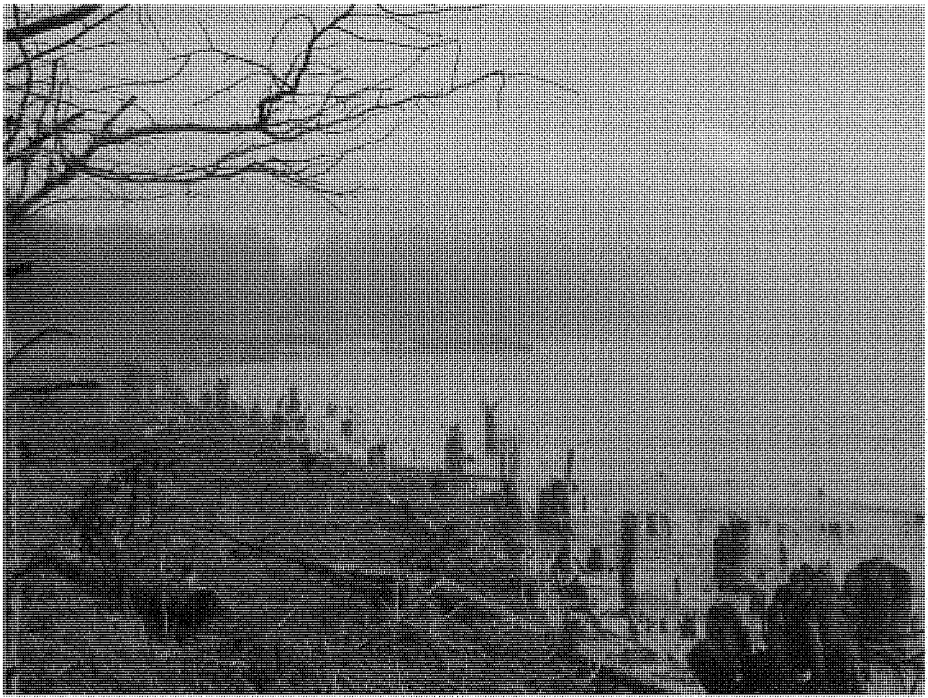


Figure 6. Eroded shoreline of Gum Thicket

The tentatively selected plan for this area would consist of a rock sill parallel to the overall shoreline alignment and high marsh buffer with spartina plantings. A conceptual site plan of the sill is shown in Figure 7 below. Typical sections are shown in Figure 8.

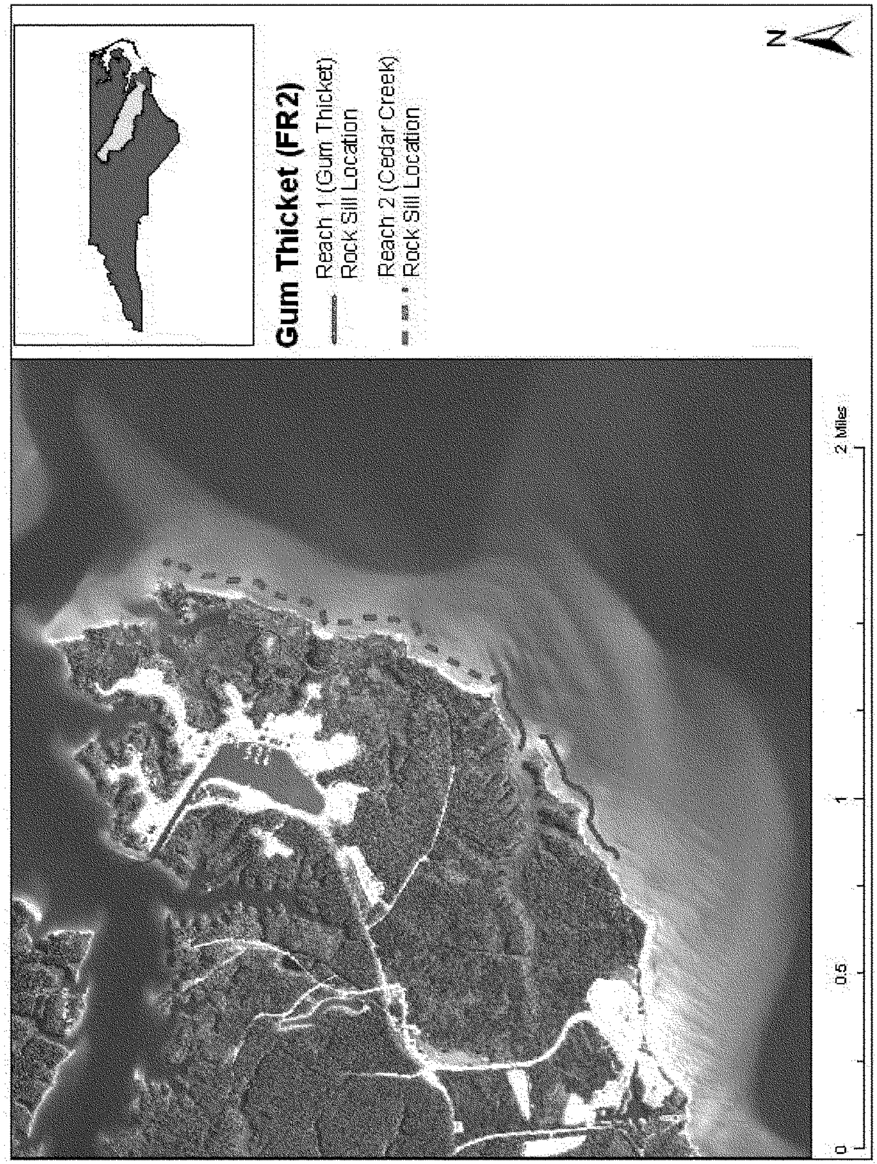


Figure 7. General concept location for proposed rock sill

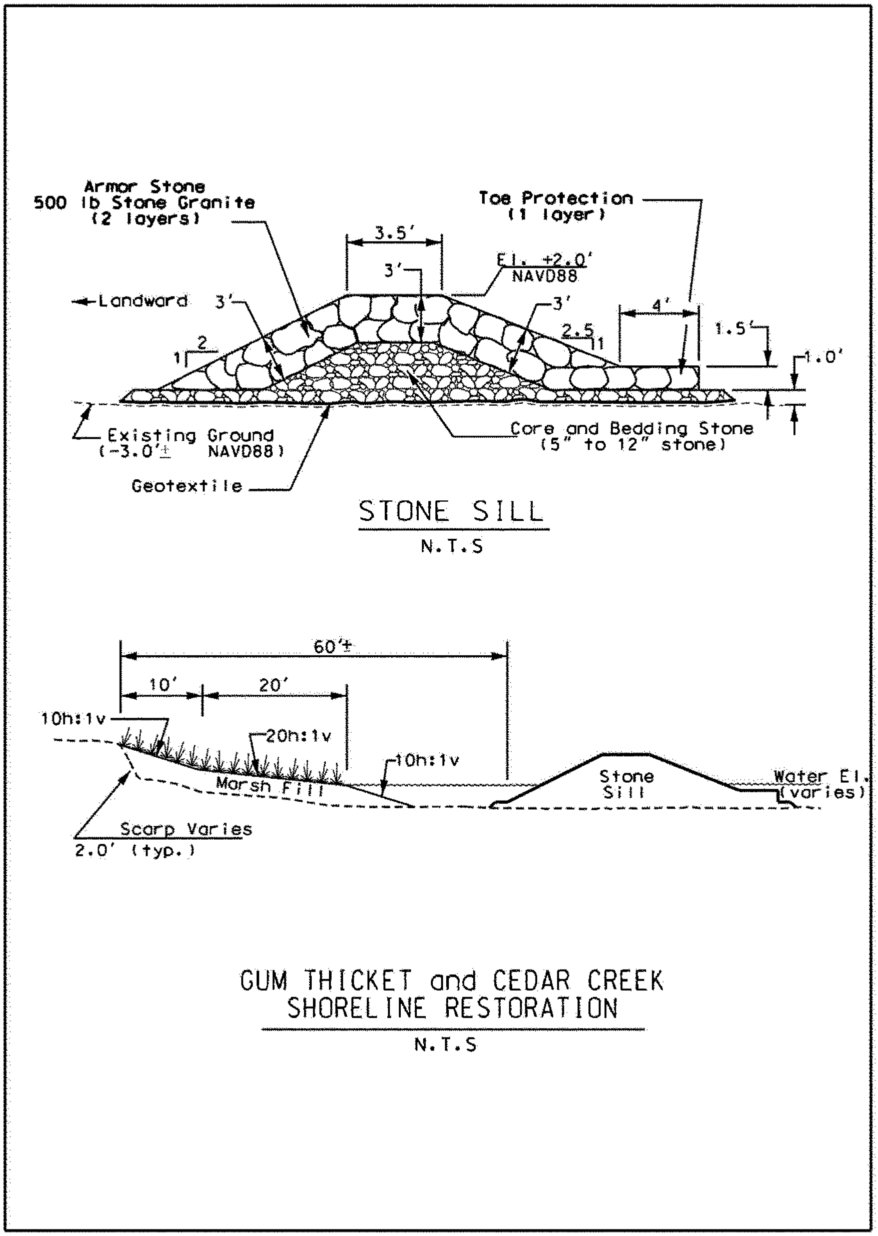


Figure 8. Preliminary cross sections of sill and marsh for Gum Thicket and Cedar Creek

The rock sill, marsh areas and oyster reefs work together to provide wave protection to stabilize the shoreline. The rock sill and oyster reefs knock down the normal everyday waves allowing the vegetated marsh to provide protection when higher water levels and waves overtop the rock sill during less frequent events.

Water level data in this area of the Neuse Estuary are very sparse. The water levels are primarily driven by wind direction and intensity in the sounds. Astronomical tides are inconsequential in this area due to the shallow nature of the estuary and the varying intensity and direction of the short term winds. Normal water level range is about plus/minus 1 ft from average water level as shown in Figure 9 (*Water level variations in the Neuse and Pamlico Estuaries*... Reed, Dickey ... 2007). Unfortunately, this data set is not tied to a vertical datum.

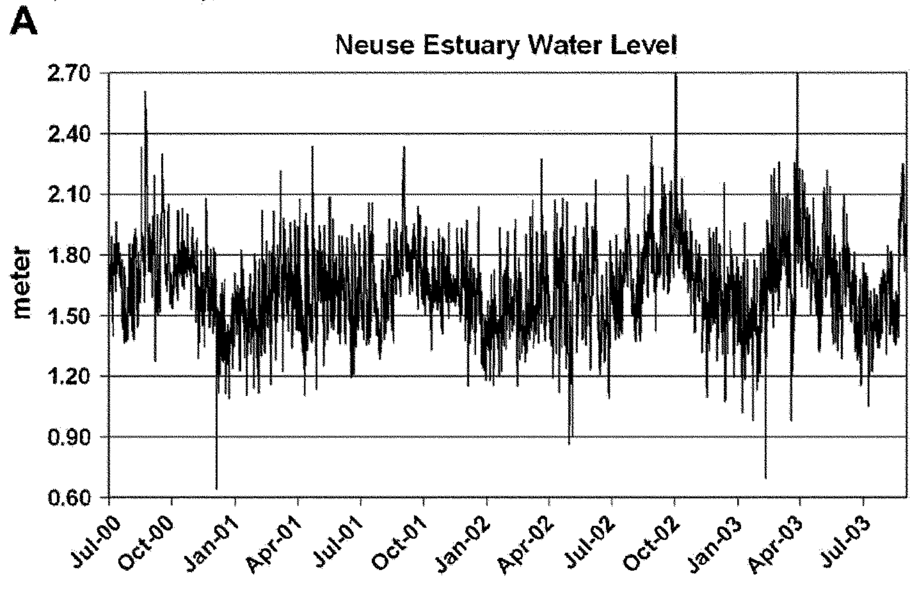


Figure 9. Graphic from referenced report (Reed, Dickey, et.al 2007) showing normal water level range of about plus/minus 0.3 meters or about 1 foot. Data is not tied to a datum.

The nearest tidal station is located about 17 miles to the west of the site within the southern portions of Pamlico Sound at Cedar Island (NOAA Station 8655151)..This station has a small mean tide range of 0.37 ft. A VDATUM study for central coastal North Carolina (NOAA Technical Report NOS CS 21, December 2005) shows that the tidal range along the project area is about the same as the Cedar Island vicinity. Further, this study established a gridded Topography of the Sea Surface (TSS) for the region. The TSS is defined as the elevation of the North American Vertical Datum of 1988 (NAVD88) relative to local mean sea level (LMSL). The results generally show that LMSL is about 13 cm (0.42 ft) below NAVD88 for the outer ocean area, but is slightly above (1-2 cm (0.03-0.06 ft)) for the sounds. Specifically, the computed relationship for Cedar Island is that NAVD88 is 0.3 cm (0.01 ft) below LMSL. Therefore, it is assumed that for the present study NAVD88 and LMSL are the same. The information is shown graphically in Figure 10.

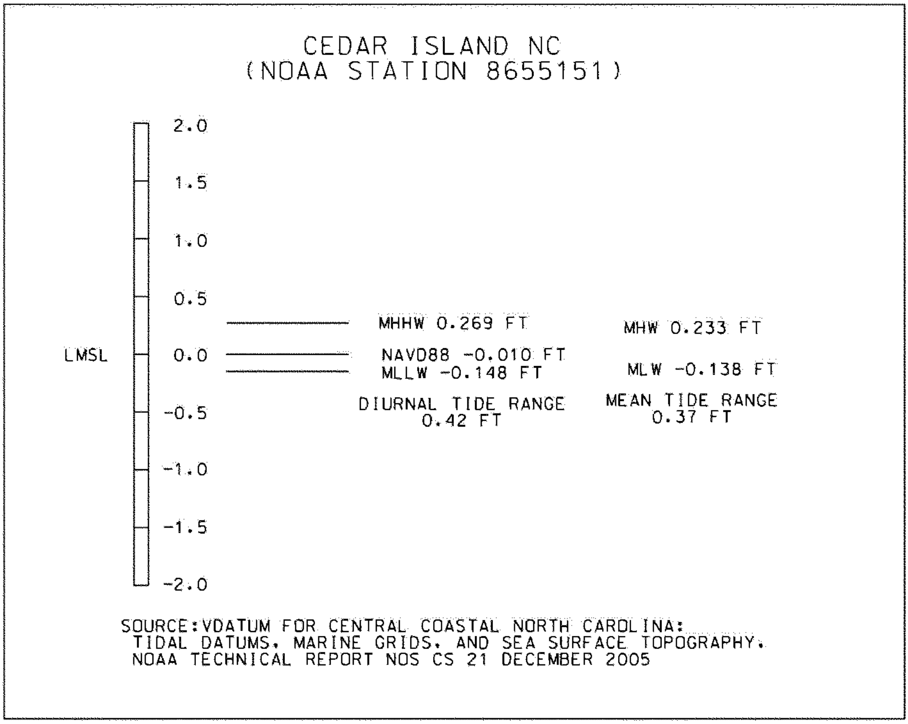


Figure 10. Tidal Datum relationships for Cedar Island NOAA Station 8655151 relative to Local Mean Sea Level (LMSL).

A wave transmission analysis was done to assess the sill crest elevation. Wave transmission through and over the sill was analyzed using the van der Meer and d'Angremond (1991) formula for low-crested, submerged, and reef breakwaters, as presented in the CEM. The results are summarized graphically as shown in Figure 11 showing a range of transmitted wave heights for a varying water level and three crest elevations. A 4 foot incident design wave height was used for all cases. The selection of the design wave height is discussed in Addendum 1 to this appendix. In assessing the function of the sill, it is assumed that the transmitted wave height should be 1.0-1.5 ft or less for the marsh shoreline to sustain itself. General observations throughout the exposed sound areas indicate that regular waves above this threshold cause active erosion of the marsh areas. The graph shows transmitted wave heights for crest elevations of +2 ft, +1 ft and 0 ft above still water level. Also noted on the graph are the projected 50-yr sea level rise elevations for three scenarios, namely Historic, NRC Curve 1 and NRC Curve 3. The sea level rise scenarios are discussed later in this appendix. The results indicate that for the +1.0 ft and 0.0 ft elevation sills, the transmitted wave height is above 1.5 ft for all still water levels zero and above. Therefore, these are too low to be effective. The +2 ft elevation limits the transmitted wave height of 1.5 ft for still water levels up to just above 1.0 ft. This elevation appears to be adequate without being to excessive and is selected for design.

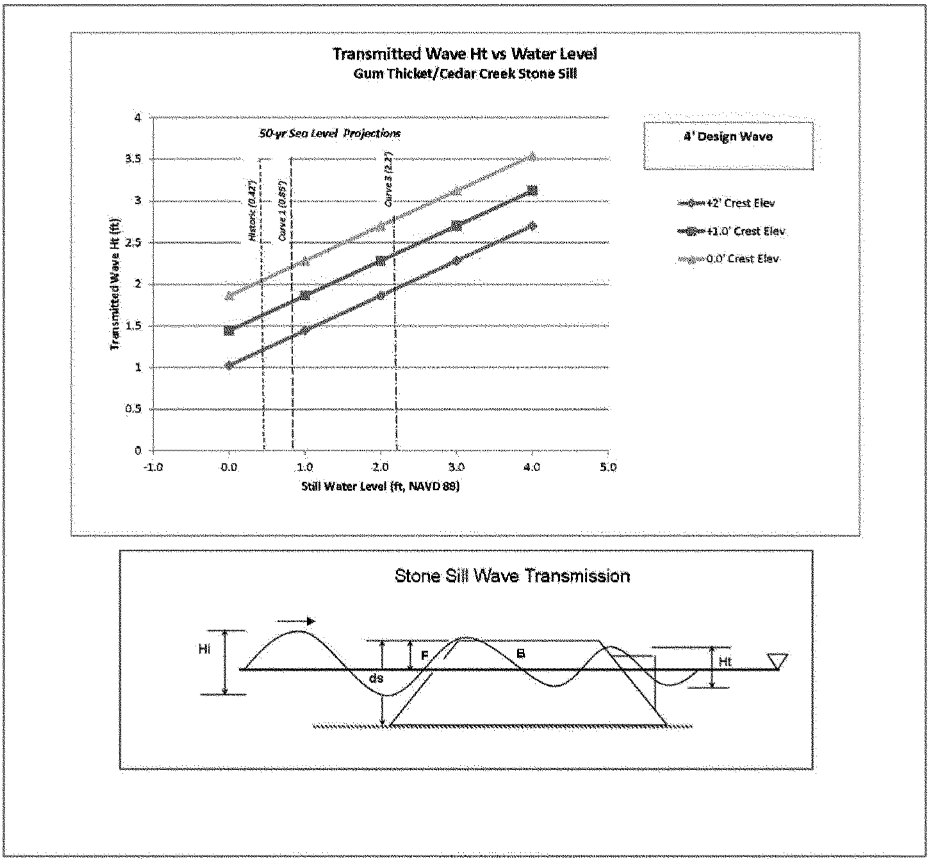


Figure 11. Transmitted Wave Height versus Water Level for various Sill Crest Elevations

Data from the Flood Insurance Study Report: Pamlico County, NC, 2004 was used to estimate the return frequency for the +2.0 ft sill elevation. In the flood insurance report, storm surge stillwater elevations are given for 10-, 50-, 100- and 500-year frequency at various coastal transects. Data for a transect in the area of Gum Thicket/Cedar creek is shown in the graph below (Figure 12). This data is extrapolated to +2 ft NAVD88 for the sill crest which gives about a 1-year return frequency. This elevation and the general rock sill design are similar to other projects in the region which have proven to function adequately (Festival Park on Roanoke Island and Wanchese marsh).

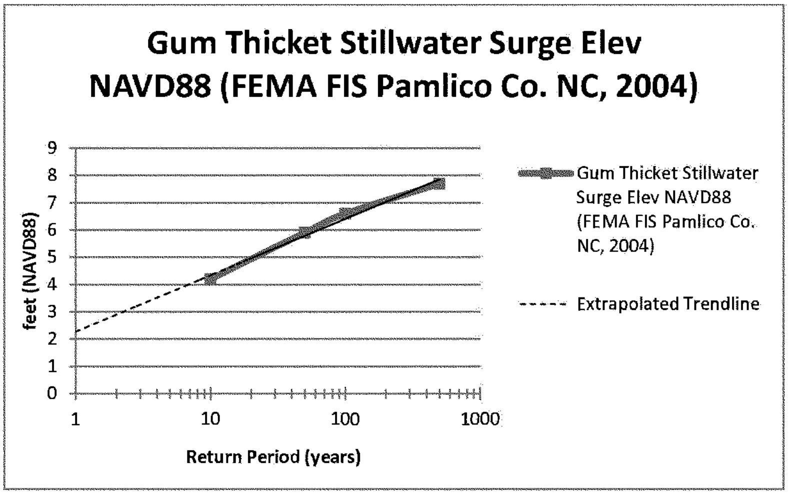


Figure 12. Storm Surge Stillwater Elevations.

Armor stone is sized using Automated Coastal Engineering Software (ACES) tools. The armor is designed to withstand wave forces when water is at the crest of the structure. Survey data is not available to derive the bathymetry of where the sill is to be constructed. Based on NOAA bathymetric charts and local knowledge, the rock sill base is assumed to be constructed at elevation -3.0 ft NAVD88. This gives an overall sill height of 5' and the significant wave height will be depth limited. Based on these design conditions, a stable armor stone of about 500-lbs will be required. See ADDENDUM P-1: Sill Armor Stone Sizing Analysis at the end of this appendix for additional stone sizing details.

The rock sill design consists of core/bedding stone (5 in to 12 in limestone rip rap) underlaid with geotextile fabric and overlaid with 2 layers of granite armor stone with a diameter of about 1.5 ft. Additional quantity of core/bedding stone is included in the estimate to account for an assumed one-foot of settlement. Next phases of this project will include sediment sampling to better estimate settlement expectations for the sill. Additional discussion on settlement is provided in ADDENDUM P-2: Calculation of Soil Settlement for Static Loads.

A survey of the work area has not been completed; therefore, quantities have been estimated rather than measured.

Table 3- Gum Thicket Quantities – 3,500 lf			
Description	Quantity	Unit	Comments
Rock sill armor stone	8,200	cy	Granite, average weight 500 lbs, range from 200 to 1,000 lbs (12,000 tons)
Rock sill core/bedding stone	5,400	cy	Limestone, 5 in to 12 in
Rock sill additional core/bedding stone for settlement	3,500	cy	Limestone, 5 in to 12 in
Fill for marsh buffer	19,000	cy	Based on 2 ft scarp, 10H:1V slope, flattened to 20H:1V in the intertidal zone
Plantings for marsh buffer	2.4	ac	Based on 30 ft planting width
Geotextile	12,000	sy	

Table 4 - Cedar Creek Quantities – 5,200 lf			
Description	Quantity	Unit	Comments
Rock sill armor stone	12,000	cy	Granite, average weight 500 lbs, range from 200 to 1,000 lbs (17,000 tons)
Rock sill core/bedding stone	8,000	cy	Limestone, 5 in to 12 in
Rock sill additional core/bedding stone for settlement	5,000	cy	Limestone, 5 in to 12 in
Fill for marsh buffer	29,000	cy	Based on 2 ft scarp, 10H:1V slope, flattened to 20H:1V in the intertidal zone
Plantings for marsh buffer	3.6	ac	Based on 30 ft planting width
Geotextile	17,000	sy	

At least one stockplile area will be needed. Two existing roads lead nearly to the shoreline. These roads could be extended. The sill would be constructed first. During construction of a sill at Harkers Island, another Wilmington District project, the contractor used equipment that was sized to fit on the top of the sill. The lower part of the sill was constructed with the equipment traveling in one direction on top of the newly placed rock, with the crest being placed as the equipment backed off. This project could be constructed in a similar fashion. The marsh fill could be placed by offroad dump trucks and shaped by dozers, starting by dumping fill material at the end of each road and continuing to expand the fill with succeeding loads, building a fill area that can be driven on by offroad equipment, and bringing it to final grade as the last step. Silt curtains would be used to limit turbidity.

Borrow material for creating the marsh buffer will be available from AIWW Disposal Area 26. Material within the borrow site (DA 26) was classified and lab tested in a 2010 geotechnical investigation. The main purpose of this investigation was to assess the stability of the disposal area in preparation for receiving future dredge disposal material; however, samples were taken within the interior in order to classify existing dredge disposal material for beneficial use. The boring logs and lab data relevant to the beneficial use of this material is included in Attachment 1 to this Engineering Appendix.

A vicinity map is shown in Figure 13. Three active borrow sites are present within AIWW DA-26 and are color-coded for reference (see Figure 14). The north borrow site contains primarily intercalated fine-medium grained, poorly graded sand and slightly silty sand. The thickness of available material ranges from 3 to 10 feet. Where lab tested, the percentage of fines varies from 1-8%, which is primarily from inorganic silt. Borings CC-26-H-09-5, CC-26-H-09-4, AIWW-DA-26-09-14-AU, and AIWW-DA-26-09-6-SS were taken in the vicinity of this area and they approximate the subsurface conditions to be expected. A small central borrow site is located to the south of the northern site. Based upon the available boring information the central site contains fine-medium grained, poorly graded sand and slightly silty sand, which has a silt content that ranges from 1-11%. Based upon boring logs CC-26-H-09-3, CC-26-H-09-4, AIWW-DA-26-09-4-SS, AIWW-DA-26-09-14-AU, and AIWW-DA-26-09-13-AU, the estimated thickness of available material is between 10 to 13 feet. The southern borrow site contains primarily slightly silty fine sand intercalated with fine-medium grained, poorly graded sand. The silt content of this material ranges from 2-11% based upon lab test data and standards of USCS soil classification. The thickness of available material varies from 6 to 14 feet based upon boring data from CC-26-H-09-1, CC-26-H-09-2, AIWW-DA-26-09-1-SS, and AIWW-DA-26-09-10-SS.

Given the limited size and scope of the proposed shoreline restoration, there is probably enough material present within AIWW DA-26 to construct a marsh buffer. Additional survey data to be gathered in the next phases will be used to determine volume requirements for the marsh buffer fill. Material will also be added by maintenance dredging. In addition, material may be available from private and commercial sources in the vicinity of the project.

During the PED phase of the project, a site survey should be completed.

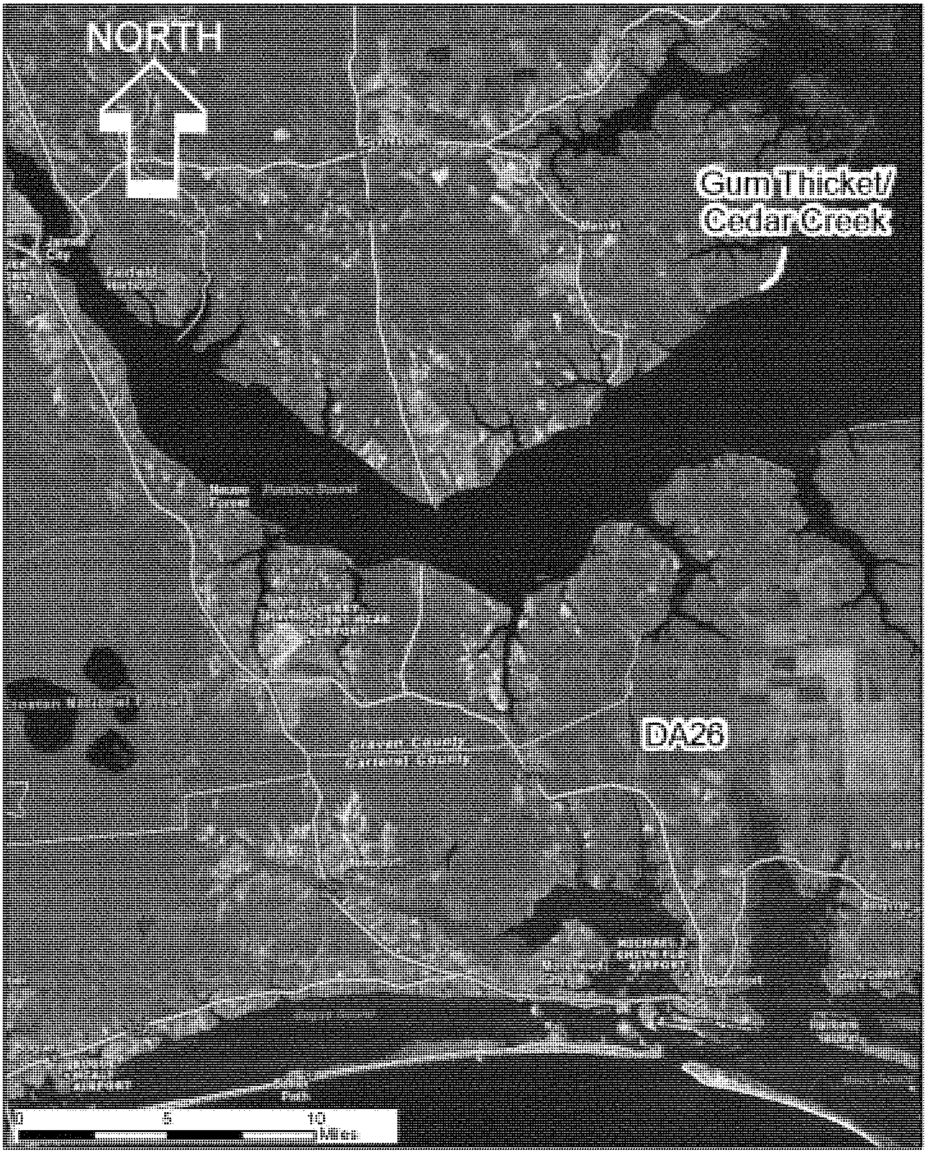


Figure 13. Map showing relationship of DA26 to Gum Thicket/Cedar Creek project site.

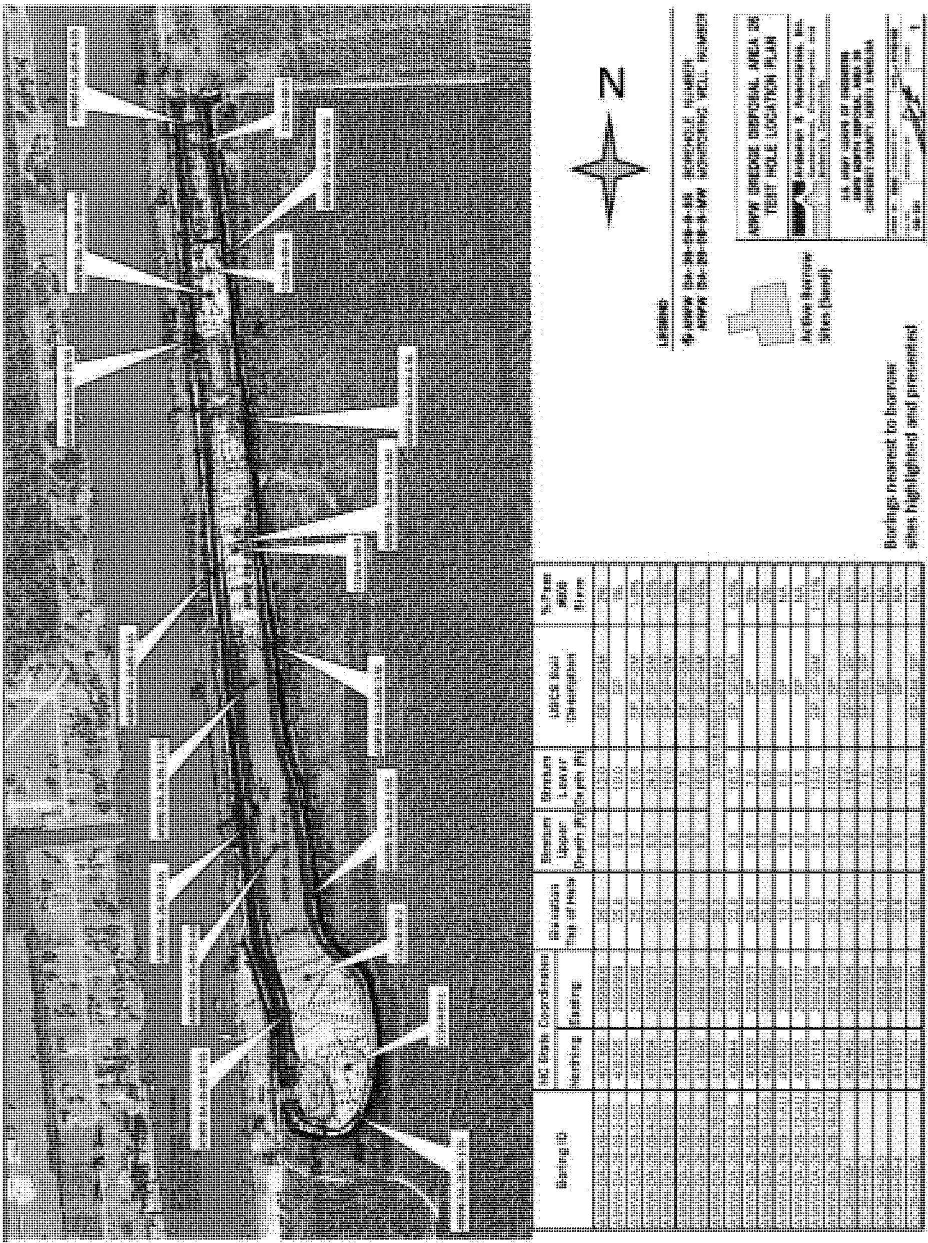


Figure 14. Potential borrow site, DA-26 with pertinent borings identified.

Considerations of Sea Level Rise in sill design. The historic rate of relative sea level rise (SLR) in the Gum Thicket/Cedar Creek area is estimated to be approximately 0.0084 feet/year. This is based on a 53 year tidal water level record at Beaufort Inlet, the closest available long-term gage with complete water level statistics (approximately 22 miles from the project location). The mean sea level trend in the project area is 0.0084 feet/year with a 95% confidence interval of +/- 0.00014 ft/yr based on monthly mean sea level data from 1953 to 2006 which is equivalent to a change of about 0.42 feet in 50 years (Figure 15).

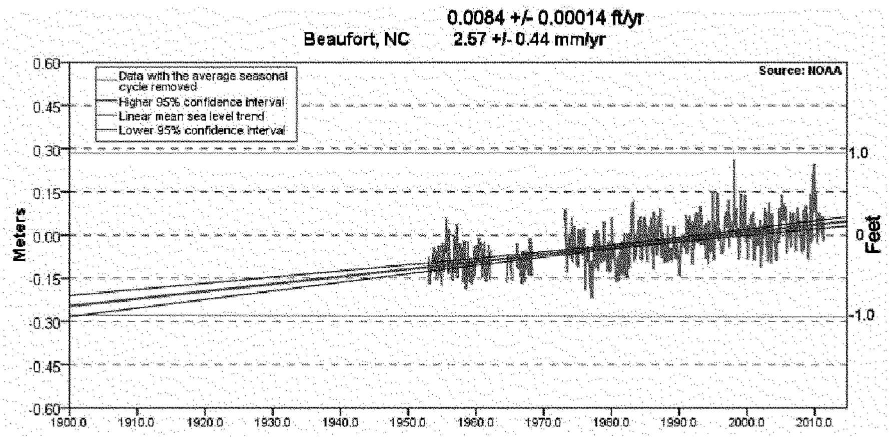


Figure 15. Mean Sea Level Trend Beaufort, NC (Ref: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8656483 Beaufort, NC)

The economic analysis of benefits uses shoreline erosion rates derived from historical aerial photographs and from published reports (Corbett et al. 2008). This report assessed shoreline change using spatially referenced aerial photographs from 1958 and 1998. The shoreline was digitally traced using ESRI GIS and mapping software, ARCGIS. Once the entire shoreline was digitized for the two time periods, the difference in shoreline position was measured at 150-ft intervals along the entire shoreline for the 40-yr period to determine the rate of shoreline change. At Gum Thicket, the historical rate of shoreline erosion averages 9 feet per year. At Cedar Creek the rate is 2 feet per year. Without knowing specifics of topography, soil differences or nearshore bathymetry, the differences could be due to the orientation of shoreline. Gum Thicket shoreline is aligned with open water to the southeast while Cedar Creek is exposed to the east. Accelerated sea level rise scenarios would increase these erosion rates.

The Intergovernmental Panel on Climate Change (IPCC) projects accelerated global warming which corresponds to accelerated sea level rise. USACE guidance (EC 1165-2-212) requires consideration of these various accelerated sea level rise scenarios for water resources projects. The sea level rise scenarios evaluated include 1) the historical rate of sea level rise – from tide data above, 2) projections using the updated National Research Council (NRC) curve 1 – representing global eustatic sea-level rise of 0.5 meters (1.64 feet) by the year 2100, and 3) projections based on NRC curve 3 – representing sea level rise of 1.5 meters (4.92 feet) by the year 2100.

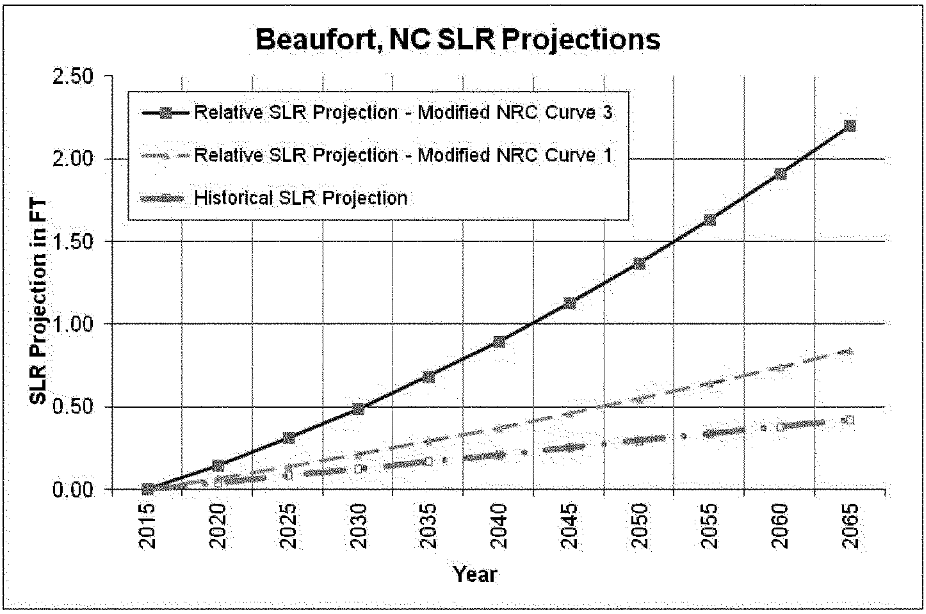


Figure 16. Sea Level Projections using historical rates and modified NRC Curves 1 & 3 rates

The NRC curves 1 and 3 in Figure 16 above have been adjusted to account for local subsidence rates for Beaufort area. These modified NRC curves 1 and 3 project an accelerated sea level rise of 0.85 feet and 2.2 feet 50 years out in the future, respectively, while the historical rate of sea level rise is 0.42 feet.

The sill concept design has a crest elevation of +2 ft. Expected wave transmission for the sill was discussed earlier in the appendix (See Figure 11). The figure included the projected sea level elevations for the three SLR scenarios discussed above. Using the results presented, it is expected that the design will accommodate the historical rise of 0.42 ft and also accommodate a moderate level of accelerated sea level rise of up to about one foot while keeping the typical transmitted waves generally less than about 1.5 feet. As sea levels rise higher, the sill becomes inundated much more often and for that matter, the marsh and low areas behind the sill see high water levels and greater potential for shore erosion. The sill/marsh would provide some erosion protection for the curve 3 scenario at least through the first 25 years while the sea level has risen one foot or so. After that time, the sill would continue to reduce the wave energy; however more frequent overtopping of the structure would allow waves to begin to erode the shoreline. There is not enough data to estimate the shoreline erosion rates that may occur behind a submerged sill (assuming curve 3 after 25 years). The submerged sill will reduce some of the wave energy – helping to slow wave erosion, but the existing low-lying marsh areas will become inundated, moving the shoreline landward at a potentially rapid rate depending upon the topography.

If no erosion protection is provided with a sill and constructed marsh project, the effects of accelerated sea level rise will increase shoreline erosion rates. Because upland topography is unknown in the project area, a proper estimate of projected erosion rates cannot be analyzed. It is assumed for the purpose of economic analysis that the shoreline erosion rates will increase linearly and will be proportional to the accelerated SLR scenarios examined (modified NRC curves 1 and 3) at the year 2065. This assumption is solely for input to the portion of the environmental benefits analysis that speaks to risk and uncertainty due to accelerated SLR scenarios. The primary purpose of the economic analysis was to demonstrate that increased sea level rise and erosion would generally lead to an increase in environmental benefits.

At Gum Thicket, the historical rate of shoreline erosion averages 9 feet per year. At Cedar Creek the rate is 2 feet per year. It is assumed that without a project, the erosion rate will increase 200% in 50 years with modified NRC Curve 1 scenario (from 0.42 feet of historical SLR to 0.85 feet of SLR with Curve 1) and 520% in 50 years with modified NRC Curve 3 scenario (from 0.42 feet of historical SLR to 2.2 feet of SLR with Curve 3). At Gum Thicket, the erosion rate will increase from 9 feet per year to 18 feet per year (curve 1) and to 47 feet per year (curve 3). At Cedar Creek the erosion rate increases from 2 feet per year to 4 and 10.4 feet per year, using curves 1 and 3 respectively.

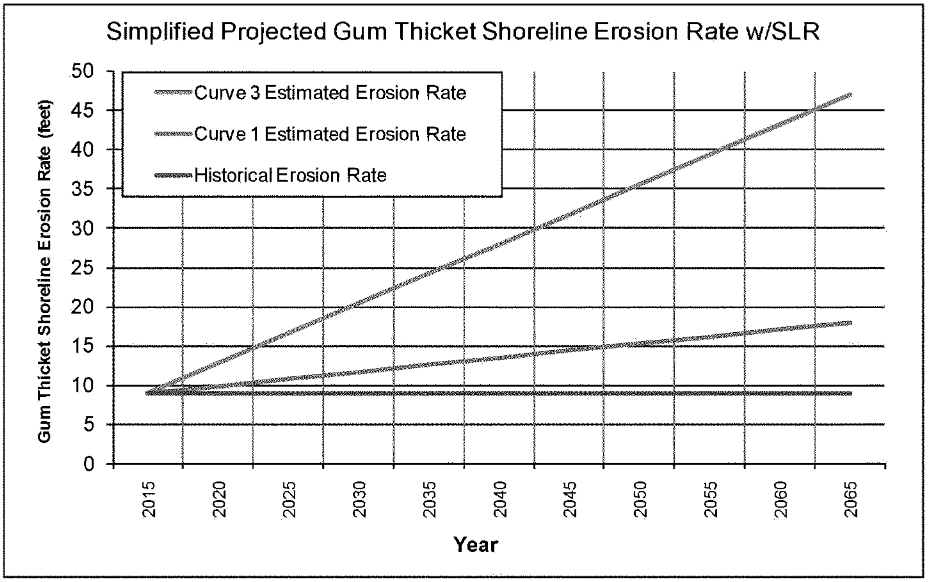


Figure 17. Simplified Projected Gum Thicket shoreline erosion rates based on increase of SLR projections in 50 years.

The above figure shows the projected erosion rates with SLR over the 50 year project life for Gum Thicket using a simplified estimating method. The without-project cumulative erosion distance increases from 450 feet using the historical erosion rate to 671 feet (curve 1) and 1381 feet (curve 3). A figure of projected erosion rates with SLR for Cedar Creek is not shown, but the percentage of erosion rate increase is the same as Gum Thicket. For Cedar Creek the without-project cumulative erosion distance increases from 100 feet using the historical erosion rate to 149 feet (curve 1) and 306 feet (curve 3).

New Oyster Reef Habitat. This component includes about 12 acres of reeftop within 80 acres of service area divided between two locations:

Mid-river site in the Lower Estuary – 40 acres of service area

Neuse Northern Shore – 40 acres of service area

See Figure 18 for possible locations for the oyster growing areas.

NEUSE ESTUARY OYSTER GROWING AREA (OGA)
Round 3 Evaluation Areas for IWR Plan

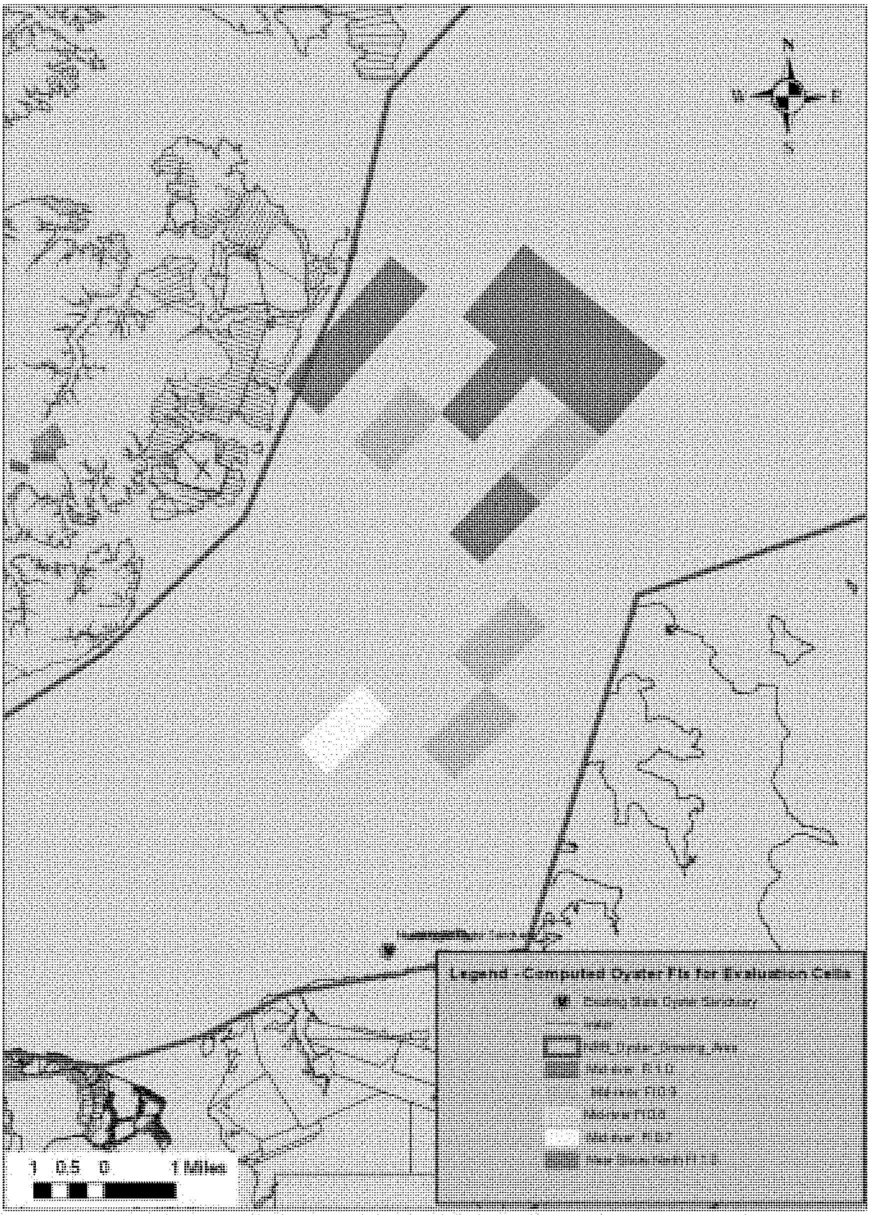


Figure 18. Neuse Estuary Oyster Growing Area

Figure 19 displays a conceptual plan of the typical reef. The 4-foot height indicated is for initial construction and includes an allowance of 1-foot for settlement.

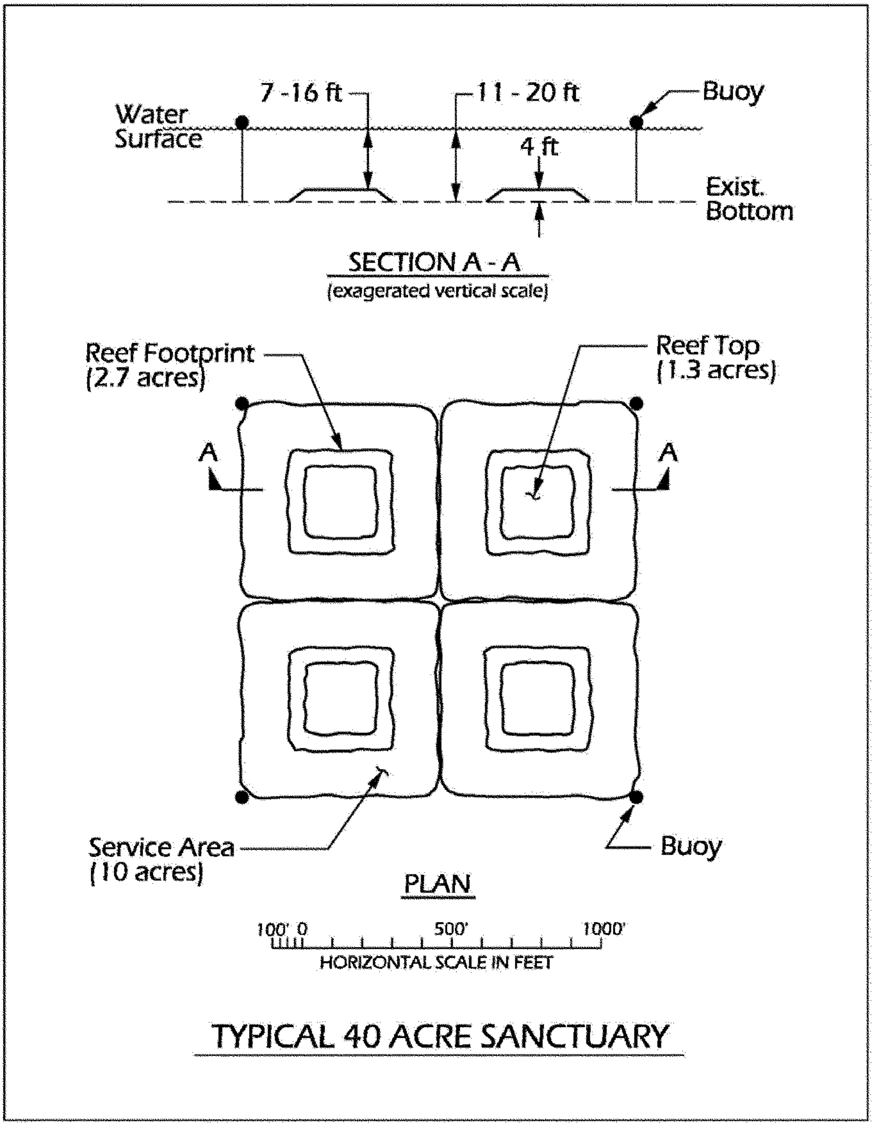


Figure 19. Preliminary design concept of oyster reef habitat.

Oyster Reef Quantities			
Description	Quantity	Unit	Comments
Rock for one unit (1.3 acre reeftop, 10 acre service area)	10,000	cy	NCDOT Class B riprap, based on 4H:1V sideslope, limestone
Oyster Shells for one unit	3,800	bushel	Based on avg 1 inch thickness
Mid-river site in the Lower Estuary (4 units)			
Rock	40,000	cy	
Oyster Shells	15,000	bushel	
Neuse Northern Shore (4 units)			
Rock	40,000	cy	
Oyster Shells	15,000	bushel	

During PED, consideration will be given to optimizing the shape of the reef units and also to using a sand core contained by sheetpile as an alternative to the all rock design displayed here. A site survey and subsurface investigations should be completed. This component will function in a range of depths; therefore, sea level rise is not a factor in design.

ADDENDUM P-1: Sill Armor Stone Sizing Analysis

Determining significant wave height is an initial step in designing armor for the sill. Wind waves are the most persistent and dominate waves that affect the project site. The orientation of the shoreline along the project site makes the site most exposed to wind waves from the NNE direction. See Figure 20 for fetch radials.

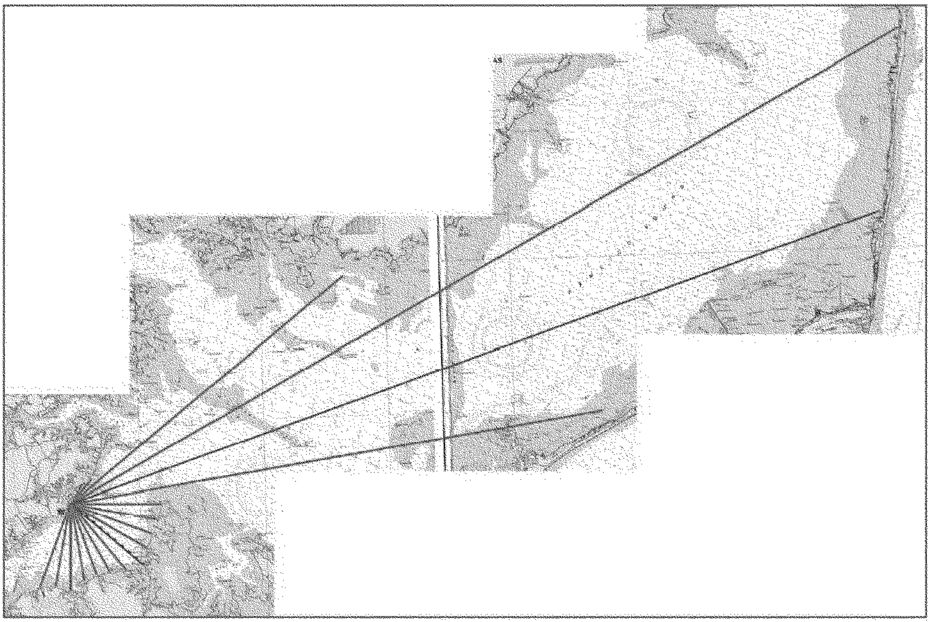


Figure 20. Illustration of wind radials and fetch lengths for Gum Thicket/Cedar Creek

The NNE fetch length is about 65 miles with an average depth of about 16 feet. Depth information was obtained from NOAA Charts 11548 and 11555. Design wave parameters were computed using "Wind Adjustment and Wave Growth Option" in the CEDAS-ACES computer program suite. It is assumed that the wind direction is aligned with the longest fetch, the NNE direction. No historical wind data is available at the site so design windspeed was selected using Coastal Engineering Technical Note I-36 (CETN-I-36 12/85, US Army Engineer Waterways Experiment Station). Table 5 shows the estimated fastest mile hurricane winds for station 2150 closest to the project site for the 50-year return period at the coast and 200 km inland. A 50-yr return period windspeed at the coast (99 mph) was selected for design purposes. The table includes a summary of computed wave heights and periods for the 50-yr design wind. Wave heights for two other wind directions were computed, but with one tenth of the fetch length and slightly shallower average depths, computed waves were smaller.

Table 5 Predicted Wave Height and Period for 99 mph Windspeed

ESTIMATED MAXIMUM HURRICANE WIND SPEED (MPH) Station 2150 (CETN-I-36)				PREDICTED WAVE HEIGHT AND PERIOD CEDAS-ACES					
	Fastest Mile Wind Speed			65 degree Wind		130 degree Wind		180 degree Wind	
Return Period	At Coast	200km Inland	At Gum Thicket	Wave Height (ft)	Wave Period (s)	Wave Height (ft)	Wave Period (s)	Wave Height (ft)	Wave Period (s)
50	99	95	99	**8.31**	**7.53**	5.93	6.06	6.80	5.20
			assume "At Coast"						

From the above selected wave height, the design armor stone for use in the sill was sized using the Structural Design module contained in the CEDAS-ACES computer program suite. Two methods were investigated with respect to the sill design. One utilized the Rubble Mound Revetment Design approach and the other the Breakwater Design using the Hudson equation. The wave height is depth limited and is calculated to be about 4.1 feet using 5 feet of water depth. The calculations for the Rubble Mound Revetment Design are summarized in Table 6 and those of the Breakwater Design in Table 7.

Table 6 Armor Stone Design Rubblemound Revetment

Rubble Mound Revetment Design

Significant wave ht (Hs):	4.11 ft
Significant wave period (Ts):	7.53 sec
Cotan of nearshore slope (cot phi):	200.00
Water depth at toe of revetment (ds):	5.00 ft
Cotan of structure slope (cot theta):	2.50
Unit weight of rock (wr):	165.00 ft
Permeability coefficient (P):	0.40
Damage level (S):	2.00
Breaking criteria:	0.78

Stone Size Gradation

Armor Layer			Filter Layer		
Thickness:	2.92326 ft		Thickness:	1.00000 ft	
% less than by weight	Weight	Dimension	% less than by weight	Weight	Dimension
	lb	ft		lb	ft
0 (min)	64.40	0.73	0 (min)	0.17	0.10
15	206.09	1.08	15	0.28	0.12
50	515.22	1.46	50	0.96	0.18
85	1009.84	1.83	85	3.22	0.27
100 (max)	2060.90	2.32	100 (max)	5.42	0.32

Table 7. Armor Stone Design-Rubblemound Breakwater/Hudson Method

Case: Breakwater design using Hudson and related e		
Breakwater Design Using Hudson and Related Equations		
Armor unit weight (Wr):	165.000	lb/ft³
Wave height (Hi):	4.100	ft
Stability coefficient (KD):	2.000	
Layer coefficient (k delta):	1.000	
Average porosity (P):	37.000	%
Cotan of structure slope (cot theta):	2.500	
No. of units comprising thickness of layer (n):	2.000	
Single armor unit weight (w):	578.069	lb
Minimum crest width (B):	4.55638	ft
Average layer thickness (r):	3.03759	ft
No single armor units per unit surface area (Nr):	546.227	per 1000 ft²

The design armor stone would be granite having a unit weight of 165 lbs per cubic foot with seaward side slope of 2.5 horizontal to 1 vertical. The Rubble Mound Revetment approach gives a median armor weight of 482 lbs with a wide gradation of about 60 lbs-1927 lbs and a very small filter layer 5.5lbs-0.2 lbs. In comparison, the Hudson approach gives a median armor weight of 578 lbs and is more applicable to a uniform gradation, typically ranging $0.75W_{50}$-$1.25W_{50}$. From these two approaches, a median armor stone of 500 lbs is selected having a uniform gradation of 375 lbs to 625 lbs. The armor layer will have an overall layer thickness of about 3.0 feet. For a uniform armor layer, the first underlayer is typically W/10 or about 50 lbs. The readily available NCDOT Class B stone has a size range of 5-12 inches with a corresponding weight range of 8-108 lbs. This is suitable for the core and bedding layer.

ADDENDUM P-2: Calculation of Soil Settlement for Static Loads

Calculation of Soil Settlement for Static Loads (Reference USACE, EM 1110-1-1904, 30SEP90).

General: The following section presents the evaluation of immediate settlement in cohesionless (sandy) and cohesive (silty-clayey) soils and consolidation settlement of soil for static loads.

Components of Soil Settlement: Total settlement ρ in feet, which is the response of stress applied to the soil, may be calculated as the sum of three components:

$$\rho = \rho_i + \rho_c + \rho_s$$

where

ρ_i = immediate or distortion settlement (ft)

ρ_c = primary consolidation settlement (ft)

ρ_s = secondary compression settlement (ft)

Immediate Settlement, ρ_i, is the change in shape or distortion of the soil in response to applied stress. Calculation of the immediate settlement in sandy soils is complicated because it follows a non-linear behavior as a result of changing states of stress; therefore, empirical and semi-empirical methods are used to calculate the immediate settlement. In silty-clayey soils, immediate settlement is estimated using elastic theory to quantify change in shape and dewatering volume loss.

Primary Consolidation Settlement, ρ_c, occurs in both cohesive and noncohesive soils as pore-pressure fluid (water) is expelled from voids as the soils are gradually compressed. Primary consolidation settlement is normally insignificant in cohesionless soils and occurs rapidly because these soils have relatively large permeabilities. However, in cohesive soils, primary consolidation takes a substantial amount of time to occur and can result in significant amounts of settlement. Consolidation time increases with thickness of the soil layer squared and is inversely related to the permeability coefficient of the soil. Consolidation settlement in cohesive soils is determined from the results of 1-dimensional (uniaxial) consolidation tests, run on undisturbed sample specimens.

Secondary Compression Settlement, ρ_s, is a form of soil creep that is controlled by the rate at which cohesive soils (clay, silt and peat) continue to consolidate long after they have lost a significant amount of their pore fluid.

Sandy to Granular (Cohesionless) Soils: The following discussion generalizes the methods to be used if cohesionless soil conditions are encountered during exploration. Settlement calculation for sandy silt, silt-sand mixtures, clean sands, and sand-gravel mixtures primarily focuses on the immediate settlement, ρ_i, because much of the settlement will occur during construction. As weight is applied to the granular strata, pore fluid (water) loss and consolidation occurs quickly, with little additional long-term consolidation. Primary consolidation settlement and secondary compression settlement are negligible; therefore, the settlement calculation for sandy soils can be simplified to:

$$\rho=\rho_i$$

where

ρ_i = immediate or distortion settlement (ft) can be estimated using any of the following methods; The Alpan, Schultze and Sherif, Modified Terrzahgi and Peck, and Schmertmann approximations. These methods are described in further detail on EM-1110-1-1904, 30SEP90.

These methods are based upon data recovered from field tests such as Standard Penetrometer Test (SPT) Cone Penetrometer Test (CPT), Dilatometer Test (DMT) and Pressuremeter Test (PMT). Due to its familiarity within Wilmington District, the field test of choice will likely be SPT; however, CPT is considered to be a highly accurate and reliable field test as well, and is the field test of choice for other Districts such as Savannah (SAS).

SPT yields N-blow count data that is used to calculate soil parameters specific to each method (described below). N can be represented as the average blowcount per foot within a particular stratum. As defined by DM 1110-1-1, N is the number of blows from a 140-lb hammer free-falling 30 inches, to drive a standard splitspoon sampler 18 inches or to refusal. Refusal is defined as a rate of penetration of less than 1 foot for 100 blows (or <6 inches of penetration after 50 blows). The Alpan, Schultze and Sherif, and Modified Terzaghi and Peck Methods rely upon the use of SPT **N**-blowcount data.

CPT provides cone tip bearing resistance $\mathbf{q_c}$ in tsf, which is used to calculate the elastic modulus of the soil. The Schertmann's Method primarily uses CPT data, however, it can be used with SPT **N**-blowcount data by correlating the soils data with the following table and solving for $\mathbf{q_c}$.

Soils Encountered	$\mathbf{q_c/N}$
Silts, sandy silts, slightly cohesive silt-sands	2
Clean, fine-medium sands, slightly silty sands	3.5
Coarse sands and sands with little gravel	5
Sandy gravel and gravel	6

Silty, Clayey and Peaty (Cohesive) Soils: If cohesive soil conditions are encountered during exploration, immediate, primary and secondary consolidation and settlement must be determined in order to determine the total settlement to be expected for a given structure. The primary soil data parameter required to calculate **Immediate Settlement,** ρ_i,is the Youngs or equivalent elastic modulus of soil (tsf), which is estimated from the undrained shear strength of soil (tsf). This data can be derived from lab testing of compressive strength of undisturbed soils that are collected using a Shelby-tube sampler. The Improved Janbu Method may be used to approximate the immediate settlement of a foundation on an elastic soil:

$$\rho_i = \mu_0 \times \mu_1 \times ((q \times B)/E_s)$$

where

μ0 = influence factor for depth D of foundation below ground surface

μ1 = influence factor for foundation shape

Es = equivalent Young's modulus of the soil, from uniaxial, triaxial compressive or simple shear testing (tsf) of undisturbed samples.

B = base of foundation footing.

Shape factors for the foundation shape can be found in EM-1110-1-1904, page 3-18 to 3-21.

The **Primary Consolidation Settlement,** ρ_c is calculated through the use of laboratory one-dimensional consolidation testing of undisturbed samples, collected from the field using a Shelby-tube sampler. The method used is explained in detail within EM 1110-1-1904, page 3-29. The ultimate one dimensional consolidation settlement of a given stratum **j** with thickness $\mathbf{H_j}$ is expressed as:

$$\rho_{cj} = (\Delta e_j/(1 + e_{oj})) \times H_j$$

where

ρ_{cj} = consolidation settlement of stratum j (ft)

Δe_j = change in void ratio of stratum j, $(e_{oj} - e_{fj})$

e_{oj} = initial void ratio of stratum j at initial test pressure.

e_{fj} = final void ratio of stratum j at final test pressure.

H_j = height of stratum j (ft)

Additional parameters such as time factors and degree of consolidation are also factored into the ultimate one-dimensional consolidation settlement (EM-1110-1-1904, pages 3-34 to 3-52).

The **Secondary Compression Settlement, ρ_s** can be estimated and calculated from a comparison of established compression coefficients of various soils with respect to the time in which the consolidation is estimated to occur. The evaluation of settlement strictly caused by secondary compression is often not reliable as discussed within EM-1110-1-1904, because secondary consolidation is smaller than primary consolidation, but it can last for a significantly much longer period of time (the length of which, may be hard to quantify).

Data Collection for Determining Engineering Parameters for Soil Settlement.

The following table summarizes the appropriate sampling and testing techniques that can be used to estimate the amount of settlement that should occur during construction of a rock sill. The specific type of sampling and testing that would be conducted will depend upon the soil conditions that are to be encountered within the footprint of the sill foundation.

Soil Condition	Relevent Settlement Components	Sampling	Platform	Field Tests	Parameter Resolved	Lab Tests	Parameter Resolved	Settlement Analysis Methods
Sands and Gravels	Immediate Settlement Only: ρ=ρi	SPT/CPT	Std Drilling/CPT Rig on Floating Plant	blow count/cone tip resistance	$N' = \alpha_0$	Grain Size	phi (ϕ)	Alpan, Schultze and Sherif, Modified Terzaghi and Peck
Silts and Clays	Total Settlement: ρ=ρi + ρc + ρs	Shelby Tube	Std Drilling Rig on Floating Plant	N/A	N/A	Undrained Triaxial Shear Test and Consolidation Test	C_u, E_s and c_v	Improved Janbu, Perloff Approximation

Table XX. Sampling and testing criteria as function of encountered soil conditions.

α_0 = soil parameter from adjusted blow count
N = blow count
Φ = angle of friction, granular soil
Cu = Undrained shear strength of soil (tsf)
Es = Young's soil modulus
c_v = coefficient of consolidation

Reference:

EM-1110-1-1904, 30SEP90, USACE Engineering and Design Manual "Settlement Analysis"

DM 1110-1-1, 30JUL85, USACE "Geotechnical Manual for Subsurface Investigations"

ATTACHMENT 1 TO ENGINEERING APPENDIX

BORING LOGS & LAB DATA

AIWW DA-26

Boring Designation AIWW DA-26-09-1-SS

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Wilmington District	SHEET 1 OF 3 SHEETS

1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone
2. HOLE NUMBER: AIWW DA-26-09-1-SS; LOCATION COORDINATES: N 407,165.5 E 2,693,907.9	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES: DISTURBED 40; UNDISTURBED 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: —; BEARING	14. ELEVATION GROUND WATER: 16.0 MSL
	15. DATE BORING: STARTED 10/12/09; COMPLETED 10/12/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 26.0 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING (ft): 60.0	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Messing Geologist

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1, 2, 3				0' to 4': SAND, with shell fragments, light brown (SP)	100	1								
		3, 3, 5	5				100	2	1	97	2			6	SP	
22.0	4.0	4, 3, 3	8			4' to 6': SAND, with shell, brown (SP)	100	3								
20.0	6.0	2, 2, 8	6				100	4								
		8, 10, 7	10			6' to 9.5': SAND, trace shell, light brown (SP)	100	5						5		
		5, 4, 4	17				67	6								
16.5 15.5	9.5 10.5	2, 1, 2	8			9.5' to 10.5': SAND, with silt, trace clay, organics, dark brown (SP-SM)	100	7								
14.5 14.0	11.5 12.0	1, 1, 2	3			10.5' to 11.5': SAND, with shell, light brown (SP) 11.5' to 12': SAND, with silt, with organics (SP-SM)	55	8								
		1, 1, 1	3			12' to 15': SAND, silty, brown (SM)	100	9								
11.0	15.0	1, 1, 2	2				100	10			20	NP	NP	24	SM	
9.7	16.3	2, 3, 3	3			15' to 16.3': SAND, silty, with trace organics, gray (SM)	100	11								
9.0	17.0	2, 3, 4	6			16.3' to 17': SAND, clayey, with trace shell, gray (SC) 17' to 19': SAND, clayey, few shell fragments, brown (SC)	100	12								
7.0	19.0	3, 5, 5	7				100	13						21		
6.0 5.0	20.0 21.0	2, 4, 6	10			19' to 20': SAND, with silt, organic, gray (SP-SM) 20' to 21': SAND, clayey, organic, gray (SC)	100	14								
3.5	22.5	9, 5, 6	10			21' to 22.5': SAND, few shell fragments, trace silt, light brown (SP)	100	15								
2.0	24.0	2, 4, 8	11			22.5' to 24': SAND, silty, brown (SM)	100	16			31			25	SM	
		10, 10	12			24' to 25.5': SAND, light gray (SP)	100	17								

Scale: 0.0 – 2.5 – 5.0 – 7.5 – 10.0 – 12.5 – 15.0 – 17.5 – 20.0 – 22.5 – 25.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 3/2/10

Boring Designation AIWW DA-26-09-1-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District			SHEET 2 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL	
LOCATION COORDINATES N 407,165.5 E 2,693,907.9	ELEVATION TOP OF BORING 26.0			

ELEV	DEPTH	Blows/ 0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory: Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS	
0.5	25.5	13															-25.0
-1.0	27.0	6 6 10	23			**25.5' to 27':** SAND, with few clay seams, coarse to medium grained, gray (SP)	100	18									
-2.5	28.5	6 9 20	16			**27' to 28.5':** SAND, with shell fragments, trace silt, coarse to medium grained, gray (SP)	100	19									-27.5
		11 14 15	29			**28.5' to 34.5':** SAND, with few shell fragments, coarse to medium grained, gray (SP)	100	20									
		8 7 11	29				100	21									-30.0
		8 7 11	18				100	22	0	96	4			22	SP		-32.5
-8.5	34.5	7 10 10	18				100	23									
		6 7 9	20			**34.5' to 37.5':** SAND, with shell fragments, coarse to medium grained, gray (SP)	100	24									-35.0
-11.5	37.5	4 6 9	16				100	25						21			-37.5
		7 8 7	15			**37.5' to 40.5':** SAND, trace shell fragments, coarse to medium grained, gray (SP)	100	26									
-14.5	40.5	7 5 5	15				100	27									-40.0
-16.0	42.0	3 2 6	10			**40.5' to 42':** SAND, with silt, with shell fragments, trace clay, fine grained, gray (SP-SM)	100	28	5	84	11			24	SP-SM		
		5 6 10	8			**42' to 49.5':** SAND, with silt, with few shell fragments, fine grained, gray (SP-SM)	100	29									-42.5
		7 12 10	16				100	30									
		6 6 6	22				100	31			9			25	SP-SM		-45.0
		7 8 10	12				100	32									-47.5
-23.5	49.5	7 11 9	18				100	33									
-25.0	51.0	4 2 3	20			**49.5' to 51':** SAND, silty, trace clay, very fine grained, gray (SM)	100	34									-50.0
-26.5	52.5	3 3 2	5			**51' to 52.5':** SAND, silty, with shell fragments, light gray green (SM)	100	35			32	NP	NP	31	SM		
		2 2 2	5			**52.5' to 57':** SAND, clayey, with shell fragments, light gray green (SC)	100	36									-52.5
		2 2	4				100	37			37	38	23	28	SC		-55.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 3/2/10

Boring Designation AIWW DA-26-09-1-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District		SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL
LOCATION COORDINATES N 407,165.5 E 2,693,907.9	ELEVATION TOP OF BORING 26.0		

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-31.0	57.0	3 1 2	5			**52.5' to 57':** SAND, clayey, with shell fragments, light gray green (SC) *(continued)*	100	38								
-32.5	58.5	4 6 7	6			**57' to 58.5':** SHELL, with sand, silt	100	39								
-34.0	60.0	11 7 9 14	18			**58.5' to 60':** SAND, with shells, coarse grained, gray (SP)		40								
			23													

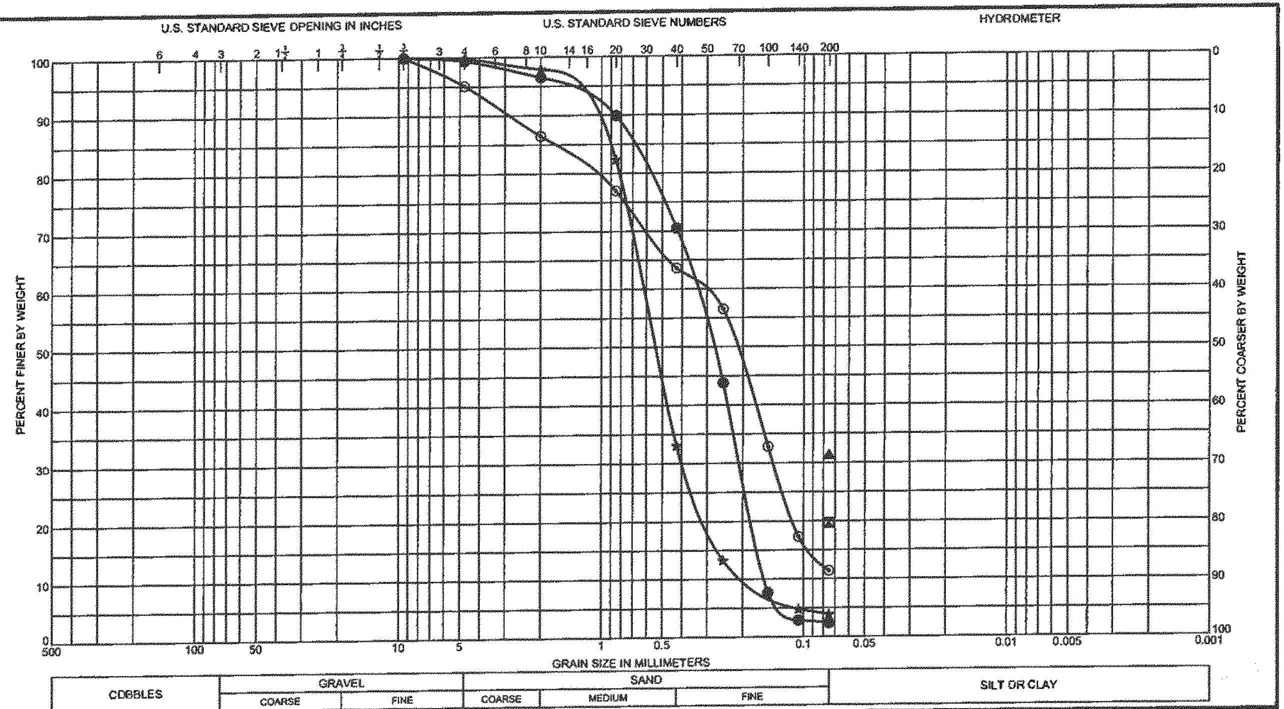
Boring terminated at 60 feet below ground surface.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 05-09-08.GDT 3/2/10

SPK FORM 1836-A
SEP 05



	Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
●	2	24.5 / 1.5	POORLY GRADED SAND(SP)	6.1			
⊠	10	12.5 / 13.5	SILTY SAND(SM)	24.4	NP	NP	NP
▲	16	3.5 / 22.5	SM	24.6			
★	22	-5.5 / 31.5	POORLY GRADED SAND(SP)	21.6			
⊙	28	-14.5 / 40.5	SP-SM	23.9			

GRADATION CURVES

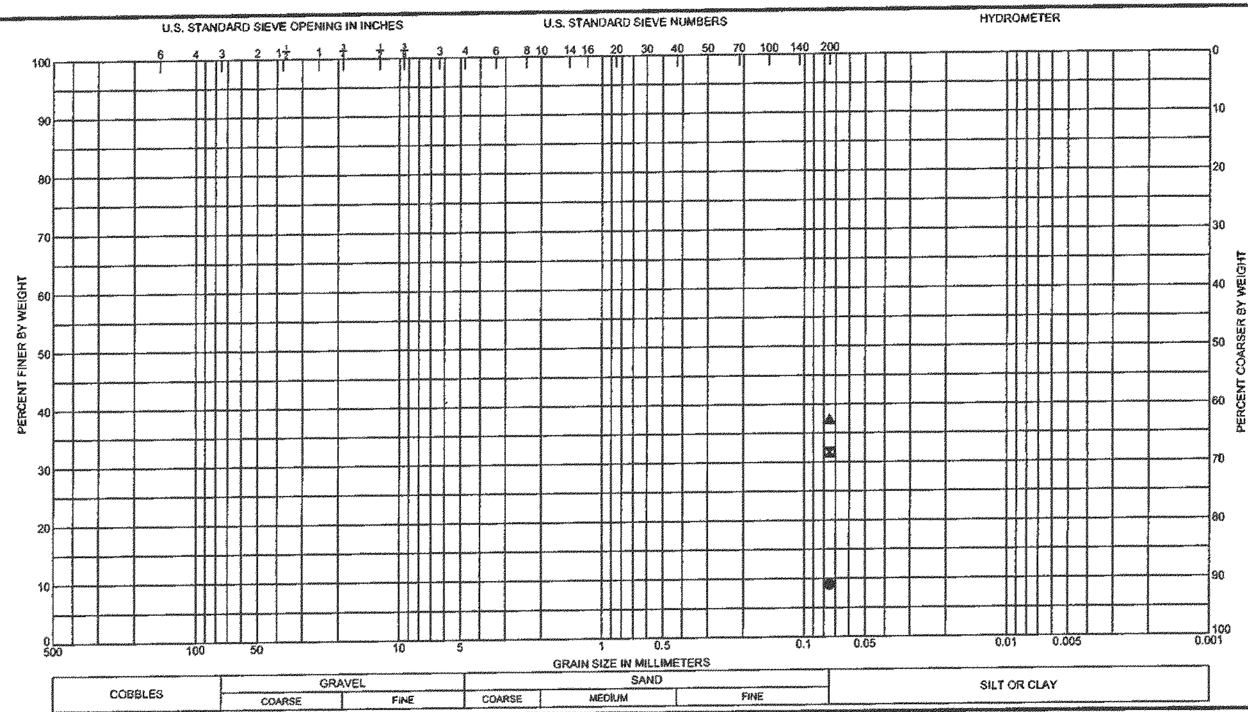
Project: AIWW North Disposal Area 26

Area:

Boring No.: AIWW DA-26-09-1-SS

Date: 2/24/10

ENG FORM 1 MAY 63 2087



	Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
●	31	-19.0 / 45.0	SP-SM	24.5			
⊠	35	-25.0 / 51.0	SILTY SAND(SM)	30.8	NP	NP	NP
▲	37	-28.0 / 54.0	SC	28.2	38	15	23

Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-1-SS

Date 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-10-SS

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Wilmington District	SHEET 1 OF 3 SHEETS

1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone
2. HOLE NUMBER: AIWW DA-26-09-10-SS; LOCATION COORDINATES: N 407,692.8 E 2,693,527.1	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES: DISTURBED 40; UNDISTURBED 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: —; BEARING	14. ELEVATION GROUND WATER: 14.0 MSL
	15. DATE BORING: STARTED 10/12/09; COMPLETED 10/12/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 25.0 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING (ft): 60.0	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Messing Geologist

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
23.5	1.5	1, 1, 4			0' to 1.5': SAND, few shell fragments, light brown (SP)	100	1	2	97	2			5	SP	
22.0	3.0	9, 12, 15	5		1.5' to 3': SAND, trace silt, few shell fragments, light brown (SP)	100	2								
20.5	4.5	11, 12, 14	27		3' to 4.5': SAND, very light brown (SP)	100	3								
19.0	6.0	11, 15, 13	26		4.5' to 6': SAND, few shell fragments, light brown (SP)	100	4								
17.0	8.0	5, 6, 5	28		6' to 8': SAND, clayey, few shells, dark brown (SC)	100	5	0	86	14			13	SC	
		7, 6, 7	11		8' to 10.5': SAND, silty, dark borwn (SM)	100	6								
14.5	10.5	5, 4, 4	13			100	7								
13.0 (▼)	12.0	4, 3, 4	8		10.5' to 12': SAND, with silt, trace clay, dark brown (SP-SM)	100	8								
11.5	13.5	3, 7, t2	7		12' to 13.5': SAND, with silt, trace clay, dark brown (SP-SM) (top 15 inches) SAND, coarse grained, brown (SP) (bottom 3 inches)	100	9						13		
10.0	15.0	5, 8, 9	19		13.5' to 15': SAND, with silt, brown (SP-SM)	100	10								
9.5	15.5	4, 2, 3	17		15' to 15.5': SAND, silty, clayey, brown (SC-SM) / 15.5' to 18': PEAT, amorphous, dark brown (Pt)	45	11								
7.0	18.0	8, 8, 9	5			100	12								
5.5	19.5	4, 11, 10	17		18' to 19.5': SAND, silty, brown (SM)	100	13				NP	NP	20	SM	
4.0	21.0	3, 2, 3	21		19.5' to 21': SAND, silty, dark brown (SM)	45	14								
		5, 2, 3	5		21' to 23': SAND, silty, brown (SM)	45	15			25			25	SM	
2.0 / 1.0	23.0 / 24.0	2, 4, 11	5		23' to 24': SAND, with silt, trace clay, brown (SP-SM)	100	16								
		11, 18	15		24' to 25.5': SAND, trace wood, medium grained, brown (SP)	100	17								

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 3/2/10

SPK FORM 1836-A
SEP 05

Boring Designation AIWW DA-26-09-10-SS

Boring Designation AIWW DA-26-09-10-SS

DRILLING LOG (Cont Sheet)	INSTALLATION	SHEET 2 OF 3 SHEETS
PROJECT: AIWW North Disposal Area 26	COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL	
LOCATION COORDINATES: N 407,692.8 E 2,693,527.1	ELEVATION TOP OF BORING: 25.0	

INSTALLATION: Wilmington District

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-0.5	25.5	19														
		8 8 13	37			25.5' to 28.5': SAND, fine grained, gray (SP)	100	18								
-3.5	28.5	4 2 5	21				100	19								
-5.0	30.0	8 17 11	7			28.5' to 30': SAND, fine to medium grained, gray (SP)	100	20								
-6.5	31.5	5 2 4	28			30' to 31.5': SAND, clayey, fine to medium grained, gray (SC)	33	21	0	72	28			32	SC	
		8 12 10	6			31.5' to 34.5': SAND, fine to medium grained, gray (SP)	55	22								
-9.5	34.5	7 16 19	22				100	23								
-11.0	36.0	7 9 13	35			34.5' to 36': SAND, with silt, with shell, medium grained, gray (SP-SM)	100	24			5			22	SP-SM	
		14 19 28	22			36' to 39': SAND, fine grained, gray (SP)	100	25								
-14.0	39.0	13 11 10	47				100	26								
-15.5	40.5	3 6 13	21			39' to 40.5': SAND, with shell fragments, very fine grained, gray (SP)	45	27								
-17.0	42.0	10 8 9	19			40.5' to 42': SAND, with shell fragments, medium grained, gray (SP)	100	28								
		5 10 16	17			42' to 46.5': SAND, silty, with shell fragments, fine grained, gray (SM)	100	29								
		9 10 13	26				100	30	0	86	14			20	SM	
-21.5	46.5	10 10 10	23				100	31								
-23.0	48.0	6 8 8	20			46.5' to 48': SAND, with few shell fragments, fine grained, gray (SP)	33	32								
-24.5	49.5	9 16 12	16			48' to 49.5': SAND, fine to medium grained, gray (SP)	45	33								
-26.0	51.0	9 6 5	28			49.5' to 51': SAND, silty, gray (SM)	100	34			23	NP	NP	27	SM	
-27.9	52.9	2 2 3	11			51' to 52.9': CLAY, gray (CL)	100	35								
-29.0	54.0	2 3 3	5			52.9' to 54': CLAY, with shell, gray (CL)	100	36								
		1 2	6			54' to 55.5': SAND, clayey, light gray green (SC)	100	37			35			33	SC	

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 3/2/10

Boring Designation AIWW DA-26-09-10-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District		SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL
LOCATION COORDINATES N 407,692.8 E 2,693,527.1	ELEVATION TOP OF BORING 25.0		

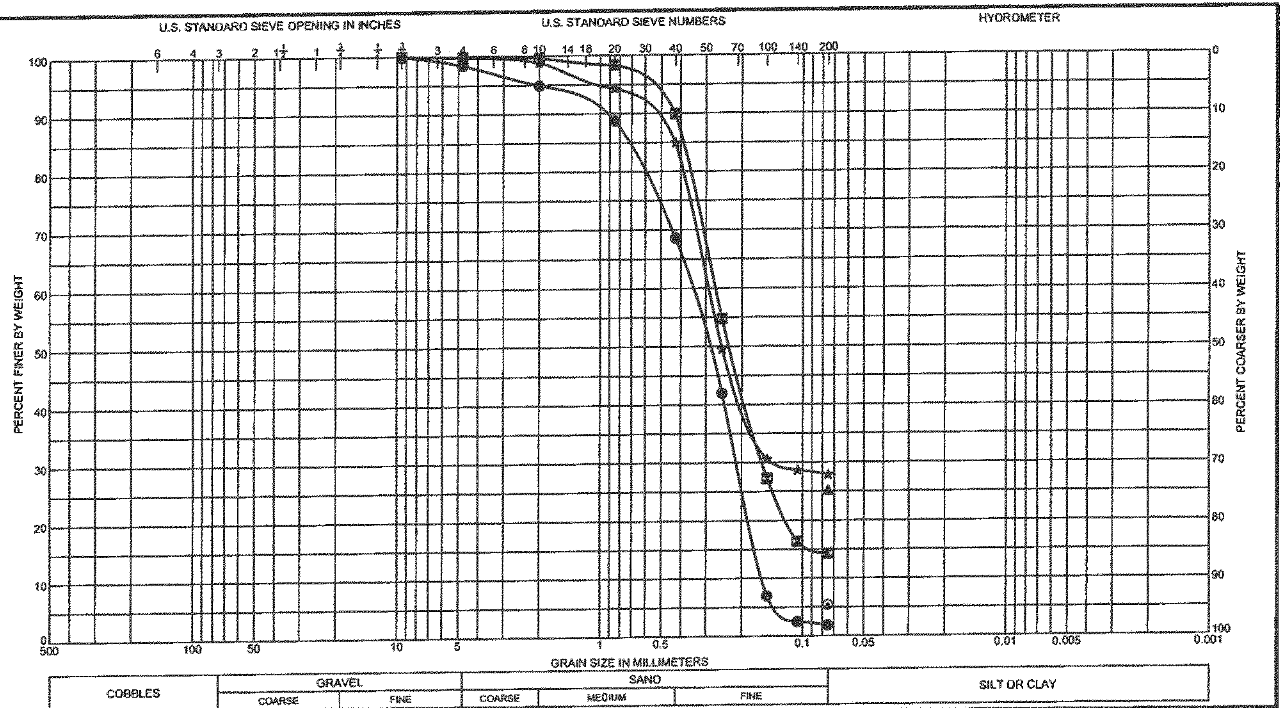
ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS	
-30.5	55.5	3 5 8 8	5			**55.5' to 58.5':** SAND, silty, with shell, light gray green (SM)	100	38									
		2 4 6	16				100	39			38	NP	NP	31	SM		57.5
-33.5	58.5																
		11 8 11	10			**58.5' to 60':** SHELLS, with clay and sand, light gray green	100	40									
-35.0	60.0		19														60.0

Boring terminated at 60 feet below ground surface.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVO WITH RAPID CPT 09-08-08.GDT 3/2/10



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 1	25.0 / 0.0	POORLY GRADED SAND(SP)	4.6			
⊠ 5	19.0 / 6.0	SC	13.4			
▲ 15	4.0 / 21.0	SM	25.1			
★ 21	-5.0 / 30.0	SC	32.3			
⊙ 24	-9.5 / 34.5	SP-SM	22.0			

Project: AIWW North Disposal Area 26

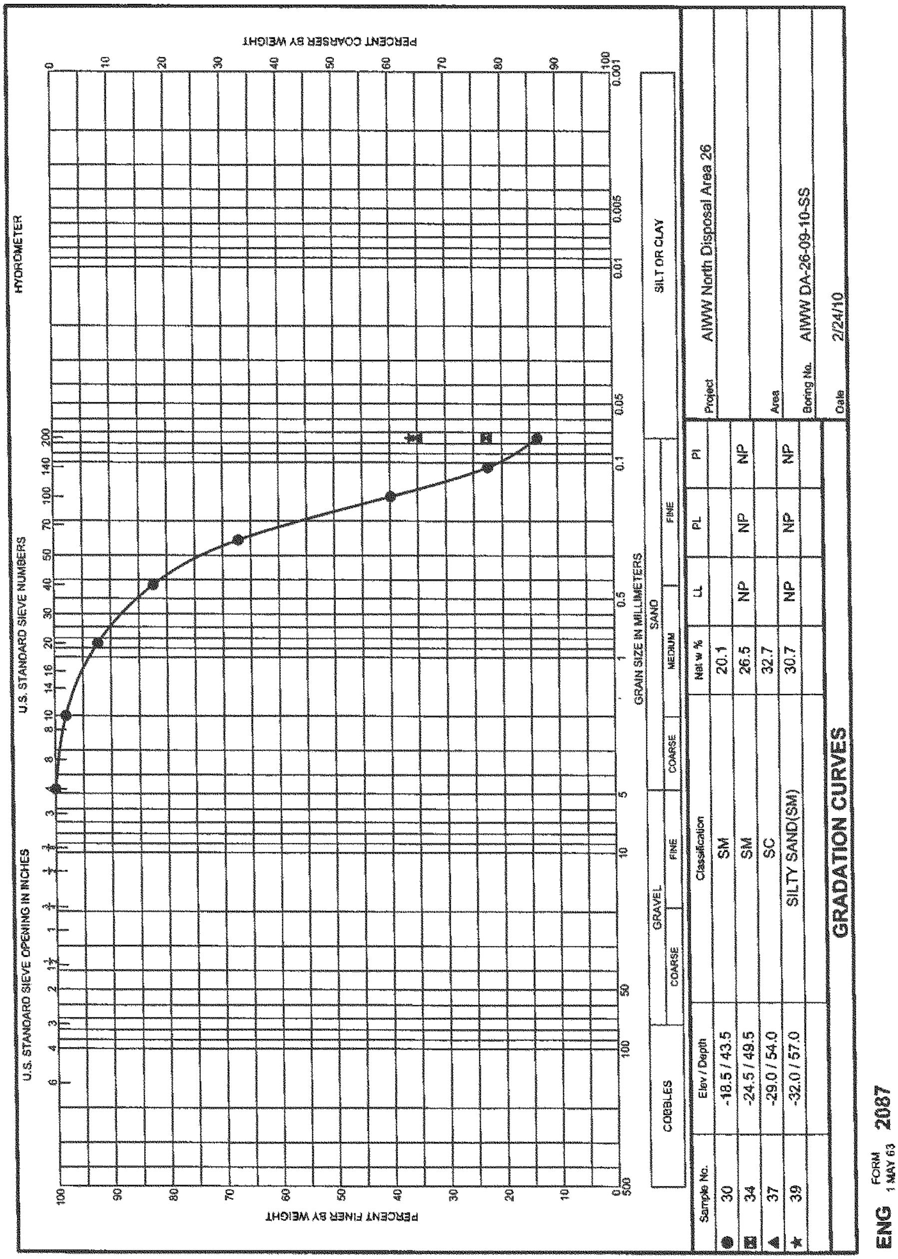
Area:

Boring No.: AIWW DA-26-09-10-SS

Date: 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087


U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
6 4 3 2 1½ 1 ¾ ½ ⅜ 3 4 6 8 10 14 16 20 30 40 50 70 100 140 200
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
PERCENT COARSER BY WEIGHT
0 10 20 30 40 50 60 70 80 90 100
500 100 50 10 5 1 0.5 0.1 0.05 0.01 0.005 0.001
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No. | Elev / Depth | Classification | Nat w % | LL | PL | PI
● 30 | -18.5 / 43.5 | SM | 20.1 | | |
⊠ 34 | -24.5 / 49.5 | SM | 26.5 | NP | NP | NP
▲ 37 | -29.0 / 54.0 | SC | 32.7 | | |
★ 39 | -32.0 / 57.0 | SILTY SAND(SM) | 30.7 | NP | NP | NP
Project AIWW North Disposal Area 26
Area
Boring No. AIWW DA-26-09-10-SS
Date 2/24/10
GRADATION CURVES
ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-14-AU

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Wilmington District	SHEET 1 OF 1 SHEETS

1. PROJECT AIWW North Disposal Area 26	9. COORDINATE SYSTEM North Carolina State Plane; HORIZONTAL NAD83; VERTICAL MSL
	10. SIZE AND TYPE OF BIT 4-inch flight auger
2. HOLE NUMBER AIWW DA-26-09-14-AU; LOCATION COORDINATES N 411,311.7 E 2,693,165.5	11. MANUFACTURER'S DESIGNATION OF DRILL CME-45
3. DRILLING AGENCY Ardaman and Associates, Inc.	12. TOTAL SAMPLES; DISTURBED 3; UNDISTURBED 0
4. NAME OF DRILLER Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL —; BEARING	14. ELEVATION GROUND WATER MSL
	15. DATE BORING STARTED 10/9/09 COMPLETED 10/9/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft) 26.4 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING (ft) 15.0	18. SIGNATURE AND TITLE OF INSPECTOR Michael Messing Geologist

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						0' to 3': SAND, fine grained, light brown (SP)										
23.4	3.0					3' to 7': SAND, with oxidized mottles, fine grained, light brown (SP)		1	0	98	2			4	SP	
19.4	7.0					7' to 10': SAND, fine grained, light gray brown (SP)		2								
16.4	10.0					10' to 15': SAND, silty, light gray brown (SM)		3	0	86	15			16	SM	
11.4	15.0															

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0

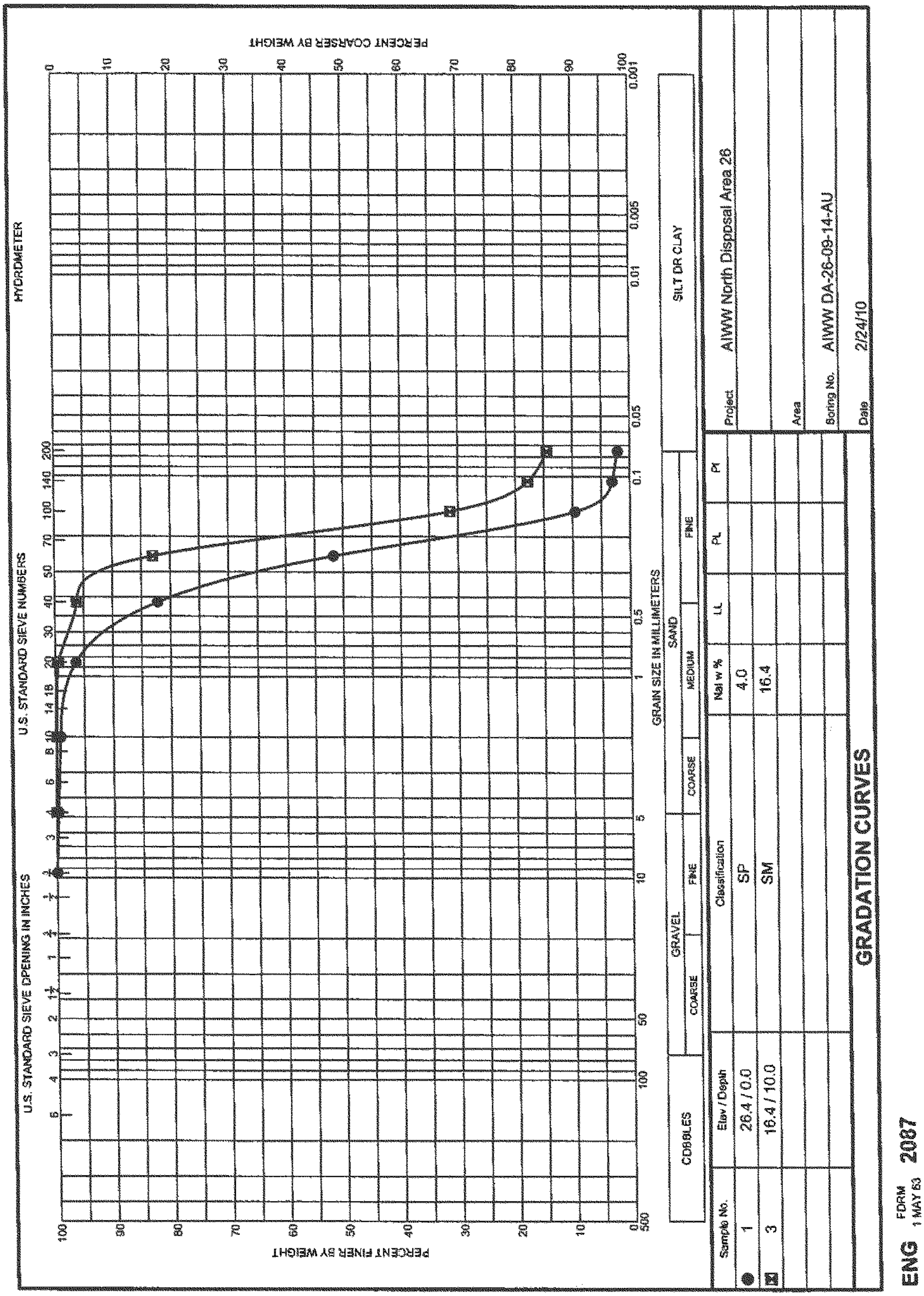
Boring terminated at 15 feet below ground surface.

NOTES:

1. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 08-09-08.GDT 2/24/10

SPK FORM 1836-A
SEP 05


GRADATION CURVES
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No. | Elev / Depth | Classification | Nat w % | LL | PL | PI
1 | 26.4 / 0.0 | SP | 4.0
3 | 16.4 / 10.0 | SM | 16.4
Project AIWW North Disposal Area 26
Area
Boring No. AIWW DA-26-09-14-AU
Date 2/24/10
ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-4-SS

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Wilmington District	SHEET 1 OF 3 SHEETS

1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone
2. HOLE NUMBER: AIWW DA-26-09-4-SS; LOCATION COORDINATES: N 410,683.9 E 2,693,320.9	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES: DISTURBED 40; UNDISTURBED 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: —; BEARING	14. ELEVATION GROUND WATER: 10.3 MSL
	15. DATE BORING: STARTED 10/19/09; COMPLETED 10/19/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 32.3 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING (ft): 60.0	18. SIGNATURE AND TITLE OF INSPECTOR: Brian Runkles Geotechnical Engineer

ELEV	DEPTH	Blows/ 0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1, 1, 2				0' to 4': SAND, fine grained, light brown (SP)	100	1								
		2, 1, 2	3				100	2								
28.3	4.0	3, 6, 7	3				100	3								
						4' to 6': SAND, trace shell, fine grained, light brown (SP)										
26.3	6.0	5, 5, 4	13				100	4	0	99	1			7	SP	
24.8	7.5	4, 6, 8	9			6' to 7.5': SAND, fine grained, light brown (SP)	100	5								
23.3	9.0	6, 12, 18	14			7.5' to 9': SAND, with silt, trace shell, fine grained, brown (SP-SM)	100	6			5			8	SP-SM	
		17, 19, 25	30			9' to 13.5': SAND, fine grained, light brown (SP)	100	7								
		15, 26, 30	44				100	8	0	97	3			4	SP	
18.8	13.5	17, 18, 21	56				100	9								
		13, 17, 26	39			13.5' to 18': SAND, trace silt, fine to medium grained, light brown (SP)	100	10								
		20, 25, 25	43				100	11								
14.3	18.0	18, 20, 25	50				100	12								
		18, 20, 22	45			18' to 21': SAND, trace silt, fine grained, light brown (SP)	100	13								
11.3	21.0	15, 11, 10	42				100	14								
	▼	4, 3, 10	21			21' to 24': SAND, with silt, with few shells, fine grained, brown (SP-SM)	100	15			5			19	SP-SM	
8.3	24.0	14, 16, 16	13				100	16								
7.5	24.8	10, 5	32			24' to 24.8': SAND, with silt, fine grained, dark gray (SP-SM)	100	17								

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

Boring Designation AIWW DA-26-09-4-SS

DRILLING LOG (Cont Sheet)	INSTALLATION: Wilmington District	SHEET 2 OF 3 SHEETS
PROJECT: AIWW North Disposal Area 26	COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83	VERTICAL: MSL
LOCATION COORDINATES: N 410,683.9 E 2,693,320.9	ELEVATION TOP OF BORING: 32.3	

ELEV	DEPTH	Blows/ 0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
6.8	25.5	4				24.8' to 25.5': SILT, organic, dark gray (OL) *(continued)*										
		1, 2, 4	9			25.5' to 28.5': SAND, clayey, with organics, dark brown (SC)	100	18								
3.8	28.5	3, 2, 2	6				100	19			48	27	13	31	SC	
		0, 1, 2	4			28.5' to 31.5': SAND, silty, very fine grained, gray (SM)	100	20			34			31	SM	
0.8	31.5	2, 1, 2	3				100	21								
		2, 2, 3	3			31.5' to 34.5': SAND, silty, gray (SM)	100	22								
-2.2	34.5	4, 2, 2	5				100	23			17			27	SM	
		2, 0, 1	4			34.5' to 40.5': SAND, silty, with clay seams, gray (SM)	100	24								
		1, 1, 2	1				100	25								
		1, 1, 2	3				100	26			26	NP	NP	37	SM	
-8.2	40.5	1, 1, 1	3				100	27								
-9.7	42.0	1, 1, 2	2			40.5' to 42': CLAY, with sand lenses, trace shell, gray (CH)	100	28			89	100	71	74	CH	
-11.2	43.5	2, 1, 2	3			42' to 43.5': CLAY, gray (CH)	100	29								
-12.7	45.0	1, 2, 4	3			43.5' to 45': SHELL, with gray silty clay fines, medium to coarse, trace fine quartz	100	30								
-14.2	46.5	4, 3, 7	6			45' to 46.5': SAND, with some shell, medium grained, light gray (SP)	100	31								
		4, 8, 4	10			46.5' to 49.5': CLAY, gray (CL)	100	32	1	49	51			34	CL	
-17.2	49.5	4, 9, 12	12				100	33								
-18.7	51.0	4, 3, 5	21			49.5' to 51': SAND, fine grained, light gray (SP) 2-inch silty clay clayer (CL) in middle of sample	83	34								
-20.2	52.5	4, 3, 3	8			51' to 52.5': SAND, clayey, with some shell, light gray (SC)	100	35								
-21.7	54.0	3, 3, 3	6			52.5' to 54': SAND, clayey, with few shells, fine grained, light gray (SC)	100	36			28			31	SC	
		4, 3	6			54' to 60': CLAY, sandy, trace shell, gray green (CL)	100	37			51	40	20	33	CL	

-25.0 -27.5 -30.0 -32.5 -35.0 -37.5 -40.0 -42.5 -45.0 -47.5 -50.0 -52.5 -55.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

SPK FORM 1836-A
SEP 05

Boring Designation AIWW DA-26-09-4-SS

Boring Designation AIWW DA-26-09-4-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District			SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL	
LOCATION COORDINATES N 410,683.9 E 2,693,320.9	ELEVATION TOP OF BORING 32.3			

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		3 3 2	6			**54' to 60':** CLAY, sandy, trace shell, gray green (CL) *(continued)*	100	38								
		3 3 3	5				100	39								
-27.7	60.0	3 2 3 3	6				100	40								

-57.5

-60.0

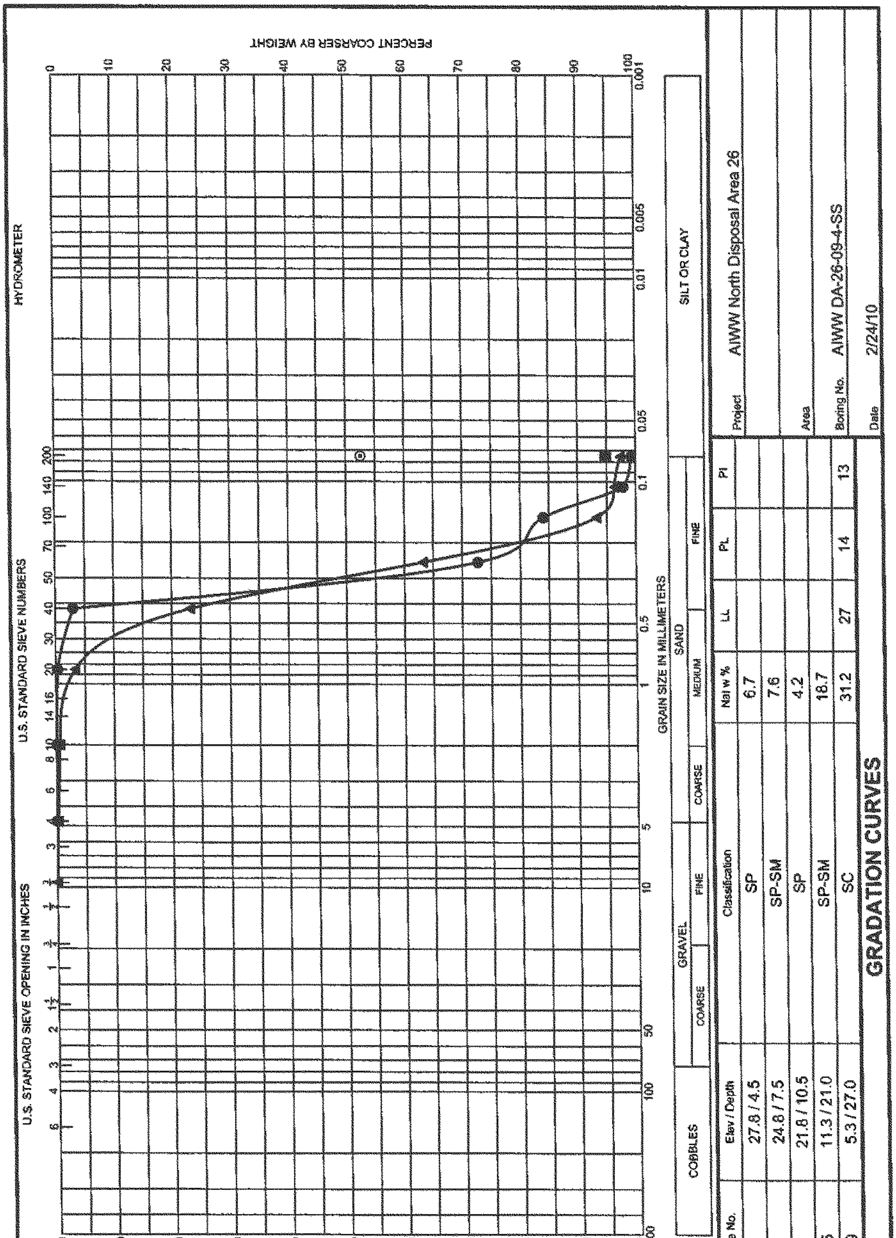
6

Boring terminated at 60 feet below ground surface.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 4	27.8 / 4.5	SP	6.7			
⊠ 6	24.8 / 7.5	SP-SM	7.6			
▲ 8	21.8 / 10.5	SP	4.2			
★ 15	11.3 / 21.0	SP-SM	18.7			
⊙ 19	5.3 / 27.0	SC	31.2	27	14	13

Project: AIWW North Disposal Area 26

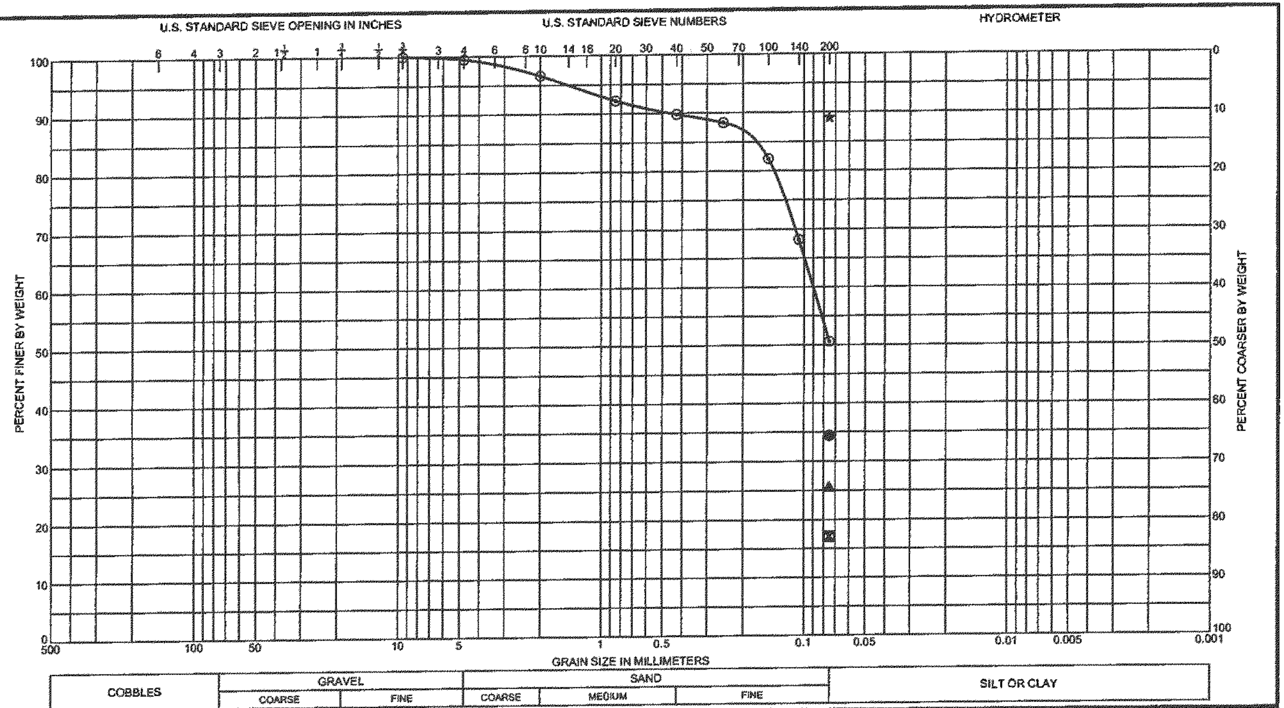
Area:

Boring No.: AIWW DA-26-09-4-SS

Date: 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

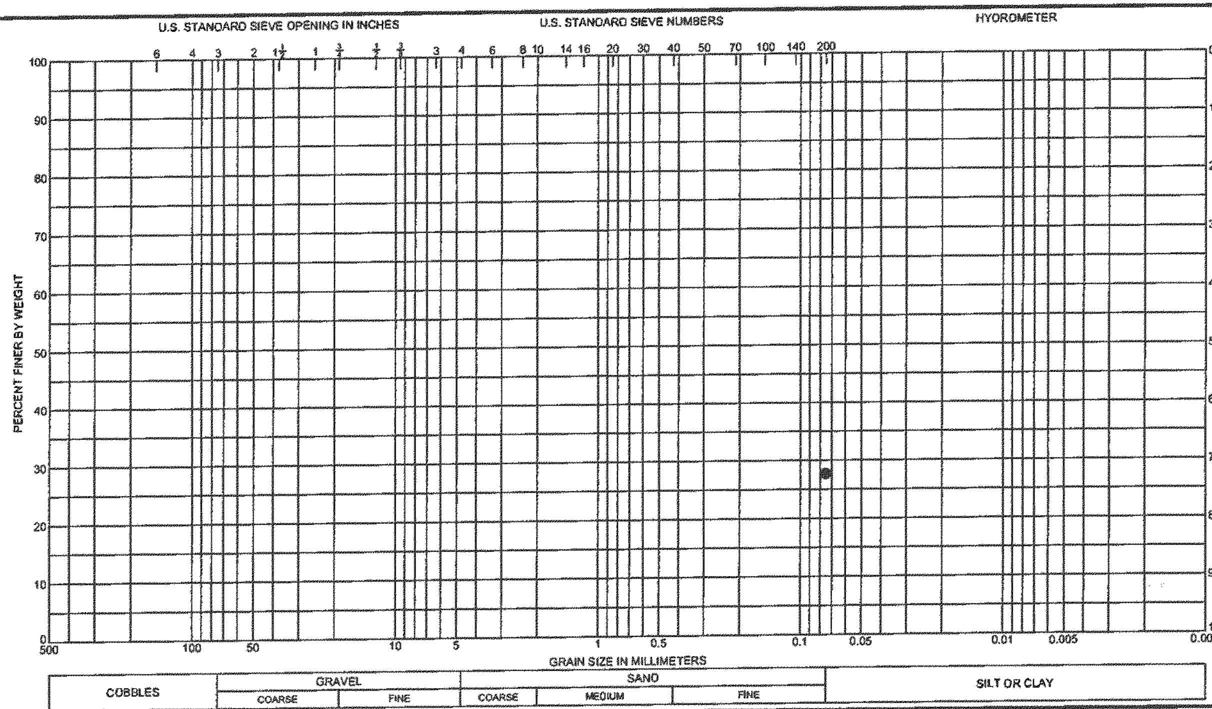


	Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
●	20	3.8 / 28.5	SM	30.9			
⊠	23	-0.7 / 33.0	SM	26.8			
▲	26	-5.2 / 37.5	SILTY SAND(SM)	36.6	NP	NP	NP
★	28	-8.2 / 40.5	CH	73.5	100	29	71
⊙	32	-14.2 / 46.5	CL	33.6			

Project	AIWW North Disposal Area 26
Area	
Boring No.	AIWW DA-26-09-4-SS
Date	2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 36	-20.2 / 52.5	SC	31.0			

Project	AIWW North Disposal Area 26
Area	
Boring No.	AIWW DA-26-09-4-SS
Date	2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-5-SS

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Wilmington District	SHEET 1 OF 3 SHEETS

1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone
2. HOLE NUMBER: AIWW DA-26-09-5-SS; LOCATION COORDINATES: N 411,501.0 E 2,693,220.6	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES: DISTURBED 40; UNDISTURBED 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: —; BEARING	14. ELEVATION GROUND WATER: 11.8 MSL
	15. DATE BORING: STARTED 10/13/09; COMPLETED 10/13/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 25.3 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING (ft): 60.0	18. SIGNATURE AND TITLE OF INSPECTOR: Michael Messing Geologist

ELEV	DEPTH	Blows/ 0.5 ft	N_1	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		1 2 3				0' to 3': SAND, light brown (SP)	100	1								
22.3	3.0	3 3 2	5				100	2								
		1 2 5	5			3' to 6': SAND, trace shell, brown (SP)	100	3	1	98	1			4	SP	
19.3	6.0	3 2 2	7				100	4								
		3 8 11	4			6' to 9': SAND, trace shell, very light brown (SP)	100	5	0	99	1			6	SP	
16.3	9.0	9 9 9	19				100	6								
15.8 14.8	9.5 10.5	4 4 5	18			9' to 9.5': SAND, with shell, very light brown (SP) 9.5' to 10.5': SAND, with silt, with shell, brown (SP-SM)	100	7								
		7 10 14	9			10.5' to 13.5': SAND, with shell, brown (SP)	100	8								
11.8 ▼	13.5	10 8 20	24				100	9			5			12	SP	
10.3	15.0	28 25 20	28			13.5' to 15': SAND, with silt, with shell, gray brown (SP-SM)	100	10								
		15 16 14	45			15' to 18': SAND, with shell, light brown (SP)	100	11								
7.3	18.0	8 4 3	30				100	12						21		
6.8 6.5	18.5 18.8	8 1 2	7			18' to 18.5': SAND, silty, with shell, gray (SM) 18.5' to 18.8': CLAY, with silt lenses, gray (CH)	100	13			46	52	22	47	SM	
4.3	21.0	1 2 6	3			18.8' to 21': CLAY, with organics, trace roots, dark brown (CH)	100	14								Organic Content = 5%
2.8	22.5	6 6 6	8			21' to 22.5': SAND, trace silt, fine grained, gray (SP)	100	15						39		
1.3	24.0	3 2 1	12			22.5' to 24': SAND, silty, gray (SM)	100	16								
		2 2	3			24' to 25.5': SAND, silty, trace clay, gray (SM)	100	17			23			28	SM	

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

Boring Designation AIWW DA-26-09-5-SS

DRILLING LOG (Cont Sheet)

INSTALLATION: Wilmington District			SHEET 2 OF 3 SHEETS
PROJECT: AIWW North Disposal Area 26	COORDINATE SYSTEM: North Carolina State Plane	HORIZONTAL: NAD83	VERTICAL: MSL
LOCATION COORDINATES: N 411,501.0 E 2,693,220.6	ELEVATION TOP OF BORING: 25.3		

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-0.2	25.5	2														
		4 4 5	4			**25.5' to 28.5':** SAND, silty, gray (SM)	100	18								
-3.2	28.5	2 2 3	9				100	19								
-4.7	30.0	2 0 0	5			**28.5' to 30':** SAND, silty, trace clay, gray (SM)	100	20			35			43	SM	
		2 0 1	0			**30' to 32.5':** SAND, silty, clayey, very loose, gray (SC-SM)	100	21								
-7.2 -7.7	32.5 33.0	2 1 10	1			**32.5' to 33':** SAND, clayey, with shell, gray (SC)	100	22								
-9.2	34.5	6 9 15	11			**33' to 34.5':** SAND, with shell, fine to medium grained, gray (SP)	100	23								
		11 18 14	24			**34.5' to 37.5':** SAND, with silt, with shell, fine to medium grained, gray (SP-SM)	100	24								
-12.2	37.5	12 13 9	32				100	25	1	94	5			18	SP-SM	
		15 15 16	22			**37.5' to 40.5':** SAND, fine grained, gray (SP)	45	26								
-15.2	40.5	8 8 16	31				45	27								
-16.7	42.0	19 16 13	24			**40.5' to 42':** SAND, fine to medium grained, gray (SP)	45	28								
-18.2	43.5	10 21 16	29			**42' to 43.5':** SAND, fine grained, gray (SP)	67	29								
-19.7	45.0	5 3 4	37			**43.5' to 45':** SAND, silty, with shell, fine grained, gray (SM)	100	30			18			31	SM	
-21.2	46.5	4 3 4	7			**45' to 46.5':** SAND, silty, with shell, trace clay, gray (SM)	100	31								
-22.7	48.0	4 3 4	7			**46.5' to 48':** SAND, silty, clayey, with shell, gray (SC-SM)	100	32								
		2 2 3	7			**48' to 57':** SAND, clayey, with shell, gray (SC)	100	33								
		3 2 3	5				100	34			43	35	17	30	SC	
		3 2 4	5				100	35								
		3 2 3	6				100	36								
		2 3	5				100	37			50	44	27	36	SC	

-25.0 -27.5 -30.0 -32.5 -35.0 -37.5 -40.0 -42.5 -45.0 -47.5 -50.0 -52.5 -55.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

Boring Designation AIWW DA-26-09-5-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District		SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL
LOCATION COORDINATES N 411,501.0 E 2,693,220.6	ELEVATION TOP OF BORING 25.3		

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
		4														
-3t.7	57.0	2 2 4	7			48' to 57': SAND, clayey, with shell, gray (SC) *(continued)*	t00	38								
		5 7 8	6			57' to 60': SAND, with silt, with shell, light gray to gray (SP-SM)	t00	39								
-34.7	60.0	9 9 t0	t5					40								
			t9													

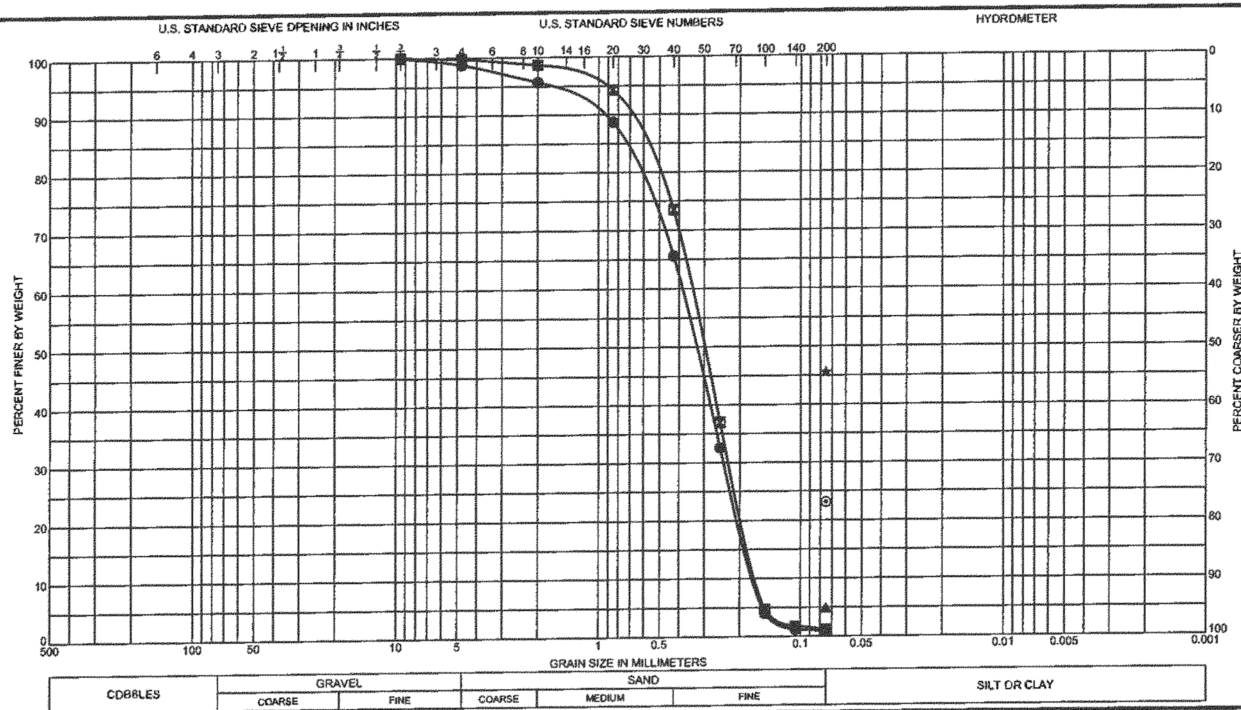
Depth scale: 57.5, 60.0

Boring terminated at 60 feet below ground surface.

NOTES:
t. BLOWS/FOOT: number required to drive t 3/8" ID splitspoon with a t40 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10



Sample No.		Elev / Depth	Classification	Nat w %	LL	PL	PI
●	3	22.3 / 3.0	SP	4.1			
⊠	5	19.3 / 6.0	SP	5.6			
▲	9	13.3 / 12.0	SP	12.2			
★	13	7.3 / 18.0	SM	47.2	52	30	22
⊙	17	1.3 / 24.0	SM	27.8			

GRADATION CURVES

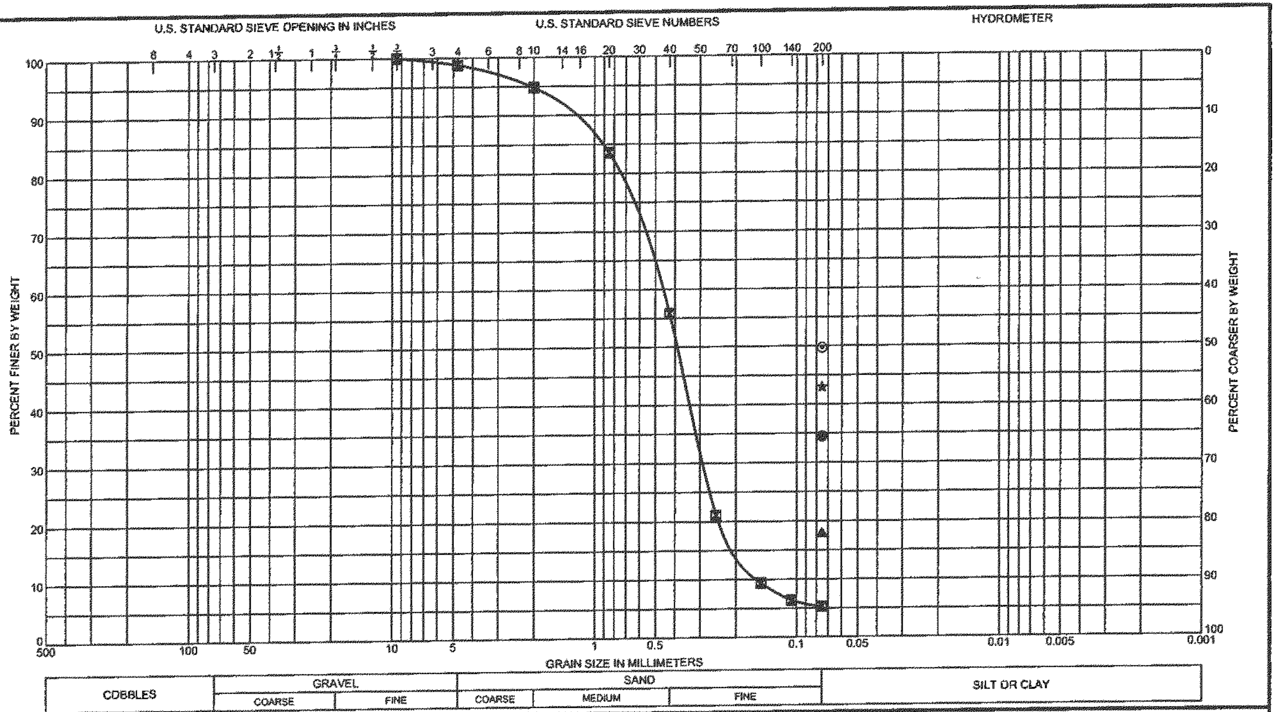
Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-5-SS

Date 2/24/10

ENG FORM 1 MAY 63 2087



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 20	-3.2 / 28.5	SM	42.5			
⊠ 25	-10.7 / 36.0	SP-SM	17.6			
▲ 30	-18.2 / 43.5	SM	31.2			
★ 34	-24.2 / 49.5	CLAYEY SAND(SC)	29.8	35	18	17
⊙ 37	-28.7 / 54.0	SC	36.2	44	17	27

Project: AIWW North Disposal Area 26

Area:

Boring No.: AIWW DA-26-09-5-SS

Date: 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-6-SS

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Wilmington District		SHEET 1 OF 3 SHEETS
1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane	HORIZONTAL: NAD83	VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone		
2. HOLE NUMBER: AIWW DA-26-09-6-SS; LOCATION COORDINATES: N 412,174.0 E 2,693,007.3	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45		
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES	DISTURBED: 34	UNDISTURBED: 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES		
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: —; BEARING:	14. ELEVATION GROUND WATER: 13.6 MSL		
	15. DATE BORING	STARTED: 10/8/09	COMPLETED: 10/17/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 15.1 MSL		
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A		
6. TOTAL DEPTH OF BORING (ft): 51.0	16. SIGNATURE AND TITLE OF INSPECTOR: Michael Messing Geologist		

ELEV	DEPTH	Blows/ 0.5 ft	N_1	N_{60}	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
13.6 ▼	1.5	3, 7, 8			0' to 1.5': SAND, trace shell, very light brown (SP)	100	1								
12.6	2.5	9, 11	15		1.5' to 2.5': SAND, light brown (SP)	100	2								
12.1	3.0	13			2.5' to 3': SAND, gray (SP)										
10.6	4.5	10, 12, 21	24		3' to 4.5': SAND, with silt, trace shell fragments, gray (SP-SM)	100	3	0	92	8			14	SP-SM	
9.1	6.0	7, 15, 18	33		4.5' to 6': SAND, trace silt, trace shell fragments, gray, (SP)	100	4								
7.6	7.5	9, 4, 4	33		6' to 7.5': SAND, trace silt, with few shells, gray (SP) (top 6 inches) SAND, clayey, with few shells, gray (SC) (bottom 2 inches)	45	5								
6.7	8.4	1, 1, 2	8		7.5' to 8.4': CLAY, with silt lenses, gray (CH)	100	6			48			32	SM	
5.6	9.5	1	3		8.4' to 9.5': SAND, silty, with organics, trace roots, dark brown (SM)	100	7								
5.1	10.0	2, 2			9.5' to 10': CLAY, sandy, trace roots, brown (CL)										
3.1	12.0	4, 5, 5	4		10' to 12': SAND, clayey, trace roots, gray (SC)	89	8			23	25	13	27	SC	
1.6	13.5	1, 3, 11	10		12' to 13.5': SAND, clayey, light gray (SC)	100	9								
-0.4	15.5	6, 13, 13	14		13.5' to 15.5': SAND, gray (SP)	100	10								
-1.4	16.5	3, 2, 2	26		15.5' to 16.5': SAND, light gray (SP)	100	11								
-2.9	18.0	1, 1, 2	4		16.5' to 18': SAND, silty, gray (SM)	100	12			16	NP	NP	30	SM	
		3, 7, 16	3		18' to 22.5': SAND, with shell, gray (SP)	100	13								
		18, 24, 29	23			100	14	0	96	4			19	SP	
-7.4	22.5	9, 10, 12	53			100	15								
		6, 9, 9	22		22.5' to 25.5': SAND, with few clay seams, with shell, gray (SP)	100	16								
		4, 5	18			100	17								

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

Boring Designation AIWW DA-26-09-6-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District			SHEET 2 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL	
LOCATION COORDINATES N 412,174.0 E 2,693,007.3	ELEVATION TOP OF BORING 15.1			

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
-10.4	25.5	5														
-11.9	27.0	9 18 20	10			25.5' to 27': SAND, with shell, gray (SP)	100	18								
-13.4	28.5	8 8 13	38			27' to 28.5': SAND, with silt, gray (SP-SM)	100	19			6			20	SP-SM	
		13 18 24	21			28.5' to 34.5': SAND, fine grained, gray (SP)	100	20								
		18 27 35	42				100	21								
		14 22 25	62				100	22								
-19.4	34.5	19 20 14	47				100	23								
		7 3 4	34			34.5' to 37.5': SAND, silty, with shell, fine grained, greenish gray (SM)	100	24			27			30	SM	
-22.4	37.5	4 3 3	7				100	25								
		4 3 3	6			37.5' to 40.5': SAND, clayey, with shell, fine grained, green gray (SC)	100	26			37	34	14	31	SC	
-25.4	40.5	2 2 3	6				100	27								
-26.9	42.0	3 3 3	5			40.5' to 42': SILT, with few shells, green gray (MH)	100	28			61	51	5	43	MH	
-28.4	43.5	2 2 3	6			42' to 43.5': SAND, clayey, few shells, fine grained, green gray (SC)	100	29								
-29.9	45.0	2 2 3	5			43.5' to 45': CLAY, sandy,with few shells, green gray (CL)	100	30			57			38	CL	
-31.4	46.5	3 3 4	5			45' to 46.5': SAND, clayey, with few shells, fine to medium grained, light green gray (SC)	100	31								
		5 9 9	7			46.5' to 51': SAND, with silt, few shells, fine grained, light green gray (SP-SM)	100	32	37	55	9			21	SP-SM	
		9 4 7	18				100	33								
-35.9	51.0	7 5 9	11				100	34								
			14													

-25.0 -27.5 -30.0 -32.5 -35.0 -37.5 -40.0 -42.5 -45.0 -47.5 -50.0

Boring terminated at 51 feet below ground surface.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 28.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

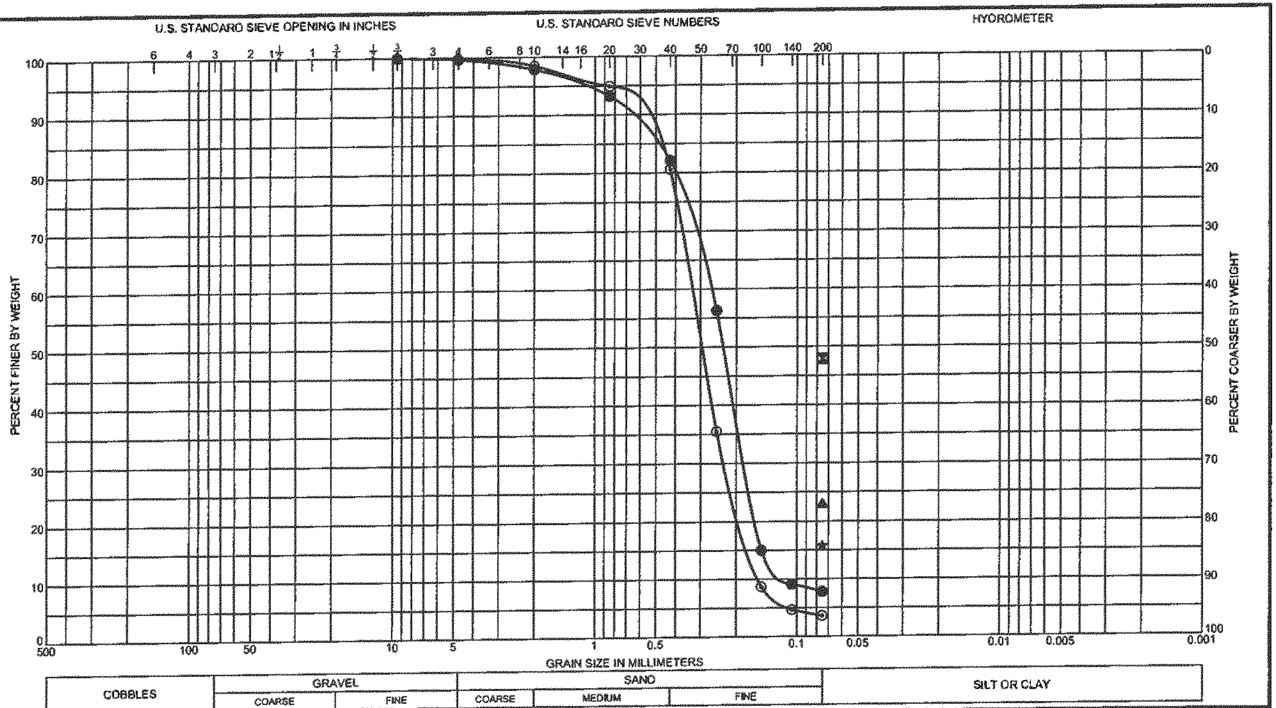
Boring Designation AIWW DA-26-09-6-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District			SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL	
LOCATION COORDINATES N 412,174.0 E 2,693,007.3	ELEVATION TOP OF BORING 15.1			

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						2. Soils are field visually classified in accordance with the Unified Soil Classification system.										

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

SPK FORM 1836-A
SEP 05



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 3	12.1 / 3.0	SP-SM	13.9			
⊠ 6	7.6 / 7.5	SM	31.7			
▲ 8	4.6 / 10.5	SC	26.9	25	12	13
★ 12	-1.4 / 16.5	SM	29.8	NP	NP	NP
⊙ 14	-4.4 / 19.5	SP	19.1			

GRADATION CURVES

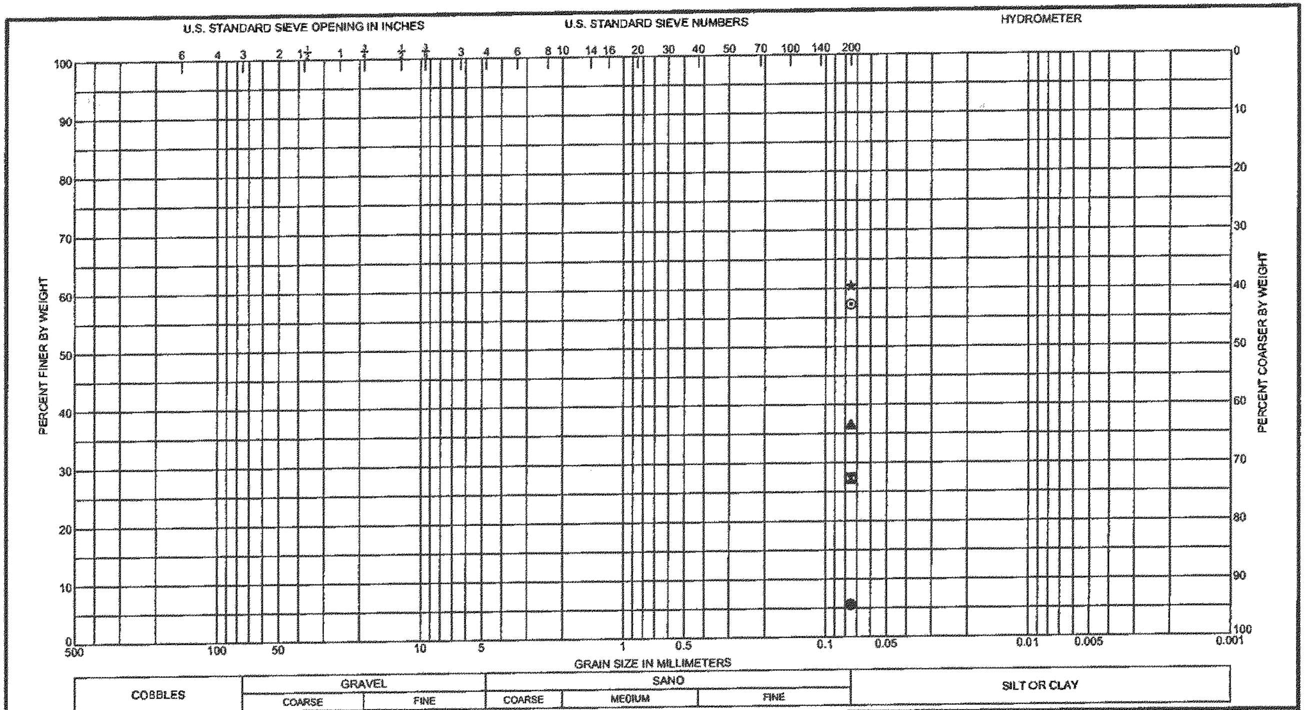
Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-6-SS

Date 2/24/10

ENG FORM 1 MAY 63 2087



Sample No.		Elev / Depth	Classification	Nat w %	LL	PL	PI
●	19	-11.9 / 27.0	SP-SM	19.7			
⊠	24	-19.4 / 34.5	SM	30.0			
▲	26	-22.4 / 37.5	SC	30.8	34	20	14
★	28	-25.4 / 40.5	MH	43.2	51	46	5
⊙	30	-28.4 / 43.5	CL	38.1			

GRADATION CURVES

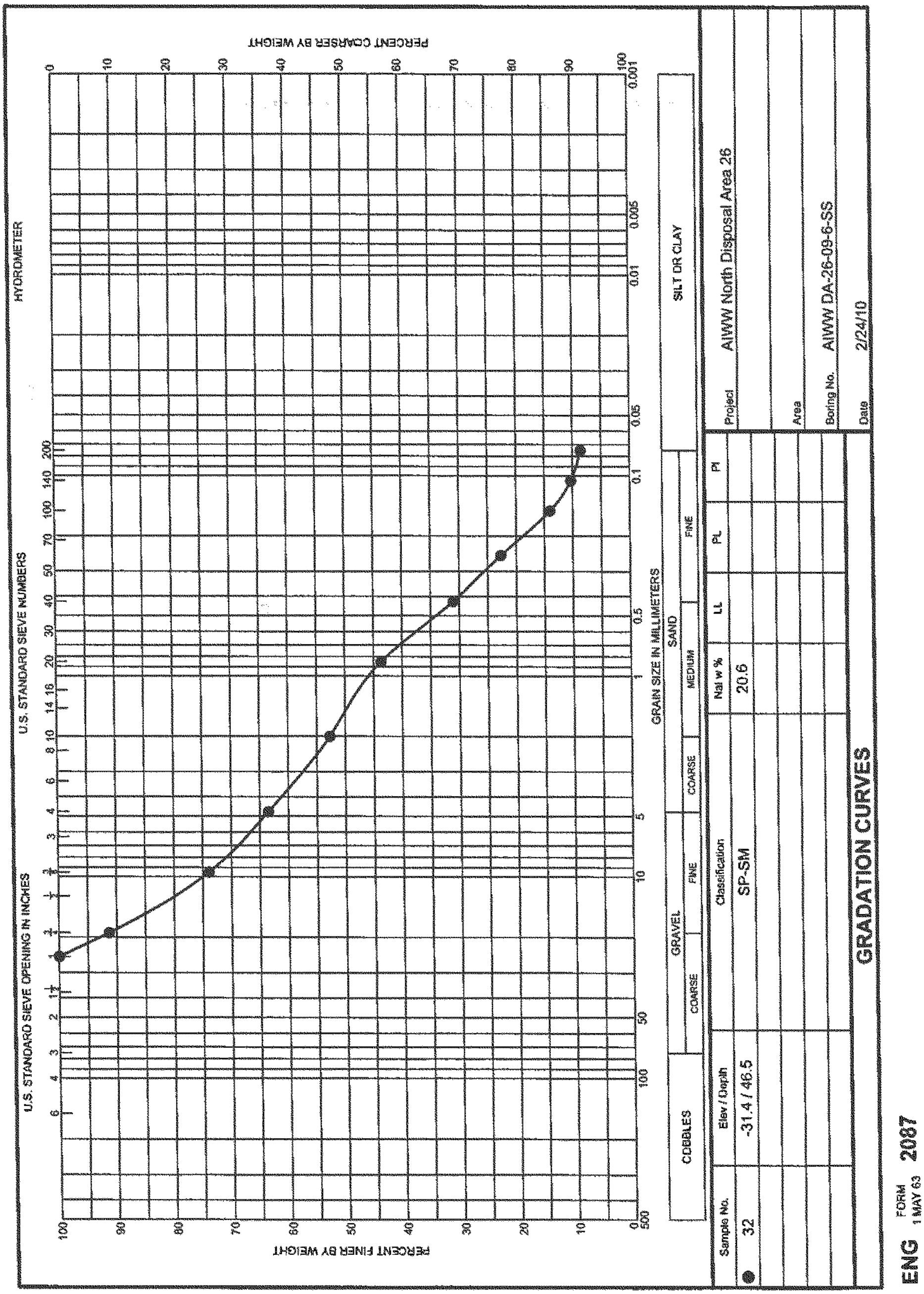
Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-6-SS

Date 2/24/10

ENG FORM 1 MAY 63 2087


HYDROMETER
U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
Sample No.
Elev / Depth
Classification
Nat w %
LL
PL
PI
32
-31.4 / 46.5
SP-SM
20.6
Project
AIWW North Disposal Area 26
Area
Boring No.
AIWW DA-26-09-6-SS
Date
2/24/10
GRADATION CURVES
ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-7-SS

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Wilmington District	SHEET 1 OF 1 SHEETS

1. PROJECT AIWW North Disposal Area 26	9. COORDINATE SYSTEM North Carolina State Plane; HORIZONTAL NAD83; VERTICAL MSL
	10. SIZE AND TYPE OF BIT 2 5/16-inch tricone
2. HOLE NUMBER AIWW DA-26-09-7-SS; LOCATION COORDINATES N 411,092.4 E 2,693,107.3	11. MANUFACTURER'S DESIGNATION OF DRILL CME-45
3. DRILLING AGENCY Ardaman and Associates, Inc.	12. TOTAL SAMPLES; DISTURBED 11; UNDISTURBED 0
4. NAME OF DRILLER Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL ---; BEARING	14. ELEVATION GROUND WATER 11.5 MSL
	15. DATE BORING; STARTED 10/17/09; COMPLETED 10/17/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft) 26.3 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING N/A
8. TOTAL DEPTH OF BORING (ft) 17.0	18. SIGNATURE AND TITLE OF INSPECTOR Brian Runkles Geotechnical Engineer

ELEV	DEPTH	Blows/0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS	
		2 2 2				0' to 9': SAND, trace shell fragments, fine grained, light brown (SP)	100	1									0.0
		2 2 2	4				100	2	0	99	1			6	SP		2.5
		4 3 4	4				100	3									
		4 5 7	7				100	4									5.0
		6 12 16	12				100	5									
17.3	9.0	16 20 15	28				100	6									7.5
		7 7 6	35			9' to 12': SAND, trace shell, fine grained, gray brown (SP)	100	7									-10.0
14.3	12.0	4 5 6	13				100	8	0	96	4			14	SP		
		6 9 15	11			12' to 16.5': SAND, with silt, with shell, fine grained, gray brown (SP-SM)	100	9									-12.5
		14 12 10	24				100	10									-15.0
9.8	16.5	4 4 8	22				100	11			5			21	SP-SM		
			12														

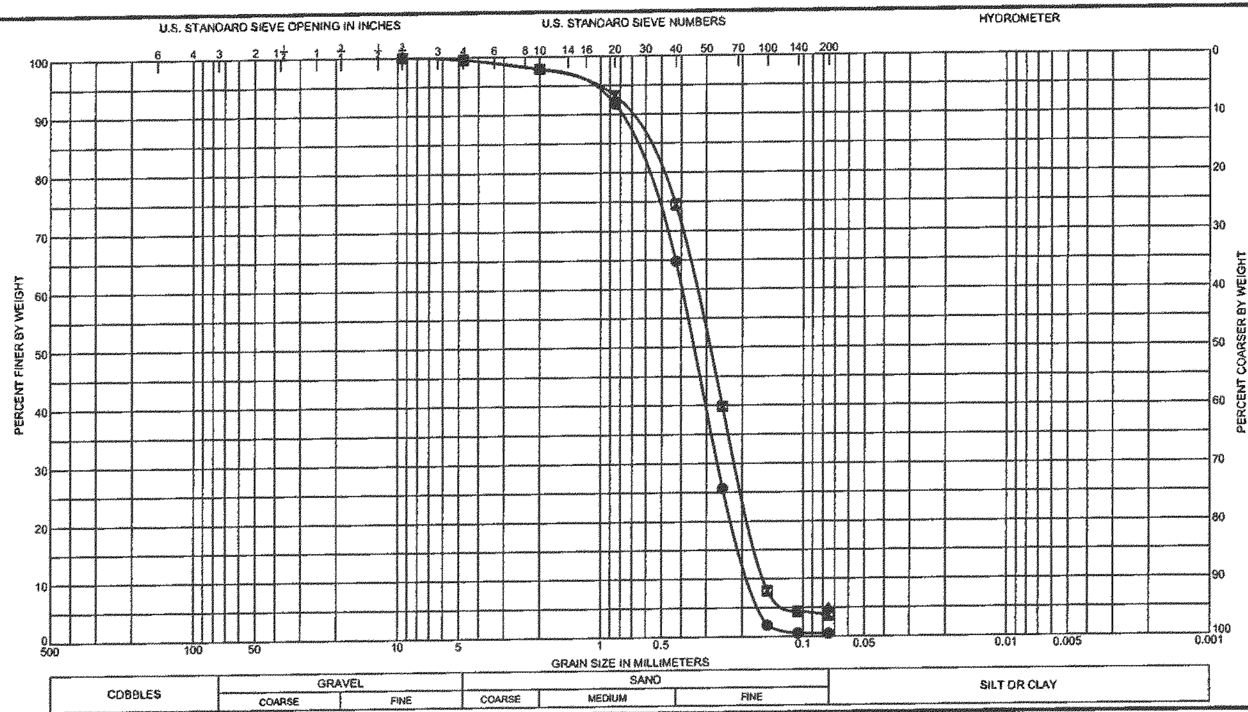
Boring terminated at 17 feet below ground surface. Hit buried tree 17 feet below grade; could not advace boring.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/25/10

SPK FORM 1836-A
SEP 05



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 2	24.8 / 1.5	POORLY GRADED SAND(SP)	5.6			
⊠ 8	15.8 / 10.5	POORLY GRADED SAND(SP)	13.7			
▲ 11	11.3 / 15.0	SP-SM	20.7			

Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-7-SS

Date 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Boring Designation AIWW DA-26-09-7B-SS

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Wilmington District	SHEET 1 OF 3 SHEETS

1. PROJECT: AIWW North Disposal Area 26	9. COORDINATE SYSTEM: North Carolina State Plane; HORIZONTAL: NAD83; VERTICAL: MSL
	10. SIZE AND TYPE OF BIT: 2 5/16-inch tricone
2. HOLE NUMBER: AIWW DA-26-09-7B-SS; LOCATION COORDINATES: N 411,087.4 E 2,693,107.3	11. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
3. DRILLING AGENCY: Ardaman and Associates, Inc.	12. TOTAL SAMPLES: DISTURBED 29; UNDISTURBED 0
4. NAME OF DRILLER: Donny Tindall	13. TOTAL NUMBER CORE BOXES
5. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG FROM VERTICAL: --; BEARING	14. ELEVATION GROUND WATER: 11.5 MSL
	15. DATE BORING: STARTED 10/17/09; COMPLETED 10/17/09
6. THICKNESS OF OVERBURDEN	16. ELEVATION TOP OF BORING (ft): 26.3 MSL
7. DEPTH DRILLED INTO ROCK	17. TOTAL CORE RECOVERY FOR BORING: N/A
8. TOTAL DEPTH OF BORING (ft): 60.0	18. SIGNATURE AND TITLE OF INSPECTOR: Brian Runkles Geotechnical Engineer

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
						0' to 16.5': Wash to 16.5 feet										
9.8	16.5															
8.3	18.0	7 2 3				**16.5' to 18':** SAND, silty, few shell fragments, fine grained, brown gray (SP-SM)	67	12								
7.8 7.3	18.5 19.0	0 2 1	5			**18' to 18.5':** SAND, clayey, with shell, gray (SC) **18.5' to 19':** CLAY, with silt lenses, trace roots, gray (CL)	100	13			56			33	MH	
6.3	20.0	1 1 1	3			**19' to 20':** SILT, sandy, with organics, trace roots, dark brown (MH)	100	14			82	30	13	35	CL	
4.3 3.8	22.0 22.5	1 3 7	2			**20' to 22':** CLAY, sandy, with organics, trace roots, brown (CL) **22' to 22.5':** SAND, clayey, gray (SC)	100	15			33			24	SC	
2.3	24.0	4 6 8	10			**22.5' to 24':** SAND, trace silt, fine grained, gray (SP-SM)	100	16								
		3 2	14			**24' to 25.5':** SAND, trace clay, silty, fine grained, dark gray (SM)	100	17								

Depth scale: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

SPK FORM 1836-A
SEP 05

Boring Designation AIWW DA-26-09-7B-SS

Boring Designation AIWW DA-26-09-7B-SS

DRILLING LOG (Cont Sheet)	INSTALLATION: Wilmington District			SHEET 2 OF 3 SHEETS
PROJECT: AIWW North Disposal Area 26	COORDINATE SYSTEM: North Carolina State Plane	HORIZONTAL: NAD83	VERTICAL: MSL	
LOCATION COORDINATES: N 411,087.4 E 2,693,107.3	ELEVATION TOP OF BORING: 26.3			

ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS
0.8	25.5	1														
-0.7	27.0	2, 2, 1	3			**25.5' to 27':** SAND, trace clay, silty, fine grained, dark gray (SM)	100	18								
		3, 3, 5	3			**27' to 34.5':** SAND, silty, fine grained, gray (SM)	100	19			13	NP	NP	25	SM	
		2, 1, 3	8				100	20								
		2, 2, 3	4				100	21								
		1, 2, 2	5				100	22								
-8.2	34.5	3, 3, 6	4				100	23								
-9.7	36.0	3, 3, 2	9			**34.5' to 36':** SAND, slightly silty, trace shell, fine grained, gray (SP-SM)	100	24								
-11.2	37.5	1, 2, 2	5			**36' to 37.5':** CLAY, with sand, gray (CH)	100	25			78	79	53	68	CH	
-12.7	39.0	2, 3, 6	4			**37.5' to 39':** SAND, clayey, medium to coarse shells, fine grained, gray (SC)	100	26								
-14.2	40.5	6, 10, 9	9			**39' to 40.5':** SAND, few shells, medium to coarse grained, light gray (SP)	100	27								
		7, 9, 9	19			**40.5' to 43.5':** SAND, with clay, with shell, medium grained, light gray (SP-SC)	100	28	2	92	6			20	SP-SC	
-17.2	43.5	7, 8, 10	18				100	29								
-18.7	45.0	9, 5, 9	18			**43.5' to 45':** SAND, trace shell, fine grained, light gray (SP)	100	30								
-20.2	46.5	4, 4, 3	14			**45' to 46.5':** SAND, silty, few shells, fine grained, green gray (SP-SM)	100	31								
-21.7	48.0	4, 3, 3	7			**46.5' to 48':** SAND, silty, with shell, fine grained, green gray (SM)	100	32			30	NP	NP	30	SM	
		2, 3, 2	6			**48' to 52.5':** SAND, clayey, silty, with shell, very fine grained, green gray (SM-SC)	100	33								
		2, 2, 3	5				100	34								
-26.2	52.5	3, 2, 3	5				100	35								
-27.7	54.0	4, 3, 4	5			**52.5' to 54':** CLAY, sandy, with shell, gray (CL)	100	36			61			38	CL	
		2, 3	7			**54' to 56.5':** SAND, clayey, with shell fragments, gray green (SC)	100	37								

Elevation scale: -25.0, -27.5, -30.0, -32.5, -35.0, -37.5, -40.0, -42.5, -45.0, -47.5, -50.0, -52.5, -55.0

ACE 1836-A (DRILLING LDG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10

Boring Designation AIWW DA-26-09-7B-SS

DRILLING LOG (Cont Sheet)	INSTALLATION Wilmington District		SHEET 3 OF 3 SHEETS
PROJECT AIWW North Disposal Area 26	COORDINATE SYSTEM North Carolina State Plane	HORIZONTAL NAD83	VERTICAL MSL
LOCATION COORDINATES N 411,087.4 E 2,693,107.3	ELEVATION TOP OF BORING 26.3		

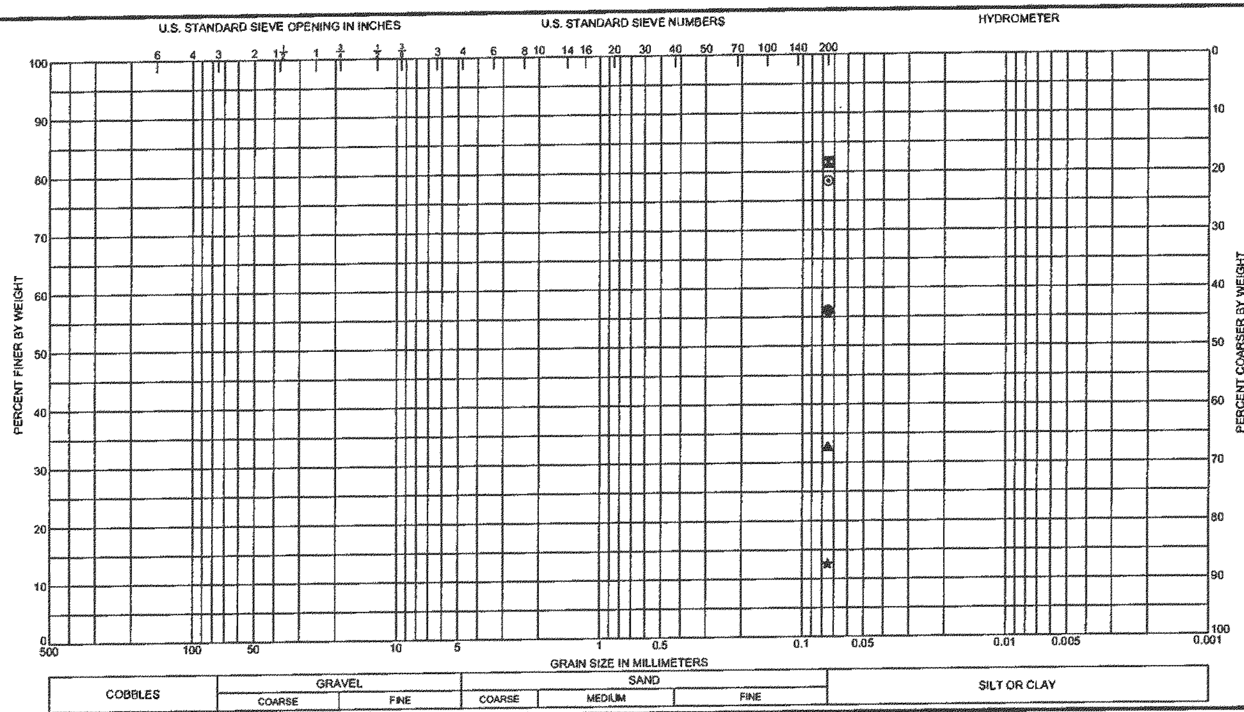
ELEV	DEPTH	Blows/ 0.5 ft	N_f	N_{60}	LEGEND	FIELD CLASSIFICATION OF MATERIALS (Description)	% REC	Samp No.	Laboratory Gravel	Sand	Fines	LL	PI	MC	ASTM Class	REMARKS	
-30.2 -30.7	56.5 57.0	2 2 2	5			**54' to 56.5':** SAND, clayey, with shell fragments, gray green (SC) *(continued)*	100	38			25			30	SC		
-32.2	58.5	7 8 9	9			**56.5' to 57':** SAND, silty, with shell fragments, fine grained, gray green (SM) **57' to 58.5':** SAND, silty, with medium shell fragments, fine grained, light gray green (SM)	100	39									57.5
-33.7	60.0	12 14 11	21			**58.5' to 60':** SAND, silty, with shell,cemented, light gray (SM)	100	40									60.0
		6	17														

Boring terminated at 60 feet below ground surface.

NOTES:
1. BLOWS/FOOT: number required to drive 1 3/8" ID splitspoon with a 140 lb. hammer falling 30 inches

2. Soils are field visually classified in accordance with the Unified Soil Classification system.

ACE 1836-A (DRILLING LOG) 09-131 AIWW NORTH DISPOSAL AREA 26.GPJ ACE MVD WITH RAPID CPT 06-09-08.GDT 2/24/10



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 13	8.3 / 18.0	MH	33.1			
⊠ 14	6.8 / 19.5	CL	34.6	30	17	13
▲ 15	5.3 / 21.0	SC	23.8			
★ 19	-0.7 / 27.0	SM	25.3	NP	NP	NP
⊙ 25	-9.7 / 36.0	CH	68.0	79	26	53

Project AIWW North Disposal Area 26

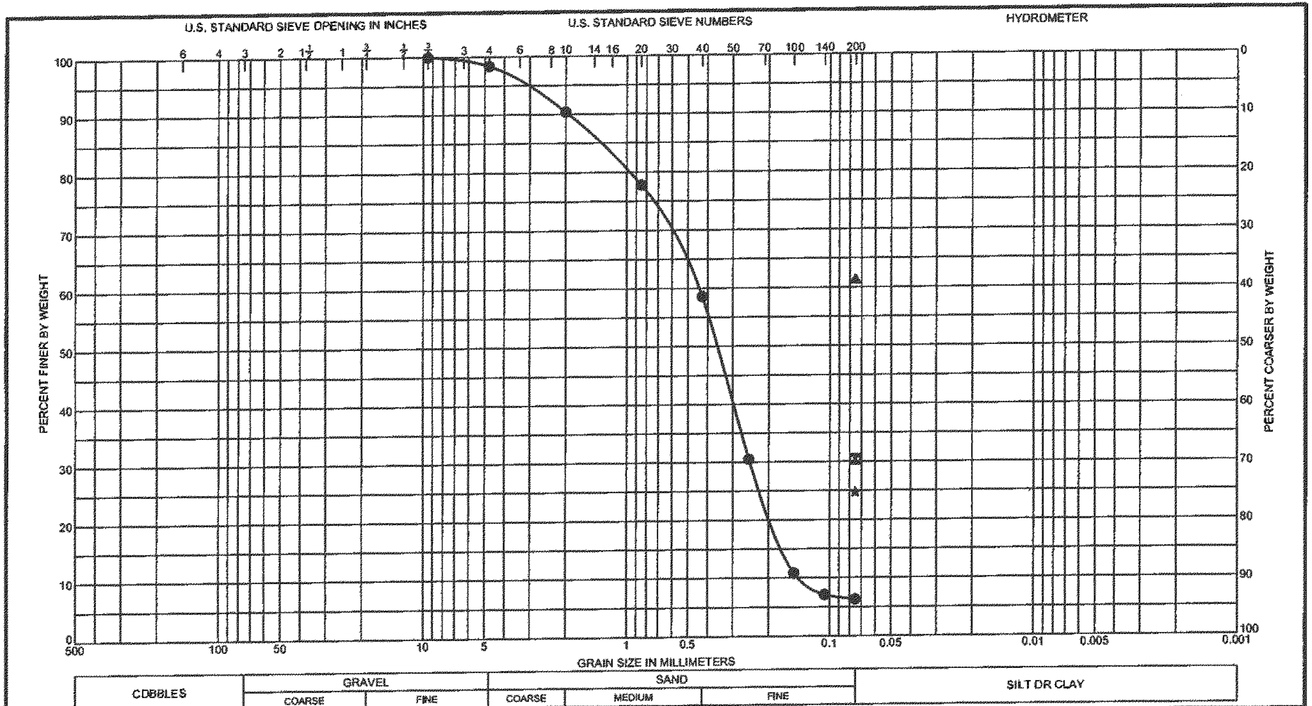
Area

Boring No. AIWW DA-26-09-7B-SS

Date 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev / Depth	Classification	Nat w %	LL	PL	PI
● 28	-14.2 / 40.5	SP-SC	19.6			
⊠ 32	-20.2 / 46.5	SILTY SAND(SM)	30.2	NP	NP	NP
▲ 36	-26.2 / 52.5	CL	37.7			
★ 38	-29.2 / 55.5	SC	29.5			

Project AIWW North Disposal Area 26

Area

Boring No. AIWW DA-26-09-7B-SS

Date 2/24/10

GRADATION CURVES

ENG FORM 1 MAY 63 2087

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS
1. PROJECT DISPOSAL AREA 26		10. SIZE AND TYPE OF BIT 3" HAND AUGER	
2. LOCATION (Coordinates or Station) N 407443 E 2693834		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY WILMINGTON DISTRICT		12. MANUFACTURER'S DESIGNATION OF DRILL 3" HAND AUGER	
4. HOLE NO. (As shown on drawing title and file number) CC26-H-09-01		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0	
5. NAME OF DRILLER LARRY BENJAMIN		14. TOTAL NUMBER CORE BOXES N/A	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER N/A	
		16. DATE HOLE: STARTED 08/17/2009; COMPLETED 08/17/2009	
7. THICKNESS OF OVERBURDEN N/A		17. ELEVATION TOP OF HOLE 18.8 APPROX.	
8. DEPTH DRILLED INTO ROCK 0.0'		18. TOTAL CORE RECOVERY FOR BORING N/A %	
9. TOTAL DEPTH OF HOLE 14.5'		19. SIGNATURE OF INSPECTOR LARRY BENJAMIN	

ELEVATION MSL	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
18.8			SP-SM Light gray, fine poorly graded sand		0.0' 1 0.5'	Soils described by Larry Benjamin, Civil Engr. Tech. NOTE: Hit water at 3.0', wet. Maybe a water pocket No 24 hr Water Level
	2.0					
			3.0' Wet		3.0' 2 3.5'	NOTE: Hole was backfilled after completion of drilling
	4.0					
13.8			SP-Beige, coarse poorly graded sand		5.0' 3 5.5'	
	6.0					
	8.0					
	10.0				10.0' 4 10.5'	LAB CLASSIFICATION — Jar Number / Classification — NO SAMPLES TESTED
	12.0					
4.8	14.0		CL Dark gray, lean clay with sand		14.0' 5 14.5'	
4.3	14.5		BOTTOM OF HOLE AT 14.5' SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: HOLE TERMINATED DEPTH AT 14.5'.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT DISPOSAL AREA 26 HOLE NO. CC26-09-H-01

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT DISPOSAL AREA 26	10. SIZE AND TYPE OF BIT 3" HAND AUGER
2. LOCATION (Coordinates or Station) N 407893 E 2693654	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL 3" HAND AUGER
4. HOLE NO. (As shown on drawing title and file number) CC26-H-09-02	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4, UNDISTURBED 0
5. NAME OF DRILLER LARRY BENJAMIN	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. THICKNESS OF OVERBURDEN N/A	16. DATE HOLE STARTED 08/17/2009, COMPLETED 08/17/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 16.5 APPROX.
9. TOTAL DEPTH OF HOLE 10.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION MSL	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
16.5			SP-SM Gray, fine poorly graded silty sand		0.0' 1 0.5'	Soils described by Larry Benjamin, Civil Engr. Tech. NOTE: Hit water at 8.0' NOTE: Hole was caving in at 10.0'. No 24 hr Water Level
	2.0					
13.5			SP-Tan, coarse poorly graded sand		3.0' 2 3.5'	NOTE: Hole was backfilled after completion of drilling
	4.0		4.5' Gray, Moist			
	6.0					LAB CLASSIFICATION — Jar Number / Classification: NO SAMPLES TESTED
9.5			SM Gray, fine silty sand with roots		7.0' 3 7.5'	
8.5	8.0		SP-Gray, coarse poorly graded sand, wet		4 8.5'	
6.5	10.0		BOTTOM OF HOLE AT 10.0' SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: HOLE TERMINATED DEPTH AT 10.0'.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT DISPOSAL AREA 26 HOLE NO. CC26-09-H-02

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT DISPOSAL AREA 26	10. SIZE AND TYPE OF BIT 3" HAND AUGER
2. LOCATION (Coordinates or Station) N 411412 E 2693165	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL 3" HAND AUGER
4. HOLE NO. (As shown on drawing title and file number) CC26-H-09-04	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 5, UNDISTURBED 0
5. NAME OF DRILLER LARRY BENJAMIN	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. THICKNESS OF OVERBURDEN N/A	16. DATE HOLE: STARTED 08/17/2009, COMPLETED 08/17/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 26.6 APPROX.
9. TOTAL DEPTH OF HOLE 10.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION MSL	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
26.6			SP Tan, coarse poorly graded sand trace of Shell fragments		0.0' 1 0.5'	Soils described by Larry Benjamin, Civil Engr. Tech. NOTE: Hole was caving in at 10.0'. No 24 hr Water Level
	2.0				2.0' 2 2.5'	
	4.0					
21.6			5.0' No Shell fragments Very loose dry sand		5.0' 3 5.5'	
	6.0				7.0' 4 7.5'	LAB CLASSIFICATION — Jar Number / Classification — NO SAMPLES TESTED
	8.0				9.5' 5	NOTE: Hole was backfilled after completion of drilling
16.6	10.0		BOTTOM OF HOLE AT 10.0'. SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM		10.0'	NOTE: HOLE TERMINATED DEPTH AT 10.0'.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT DISPOSAL AREA 26 HOLE NO. CC26-09-H-04

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: DISPOSAL AREA 26	10. SIZE AND TYPE OF BIT: 3" HAND AUGER
2. LOCATION (Coordinates or Station): N 412074 E 2693082	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: 3" HAND AUGER
4. HOLE NO. (As shown on drawing title and file number): CC26-H-09-05	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3, UNDISTURBED 0
5. NAME OF DRILLER: LARRY BENJAMIN	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
	16. DATE HOLE: STARTED 08/17/2009, COMPLETED 08/17/2009
7. THICKNESS OF OVERBURDEN: N/A	17. ELEVATION TOP OF HOLE: 16.0 APPROX.
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 3.0'	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION MSL	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
16.0			SP-SM Gray, fine poorly graded silty sand trace of clay		0.0' 1 0.5' 1.0'	Soils described by Larry Benjamin, Civil Engr. Tech. NOTE: Hit water at 1.0'. NOTE: Hole was caving in at 3.0'. No 24 hr Water Level
15.0	1.0		SP-Tan, coarse poorly graded sand trace roots and shell fragments		2 1.5' 2.5' 3	LAB CLASSIFICATION — Jar Number / Classification: NO SAMPLES TESTED
	2.0					
13.0	3.0		BOTTOM OF HOLE AT 3.0' SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM		3.0'	NOTE: Hole was backfilled after completion of drilling NOTE: HOLE TERMINATED DEPTH AT 3.0'.

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: DISPOSAL AREA 26 — HOLE NO.: CC26-09-H-05

SOIL CHARACTERISTICS

SOIL DESCRIPTION	γ_{SAT} (pcf)	$\bar{\phi}$ (Deg.)	$\bar{c}$ (psf)	K_v (cm/sec)	K_h/K_v
Sand to Silty Sand, Clayey Sand	125	32°	0	1.2×10^{-2}	2
Clayey Sand to Clay*	106	-	700	5.0×10^{-5}	1
Sand to Silty Sand, Clayey Sand	110	30°	0	1.2×10^{-2}	2
Clayey Sand to Clay	114	-	800	5.0×10^{-5}	1
Sand to Silty Sand, Clayey Sand	125	32°	0	1.2×10^{-2}	2
Clayey Sand to Clay	120	-	800	5.0×10^{-5}	1
Shell, Sand to Silty Sand	130	32°	0	1.2×10^{-2}	2

ELEVATION — FEET, MSL

32, 30, 20, 10, 0, -10, -20, -30, -40

*NOTE: A PEAT layer, approximately 2.5 feet thick, was encountered in boring AIWW DA-26-09-10.

GENERALIZED SOIL PROFILE

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

U.S. ARMY CORPS OF ENGINEERS
AIWW NORTH DISPOSAL AREA 26
HYDE COUNTY, NORTH CAROLINA

DRAWN BY: AAD	CHECKED BY: MH	DATE: 02/25/10
FILE NO. 09-131	APPROVED BY:	FIGURE: 2

T:\Corporate\09\09-131-COE\Area 26\09131 FIG 2.dwg 3/03/2010 1:53:33 PM, archie.dodge

Appendix Q: Monitoring and Adaptive Management Plan

Neuse River Basin Integrated Feasibility Report and Environmental Assessment Monitoring and Adaptive Management Plan

Contents

1.0 Introduction

This document outlines the feasibility level monitoring and adaptive management plan for Neuse River Basin Feasibility Study and Environmental Assessment. The Project Delivery Team developed this monitoring and adaptive management plan to identify and describe the monitoring and adaptive management activities proposed for the project and estimates their cost and duration. This plan will be further developed in the preconstruction, engineering, and design (PED) phase as specific design details are made available.

The resulting project adaptive management plan for the Neuse River Basin Feasibility Study and Environmental Assessment describes and justifies whether adaptive management is needed in relation to the proposed project management alternatives identified in the Feasibility Study. The plan also identifies how adaptive management would be conducted for the Neuse River Basin Feasibility Study and Environmental Assessment. The developed plan outlines how the results of the project-specific monitoring program would be used to adaptively manage the project, including specification of conditions that will define project success.

This Neuse River Basin Feasibility Study and Environmental Assessment reflect a level of detail consistent with the project Feasibility Study. The primary intent of this Monitoring and Adaptive Management Plan is to develop monitoring and adaptive management actions appropriate for the project's restoration goals and objectives. The specified management actions permit estimation of the adaptive management program costs and duration for the Neuse River Basin Ecosystem Restoration.

This plan is based on currently available data and information developed during plan formulation as part of the feasibility study. Uncertainties remain concerning the exact project features, monitoring elements, and adaptive management opportunities. Components of the monitoring and adaptive management plan, including costs, were estimated using currently available information. Uncertainties will be addressed in preconstruction, engineering, and design (PED), and a detailed monitoring and adaptive management plan, including a detailed cost breakdown, will be drafted by the Adaptive Management Planning Team and PDT as a component of the design document.

2.0 Authority and Purpose

Per Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007), feasibility studies for ecosystem restoration are required to include a plan for monitoring the success of the ecosystem restoration. "Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be need to attain project benefits." Section 2039 also directs that a Contingency Plan (Adaptive Management Plan) be developed for all ecosystem restoration projects.

3.0 Management and Restoration Actions

The PDT performed a thorough plan formulation process to identify potential management measures and restoration actions that address the project objectives. Many alternatives were considered, evaluated, and screened in producing a final array of alternatives. The PDT subsequently identified a tentatively selected plan (TSP) which included the following components:

1. Modifying low-head dam on Little River near Goldsboro
2. Kinston East Wetland Restoration complex
3. Stabilizing Gum Thicket Creek and Cedar Creek
4. Restoring oyster reef habitat

4.0 Objectives of Project to be Measured through Monitoring

According to the CECW-PB Memo dated 31 August 2009, "Monitoring includes the systemic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits." The restoration objectives are summarized below. An effective monitoring program will be required to determine if the project outcomes are consistent with original project objectives. These project objectives are summarized below:

- Improve anadromous fish access to Little River.
- Restore degraded floodplain forested wetlands.
- Restore estuarine shoreline marsh and shallow water habitat.
- Provide additional oyster sanctuary reefs.

5.0 Risk and Uncertainties

Adaptive management provides a coherent process for making decisions in the face of uncertainty. Scientific uncertainties and technological challenges are inherent with any large-scale ecosystem restoration project. The team used experience from previous projects i.e expanding on and referencing successful similar work completed by the USACE Wilmington District and others on adjacent/nearby stream or shoreline segments or oyster reef, to identify possible risks and decrease uncertainty in plan formulation. No measures in the TSP are believed to be burdened by significant risk or uncertainty regarding the eventual success of the proposed habitats. Significant risk would be avoided by proper design, appropriate site selection, and correct seasonal timing of biotic applications.

Below is a list of remaining risks and uncertainties associated with the proposed plan:

Risks

- Unusual wind and weather conditions during construction could produce damaging waves, causing flood or drought, alter wind driven hydrology, exacerbate low DO conditions and change normal current and larval distribution patterns. Aberrations from normal conditions could affect plant and oyster establishment and survival.
- Sites will be posted preclude unauthorized vehicle access or oyster harvest; however, the potential remains that anthropogenic damage could occur.

Uncertainties

- Is expected that sufficient quantities of oyster larvae will be are present at proposed reef sites for colonization/oyster recruitment of the newly placed reef structures, as a result, the plan does not include the placement of seeded cultch. There is however uncertainty regarding this expectation. If monitoring shows that natural recruitment has not occurred, an adaptive management measure to apply seeded spat on shell will be implemented.
- Additionally, potential climate change issues, such as sea level rise are significant scientific uncertainties for all coastal projects. These issues were incorporated in the plan formulation process and will be monitored by gathering data on water levels, salinities, and land elevation. These data will inform adaptive management actions, but future climate change projections remain highly uncertain at this time.

6.0 Rationale for Adaptive Management

The primary incentive for implementing adaptive management is to increase the likelihood of achieving desired project outcomes given the identified uncertainties. Adaptive management provides an organized, coherent, and documented process that suggests management actions in relation to measured project performance compared to desired project outcomes. Adaptive management establishes the critical feedback among project monitoring and informed project management, and learning through reduced uncertainty.

Several questions were considered to determine if adaptive management should be applied to the Neuse River Basin Project:

1) Is the ecosystem to be restored sufficiently understood in terms of hydrology and/or ecology, and can project outcomes be accurately predicted given recognized natural and anthropogenic stressors?
2) Can the most effective project design and/or operation to achieve project goals and objectives be readily identified?
3) Are the measures of this restoration project's performance well understood and agreed upon by all parties?
4) Can project management actions be adjusted in relation to monitoring results?

A 'NO' answer to questions 1-3 and a "YES" answer to question 4 qualifies the project as a candidate that could benefit from adaptive management. These questions were asked for each component of the Neuse Plan; only the oyster component received a "no" for one of the 1st three question (#2) and a "yes" for the 4th and therefore met the requirement for AM.

Relative to the #2 question, there is uncertainty remaining as to whether or not adequate oyster will be present in the estuary at proposed reef sites to assure natural recruitment. If natural recruitment does not occur as predicted, an adaptive management measure to apply seeded spat on shell would be needed.

7.0 Monitoring for Adaptive Management

Oyster Reef Restoration

Proposed Plan. Construct 10 acres of sustainable oyster reef top habitat supporting 80 acres of reef and adjacent service area.

Recruitment monitoring will occur annually for the first 5 years. Methods will be consistent with NCDMF sanctuary sampling methods to the degree practical. The information obtained will be compared to the previous year's sampling results from the restoration site and annual state sanctuary Indexes as available. The following information will be collected for each sample

- Length x Width x Height of rock (mm)
- Number of live and dead oysters
    - 3 size classes spat, sublegal and legal size oysters
- Height of each alive and dead (box) oyster. (Size distribution)

Success Criteria and Adaptive Management Measures

Success Criteria. Successful recruitment will be identified when all 3 size class are present with each class well represented.

Adaptive Management Trigger. If monitoring shows that spat settlement is not adequate (less that 50 spat per m^2) for two consecutive years, spat on shell will be applied during the following reproductive season.

Monitoring. Methods will be consistent with NC Division of Marine Fisheries oyster sampling methods to the degree practical. The information obtained will be compared to the previous year's sampling results from the restoration site and annual state sanctuary Indexes as available. Faunal utilization of the site will be assessed by qualitative methods. An annual monitoring report will be prepared and coordinated with interested parties.

The following additional information will be collected for each sample

- Organisms found attached to rock and extent (fouling)
    - Barnacles, mussels, tunicates, bryozoans, sponges, limpets, etc.
    - Recorded as percent coverage using 7 graded scale (1, 5, 10, 25, 50, 75, 100)
- Presence and number of predators

- Oyster drills, crabs, etc.

8.0 Additional Monitoring of Objectives to Determine Project Success

Oyster Reef Restoration

Structural Persistence. A bathymetric survey of the reef site identifying significant project features will be made upon completion (year 1), which will document base conditions and construction compliance. A comparison survey will also be made at the end of the monitoring period (year 5) to determine structural persistence of project components. The extent of reef will be mapped and quantified.

> ***Success Criteria.*** Neuse River Reef Sanctuaries will be considered successful if at the end of 5 years, the average reef top area (elevations greater than 2 ft above the adjacent river bottom) for all sanctuary reefs is at least 75 percent of the average reef top area for all sanctuary reefs for the as built condition.

Biological Persistence. Oyster sampling would be conducted annually for the first 5 Years and also at Year 10. Monitoring would include abundance of oysters and size class distribution by collection of individual reef stones (Class B) and/or quadrate samples by divers at each project sanctuary reef and an associated nearby reference reef. Three randomly selected target areas per reef top would be evaluated by collection and analysis of 3 samples each, on an annual basis between years 1- 5 and 10.

Methods will be consistent with NC Division of Marine Fisheries oyster sampling methods to the degree practical. The information obtained will be compared to the previous year's sampling results from the restoration site and annual state sanctuary indices as available. Faunal utilization of the site will be assessed by qualitative methods. An annual monitoring report will be prepared and coordinated with interested parties.

The following additional information will be collected for each sample

- Organisms found attached to rock and extent (fouling)
    - Barnacles, mussels, tunicates, bryozoans, sponges, limpets, etc.
    - Recorded as percent coverage using 7 graded scale (1, 5, 10, 25, 50, 75, 100).
- Presence and number of predators
    - Oyster drills, crabs, etc.

Success Criteria. Neuse River reef sanctuaries will be considered successful if at the end of 5 years, at least 25 oyster /m^2 are present. (combined all size classes)

Kinston East Wetland Complex

Proposed Plan. Fill material would be excavated on 14.5 ac of land to approximately match the elevation of the adjacent bottomland hardwood forest (4 ft) allowing high Neuse River flows to flood the area. This measure would restore 14.5 ac of bottomland hardwood forest. The site will be initially planted in grasses. Because the site is located adjacent to mature forest it expected to naturally revegetate with appropriate tree species, without additional planting.

Structural Persistence. A topographic survey of the restoration area will be made upon completion (year 1) as a requirement of the construction contract, which will document base conditions and construction compliance. A comparison monitoring survey will be made at the end of the monitoring period (year 5).

> ***Success Criteria.*** The site will be considered persistent if at least 80 percent of the restored area remains at or below elevations appropriate to support wetlands.

Biological Persistence. Vegetative monitoring would be conducted by plot sampling that is generally consistent with methods for sampling vegetation as described in *A Standard Operating Procedures Manual for the Coast-Wide Reference Monitoring System-Wetlands* (Folse et.al 2008). Monitoring would be conducted annually for the first 5 years and then in years 7 and 10.

Large trees and shrubs (>5 cm DBH) would be counted and measured in three 20m x 20m plots that would be randomly placed along a diagonal transect located across the restoration site. Within each plot, all woody shrubs and trees (saplings and seedlings) >5 cm DBH will be identified to the species level, counted, and their height measured. Diameter at breast height measurements shall be taken for shrubs and saplings of adequate height.

Trees and shrub seedlings and saplings would be counted in at least nine 6m x 6m plots nested (3 each) within the three larger plots. Within each plot, all woody shrubs and trees (saplings and seedlings) <5 cm diameter at breast height (DBH) will be identified to the species level, counted, and their height measured. DBH measurements shall be taken for shrubs and saplings of adequate height.

Herbaceous coverage would be assessed within three 2m x 2m plots nested within each of the $6m^2$ plots. Species composition and cover for each station would be determined using visual estimates of cover following the Braun-Blanquet cover scale (Mueller-Dombois and Ellenburg 1974). Estimates of total percent cover in the plot and percent cover by individual species will be determined.

> ***Success Criteria.*** An assumed success criterion of 260 trees per acres at year 10 with at least 5 species including a mix of Oaks, and or Cypress and or Gum present has been identified. The success criteria will be verified by sampling during PED. Targets for tree density and diversity will be developed considering counts made in an adjacent reference

area using methods described above. Target species would be selected from a list of dominate species located in the reference site. The forested wetland would be considered successful when, at or after year 10, at least 80 percent of the reference area densities (number of tree species established) and coverage (trees/acre) has been established.

Gum Thicket Cedar Creek

Rock sills approximately 4,500 ft-long at Gum Thicket Creek and 6,700 ft-long at Cedar Creek would be built at distances of up to 90 ft offshore. Constructing the rock sill and replacing eroded sediment landward of the sill would create new marsh after initial planting with *Spartina* species to create a *living shoreline* consisting of planted and open-water areas.

Structural Persistence. A topographic survey of the restoration area will be made during PED, and upon completion (year 1) as a requirement of the construction contract, which will document pre and post project conditions, and construction compliance. A comparison monitoring survey will be made at the end of the monitoring period (year 5).

Success Criteria. The site will be considered persistent if at year 5 at least 75 percent of the restored wetland area remains within the range of elevations appropriate to support wetland habitats and shorelines remain seaward of the area where existing wetlands are being protected.

Biological Persistence. Vegetative monitoring would be conducted by plot sampling that is generally consistent with methods for sampling vegetation as described in *A Standard Operating Procedures Manual for the Coast-Wide Reference Monitoring System-Wetlands* (Folse et.al 2008). Monitoring would be conducted annually for 5 years.

Marsh cover would be assessed within a minimum of two hundred 1m x 1m quadrates. Species composition and cover for each station would be determined using visual estimates of cover following the Braun-Blanquet (B-B) cover scale (Mueller-Dombois and Ellenburg 1974) Estimates of Frequency of Occurrence of vegetate samples, total percent cover and percent cover by individual species per plot, and for Gum Thicket and Cedar Creek will be determined. Invasion by exotic non-native plants such as Phragmites will also be assessed.

Plots will be identified in the field by GPS from random points generated by GIS. GPS will also be used to establish the location of the shoreline during each monitoring year.

Success Criteria. An assumed success criteria of 80% cover of *Spartina alterniflora* and *S. patens* in appropriate high marsh or low marsh positions. Success criteria will be verified base on (BB) sampling of an adjacent reference area using methods described above during PED. The marsh would be considered successful when the site is generally vegetated along its entire length, where Frequency of Occurrence for vegetated quadrates is at least 80 percent, and average B-B value for percent total cover is no less than 1 increment below the B-B target.

Little River Dam near Goldsboro

Modification of Little River Dam near Goldsboro will include removal of approximately 20-ft section of the existing 100-ft-wide, 4-ft-high concrete dam. Either a hydraulic gate or a stop log structure would be installed within the 20-ft opening. The gate in the existing dam would remain open during the anadromous fish migration season (i.e., about January to May). Only during low-flow conditions (i.e., July to September) would Goldsboro close the gate to use the upstream secondary water intake structure. The PDT estimates fish passage efficiency for the measure to be 99 percent.

Structural Persistence. The up/down river connection would be monitored by visual inspection annually for 5 years to assure that hydrologic connectivity remains intact.

Success Criteria. Retain 80% of the design cross section of 60 sq. ft. at year 5 The connection would be considered successful when the removed dam section is generally un-obscured Retains 80% of the design cross section of 60 sq. ft. at year 5.9.0 Cost Estimate

Monitoring Component	Estimated Total Cost (10 years)
Oyster Reef Restoration	$118,000
Kinston East Wetland Complex	$41,000
Gum Thicket Cedar Creek	$147,000
Little River Dam Removal	$6,000
10 year total monitoring cost	$312,000
Adaptive Management	**Estimated Total Cost (10 years)**
Oyster Reef Restoration	$354,000

10.0 References

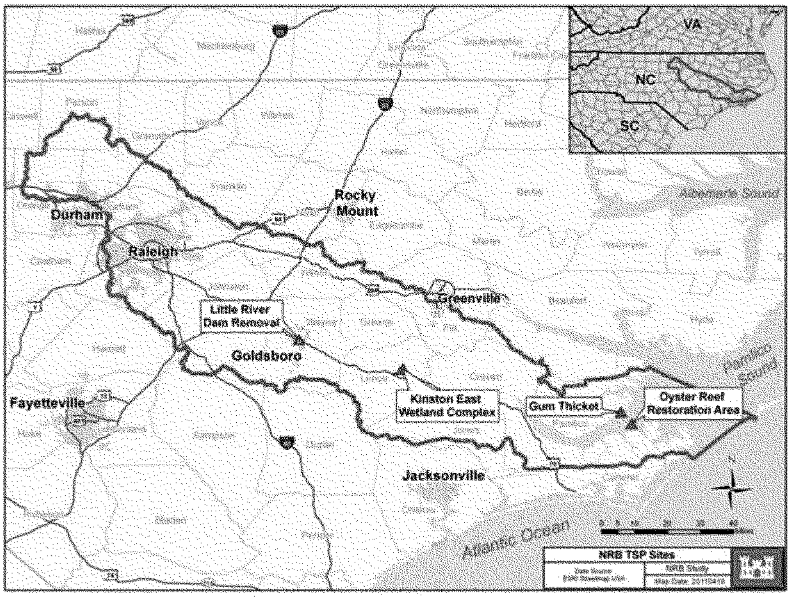
Folse, T.M., J.L. West, M.K. Hymel, J.P. Troutman, L.A. Sharp, D. Weifenbach, T. McGinnis, and L.B. Rodrigue 2008. A standard operating procedures manual for the Coast-wide Reference Monitoring System-Wetlands— Methods for site establishment, data collection, and quality assurance/quality control: Baton Rouge, LA., Louisiana Coastal Protection and Restoration Authority, Office of Coastal Protection and Restoration, 191 p.

Mueller-Dombois, D., and H. Ellenberg. (1974). "Aims and Methods of Vegetation Ecology." John Wiley and Sons, New York.

Water Resources Development Act 2007. Pub.L. 110-114.

Appendix R: Neuse River Basin Cultural Resources Study Plan

Neuse River Basin Cultural Resources Study Plan



June, 2012

Prepared by:

John L. Mayer
U.S. Army Corps of Engineers
Wilmington District

Neuse River Basin Cultnral Resources Study Plan

The U.S. Army Corps of Engineers, Wilmington District, is preparing a *Draft Interim Integrated Feasibility Report and Environmental Assessment* for the Neuse River Basin. The District is partnering with the North Carolina Division of Water Resources (NCDWR) to investigate the Neuse River Basin and recommend appropriate federal actions to accomplish ecosystem restoration and flood risk management. The authority for this study, contained in House Document 175, 89th Congress, allows the federal government an opportunity to assist state agencies in protecting the Neuse River Basin.

The primary goal of the Neuse River Basin project is environmental restoration. Some project alternatives may have a potential to impact uplands or river bottom include projects such as dam removal, reestablishing oyster beds, and wetland restoration. Per the provisions of the National Historic Preservation Act (36 CFR 800), the North Carolina State Historic Preservation Officer (SHPO) will be consulted regarding all phases of the study. The project features (Figure 1) that are currently in the Tentatively Selected Plan include:

Geographic site	County	USGS Quadrangle	Site measure
Low Head Dam, Little River, near Goldsboro	Wayne	Wayne	Rock ramp
Kinston East Complex	Lenoir	NW Goldsboro	Wetland restoration
Stabilizing Gum Thicket and Cedar Creek	Pamlico	Broad Creek	Constructing rock sills
C2C and C3C	Pamlico	Broad Creek, Jones Bay, Little Fishing Point, Point of Marsh, South River	New oyster reef sanctuary

The Neuse River Basin is the third-largest river basin in North Carolina, encompassing a total area of 6,234 square miles. The basin is one of only four located entirely within the state. The Neuse River originates with the convergence of the Eno and Flat rivers in north-central North Carolina in Person and Orange Counties. The first 22 miles of the river are impounded by Falls Lake Dam. The Neuse then flows southeast until it reaches tidal waters near Sneads Ferry upstream of New Bern. The river broadens dramatically at New Bern and changes from a free-flowing river to a tidal estuary known as the Neuse River Estuary, which eventually flows into Pamlico Sound.

Cultural Resources Considerations and Study Needs

Low Head Dam, Little River near Goldsboro

The low-head dam near Goldsboro, North Carolina, is the last major obstruction to fish passage on the mainstream of Little River (Figures 2 and 3). The presence of the dam (100 feet long by 4 feet high) affects the timing of migration and possibly spawning for anadromous fish species. Species that rely on habitat structure from the Neuse River Estuary upstream would be allowed access to additional features in the estuary and more than 100 miles upstream from the estuary.

The tentatively selected plan would involve removing an additional portion of the dam to lower the invert of the notch, providing a path for fish migration. A stoplog type, aluminum water control structure will be needed in order to provide sufficient water depth for the operation of the water treatment plant intake structure during the low flow periods in the summer.

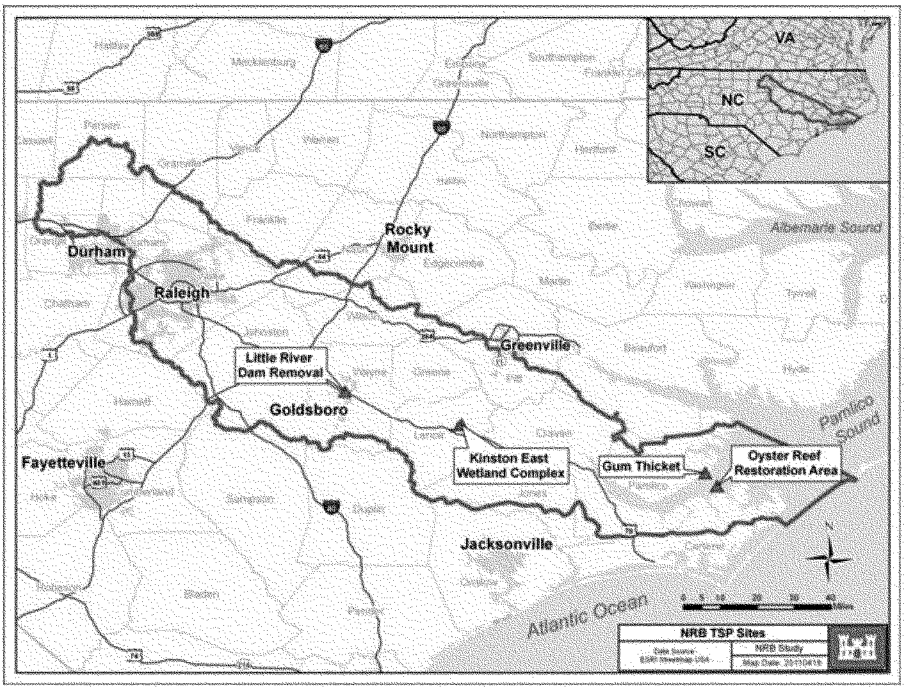


Figure 1. Location of the four potential restoration areas.

Given the location of this site at the existing Goldsboro water treatment plant, the contractor would use a proposed 2-acre upland staging area, adjacent to the dam. A large portion of the proposed upland staging area is asphalt/concrete covered, with the remainder being grassed with lawn species. No woody vegetation would be removed, cleared, or grubbed. The area of potential effect (APE) includes the dam and 2-acre upland staging area (Figure 2).

Based on consultation with the North Carolina Office of State Archaeology (OSA), the dam is not a unique feature and is considered not eligible for nomination to the National Register of Historic Places. Equipment operating and staging areas would be located within paved and previously disturbed (open field/lawn). No further archaeological investigations are required at this site.

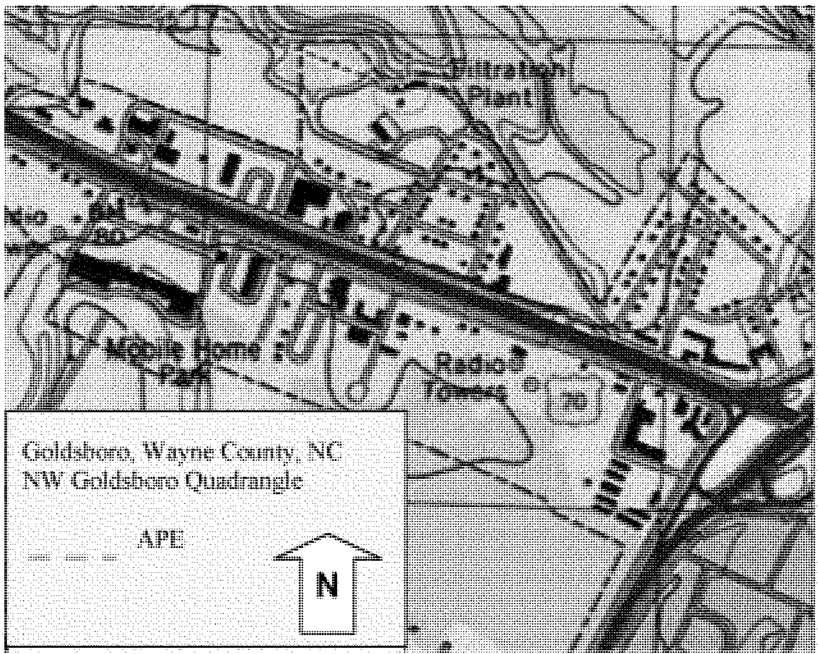


Figure 2. Low-head dam APE

Figure 3. Low-head dam at Goldsboro.

Restoration of Kinston East Wetland Complex, Kinston, NC

The project features fall within highly disturbed portions of the floodplain east of Kinston, NC along the Neuse River (Figure 4). The grade of the site was apparently raised with hauled-in fill material in preparation for development, but the project did not go forward. Examples of disturbance include pond and drainage construction and deposition of fill material over 14.5 acres of a 30-acre tract of wetland (APE). The site is bordered on the east, west, and south by mature bottomland hardwoods wetland (Figure 5).

The proposed measures consist of regrading the site to the approximate elevation of the adjacent bottomland hardwood forest, and allowing natural revegetation of the site by bottomland hardwood species without replanting trees. Starting nearest the river and working north toward Lincoln Street, each area would be cleared, grubbed, and brought to final grade, and seeded. Sediment control devices will be used to prevent sediment from leaving the site during the regrading process and until stabilization is achieved. About 14.5 ac of fill material would be excavated to approximately match the elevation of the adjacent bottomland hardwood forest (4 ft). The two existing ditches would be filled to allow for a more natural hydrology at the site.

No recorded archaeological or historic sites in the proposed restoration area (APE) were identified during a review of site files at the OSA. A Civil War battlefield, Wyse Forks, lies across the river approximately one mile to the south. In consultation with OSA, no further archaeological investigation based on the project's location within a wetland and past disturbances are required.

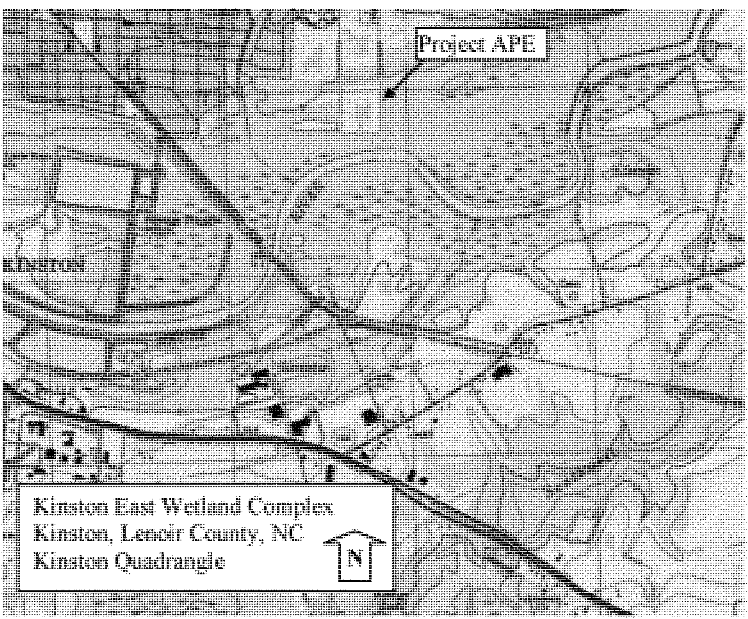


Figure 4. Kinston East Wetland Complex APE.

Figure 5. Bottomlands adjacent to and south of the filled 14.5 acre tract at Kinston East wetland complex.

Gum Thicket and Cedar Creek Restoration

This element would minimize erosion on approximately 60 acres of existing estuarine wetland at the Gum Thicket and Cedar Creek sub-estuaries, create approximately 6 acres of additional estuarine wetland, and also 1.3 acres of oyster reef (Figures 6, 7, 8, and 9). Parallel rock sills approximately 3,500 ft long at Gum Thicket Creek and 5,200 ft long at Cedar Creek would be constructed. The rock sill would have a 4-ft wide top elevation with a 30-ft bottom width and 2:1 side slopes approximately 90 ft offshore

Two existing roads leading nearly to the shoreline would be extended for access (Figures 7 and 8). Construction would begin from these shoreline points out to the 90-ft offshore distance. From this offshore point, construction would begin parallel to the shoreline. Equipment sized to fit on the top of the sill would be used for travel along the lower part of the sill, with the equipment traveling in one direction on top of the newly placed rock. The crest would be placed as the equipment is backed off.

The marsh fill would be placed by off-road dump trucks and shaped by bulldozers, starting by dumping fill material at the end of each road and continuing to expand the fill with succeeding loads, building a fill area that can be driven on by off-road equipment, and bringing it to final grade as the last step. Borrow material for creating the marsh buffer will be available from an existing disposal area for the Atlantic Intracoastal Waterway. An existing, 3-acre staging area associated with the current land development would be available during project construction (Figure 7).

Four known historic and prehistoric archaeological sites (31PM28, 31PM32, 31PM33, and 31PM34) are along the shore in the Gum Thicket Creek and Cedar Creek area and within the project feature APE (Figure 8). The four sites were visited by an archaeologist with the North Carolina Office of State Archaeology in the late 1980s and found to be heavily eroded and containing historic and prehistoric components (Robinson 2000). Robinson (2000) also noted heavy erosion along the Gum Thicket and Cedar Creek shoreline during a reconnaissance level investigation of the area. The sites are now believed to have been lost to erosion (David Brook to Kim Williams, Land Management Group, Inc., letter October 18, 1999, North Carolina Office of State Archaeology, Raleigh, NC).

While previous investigations indicate historic properties are no longer located within this project component's APE, a shoreline examination and inspection of two sites (31PM35 and 31PM98) near the APE by the Wilmington District archaeologist and coordination with the North Carolina Office of State Archaeology will be conducted prior to project implementation. Evaluation, determination of effects, and measures to avoidance or mitigate adverse effects will be conducted under a programmatic agreement (PA) pursuant to Section 800.14(b) of the regulations implementing Section 106 of the National Historic Preservation Act should unknown historic properties be identified during the shoreline examination.

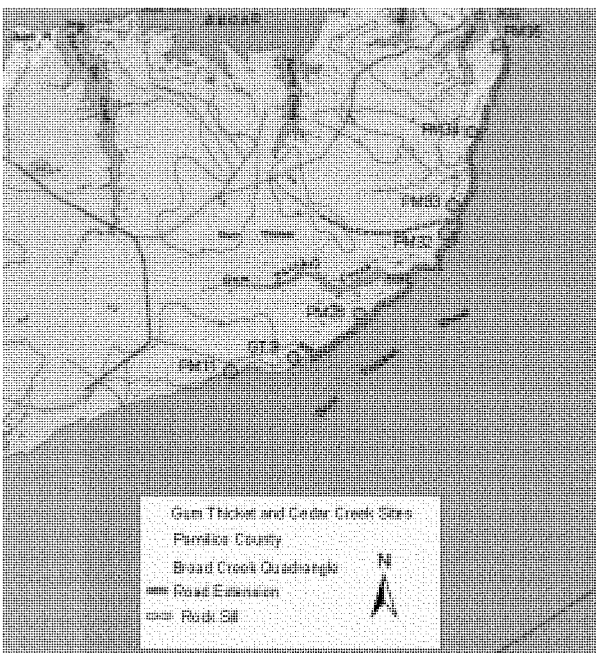


Figure 6. Gum Thicket and Cedar Creek Restoration

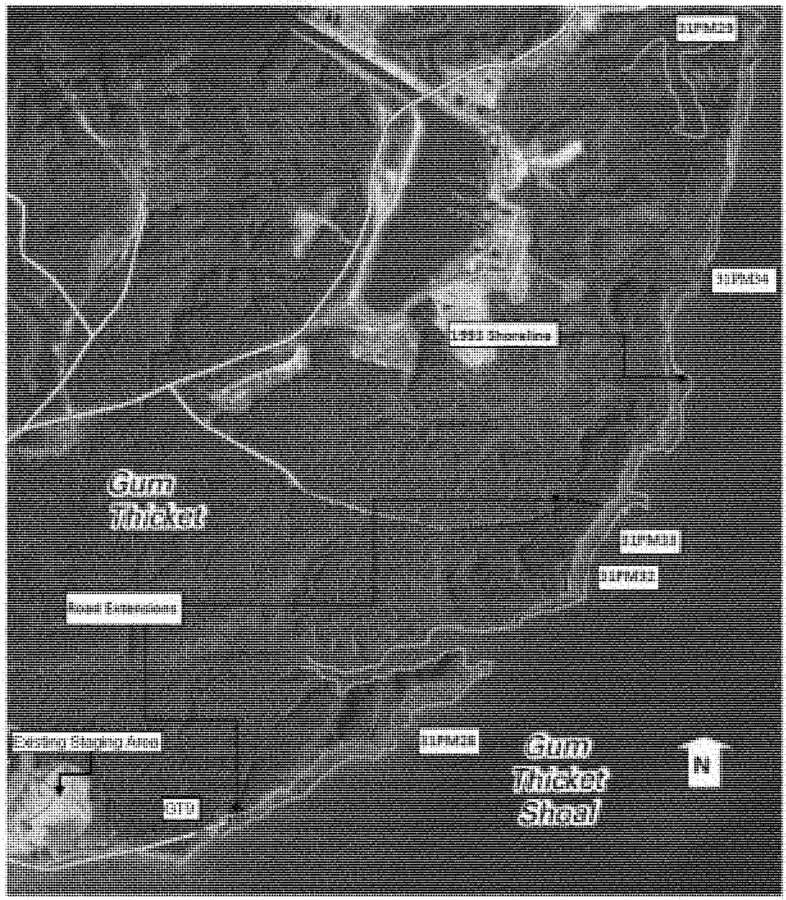


Figure 7. 2009 Aerial Photographs with known site locations, 1993 shoreline (approximate), and proposed road extensions.

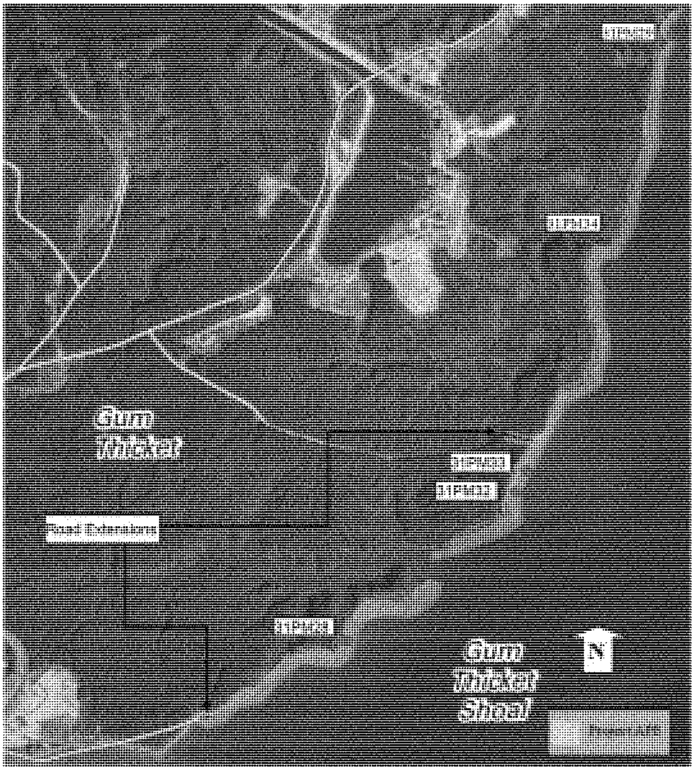


Figure 8. Gum Thicket and Cedar Creek restoration Area of Potential Effect.

Oyster Reef Restoration

This component includes constructing approximately 12 acres of new elevated reef top (20-acre footprint) within a 94-acre service area that would be demarcated by corner buoys and managed as oyster sanctuary by the state. Three locations have been tentatively selected including (1) an area adjacent to the existing Neuse Sanctuary on the Neuse Southern Shore, (2) a Mid-river site in the lower estuary, and (3) a site on Neuse Northern Shore (Figure 10). Reef development of those areas would contribute to ongoing state efforts to offset historic reef loss in the Neuse River and Albemarle Pamlico Estuary. Each site would contain a matrix of several 4-ft high, flat-top plateau plateaus of about 1 acre each.

Determination of this project component's Area of Potential Effect, determination of level of identification efforts, evaluation of historic properties, determination of effects, and measures to avoid or mitigate adverse effects will be conducted under a programmatic agreement in accordance with 36 CFR 800.14(b) of the regulations implementing Section 106 of the National Historic Preservation Act. Locations for constructing the oyster reefs in the lower Neuse River

Estuary would be coordinated with the North Carolina Underwater Archaeology Branch (UAB) to avoid known or suspected underwater cultural resources.

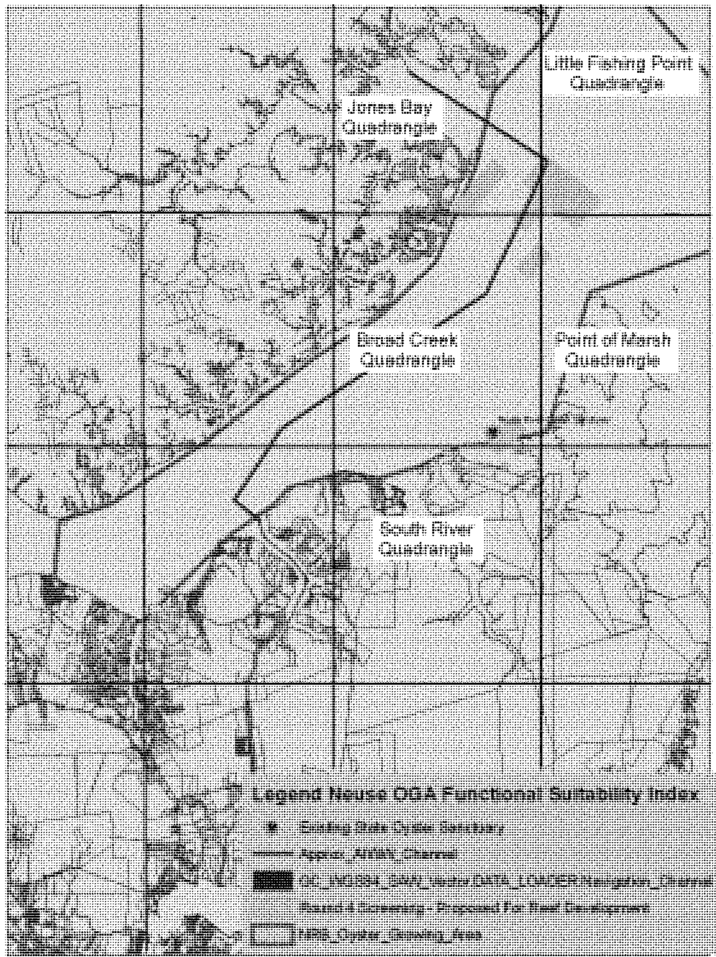


Figure 10. Neuse River Estuary oyster growing area

<u>Project Effects</u>

In consultation with the NC SHPO, no known historic properties are located within the Area of Potential Effects for the Low Head Dam and Kinston East Wetland Restoration components and no additional cultural resource investigations are recommended.

No known historic properties are believed to be extant in the Gum Thicket and Cedar Creek restoration component based on documented erosion. A shoreline examination and inspection of two sites near the Gum Thicket/Cedar Creek APE will be conducted prior to project implementation through a PA under development with the NC SHPO and Advisory Council on Historic Properties. Measures to avoid or mitigate adverse effects will also be developed under the PA.

Specific oyster reef restoration sites have not been identified at this time. Determination of this project component's Area of Potential Effect, determination of level of identification efforts, evaluation of historic properties, determination of effects, and measures to avoid or mitigate any adverse effects will be conducted under a programmatic agreement in accordance with 800.14(b) of the regulations implementing Section 106 of the National Historic Preservation Act. The Tentatively Selected Plan would have no effect on known historic properties.

REFERENCES

Robinson, Kenneth W.

2000 *Management Summary, Stage 1 Archaeological Reconnaissance, 1400-acre Gum Thicket Residential and Marina Development, Pamlico County, SHPO # ER 00-7785*. Report on file at the North Carolina Office of State Archaeology, Raleigh, NC.

Appendix S: Letter of Support

NCDENR

North Carolina Department of Environment and Natural Resources
Division of Water Resources

Beverly Eaves Perdue
Governor

Thomas A. Reeder
Director

Dee Freeman
Secretary

February 27, 2012

Colonel Steven A. Baker
District Commander, Wilmington District
U.S. Army Corps of Engineers
69 Darlington Avenue
Wilmington, NC 28403

Dear Colonel Baker:

It is the intent of the State of North Carolina to be the non-Federal sponsor for the Neuse River Basin ecosystem restoration project. We have reviewed the draft Integrated Feasibility Report and Environmental Assessment dated October 2011 and the State expresses its support for the Tentatively Selected Plan as described in the draft report.

As the non-Federal project sponsor we anticipate that implementation costs of the project, currently estimated at $35,318,000, would be shared 35% non-Federal and 65% Federal. The State's share is currently estimated at $12,361,000 including cash, in-kind services, and lands, easements, relocations, rights-of-way, and borrow or disposal areas. The State's ability to provide these funds is dependent upon the approval of appropriations for the project in future State budgets.

We would also assume all responsibility for operation, maintenance, repair, rehabilitation and replacement for the life of the project, at an estimated $390,000 average annual cost. Prior to construction, we anticipate signing a Design Agreement and a Project Partnership Agreement (PPA) that will explicitly state Federal and non-Federal costs and responsibilities.

We appreciate the efforts of the Corps of Engineers on this project.

Sincerely,

Tom Reeder

1611 Mail Service Center, Raleigh, North Carolina 27699-1611
Phone: 919-733-4064 \ FAX: 919-733-3558 \ Internet: www.ncwater.org

One NorthCarolina Naturally

Appendix T: Final Section 404 (b) (1) Evaluations for the Tentatively Selected Plan

Neuse River Basin Final Feasibility Report and Finding of No Significant Impact (FONSI)

Final Evaluation of Section 404 (b) (1) Guidelines 40 CFR 230 for *Modifying Low-head Dam on Little River near Goldsboro*

This evaluation covers the placement of all fill material into waters and wetlands of the United States required for construction of the four components of the Tentatively Selected Plan.

		Preliminary 1/	Final 2/
1.	Review of Compliance (230.10(a)-(d)) A review of the NEPA Document indicates that:		
a.	The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and NEPA document);	YES ☐ NO☒	YES☐ NO☒
b.	The activity does not: 1) violate applicable State water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of federally listed endangered or threatened species or their habitat; and 3) violate requirements of any federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	YES☒ NO☐*	YES☒ NO☐
c.	The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (if no, see section 2);	YES☐ NO☒	YES☐ NO☒
d	Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5).	YES☒ NO☐*	YES☒ NO☐

Proceed to Section 2

See Footnote *, 1, and 2 on page 7.

2. Technical Evaluation Factors (Subparts C-F)	N/A	Not Significant	Significant
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
(1) Substrate impacts.		X	
(2) Suspended particulates/turbidity impacts		X	
(3) Water column impacts.		X	
(4) Alteration of current patterns and water circulation.		X	
(5) Alteration of normal water fluctuations/hydroperiod.		X	
(6) Alteration of salinity gradients.	NA		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
(1) Effect on threatened/endangered species and their habitat.	NA		
(2) Effect on the aquatic food web.		X	
(3) Effect on other wildlife (mammals birds, reptiles, and amphibians).		X	
c Special Aquatic Sites (Subpart E)			
(1) Sanctuaries and refuges.	NA		
(2) Wetlands.	NA		
(3) Mud flats.	NA		
(4) Vegetated shallows.	NA		
(5) Coral reefs.	NA		
(6) Riffle and pool complexes.	NA		
d. Human Use Characteristics (Subpart F)			
(1) Effects on municipal and private water supplies.	NA		
(2) Recreational and commercial fisheries impacts		X	
(3) Effects on water-related recreation.		X	
(4) Aesthetic impacts.		X	
(5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites,, and similar preserves.	NA		

Remarks: Where a check is placed under the significant category, preparer add explanation below.

Proceed to Section 3

See Footnote * on page7.

3. Evaluation of Dredged or Fill Material (Subpart G) 3/

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

(1) Physical characteristics .... ☒
(2) Hydrography in relation to known or anticipated sources of contaminants........ ☒
(3) Results from previous testing of the material or similar material in the vicinity of the project........ ☐
(4) Known, significant sources of persistent pesticides from land runoff or percolation........ ☒
(5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances........ ☐
(6) Other public records of significant introduction of contaminants from industries, municipalities, or other sources .... ☒
(7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities........ ☒

(8) Other sources (specify). .... ☐

List appropriate references.

Reference: . Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to result in degradation of the disposal site.** YES ☐ NO☒*

Proceed to Section 4
See Footnote *, 3 on page 7.

4. Disposal Site Determinations (230.11(f)).

a. The following factors as appropriate, have been considered in evaluating the disposal site.

(1) Depth of water at disposal site ☒

(2) Current velocity, direction, and variability at disposal site ☐

(3) Degree of turbulence. ☒

(4) Water column stratification ☐

(5) Discharge vessel speed and direction ☐

(6) Rate of discharge ☐

(7) Dredged material characteristics (constituents, amount and type of material, settling velocities) ☒

(8) Number of discharges per unit of time. ☐

(9) Other factors affecting rates and patterns of mixing (specify)

List appropriate references.

Reference: Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable. YES ☒ NO ☐*

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77, to ensure minimal adverse effects of the proposed discharge. List actions taken. YES ☒ NO ☐*

Return to section 1 for final stage of compliance review.
See also Footnote 3/, page 4.
*See Footnote on page 7.

6. Factual Determinations (230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

a. Physical substrate at the disposal site (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

b. Water circulation, fluctuation, and salinity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

d Contaminant availability (review sections 2a, 3, and 4). YES ☒ NO ☐*

e. Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5). YES ☐ NO ☐*

f. Disposal site (review sections 2, 4, and 5). YES ☒ NO ☐*

g. Cumulative impact on the aquatic ecosystem. YES ☒ NO ☐*

h. Secondary impacts on the aquatic ecosystem. YES ☐ NO ☐*

7. Findings.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines. . . . . ☒

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions:. . . . . ☐

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reasons(s):

(1) There is a less damaging practicable alternative . . . . ☐

(2) The proposed discharge will result in significant degradation of the aquatic ecosystem . . . . ☐

*See Footnote on page 7.

(3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem. ☐

8.

____
Steven A Baker
Colonel, U.S. Army
District Engineer

Date: ____________________

*A negative, significant, or unknown response indicates that the permit application may not be in compliance with the Section 404(b)(1) Guidelines.

1/ Negative responses to three or more of the compliance criteria at this stage indicate that the proposed projects may not be evaluated using this "short form procedure." Care should be used in assessing pertinent portions of the technical information of items 2 a-d, before completing the final review of compliance.

2/ Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate."

3/ If the dredged or fill material cannot be excluded from individual testing, the "short-form" evaluation process is inappropriate.

Neuse River Basin Final Feasibility Report and Finding of No Significant Impact (FONSI)

Final Evaluation of Section 404 (b) (1) Guidelines 40 CFR 230 for Construction of Shoreline Stabilization and Marsh Planting at Gum Thicket and Cedar Creek

This evaluation covers the placement of all fill material into waters and wetlands of the United States required for construction of the four components of the Tentatively Selected Plan.

		Preliminary 1/	Final 2/
1.	Review of Compliance (230.10(a)-(d)) A review of the NEPA Document indicates that:		
a.	The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and NEPA document);	YES ☐ NO☒	YES☐ NO☒
b.	The activity does not: 1) violate applicable State water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of federally listed endangered or threatened species or their habitat; and 3) violate requirements of any federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	YES☒ NO☐*	YES☒ NO☐
c.	The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (if no, see section 2);	YES☐ NO☒	YES☐ NO☒
d	Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5).	YES☒ NO☐*	YES☒ NO☐

Proceed to Section 2
See Footnote *, 1, 2/ on page 13.

2. Technical Evaluation Factors (Subparts C-F)	N/A	Not Significant	Significant
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
(1) Substrate impacts.		X	
(2) Suspended particulates/turbidity impacts		X	
(3) Water column impacts.		X	
(4) Alteration of current patterns and water circulation.		X	
(5) Alteration of normal water fluctuations/hydroperiod.		X	
(6) Alteration of salinity gradients.	NA		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
(1) Effect on threatened/endangered species and their habitat.	NA		
(2) Effect on the aquatic food web.		X	
(3) Effect on other wildlife (mammals birds, reptiles, and amphibians).		X	
c Special Aquatic Sites (Subpart E)			
(1) Sanctuaries and refuges.	NA		
(2) Wetlands.		X	
(3) Mud flats.	NA		
(4) Vegetated shallows.	NA		
(5) Coral reefs.	NA		
(6) Riffle and pool complexes.	NA		
d. Human Use Characteristics (Subpart F)			
(1) Effects on municipal and private water supplies.	NA		
(2) Recreational and commercial fisheries impacts		X	
(3) Effects on water-related recreation.		X	
(4) Aesthetic impacts.		X	
(5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites,, and similar preserves.	NA		

Remarks: Where a check is placed under the significant category, preparer add explanation below.

Proceed to Section 3

See footnote * on page13.

3. Evaluation of Dredged or Fill Material (Subpart G) 3/

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

(1) Physical characteristics ..... ☒
(2) Hydrography in relation to known or anticipated sources of contaminants..... ☒
(3) Results from previous testing of the material or similar material in the vicinity of the project..... ☐
(4) Known, significant sources of persistent pesticides from land runoff or percolation..... ☒
(5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances..... ☐
(6) Other public records of significant introduction of contaminants from industries, municipalities, or other sources ..... ☒
(7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities..... ☒

(8) Other sources (specify). ..... ☐

List appropriate references.

Reference: . Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to result in degradation of the disposal site.** YES ☐ NO☒*

Proceed to Section 4
See footnote * and 3on page 13

4. Disposal Site Determinations (230.11(f)).

a. The following factors as appropriate, have been considered in evaluating the disposal site.

(1) Depth of water at disposal site ☒

(2) Current velocity, direction, and variability at disposal site ☐

(3) Degree of turbulence. ☒

(4) Water column stratification ☐

(5) Discharge vessel speed and direction ☐

(6) Rate of discharge ☐

(7) Dredged material characteristics (constituents, amount and type of material, settling velocities) ☒

(8) Number of discharges per unit of time. ☐

(9) Other factors affecting rates and patterns of mixing (specify)

List appropriate references.

Reference: Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable. YES ☒ NO ☐*

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77, to ensure minimal adverse effects of the proposed discharge. List actions taken. YES ☒ NO ☐*

Return to section 1 for final stage of compliance review. See also note 3/, page 10.
See footnote * on page 13.

6. Factual Determinations (230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

a. Physical substrate at the disposal site (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

b. Water circulation, fluctuation, and salinity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

d Contaminant availability (review sections 2a, 3, and 4). YES ☒ NO ☐*

e. Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5). YES ☐ NO ☐*

f. Disposal site (review sections 2, 4, and 5). YES ☒ NO ☐*

g. Cumulative impact on the aquatic ecosystem. YES ☒ NO ☐*

h. Secondary impacts on the aquatic ecosystem. YES ☐ NO ☐*

7. Findings.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines. . . . . ☒

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions:. . . . . ☐

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reasons(s):

(1) There is a less damaging practicable alternative . . . . ☐

(2) The proposed discharge will result in significant degradation of the aquatic ecosystem . . . . ☐

See footnote * on page 13.

(3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem. ☐

8.

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Steven A Baker
Colonel, U.S. Army
District Engineer

Date: ____________________

*A negative, significant, or unknown response indicates that the permit application may not be in compliance with the Section 404(b)(1) Guidelines.

1/ Negative responses to three or more of the compliance criteria at this stage indicate that the proposed projects may not be evaluated using this "short form procedure." Care should be used in assessing pertinent portions of the technical information of items 2 a-d, before completing the final review of compliance.

2/ Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate."

3/ If the dredged or fill material cannot be excluded from individual testing, the "short-form" evaluation process is inappropriate.

Neuse River Basin Final Feasibility Report and Finding of No Significant Impact (FONSI)

Final Evaluation of Section 404 (b) (1) Guidelines 40 CFR 230 for *Constructing New Oyster Reef Habitat in the Lower Neuse Estuary*

This evaluation covers the placement of all fill material into waters and wetlands of the United States required for construction of the four components of the Tentatively Selected Plan.

		Preliminary 1/	Final 2/
1.	Review of Compliance (230.10(a)-(d)) A review of the NEPA Document indicates that:		
a.	The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and NEPA document);	YES ☐ NO☒	YES☐ NO☒
b.	The activity does not: 1) violate applicable State water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of federally listed endangered or threatened species or their habitat; and 3) violate requirements of any federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	YES☒ NO☐*	YES☒ NO☐
c.	The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (if no, see section 2);	YES☐ NO☒	YES☐ NO☒
d	Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5).	YES☒ NO☐*	YES☒ NO☐

Proceed to Section 2
See footnote *, 1, 2on page 19.

2.Technical Evaluation Factors (Subparts C-F)

	N/A	Not Significant	Significant
a. Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)			
(1) Substrate impacts.		X	
(2) Suspended particulates/turbidity impacts		X	
(3) Water column impacts.		X	
(4) Alteration of current patterns and water circulation.		X	
(5) Alteration of normal water fluctuations/hydroperiod.		X	
(6) Alteration of salinity gradients.	NA		
b. Biological Characteristics of the Aquatic Ecosystem (Subpart D)			
(1) Effect on threatened/endangered species and their habitat.	NA		
(2) Effect on the aquatic food web.		X	
(3) Effect on other wildlife (mammals birds, reptiles, and amphibians).		X	
c Special Aquatic Sites (Subpart E)			
(1) Sanctuaries and refuges.	NA		
(2) Wetlands.	NA		
(3) Mud flats.	NA		
(4) Vegetated shallows.	NA		
(5) Coral reefs.	NA		
(6) Riffle and pool complexes.	NA		
d. Human Use Characteristics (Subpart F)			
(1) Effects on municipal and private water supplies.	NA		
(2) Recreational and commercial fisheries impacts		X	
(3) Effects on water-related recreation.		X	
(4) Aesthetic impacts.		X	
(5) Effects on parks, national and historical monuments, national seashores, wilderness areas, research sites,, and similar preserves.	NA		

Remarks: Where a check is placed under the significant category, preparer add explanation below.

Proceed to Section 3

See footnote * on page 19.

3. Evaluation of Dredged or Fill Material (Subpart G) 3/

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

(1) Physical characteristics .... ☒
(2) Hydrography in relation to known or anticipated sources of contaminants .... ☒
(3) Results from previous testing of the material or similar material in the vicinity of the project .... ☐
(4) Known, significant sources of persistent pesticides from land runoff or percolation .... ☒
(5) Spill records for petroleum products or designated (Section 311 of CWA) hazardous substances .... ☐
(6) Other public records of significant introduction of contaminants from industries, municipalities, or other sources .... ☒
(7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities .... ☒

(8) Other sources (specify). .... ☐

List appropriate references.

Reference: . Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to result in degradation of the disposal site.** YES ☐ NO☒*

Proceed to Section 4

See footnote * and 3on page 19.

4. Disposal Site Determinations (230.11(f)).

a. The following factors as appropriate, have been considered in evaluating the disposal site.

(1) Depth of water at disposal site ☒

(2) Current velocity, direction, and variability at disposal site ☐

(3) Degree of turbulence. ☒

(4) Water column stratification ☐

(5) Discharge vessel speed and direction ☐

(6) Rate of discharge ☐

(7) Dredged material characteristics (constituents, amount and type of material, settling velocities) ☒

(8) Number of discharges per unit of time. ☐

(9) Other factors affecting rates and patterns of mixing (specify)

List appropriate references.

Reference: Neuse River Basin Draft Integrated Feasibility Report and Environmental Assessment (EA), dated October 2011

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable. YES ☒ NO ☐*

5. Actions to Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendations of 230.70-230.77, to ensure minimal adverse effects of the proposed discharge. List actions taken. YES ☒ NO ☐*

Return to section 1 for final stage of compliance review. See also note 3/, page 16.
See footnote * on page 19.

6. Factual Determinations (230.11).

A review of appropriate information as identified in items 2-5 above indicates that there is minimal potential for short- or long-term environmental effects of the proposed discharge as related to:

a. Physical substrate at the disposal site (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

b. Water circulation, fluctuation, and salinity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES ☒ NO ☐*

d Contaminant availability (review sections 2a, 3, and 4). YES ☒ NO ☐*

e. Aquatic ecosystem structure and function (review sections 2b and c, 3, and 5). YES ☐ NO ☐*

f. Disposal site (review sections 2, 4, and 5). YES ☒ NO ☐*

g. Cumulative impact on the aquatic ecosystem. YES ☒ NO ☐*

h. Secondary impacts on the aquatic ecosystem. YES ☐ NO ☐*

7. Findings.

a. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines. . . . . ☒

b. The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines with the inclusion of the following conditions:. . . . . ☐

c. The proposed disposal site for discharge of dredged or fill material does not comply with the Section 404(b)(1) guidelines for the following reasons(s):

(1) There is a less damaging practicable alternative . . . . ☐

(2) The proposed discharge will result in significant degradation of the aquatic ecosystem . . . . ☐

See footnote * on page 19.

(3) The proposed discharge does not include all practicable and appropriate measures to minimize potential harm to the aquatic ecosystem. ☐

8.

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Steven A Baker
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