112th Congress, 1st Session – – – – – – – – – – – – – – – House Document 112–43

RECOMMENDATIONS FOR THE IMPLEMENTATION OF FOUR PROJECTS

COMMUNICATION

FROM

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

TRANSMITTING

RECOMMENDATIONS FOR THE IMPLEMENTATION OF FOUR PROJECTS BY THE SECRETARY OF THE ARMY

VOLUME VI OF VI



JULY 12, 2011.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

---

U.S. GOVERNMENT PRINTING OFFICE

68–501 WASHINGTON : 2011

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

LOUISIANA COASTAL AREA (LCA) ECOSYSTEM RESTORATION STUDY

Volume VI of VI

Final Integrated Feasibility Study and Supplemental Environmental Impact Statement

for the

Medium Diversion at White Ditch Plaquemines Parish Louisiana



September 2010

U.S. Army Corps of Engineers
New Orleans District

Coastal Protection and Restoration Authority

LOUISIANA COASTAL AREA (LCA) ECOSYSTEM RESTORATION STUDY

Volume VI of VI

Final Integrated Feasibility Study and Supplemental Environmental Impact Statement

for the

Medium Diversion at White Ditch
Plaquemines Parish Louisiana

The responsible lead Federal agency for this study is the U.S. Army Corps of Engineers – Mississippi Valley, New Orleans District (CEMVN). The non-Federal sponsor for the study is Coastal Protection and Restoration Authority (CPRA). This report is a combined feasibility report and environmental impact statement complying with requirements of the U.S. Army Corps of Engineers (USACE) and the Council of Environmental Quality (CEQ), and is intended to reduce duplication and paperwork. An asterisk (*) in the table of contents notes paragraphs that are required for National Environmental Policy Act (NEPA) compliance.

September 2010

U.S. Army Corps of Engineers
New Orleans District

Coastal Protection and
Restoration Authority

This report contains six volumes.

You are at **Volume VI**, which is the Medium Diversion at White Ditch Final Integrated Feasibility Study Report and Supplemental Environmental Impact Statement.

Volume I:	Summary
Volume II:	Amite River Diversion Canal Modification
Volume III:	Convey Atchafalaya to Northern Terrebonne Marshes / Multipurpose Operation of the Houma Navigation Lock
Volume IV:	Small Diversion at Convent / Blind River
Volume V:	Terrebonne Basin Barrier Shoreline Restoration
Volume VI:	Medium Diversion at White Ditch

If you have any questions, or require additional information, please contact:

Mr. Timothy Axtman, Senior Plan Formulator
U.S. Army Corps of Engineers New Orleans District;
P.O. Box 60267, New Orleans, LA 70160-0267
(504) 862-1921, email: Timothy.J.Axtman@usace.army.mil

FINAL
INTEGRATED FEASIBILITY STUDY AND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT
Louisiana Coastal Area (LCA), Louisiana
Medium Diversion at White Ditch
Plaquemines Parish, Louisiana

LEAD AGENCY: U.S. Army Corps of Engineers (USACE) - Mississippi Valley Division, New Orleans District (District).

ABSTRACT: Four of 12 alternative plans were considered in detail: Alternative 1 would implement a 5,000 cubic feet per second (cfs) maximum diversion and outfall management features; Alternative 2 would implement a 10,000 cfs maximum diversion; Alternative 3 would implement a 15,000 cfs maximum diversion.

Alternative 4 is the Recommended Plan and would implement a 35,000 cubic feet per second maximum diversion with associated outfall management features. This project would provide a source of river sediment, freshwater and nutrients to the River aux Chenes subbasin and other nearby portions of the upper Breton Sound Basin, to restore and protect marsh soils and vegetation and maintain a functional salinity regime. The project would be expected to benefit approximately 98,000 acres of wildlife and fisheries habitat in this portion of the Breton Sound Basin. The fully funded cost of the Recommended Plan is estimated to be $387,620,000. Currently, the annual operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) costs are estimated at $1,467,836. OMRR&R costs are the responsibility of the non-Federal sponsor. These costs can be found in Tables 3.15 and 3.16 of the main report. Information presented in the LCA Main Report, Final Programmatic Environmental Impact Statement (EIS), and supporting volumes and appendices are incorporated by reference in this Final Integrated Feasibility Study with Supplemental EIS.

Comments: Please send comments or questions on this Final Supplemental Environmental Impact Statement (SEIS) to the U.S. Army Corps of Engineers, New Orleans District, Attention: Andrew D. MacInnes, P.O. Box 60267, New Orleans, LA 70160-0267. Telephone: (504) 862-1062; Fax (504) 862-1892. The official Closing Date before Federal Action can occur on this project will be 30 days from the date on which the Notice of Availability of this Final Integrated Feasibility/SEIS appeared in the *Federal Register*.

This page intentionally left blank.



Project Photographs of the White Ditch Study Area

This page intentionally left blank.

Contents[1]

Page

Abstract A-1
List of Figures xxvii
List of Tables xxviii
Executive Summary ES-1
1.0 STUDY INFORMATION 1-1
1.1 STUDY AUTHORITY 1-1
1.2 PURPOSE AND SCOPE 1-2
1.3 STUDY AREA 1-3
1.4 HISTORY OF INVESTIGATION 1-4
1.5 PRIOR REPORTS AND EXISTING PROJECTS 1-4
1.5.1 Federal 1-4
1.5.2 State 1-9
1.5.3 Local 1-10
1.6 PLANNING PROCESS AND REPORT ORGANIZATION 1-14
1.7 USACE CAMPAIGN PLAN 1-19
2.0 NEED FOR AND OBJECTIVES OF ACTION 2-1
2.1 NATIONAL OBJECTIVES 2-1
2.2 SIGNIFICANCE OF THE MDWD PROJECT AREA 2-1
2.3 PUBLIC CONCERNS 2-3
2.4 PROBLEMS, NEEDS, AND OPPORTUNITIES 2-4
2.4.1 General Problem Statement 2-4
2.4.2 Study Area Opportunities 2-6
2.4.3 Desired Future Conditions 2-7
2.5 PLANNING OBJECTIVES 2-7
2.5.1 Goals and Objectives 2-8
2.6 PLANNING CONSTRAINTS 2-9
3.0 ALTERNATIVES 3-1
3.1 PLAN FORMULATION RATIONALE 3-1
3.1.1 Plan Formulation Rationale 3-1
3.1.2 Plan Formulation Criteria 3-1
3.1.2.1 Completeness 3-1
3.1.2.2 Effectiveness 3-1
3.1.2.3 Efficiency 3-1
3.1.2.4 Acceptability 3-1
3.1.3 Environmental Operating Principles 3-1
3.1.4 White Ditch Study Area Land Loss 3-2
3.1.5 Future Study Area Loss Rates 3-4
3.2 MANAGEMENT MEASURES 3-7
3.2.1 Value Engineering Study 3-7
3.2.2 Development of Management Measures 3-8

[1] An asterisk (*) denotes paragraphs that are required for National Environmental Policy Act (NEPA) compliance.

Page

3.2.3 Description of Management Measures 3-9
3.2.3.1 Freshwater Supply 3-10
3.2.3.2 Hydraulic Distribution 3-10
3.2.3.3 Sediment Supply and Distribution 3-10
3.2.3.4 Protection (Existing Marshes) 3-11
3.2.3.5 Invasive Species Management 3-11
3.2.3.6 Freshwater Supply 3-11
3.2.3.7 Hydraulic Distribution 3-12
3.2.3.8 Sediment Supply and Distribution 3-13
3.2.3.9 Protection (Existing Marshes) 3-13
3.2.3.10 Invasive Species Management 3-15
3.2.4 Screening / Evaluation of Alternative Plans 3-15
3.2.5 Alternative Plans not Carried Forward for Further Analysis 3-16
3.3 PRELIMINARY ALTERNATIVE PLANS 3-18
3.3.1 Development of Alternative Plans 3-18
3.3.2 Location for Diversion Structure(s) 3-21
3.3.3 Description of Alternative Plans 3-27
3.3.4 Screening / Evaluation of Alternative Plans 3-29
3.3.4.1 The ERDC-SAND2 Model 3-29
3.3.4.2 CE/IC Analysis 3-33
3.3.5 Alternative Plans not Carried for Further Analysis 3-34
3.4 FINAL ARRAY OF ALTERNATIVES 3-35
3.4.1 No Action (Future Without Project Conditions) 3-35
3.4.2 Alternative 1 – 5,000 cfs diversion 3-38
3.4.3 Alternative 2 – 10,000 cfs Max Diversion 3-40
3.4.4 Alternative 3 – 15,000 cfs Max Diversion 3-40
3.4.5 Alternative 4 – 35,000 cfs Max Diversion (Recommended Plan) 3-43
3.5 COMPARISON OF ALTERNATIVE PLANS 3-43
3.5.1 Incremental Cost/Cost Effectiveness Analysis Process. 3-43
3.5.2 Wetland Value Assessment (WVA) 3-45
3.5.3 Results of the Incremental Cost/Cost Effectiveness Analysis 3-50
3.5.4 Other Factors 3-52
3.5.4.1 Recreational Benefits 3-52
3.5.4.2 Desired Future Condition 3-53
3.5.4.3 Relative Sea Level Rise 3-54
3.5.4.4 Breton Sound Benefits 3-55
3.5.4.5 Adaptive Management 3-55
3.5.4.6 Acceptability, Completeness, Effectiveness, and Efficiency. 3-56
3.5.4.7 Selection of the Recommended Plan 3-56
3.6 NER PLAN 3-56
3.7 PLAN SELECTION – RECOMMENDED PLAN 3-58
3.7.1 Budget and Reauthorization 3-58
3.7.2 Components 3-58
3.7.3 Design, Environmental, and Construction Considerations 3-59
3.7.4 Real Estate Requirements 3-60
3.7.5 Operations and Maintenance Considerations 3-60

Page

3.7.6 Monitoring Plan and Adaptive Management ... 3-61
3.7.7 Effectiveness of Recommended Plan in Meeting Goals and Objectives ... 3-64
3.7.8 Effectiveness of Recommended Plan in Meeting Environmental Operating Principles ... 3-65
3.7.9 Compensatory Mitigation Measures ... 3-65
3.8 RISK AND UNCERTAINTY ... 3-65
3.8.1 Induced Shoaling ... 3-65
3.8.2 Relative Sea Level Rise ... 3-66
3.8.3 ERDC-SAND2 Model Background ... 3-66
3.8.4 Real Estate ... 3-67
3.8.5 Sediment Modeling ... 3-67
3.8.6 Reauthorization ... 3-68
3.8.7 Other Diversions ... 3-68
3.8.8 Water Quality ... 3-69
3.8.9 Fisheries ... 3-69
3.9 IMPLEMENTATION REQUIREMENTS ... 3-69
3.9.1 Milestone Schedule ... 3-69
3.9.2 Implementation Responsibilities ... 3-70
3.9.3 Cost Sharing ... 3-72
3.9.4 Environmental Commitments ... 3-73
3.9.5 Financial Requirements ... 3-75
3.9.5.1 Sponsorship Agreement ... 3-75
3.9.5.2 Financial Requirements ... 3-76
3.9.5.3 Local Cooperation ... 3-76
3.9.5.4 Project Management Plan ... 3-76
3.9.5.5 Procedures for Project Implementation ... 3-76
3.9.6 Views of Non-Federal Sponsor ... 3-78
4.0 AFFECTED ENVIRONMENT ... 4-1
4.1 ENVIRONMENTAL SETTING OF STUDY AREA ... 4-1
4.1.1 Location ... 4-1
4.1.2 Climate ... 4-1
4.1.3 Geomorphic and Physiographic Setting ... 4-2
4.2 SIGNIFICANT RESOURCES ... 4-2
4.2.1 Soils and Waterbottoms ... 4-2
4.2.1.1 Soils and Waterbottoms ... 4-3
4.2.1.1.1 Historic Conditions ... 4-3
4.2.1.1.2 Existing Conditions ... 4-3
4.2.2 Hydrology ... 4-3
4.2.2.1 Flow and Water Levels ... 4-3
4.2.2.1.1 Historic Conditions ... 4-3
4.2.2.1.2 Existing Conditions ... 4-4
4.2.2.2 Sedimentation and Erosion ... 4-4
4.2.2.2.1 Historic Conditions ... 4-4
4.2.2.2.2 Existing Conditions ... 4-5
4.2.2.3 Water Use and Supply ... 4-5
4.2.2.3.1 Historic Conditions ... 4-5

Page

4.2.2.3.2 Existing Conditions 4-6
4.2.2.4 Groundwater 4-6
4.2.2.4.1 Historic Conditions 4-6
4.2.2.4.2 Existing Conditions 4-6
4.2.3 Water Quality and Salinity 4-6
4.2.3.1 Historic Conditions 4-6
4.2.3.2 Existing Conditions 4-6
4.2.4 Air Quality 4-8
4.2.4.1 Historic Conditions 4-8
4.2.4.2 Existing Conditions 4-8
4.2.5 Noise 4-11
4.2.5.1 Historic Conditions 4-11
4.2.5.2 Existing Conditions 4-11
4.2.6 Vegetation Resources 4-11
4.2.6.1 Riparian Vegetation 4-12
4.2.6.1.1 Historic Conditions 4-12
4.2.6.1.2 Existing Conditions 4-12
4.2.6.2 Wetland Vegetation 4-13
4.2.6.2.1 Historic Conditions 4-13
4.2.6.2.2 Existing Conditions 4-13
4.2.6.3 Upland Vegetation 4-16
4.2.6.3.1 Historic Conditions 4-16
4.2.6.3.2 Existing Conditions 4-16
4.2.6.4 Submerged Aquatic Vegetation (SAV) 4-16
4.2.6.4.1 Historic Conditions 4-16
4.2.6.4.2 Existing Conditions 4-16
4.2.6.5 Invasive Species – Vegetation 4-17
4.2.6.5.1 Historic Conditions 4-17
4.2.6.5.2 Existing Conditions 4-17
4.2.7 Wildlife and Habitat 4-17
4.2.7.1 Historic Conditions 4-17
4.2.7.2 Existing Conditions 4-18
4.2.8 Aquatic Resources 4-19
4.2.8.1 Historic Conditions 4-19
4.2.8.2 Existing Conditions 4-19
4.2.9 Fisheries 4-20
4.2.9.1 Historic Conditions 4-20
4.2.9.2 Existing Conditions 4-20
4.2.10 Essential Fish Habitat (EFH) 4-21
4.2.10.1 Historic Conditions 4-21
4.2.10.2 Existing Conditions 4-22
4.2.11 Threatened and Endangered Species 4-23
4.2.11.1 Historic Conditions 4-23
4.2.11.2 Existing Conditions 4-23
4.2.12 Cultural and Historic Resources 4-25
4.2.12.1 Historic Conditions 4-25

Page

4.2.12.2 Existing Conditions 4-25
4.2.13 Aesthetics 4-25
4.2.13.1 Historic Conditions 4-25
4.2.13.2 Existing Conditions 4-26
4.2.14 Recreational Resources 4-26
4.2.14.1 Historic Conditions 4-26
4.2.14.2 Existing Conditions 4-27
4.2.15 Socioeconomics and Human Resources 4-28
4.2.15.1 Population and Housing 4-30
4.2.15.1.1 Historic Conditions 4-30
4.2.15.1.2 Existing Conditions 4-30
4.2.15.2 Employment, Business, and Industrial Activity 4-30
4.2.15.2.1 Historic Conditions 4-30
4.2.15.2.2 Existing Conditions 4-31
4.2.15.3 Community Cohesion 4-31
4.2.15.3.1 Historic Conditions 4-31
4.2.15.3.2 Existing Conditions 4-32
4.2.15.4 Environmental Justice 4-32
4.2.15.4.1 Historic Conditions 4-33
4.2.15.4.2 Existing Conditions 4-34
4.2.15.5 Infrastructure 4-34
4.2.15.5.1 Historic Conditions 4-34
4.2.15.5.2 Existing Conditions 4-34
4.2.15.6 Business and Industry 4-34
4.2.15.6.1 Historic Conditions 4-34
4.2.15.6.2 Existing Conditions 4-35
4.2.15.7 Traffic and Transportation 4-35
4.2.15.7.1 Historic Conditions 4-35
4.2.15.7.2 Existing Conditions 4-35
4.2.15.8 Public Facilities and Services 4-35
4.2.15.8.1 Historic Conditions 4-35
4.2.15.8.2 Existing Conditions 4-35
4.2.15.9 Tax Revenues and Property Values 4-36
4.2.15.9.1 Historic Conditions 4-36
4.2.15.9.2 Existing Conditions 4-36
4.2.15.10 Community and Regional Growth 4-36
4.2.15.10.1 Historic Conditions 4-36
4.2.15.10.2 Existing Conditions 4-36
4.2.15.11 Land Use Socioeconomics 4-37
4.2.15.11.1 Agriculture 4-37
4.2.15.11.2 Forestry 4-37
4.2.15.11.3 Public Lands 4-37
4.2.15.12 Water Use and Supply 4-38
4.2.15.12.1 Historic Conditions 4-38
4.2.15.12.2 Existing Conditions 4-38

Page

4.2.15.13 Navigation 4-38
4.2.15.13.1 Historic Conditions 4-38
4.2.15.13.2 Existing Conditions 4-38
4.2.15.14 Man-Made Resources 4-38
4.2.15.14.1 Oil, Gas, Utilities, Pipelines 4-38
4.2.15.14.2 Flood Control and Hurricane Protection 4-39
4.2.15.15 Natural Resources 4-41
4.2.15.15.1 Commercial Fisheries 4-41
4.2.15.15.2 Oyster Leases 4-41
4.2.16 Hazardous, Toxic, and Radioactive Wastes 4-42
4.2.16.1 Historic Conditions 4-42
4.2.16.2 Existing Conditions 4-45
5.0 ENVIRONMENTAL CONSEQUENCES 5-1
5.1 SOILS AND WATERBOTTOMS 5-2
5.1.1 Soils and Waterbottoms 5-2
5.1.1.1 No Action Alternative (Future Without Project Conditions) 5-2
5.1.1.1.1 Direct 5-2
5.1.1.1.2 Indirect 5-2
5.1.1.1.3 Cumulative 5-2
5.1.1.2 Alternative 1 – 5,000 cfs max Diversion 5-3
5.1.1.2.1 Direct 5-3
5.1.1.2.2 Indirect 5-3
5.1.1.2.3 Cumulative 5-3
5.1.1.3 Alternative 2 – 10,000 cfs max Diversion 5-3
5.1.1.3.1 Direct 5-3
5.1.1.3.2 Indirect 5-3
5.1.1.3.3 Cumulative 5-3
5.1.1.4 Alternative 3 – 15,000 cfs max Diversion 5-4
5.1.1.4.1 Direct 5-4
5.1.1.4.2 Indirect 5-4
5.1.1.4.3 Cumulative 5-4
5.1.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-4
5.1.1.5.1 Direct 5-4
5.1.1.5.2 Indirect 5-4
5.1.1.5.3 Cumulative 5-4
5.2 HYDROLOGY 5-5
5.2.1 Flow and Water Levels 5-5
5.2.1.1 No Action Alternative (Future Without Project Conditions) 5-5
5.2.1.1.1 Direct 5-5
5.2.1.1.2 Indirect 5-5
5.2.1.1.3 Cumulative 5-6
5.2.1.2 Alternative 1 – 5,000 cfs max Diversion 5-6
5.2.1.2.1 Direct 5-6
5.2.1.2.2 Indirect 5-7
5.2.1.2.3 Cumulative 5-7

Page

5.2.1.3 Alternative 2 – 10,000 cfs max Diversion 5-7
5.2.1.3.1 Direct 5-7
5.2.1.3.2 Indirect 5-8
5.2.1.3.3 Cumulative 5-8
5.2.1.4 Alternative 3 – 15,000 cfs max Diversion 5-8
5.2.1.4.1 Direct 5-8
5.2.1.4.2 Indirect 5-9
5.2.1.4.3 Cumulative 5-9
5.2.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-9
5.2.1.5.1 Direct 5-9
5.2.1.5.2 Indirect 5-10
5.2.1.5.3 Cumulative 5-10
5.2.2 Sedimentation and Erosion 5-11
5.2.2.1 No Action Alternative (Future Without Project Conditions) 5-11
5.2.2.1.1 Direct 5-11
5.2.2.1.2 Indirect 5-11
5.2.2.1.3 Cumulative 5-11
5.2.2.2 Alternative 1 – 5,000 cfs max Diversion 5-11
5.2.2.2.1 Direct 5-11
5.2.2.2.2 Indirect 5-12
5.2.2.2.3 Cumulative 5-12
5.2.2.3 Alternative 2 – 10,000 cfs max Diversion 5-12
5.2.2.3.1 Direct 5-12
5.2.2.3.2 Indirect 5-13
5.2.2.3.3 Cumulative 5-13
5.2.2.4 Alternative 3 – 15,000 cfs max Diversion 5-14
5.2.2.4.1 Direct 5-14
5.2.2.4.2 Indirect 5-14
5.2.2.4.3 Cumulative 5-14
5.2.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-15
5.2.2.5.1 Direct 5-15
5.2.2.5.2 Indirect 5-15
5.2.2.5.3 Cumulative 5-16
5.2.3 Water Use and Supply 5-16
5.2.3.1 No Action Alternative (Future Without Project Conditions) 5-16
5.2.3.1.1 Direct 5-16
5.2.3.1.2 Indirect 5-16
5.2.3.1.3 Cumulative 5-16
5.2.3.2 Alternative 1 – 5,000 cfs max Diversion 5-17
5.2.3.2.1 Direct 5-17
5.2.3.2.2 Indirect 5-17
5.2.3.2.3 Cumulative 5-17
5.2.3.3 Alternative 2 – 10,000 cfs max Diversion 5-17
5.2.3.3.1 Direct 5-17
5.2.3.3.2 Indirect 5-17

Page

5.2.3.3.3 Cumulative 5-17
5.2.3.4 Alternative 3 – 15,000 cfs max Diversion 5-17
5.2.3.4.1 Direct 5-17
5.2.3.4.2 Indirect 5-17
5.2.3.4.3 Cumulative 5-18
5.2.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-18
5.2.3.5.1 Direct 5-18
5.2.3.5.2 Indirect 5-18
5.2.3.5.3 Cumulative 5-18
5.2.4 Groundwater 5-18
5.2.4.1 No Action Alternative (Future Without Project Conditions) 5-18
5.2.4.1.1 Direct 5-18
5.2.4.1.2 Indirect 5-18
5.2.4.1.3 Cumulative 5-18
5.2.4.2 Alternative 1 – 5,000 cfs max Diversion 5-18
5.2.4.2.1 Direct 5-18
5.2.4.2.2 Indirect 5-19
5.2.4.2.3 Cumulative 5-19
5.2.4.3 Alternative 2 – 10,000 cfs max Diversion 5-19
5.2.4.3.1 Direct 5-19
5.2.4.3.2 Indirect 5-19
5.2.4.3.3 Cumulative 5-19
5.2.4.4 Alternative 3 – 15,000 cfs max Diversion 5-19
5.2.4.4.1 Direct 5-19
5.2.4.4.2 Indirect 5-19
5.2.4.4.3 Cumulative 5-19
5.2.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-20
5.2.4.5.1 Direct 5-20
5.2.4.5.2 Indirect 5-20
5.2.4.5.3 Cumulative 5-20
5.3 WATER QUALITY AND SALINITY 5-20
5.3.1 Water Quality 5-20
5.3.1.1 No Action Alternative (Future Without Project Conditions) 5-20
5.3.1.1.1 Direct 5-20
5.3.1.1.2 Indirect 5-20
5.3.1.1.3 Cumulative 5-20
5.3.1.2 Alternative 1 – 5,000 cfs max Diversion 5-22
5.3.1.2.1 Direct 5-22
5.3.1.2.2 Indirect 5-22
5.3.1.2.3 Cumulative 5-22
5.3.1.3 Alternative 2 – 10,000 cfs max Diversion 5-22
5.3.1.3.1 Direct 5-22
5.3.1.3.2 Indirect 5-22
5.3.1.3.3 Cumulative 5-22
5.3.1.4 Alternative 3 – 15,000 cfs max Diversion 5-22

Page

5.3.1.4.1 Direct ... 5-22
5.3.1.4.2 Indirect ... 5-22
5.3.1.4.3 Cumulative ... 5-23
5.3.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) ... 5-23
5.3.1.5.1 Direct ... 5-23
5.3.1.5.2 Indirect ... 5-24
5.3.1.5.3 Cumulative ... 5-27
5.3.2 Salinity ... 5-29
5.3.2.1 No Action Alternative (Future Without Project Conditions) ... 5-29
5.3.2.1.1 Direct ... 5-29
5.3.2.1.2 Indirect ... 5-29
5.3.2.1.3 Cumulative ... 5-29
5.3.2.2 Alternative 1 – 5,000 cfs max Diversion ... 5-29
5.3.2.2.1 Direct ... 5-29
5.3.2.2.2 Indirect ... 5-30
5.3.2.2.3 Cumulative ... 5-30
5.3.2.3 Alternative 2 – 10,000 cfs max Diversion ... 5-30
5.3.2.3.1 Direct ... 5-30
5.3.2.3.2 Indirect ... 5-35
5.3.2.3.3 Cumulative ... 5-35
5.3.2.4 Alternative 3 – 15,000 cfs max Diversion ... 5-35
5.3.2.4.1 Direct ... 5-35
5.3.2.4.2 Indirect ... 5-35
5.3.2.4.3 Cumulative ... 5-36
5.3.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) ... 5-36
5.3.2.5.1 Direct ... 5-36
5.3.2.5.2 Indirect ... 5-36
5.3.2.5.3 Cumulative ... 5-36
5.4 AIR QUALITY ... 5-37
5.4.1 No Action Alternative (Future Without Project Conditions) ... 5-37
5.4.2 Alternative 1 – 5,000 cfs max Diversion ... 5-37
5.4.2.1 Direct ... 5-37
5.4.2.2 Indirect ... 5-37
5.4.2.3 Cumulative ... 5-37
5.4.3 Alternative 2 – 10,000 cfs max Diversion ... 5-37
5.4.3.1 Direct ... 5-37
5.4.3.2 Indirect ... 5-38
5.4.3.3 Cumulative ... 5-38
5.4.4 Alternative 3 – 15,000 cfs max Diversion ... 5-38
5.4.4.1 Direct ... 5-38
5.4.4.2 Indirect ... 5-38
5.4.4.3 Cumulative ... 5-38
5.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) ... 5-38
5.4.5.1 Direct ... 5-38
5.4.5.2 Indirect ... 5-38

Page

5.4.5.3 Cumulative 5-39
5.5 NOISE 5-39
5.5.1 No Action Alternative (Future Without Project Conditions) 5-39
5.5.2 Alternative 1 – 5,000 cfs max Diversion 5-39
5.5.2.1 Direct 5-39
5.5.2.2 Indirect 5-39
5.5.2.3 Cumulative 5-40
5.5.3 Alternative 2 – 10,000 cfs max Diversion 5-40
5.5.3.1 Direct 5-40
5.5.3.2 Indirect 5-40
5.5.3.3 Cumulative 5-40
5.5.4 Alternative 3 – 15,000 cfs max Diversion 5-40
5.5.4.1 Direct 5-40
5.5.4.2 Indirect 5-40
5.5.4.3 Cumulative 5-40
5.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-41
5.5.5.1 Direct 5-41
5.5.5.2 Indirect 5-41
5.5.5.3 Cumulative 5-41
5.6 VEGETATIVE RESOURCES 5-42
5.6.1 Riparian Vegetation Resources 5-42
5.6.1.1 No Action Alternative (Future Without Project Conditions) 5-42
5.6.1.1.1 Direct 5-42
5.6.1.1.2 Indirect 5-42
5.6.1.1.3 Cumulative 5-42
5.6.1.2 Alternative 1 – 5,000 cfs max Diversion 5-42
5.6.1.2.1 Direct 5-42
5.6.1.2.2 Indirect 5-43
5.6.1.2.3 Cumulative 5-43
5.6.1.3 Alternative 2 – 10,000 cfs max Diversion 5-43
5.6.1.3.1 Direct 5-43
5.6.1.3.2 Indirect 5-43
5.6.1.3.3 Cumulative 5-43
5.6.1.4 Alternative 3- 15,000 cfs max Diversion 5-44
5.6.1.4.1 Direct 5-44
5.6.1.4.2 Indirect 5-44
5.6.1.4.3 Cumulative 5-44
5.6.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-44
5.6.1.5.1 Direct 5-44
5.6.1.5.2 Indirect 5-44
5.6.1.5.3 Cumulative 5-44
5.6.2 Wetland Vegetation Resources 5-45
5.6.2.1 No Action Alternative (Future Without Project Conditions) 5-45
5.6.2.1.1 Direct 5-45
5.6.2.1.2 Indirect 5-45

Page

5.6.2.1.3 Cumulative 5-45
5.6.2.2 Alternative 1 – 5,000 cfs max Diversion 5-45
5.6.2.2.1 Direct 5-45
5.6.2.2.2 Indirect 5-46
5.6.2.2.3 Cumulative 5-46
5.6.2.3 Alternative 2 – 10,000 cfs max Diversion 5-46
5.6.2.3.1 Direct 5-46
5.6.2.3.2 Indirect 5-46
5.6.2.3.3 Cumulative 5-47
5.6.2.4 Alternative 3 – 15,000 cfs max Diversion 5-47
5.6.2.4.1 Direct 5-47
5.6.2.4.2 Indirect 5-47
5.6.2.4.3 Cumulative 5-47
5.6.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-47
5.6.2.5.1 Direct 5-47
5.6.2.5.2 Indirect 5-48
5.6.2.5.3 Cumulative 5-48
5.6.3 Upland Vegetation Resources 5-48
5.6.4 Submerged Aquatic Vegetation (SAV) 5-48
5.6.4.1 No Action Alternative (Future Without Project Conditions) 5-48
5.6.4.1.1 Direct 5-48
5.6.4.1.2 Indirect 5-48
5.6.4.1.3 Cumulative 5-49
5.6.4.2 Alternative 1 – 5,000 cfs max Diversion 5-49
5.6.4.2.1 Direct 5-49
5.6.4.2.2 Indirect 5-49
5.6.4.2.3 Cumulative 5-49
5.6.4.3 Alternative 2 – 10,000 cfs max Diversion 5-50
5.6.4.3.1 Direct 5-50
5.6.4.3.2 Indirect 5-50
5.6.4.3.3 Cumulative 5-50
5.6.4.4 Alternative 3 – 15,000 cfs max Diversion 5-50
5.6.4.4.1 Direct 5-50
5.6.4.4.2 Indirect 5-50
5.6.4.4.3 Cumulative 5-50
5.6.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-51
5.6.4.5.1 Direct 5-51
5.6.4.5.2 Indirect 5-51
5.6.4.5.3 Cumulative 5-51
5.6.5 Invasive Species – Vegetation 5-51
5.6.5.1 No Action Alternative (Future Without Project Conditions) 5-51
5.6.5.1.1 Direct 5-51
5.6.5.1.2 Indirect 5-51
5.6.5.1.3 Cumulative 5-51
5.6.5.2 Alternative 1 – 5,000 cfs max Diversion 5-52

Page

5.6.5.2.1 Direct ... 5-52
5.6.5.2.2 Indirect ... 5-52
5.6.5.2.3 Cumulative ... 5-52
5.6.5.3 Alternative 2 – 10,000 cfs max Diversion ... 5-52
5.6.5.3.1 Direct ... 5-52
5.6.5.3.2 Indirect ... 5-52
5.6.5.3.3 Cumulative ... 5-53
5.6.5.4 Alternative 3 – 15,000 cfs max Diversion ... 5-53
5.6.5.4.1 Direct ... 5-53
5.6.5.4.2 Indirect ... 5-53
5.6.5.4.3 Cumulative ... 5-53
5.6.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) ... 5-53
5.6.5.5.1 Direct ... 5-53
5.6.5.5.2 Indirect ... 5-53
5.6.5.5.3 Cumulative ... 5-53
5.7 WILDLIFE AND HABITAT ... 5-54
5.7.1 No Action Alternative (Future Without Project Conditions) ... 5-54
5.7.1.1 Direct ... 5-54
5.7.1.2 Indirect ... 5-54
5.7.1.3 Cumulative ... 5-54
5.7.2 Alternative 1 – 5,000 cfs max Diversion ... 5-54
5.7.2.1 Direct ... 5-54
5.7.2.2 Indirect ... 5-54
5.7.2.3 Cumulative ... 5-55
5.7.3 Alternative 2 – 10,000 cfs max Diversion ... 5-55
5.7.3.1 Direct ... 5-55
5.7.3.2 Indirect ... 5-55
5.7.3.3 Cumulative ... 5-55
5.7.4 Alternative 3 – 15,000 cfs max Diversion ... 5-56
5.7.4.1 Direct ... 5-56
5.7.4.2 Indirect ... 5-56
5.7.4.3 Cumulative ... 5-56
5.7.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) ... 5-57
5.7.5.1 Direct ... 5-57
5.7.5.2 Indirect ... 5-57
5.7.5.3 Cumulative ... 5-57
5.8 AQUATIC RESOURCES ... 5-58
5.8.1 Benthic ... 5-58
5.8.1.1 No Action Alternative (Future Without Project Conditions) ... 5-58
5.8.1.1.1 Direct ... 5-58
5.8.1.1.2 Indirect ... 5-58
5.8.1.1.3 Cumulative ... 5-58
5.8.1.2 Alternative 1 – 5,000 cfs max Diversion ... 5-59
5.8.1.2.1 Direct ... 5-59
5.8.1.2.2 Indirect ... 5-59

Page

5.8.1.2.3 Cumulative 5-59
5.8.1.3 Alternative 2 – 10,000 cfs max Diversion 5-60
5.8.1.3.1 Direct 5-60
5.8.1.3.2 Indirect 5-60
5.8.1.3.3 Cumulative 5-61
5.8.1.4 Alternative 3 – 15,000 cfs max Diversion 5-61
5.8.1.4.1 Direct 5-61
5.8.1.4.2 Indirect 5-62
5.8.1.4.3 Cumulative 5-62
5.8.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-63
5.8.1.5.1 Direct 5-63
5.8.1.5.2 Indirect 5-63
5.8.1.5.3 Cumulative 5-63
5.8.2 Plankton 5-64
5.8.2.1 No Action Alternative (Future Without Project Conditions) 5-64
5.8.2.1.1 Direct 5-64
5.8.2.1.2 Indirect 5-65
5.8.2.1.3 Cumulative 5-65
5.8.2.2 Alternative 1 – 5,000 cfs max Diversion 5-65
5.8.2.2.1 Direct 5-65
5.8.2.2.2 Indirect 5-66
5.8.2.2.3 Cumulative 5-66
5.8.2.3 Alternative 2 – 10,000 cfs max Diversion 5-66
5.8.2.3.1 Direct 5-66
5.8.2.3.2 Indirect 5-66
5.8.2.3.3 Cumulative 5-66
5.8.2.4 Alternative 3 – 15,000 cfs max Diversion 5-67
5.8.2.4.1 Direct 5-67
5.8.2.4.2 Indirect 5-67
5.8.2.4.3 Cumulative 5-67
5.8.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-67
5.8.2.5.1 Direct 5-67
5.8.2.5.2 Indirect 5-68
5.8.2.5.3 Cumulative 5-68
5.8.3 Other Aquatic Resources 5-69
5.9 FISHERIES 5-69
5.9.1 No Action Alternative (Future Without Project Conditions) 5-69
5.9.1.1 Direct 5-69
5.9.1.2 Indirect 5-69
5.9.1.3 Cumulative 5-70
5.9.2 Alternative 1 – 5,000 cfs diversion 5-70
5.9.2.1 Direct 5-70
5.9.2.2 Indirect 5-70
5.9.2.3 Cumulative 5-71
5.9.3 Alternative 2 – 10,000 cfs max Diversion 5-71

Page

5.9.3.1 Direct 5-71
5.9.3.2 Indirect 5-72
5.9.3.3 Cumulative 5-72
5.9.4 Alternative 3 – 15,000 cfs max Diversion 5-72
5.9.4.1 Direct 5-72
5.9.4.2 Indirect 5-73
5.9.4.3 Cumulative 5-74
5.9.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-74
5.9.5.1 Direct 5-74
5.9.5.2 Indirect 5-74
5.9.5.3 Cumulative 5-75
5.10 ESSENTIAL FISH HABITAT (EFH) 5-75
5.10.1 No Action Alternative (Future Without Project Conditions) 5-75
5.10.1.1 Direct 5-75
5.10.1.2 Indirect 5-75
5.10.1.3 Cumulative 5-76
5.10.2 Alternative 1 – 5,000 cfs max Diversion 5-76
5.10.2.1 Direct 5-76
5.10.2.2 Indirect 5-76
5.10.2.3 Cumulative 5-77
5.10.3 Alternative 2 – 10,000 cfs max Diversion 5-77
5.10.3.1 Direct 5-77
5.10.3.2 Indirect 5-77
5.10.3.3 Cumulative 5-78
5.10.4 Alternative 3 – 15,000 cfs max Diversion 5-78
5.10.4.1 Direct 5-78
5.10.4.2 Indirect 5-78
5.10.4.3 Cumulative 5-78
5.10.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-79
5.10.5.1 Direct 5-79
5.10.5.2 Indirect 5-79
5.10.5.3 Cumulative 5-79
5.11 THREATENED AND ENDANGERED SPECIES 5-80
5.11.1 No Action Alternative (Future Without Project Conditions) 5-80
5.11.1.1 Direct 5-80
5.11.1.2 Indirect 5-80
5.11.1.3 Cumulative 5-80
5.11.2 Alternative 1 – 5,000 cfs max Diversion 5-80
5.11.2.1 Direct 5-80
5.11.2.2 Indirect 5-80
5.11.2.3 Cumulative 5-81
5.11.3 Alternative 2 – 10,000 cfs max Diversion 5-81
5.11.3.1 Direct 5-81
5.11.3.2 Indirect 5-82
5.11.3.3 Cumulative 5-82
5.11.4 Alternative 3 – 15,000 cfs max Diversion 5-82

Page

5.11.4.1 Direct 5-82
5.11.4.2 Indirect 5-82
5.11.4.3 Cumulative 5-82
5.11.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-83
5.11.5.1 Direct 5-83
5.11.5.2 Indirect 5-85
5.11.5.3 Cumulative 5-85
5.12 CULTURAL AND HISTORIC RESOURCES 5-85
5.12.1 No Action Alternative (Future Without Project Conditions) 5-86
5.12.1.1 Direct 5-86
5.12.1.2 Indirect 5-86
5.12.1.3 Cumulative 5-86
5.12.2 Alternative 1 – 5,000 cfs max Diversion 5-86
5.12.2.1 Direct 5-86
5.12.2.2 Indirect 5-86
5.12.2.3 Cumulative 5-86
5.12.3 Alternative 2 – 10,000 cfs max Diversion 5-86
5.12.3.1 Direct 5-86
5.12.3.2 Indirect 5-86
5.12.3.3 Cumulative 5-87
5.12.4 Alternative 3 – 15,000 cfs max Diversion 5-87
5.12.4.1 Direct 5-87
5.12.4.2 Indirect 5-87
5.12.4.3 Cumulative 5-87
5.12.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-87
5.12.5.1 Direct 5-87
5.12.5.2 Indirect 5-87
5.12.5.3 Cumulative 5-87
5.13 AESTHETICS 5-88
5.13.1 No Action Alternative (Future Without Project Conditions) 5-88
5.13.1.1 Direct 5-88
5.13.1.2 Indirect 5-88
5.13.1.3 Cumulative 5-88
5.13.2 Alternative 1 – 5,000 cfs max Diversion 5-88
5.13.2.1 Direct 5-88
5.13.2.2 Indirect 5-88
5.13.2.3 Cumulative 5-89
5.13.3 Alternative 2 – 10,000 cfs max Diversion 5-89
5.13.3.1 Direct 5-89
5.13.3.2 Indirect 5-89
5.13.3.3 Cumulative 5-89
5.13.4 Alternative 3 – 15,000 cfs max Diversion 5-89
5.13.4.1 Direct 5-89
5.13.4.2 Indirect 5-89
5.13.4.3 Cumulative 5-89
5.13.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-90

Page

5.13.5.1 Direct 5-90
5.13.5.2 Indirect 5-90
5.13.5.3 Cumulative 5-90
5.14 RECREATION 5-90
5.14.1 No Action Alternative (Future Without Project Conditions) 5-90
5.14.1.1 Direct 5-90
5.14.1.2 Indirect 5-91
5.14.1.3 Cumulative 5-91
5.14.2 Alternative 1 – 5,000 cfs max Diversion 5-91
5.14.2.1 Direct 5-91
5.14.2.2 Indirect 5-92
5.14.2.3 Cumulative 5-92
5.14.3 Alternative 2 – 10,000 cfs max Diversion 5-93
5.14.3.1 Direct 5-93
5.14.3.2 Indirect 5-93
5.14.3.3 Cumulative 5-93
5.14.4 Alternative 3 – 15,000 cfs max Diversion 5-94
5.14.4.1 Direct 5-94
5.14.4.2 Indirect 5-94
5.14.4.3 Cumulative 5-94
5.14.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-94
5.14.5.1 Direct 5-94
5.14.5.2 Indirect 5-95
5.14.5.3 Cumulative 5-95
5.15 SOCIOECONOMICS AND HUMAN RESOURCES 5-95
5.15.1 Displacement of Population and Housing 5-95
5.15.1.1 No Action Alternative (Future Without Project Conditions) 5-95
5.15.1.1.1 Direct 5-95
5.15.1.1.2 Indirect 5-95
5.15.1.1.3 Cumulative 5-95
5.15.1.2 Alternative 1 – 5,000 cfs Diversion 5-96
5.15.1.2.1 Direct 5-96
5.15.1.2.2 Indirect 5-96
5.15.1.2.3 Cumulative 5-96
5.15.1.3 Alternative 2 – 10,000 cfs max Diversion 5-96
5.15.1.3.1 Direct 5-96
5.15.1.3.2 Indirect 5-96
5.15.1.3.3 Cumulative 5-96
5.15.1.4 Alternative 3 – 15,000 cfs max Diversion 5-97
5.15.1.4.1 Direct 5-97
5.15.1.4.2 Indirect 5-97
5.15.1.4.3 Cumulative 5-97
5.15.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-97
5.15.1.5.1 Direct 5-97
5.15.1.5.2 Indirect 5-97
5.15.1.5.3 Cumulative 5-97

Page

5.15.2 Employment, Business, and Industrial Activity 5-97
5.15.2.1 No Action Alternative (Future Without Project Conditions) 5-97
5.15.2.1.1 Direct 5-97
5.15.2.1.2 Indirect 5-97
5.15.2.1.3 Cumulative 5-98
5.15.2.2 Alternative 1 – 5,000 cfs Diversion 5-98
5.15.2.2.1 Direct 5-98
5.15.2.2.2 Indirect 5-98
5.15.2.2.3 Cumulative 5-98
5.15.2.3 Alternative 2 – 10,000 cfs max Diversion 5-98
5.15.2.3.1 Direct 5-98
5.15.2.3.2 Indirect 5-99
5.15.2.3.3 Cumulative 5-99
5.15.2.4 Alternative 3 – 15,000 cfs max Diversion 5-99
5.15.2.4.1 Direct 5-99
5.15.2.4.2 Indirect 5-99
5.15.2.4.3 Cumulative 5-99
5.15.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-99
5.15.2.5.1 Direct 5-99
5.15.2.5.2 Indirect 5-99
5.15.2.5.3 Cumulative 5-100
5.15.3 Community Cohesion 5-100
5.15.3.1 No Action Alternative (Future Without Project Conditions) 5-100
5.15.3.1.1 Direct 5-100
5.15.3.1.2 Indirect 5-100
5.15.3.1.3 Cumulative 5-100
5.15.3.2 Alternative 1 – 5,000 cfs Diversion 5-100
5.15.3.2.1 Direct 5-100
5.15.3.2.2 Indirect 5-100
5.15.3.2.3 Cumulative 5-101
5.15.3.3 Alternative 2 – 10,000 cfs max Diversion 5-101
5.15.3.3.1 Direct 5-101
5.15.3.3.2 Indirect 5-101
5.15.3.3.3 Cumulative 5-101
5.15.3.4 Alternative 3 – 15,000 cfs max Diversion 5-101
5.15.3.4.1 Direct 5-101
5.15.3.4.2 Indirect 5-101
5.15.3.4.3 Cumulative 5-101
5.15.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-102
5.15.3.5.1 Direct 5-102
5.15.3.5.2 Indirect 5-102
5.15.3.5.3 Cumulative 5-102
5.15.4 Environmental Justice 5-102
5.15.4.1 No Action Alternative (Future Without Project Conditions) 5-102
5.15.4.1.1 Direct 5-102

Page

5.15.4.1.2 Indirect 5-102
5.15.4.1.3 Cumulative 5-102
5.15.4.2 Alternative 1 – 5,000 cfs Diversion 5-102
5.15.4.2.1 Direct 5-102
5.15.4.2.2 Indirect 5-103
5.15.4.2.3 Cumulative 5-103
5.15.4.3 Alternative 2 – 10,000 cfs max Diversion 5-103
5.15.4.3.1 Direct 5-103
5.15.4.3.2 Indirect 5-103
5.15.4.3.3 Cumulative 5-103
5.15.4.4 Alternative 3 – 15,000 cfs max Diversion 5-103
5.15.4.4.1 Direct 5-103
5.15.4.4.2 Indirect 5-103
5.15.4.4.3 Cumulative 5-103
5.15.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-103
5.15.4.5.1 Direct 5-103
5.15.4.5.2 Indirect 5-104
5.15.4.5.3 Cumulative 5-104
5.15.5 Infrastructure 5-104
5.15.5.1 No Action Alternative (Future Without Project Conditions) 5-104
5.15.5.1.1 Direct 5-104
5.15.5.1.2 Indirect 5-104
5.15.5.1.3 Cumulative 5-104
5.15.5.2 Alternative 1 – 5,000 cfs Diversion 5-104
5.15.5.2.1 Direct 5-104
5.15.5.2.2 Indirect 5-104
5.15.5.2.3 Cumulative 5-105
5.15.5.3 Alternative 2 – 10,000 cfs max Diversion 5-105
5.15.5.3.1 Direct 5-105
5.15.5.3.2 Indirect 5-105
5.15.5.3.3 Cumulative 5-105
5.15.5.4 Alternative 3 – 15,000 cfs max Diversion 5-105
5.15.5.4.1 Direct 5-105
5.15.5.4.2 Indirect 5-105
5.15.5.4.3 Cumulative 5-105
5.15.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-105
5.15.5.5.1 Direct 5-105
5.15.5.5.2 Indirect 5-106
5.15.5.5.3 Cumulative 5-106
5.15.6 Business and Industry 5-106
5.15.6.1 No Action Alternative (Future Without Project Conditions) 5-106
5.15.6.1.1 Direct 5-106
5.15.6.1.2 Indirect 5-106
5.15.6.1.3 Cumulative 5-106
5.15.6.2 Alternative 1 – 5,000 cfs Diversion 5-106

Page

5.15.6.2.1 Direct 5-106
5.15.6.2.2 Indirect 5-107
5.15.6.2.3 Cumulative 5-107
5.15.6.3 Alternative 2 – 10,000 cfs max Diversion 5-107
5.15.6.3.1 Direct 5-107
5.15.6.3.2 Indirect 5-107
5.15.6.3.3 Cumulative 5-107
5.15.6.4 Alternative 3 – 15,000 cfs max Diversion 5-107
5.15.6.4.1 Direct 5-107
5.15.6.4.2 Indirect 5-107
5.15.6.4.3 Cumulative 5-107
5.15.6.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-108
5.15.6.5.1 Direct 5-108
5.15.6.5.2 Indirect 5-108
5.15.6.5.3 Cumulative 5-108
5.15.7 Traffic and Transportation 5-108
5.15.7.1 No Action Alternative (Future Without Project Conditions) 5-108
5.15.7.1.1 Direct 5-108
5.15.7.1.2 Indirect 5-108
5.15.7.1.3 Cumulative 5-108
5.15.7.2 Alternative 1 – 5,000 cfs Diversion 5-109
5.15.7.2.1 Direct 5-109
5.15.7.2.2 Indirect 5-109
5.15.7.2.3 Cumulative 5-109
5.15.7.3 Alternative 2 – 10,000 cfs max Diversion 5-109
5.15.7.3.1 Direct 5-109
5.15.7.3.2 Indirect 5-109
5.15.7.3.3 Cumulative 5-109
5.15.7.4 Alternative 3 – 15,000 cfs max Diversion 5-109
5.15.7.4.1 Direct 5-109
5.15.7.4.2 Indirect 5-109
5.15.7.4.3 Cumulative 5-110
5.15.7.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-110
5.15.7.5.1 Direct 5-110
5.15.7.5.2 Indirect 5-110
5.15.7.5.3 Cumulative 5-110
5.15.8 Public Facilities and Services 5-110
5.15.8.1 No Action Alternative (Future Without Project Conditions) 5-110
5.15.8.1.1 Direct 5-110
5.15.8.1.2 Indirect 5-110
5.15.8.1.3 Cumulative 5-110
5.15.8.2 Alternative 1 – 5,000 cfs Diversion 5-111
5.15.8.2.1 Direct 5-111
5.15.8.2.2 Indirect 5-111
5.15.8.2.3 Cumulative 5-111

Page

5.15.8.3 Alternative 2 – 10,000 cfs max Diversion 5-111
5.15.8.3.1 Direct 5-111
5.15.8.3.2 Indirect 5-111
5.15.8.3.3 Cumulative 5-111
5.15.8.4 Alternative 3 – 15,000 cfs max Diversion 5-111
5.15.8.4.1 Direct 5-111
5.15.8.4.2 Indirect 5-111
5.15.8.4.3 Cumulative 5-111
5.15.8.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-112
5.15.8.5.1 Direct 5-112
5.15.8.5.2 Indirect 5-112
5.15.8.5.3 Cumulative 5-112
5.15.9 Tax Revenues and Property Values 5-112
5.15.9.1 No Action Alternative (Future Without Project Conditions) 5-112
5.15.9.1.1 Direct 5-112
5.15.9.1.2 Indirect 5-112
5.15.9.1.3 Cumulative 5-112
5.15.9.2 Alternative 1 – 5,000 cfs Diversion 5-113
5.15.9.2.1 Direct 5-113
5.15.9.2.2 Indirect 5-113
5.15.9.2.3 Cumulative 5-113
5.15.9.3 Alternative 2 – 10,000 cfs max Diversion 5-113
5.15.9.3.1 Direct 5-113
5.15.9.3.2 Indirect 5-113
5.15.9.3.3 Cumulative 5-113
5.15.9.4 Alternative 3 – 15,000 cfs max Diversion 5-113
5.15.9.4.1 Direct 5-113
5.15.9.4.2 Indirect 5-113
5.15.9.4.3 Cumulative 5-113
5.15.9.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-114
5.15.9.5.1 Direct 5-114
5.15.9.5.2 Indirect 5-114
5.15.9.5.3 Cumulative 5-114
5.15.10 Disruption of Desirable Community and Regional Growth 5-114
5.15.10.1 No Action Alternative (Future Without Project Conditions) 5-114
5.15.10.1.1 Direct 5-114
5.15.10.1.2 Indirect 5-114
5.15.10.1.3 Cumulative 5-114
5.15.10.2 Alternative 1 – 5,000 cfs Diversion 5-114
5.15.10.2.1 Direct 5-114
5.15.10.2.2 Indirect 5-115
5.15.10.2.3 Cumulative 5-115
5.15.10.3 Alternative 2 – 10,000 cfs max Diversion 5-115
5.15.10.3.1 Direct 5-115
5.15.10.3.2 Indirect 5-115

Page

5.15.10.3.3 Cumulative 5-115
5.15.10.4 Alternative 3 – 15,000 cfs max Diversion 5-115
5.15.10.4.1 Direct 5-115
5.15.10.4.2 Indirect 5-115
5.15.10.4.3 Cumulative 5-115
5.15.10.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-115
5.15.10.5.1 Direct 5-115
5.15.10.5.2 Indirect 5-116
5.15.10.5.3 Cumulative 5-116
5.15.11 Land Use Socioeconomics 5-116
5.15.11.1 Agriculture 5-116
5.15.11.1.1 No Action Alternative (Future Without Project Conditions) 5-116
5.15.11.1.2 Alternative 1 – 5,000 cfs Diversion 5-116
5.15.11.1.3 Alternative 2 – 10,000 cfs max Diversion 5-117
5.15.11.1.4 Alternative 3 – 10,000 cfs max Diversion 5-117
5.15.11.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-118
5.15.11.2 Forestry 5-118
5.15.11.2.1 No Action Alternative (Future Without Project Conditions) 5-118
5.15.11.2.2 Alternative 1 – 5,000 cfs Diversion 5-119
5.15.11.2.3 Alternative 2 – 10,000 cfs max Diversion 5-119
5.15.11.2.4 Alternative 3 – 15,000 cfs max Diversion 5-119
5.15.11.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-120
5.15.11.3 Public Lands 5-120
5.15.11.3.1 No Action Alternative (Future Without Project Conditions) 5-120
5.15.11.3.2 Alternative 1 – 5,000 cfs Diversion 5-121
5.15.11.3.3 Alternative 2 – 10,000 cfs max Diversion 5-121
5.15.11.3.4 Alternative 3 – 15,000 cfs max Diversion 5-121
5.15.11.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-122
5.15.12 Water Use and Supply 5-122
5.15.12.1 No Action Alternative (Future Without Project Conditions) 5-122
5.15.12.1.1 Direct 5-122
5.15.12.1.2 Indirect 5-122
5.15.12.1.3 Cumulative 5-122
5.15.12.2 Alternative 1 – 5,000 cfs Diversion 5-122
5.15.12.2.1 Direct 5-122
5.15.12.2.2 Indirect 5-123
5.15.12.2.3 Cumulative 5-123
5.15.12.3 Alternative 2 – 10,000 cfs max Diversion 5-123
5.15.12.3.1 Direct 5-123
5.15.12.3.2 Indirect 5-123

Page

5.15.12.3.3 Cumulative 5-123
5.15.12.4 Alternative 3 – 15,000 cfs max Diversion 5-123
5.15.12.4.1 Direct 5-123
5.15.12.4.2 Indirect 5-123
5.15.12.4.3 Cumulative 5-123
5.15.12.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-123
5.15.12.5.1 Direct 5-123
5.15.12.5.2 Indirect 5-123
5.15.12.5.3 Cumulative 5-124
5.15.13 Navigation 5-124
5.15.13.1 No Action Alternative (Future Without Project Conditions) 5-124
5.15.13.1.1 Direct 5-124
5.15.13.1.2 Indirect 5-124
5.15.13.1.3 Cumulative 5-124
5.15.13.2 Alternative 1 – 5,000 cfs Diversion 5-124
5.15.13.2.1 Direct 5-124
5.15.13.2.2 Indirect 5-124
5.15.13.2.3 Cumulative 5-125
5.15.13.3 Alternative 2 – 10,000 cfs max Diversion 5-125
5.15.13.3.1 Direct 5-125
5.15.13.3.2 Indirect 5-125
5.15.13.3.3 Cumulative 5-126
5.15.13.4 Alternative 3 – 15,000 cfs max Diversion 5-126
5.15.13.4.1 Direct 5-126
5.15.13.4.2 Indirect 5-126
5.15.13.4.3 Cumulative 5-127
5.15.13.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-127
5.15.13.5.1 Direct 5-127
5.15.13.5.2 Indirect 5-127
5.15.13.5.3 Cumulative 5-128
5.15.14 Man-Made Resources 5-128
5.15.14.1 Oil, Gas, Utilities 5-128
5.15.14.1.1 No Action Alternative (Future Without Project Conditions) 5-128
5.15.14.1.2 Alternative 1 – 5,000 cfs Diversion 5-128
5.15.14.1.3 Alternative 2 – 10,000 cfs max Diversion 5-129
5.15.14.1.4 Alternative 3 – 15,000 cfs max Diversion 5-129
5.15.14.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-130
5.15.14.2 Flood Control and Hurricane Protection 5-130
5.15.14.2.1 No Action Alternative (Future Without Project Conditions) 5-130
5.15.14.2.2 Alternative 1 – 5,000 cfs Diversion 5-130
5.15.14.2.3 Alternative 2 – 10,000 cfs max Diversion 5-131
5.15.14.2.4 Alternative 3 – 15,000 cfs max Diversion 5-132

Page

5.15.14.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-132
5.15.15 Natural Resources 5-133
5.15.15.1 Commercial Fisheries 5-133
5.15.15.1.1 No Action Alternative (Future Without Project Conditions) 5-133
5.15.15.1.2 Alternative 1 – 5,000 cfs Diversion 5-133
5.15.15.1.3 Alternative 2 – 10,000 cfs max Diversion 5-134
5.15.15.1.4 Alternative 3 – 15,000 cfs max Diversion 5-135
5.15.15.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-136
5.15.15.2 Oyster Leases 5-137
5.15.15.2.1 No Action Alternative (Future Without Project Conditions) 5-137
5.15.15.2.2 Alternative 1 – 5,000 cfs Diversion 5-138
5.15.15.2.3 Alternative 2 – 10,000 cfs max Diversion 5-139
5.15.15.2.4 Alternative 3 – 15,000 cfs max Diversion 5-140
5.15.15.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-141
5.16 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES 5-142
5.16.1 No Action Alternative (Future Without Project Conditions) 5-142
5.16.2 Alternative 1 – 5,000 cfs max Diversion 5-142
5.16.2.1 Direct 5-142
5.16.2.2 Indirect 5-142
5.16.2.3 Cumulative 5-142
5.16.3 Alternative 2 – 10,000 cfs max Diversion 5-142
5.16.3.1 Direct 5-142
5.16.3.2 Indirect 5-142
5.16.3.3 Cumulative 5-142
5.16.4 Alternative 3 – 15,000 cfs max Diversion 5-143
5.16.4.1 Direct 5-143
5.16.4.2 Indirect 5-143
5.16.4.3 Cumulative 5-143
5.16.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan) 5-143
5.16.5.1 Direct 5-143
5.16.5.2 Indirect 5-143
5.16.5.3 Cumulative 5-143
5.17 UNAVOIDABLE ADVERSE EFFECTS 5-143
5.18 RELATIONSHIP OF SHORT-TERM USES AND LONG-TERM PRODUCTIVITY 5-144
5.19 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES 5-144
5.20 MITIGATION 5-145
5.21 ENVIRONMENTAL CONSEQUENCES SUMMARY 5-145
6.0 PUBLIC INVOLVEMENT 6-1
6.1 NEPA SCOPING 6-1
6.2 OTHER PUBLIC COMMENTS 6-4
6.2.1 Federal and State Agencies 6-4

Page

6.2.2 Land Owner, Non-Governmental Organization (NGO), Parish and Other Involvement ... 6-5
6.2.3 Public Comments on the Draft SEIS ... 6-8
7.0 COORDINATION AND COMPLIANCE ... 7-1
7.1 USACE PRINCIPLES AND GUIDELINES (P&G) ... 7-1
7.2 ENVIRONMENTAL COORDINATION AND COMPLIANCE ... 7-1
7.2.1 U.S. Fish and Wildlife Coordination Act ... 7-3
7.2.2 Clean Water Act – Section 404(b)(1) ... 7-6
7.2.3 Section 122 of the Rivers and Harbors Act ... 7-6
7.2.4 Coastal Zone Management Act of 1972 ... 7-7
7.2.5 Endangered Species Act of 1973 ... 7-7
7.2.6 Magnuson-Stevens Fishery Conservation and Management Act of 1996; and the Magnuson-Stevens Act Reauthorization of 2006 (Essential Fish Habitat) ... 7-7
7.2.7 Clean Air Act – Air Quality Determination ... 7-8
7.2.8 National Historic Preservation Act of 1966 ... 7-8
7.2.9 Farmland Protection Policy Act (Prime and Unique Farmlands) ... 7-8
7.2.10 Executive Order 13186 – Migratory Bird Habitat Protection ... 7-8
7.2.11 Executive Order 12898 – Environmental Justice ... 7-9
7.2.12 Executive Order 13112 – Invasive Species ... 7-9
7.2.13 Executive Order 11990 – Floodplain Management ... 7-10
7.2.14 Executive Order 11988 – Protection of Wetlands ... 7-10
7.2.15 Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) ... 7-11
7.2.16 Louisiana State Rare, Threatened, and Endangered Species, and Natural Communities Coordination ... 7-11
7.2.17 Clean Water Act – Section 401 Water Quality ... 7-11
8.0 CONCLUSIONS AND DETERMINATIONS ... 8-1
8.1 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES ... 8-1
8.2 CONCLUSIONS ... 8-4
8.3 RECOMMENDATIONS ... 8-5
9.0 DISTRIBUTION LIST AND OTHER ... 9-1
9.1 DISTRIBUTION LIST ... 9-1
9.2 LIST OF PREPARERS ... 9-1
9.3 LITERATURE CITED ... 9-3
9.4 GLOSSARY ... 9-9
9.5 ACRONYMS AND ABBREVIATIONS ... 9-20

Attachments:

1 Non-Federal Sponsor's Self-Certification of Financial Capability
2 Non-Federal Sponsor's Letter of Intent

Page

Figures

Figure 1.1: Study Area Map 1-5
Figure 1.2: Other Diversion Projects 1-15
Figure 2.1: Potential Desired Future Condition 2-8
Figure 3.1: Land Area Change in Coastal Louisiana after the 2005 Hurricanes (1956–2005) (USGS) 3-5
Figure 3.2: Land Area Trends 3-6
Figure 3.3: Future Without-Project Condition 3-6
Figure 3.4: Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without-Project Condition 3-7
Figure 3.5: Potential Diversion Structure Locations 3-22
Figure 3.6: White Ditch CE/IC Analysis—Open Diversion 3-33
Figure 3.7: White Ditch CE/IC Analysis Step 1—March–May Pulse 3-34
Figure 3.8: LCA: Medium Diversion at White Ditch Future Without Project Condition 3-35
Figure 3.9: Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without Project Condition 3-36
Figure 3.10: Alternative 1 – Location 3 3-39
Figure 3.11: Alternative 2 – Location 3 3-41
Figure 3.12: Alternative 3 – Location 3 3-42
Figure 3.13: Alternative 4 – Location 3 3-44
Figure 3.14: CE/IC Analysis of Final Alternatives 3-51
Figure 3.15: CE/IC Best Buy Plans 3-52
Figure 3.16: FWP Acres at TY50 per Operational Plan 3-53
Figure 3.17: The Recommended Plan as Compared to Evaluated Alternatives and Different Rates of Projected Sea-Level Rise 3-54
Figure 4.1: LCA White Ditch Existing Condition Salinities – July 2009 4-9
Figure 4.2: Historic Habitat Analysis of the White Ditch Project Area 4-14
Figure 4.3: Marsh Types in the White Ditch Project Area 4-15
Figure 4.4: LCA White Ditch Boat Launch/Marina 4-29
Figure 4.5: LCA White Ditch Oil/Gas Wells and Pipelines 4-40
Figure 4.6: LCA White Ditch Existing Condition Salinities – July 2009 4-43
Figure 5.1: Sea Level Rise Rates for the White Ditch Study Area 5-5
Figure 5.2: Modeled Salinities Following Maximum Diversions at White Ditch and Caernarvon – Approximately May 1st Under Our Proposed Operational Scheme 5-31
Figure 5.3: Modeled Salinities Two Months After Maximum Diversions at White Ditch and Caernarvon – Approximately July 1st Under Our Proposed Operational Scheme 5-33

Page

Tables

Table 1.1: Relevance of Prior Studies, Reports, Programs, and Water Projects to the MDWD Feasibility Study 1-7
Table 1.2: Related Studies That Played a Role in MDWD Project Development 1-17
Table 2.1: CWPPRA's Restoration Projects in the Breton Sound Basin 2-2
Table 2.2: Goals and Objectives 2-8
Table 3.1: Study Area, Medium Diversion at White Ditch 3-3
Table 3.2: Summary of the Problems, Opportunities, Goals, Objectives and Measures to this Point in the Planning Process 3-14
Table 3.3: Specific Measures Screened from Further Consideration 3-16
Table 3.4: Conceptual Alternatives Screened from Further Consideration 3-20
Table 3.5: Diversion Location Screening 3-26
Table 3.6: LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1a 3-31
Table 3.7: LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1b 3-32
Table 3.8: Direct Footprint Acreage Impacts 3-49
Table 3.9: Benefits Summary* 3-49
Table 3.10: Acreage Summary 3-49
Table 3.11: LCA: White Ditch Cost Estimates 3-50
Table 3.12: White Ditch Incremental Cost/Cost Effectiveness Step 2 3-50
Table 3.13: White Ditch Incremental Cost/Cost Effectiveness Step 2 3-51
Table 3.14: Net Increase in Recreation Benefits 3-53
Table 3.15: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area Under Historical Sea Level Rise Rates 3-55
Table 3.16: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area Under the Intermediate and High Sea Level Rise Rates 3-55
Table 3.17: Medium Diversion at White Ditch Authorized, Adjusted, and Recommended Plan Cost Table 3-59
Table 3.18: O&MRRR Annualization 3-61
Table 3.19: Cost Sharing 3-74
Table 4.1: Essential Fish Habitat (EFH) for Various Life Stages for Shrimp, Red Drum, Reef Fish, and Stone Crab (NMFS Scoping Correspondence, 2009) 4-22
Table 4.2: Fishing Licenses Year 2009 4-27
Table 4.3: Hunting Licenses Year 2009 4-27
Table 4.4: Boat Registrations Year 2008 4-28
Table 5.1: Estimated Average Total Load (Tonnes)/Month 5-24
Table 5.2: Estimated Residual N After Wetland Uptake 5-25
Table 6.1: Categorization of Scoping Comments by Draft EIS Subject Matter 6-4
Table 7.1: Relevant Federal Statutory Authorities and Executive Orders 7-2
Table 7.2: Relevant State Statutory Authorities 7-3
Table 9.1: List of Preparers 9-1

APPENDICES (VOLUME VI)

Appendix A	Biological Assessment
Appendix B	U.S. Fish and Wildlife Service Coordination Letter and Support (includes WVA Appendix and revised/updated information on WVA benefits and assumptions)
Appendix C	NOAA Fisheries Service Coordination Letter
Appendix D	404(b)(1) Water Quality Report
Appendix E	Louisiana Coastal Resources Program Consistency Determination
Appendix F	State Historic Preservation Officer Coordination Letter
Appendix G	Responses to Comments
Appendix H	Value Engineering Study Report
Appendix I	Monitoring and Adaptive Management Plan
Appendix J	Real Estate Plan
Appendix K	Benefit / Cost – Incremental Cost Analysis
Appendix L	Engineering Appendix
Appendix M	Hazardous, Toxic, and Radioactive Waste Initial Assessment Documentation
Appendix N	Qualitative Induced Shoaling Analysis

This page intentionally left blank.

Executive Summary

ES.1 Summary Introduction and Study Information

Title VII of the Water Resources Development Act (WRDA) 2007 authorizes the Louisiana Coastal Area (LCA) ecosystem restoration program. Included within that authority are requirements for comprehensive coastal restoration planning, program governance, a Science and Technology Program, a program for the beneficial use of dredged material, feasibility studies for restoration plans, project modification investigations, and restoration project construction, in addition to other program elements. This authorization was recommended by the Chief of Engineer's Report, dated January 31, 2005.

This report is an integrated Feasibility Study and Supplemental Environmental Impact Statement (SEIS) conducted for the Medium Diversion at White Ditch (MDWD) project. This report fulfills the reporting requirement to Congress of Section 7006(e)(3), which directs the Secretary of the Army to submit feasibility reports on the six projects included in that section by December 31, 2008, and authorizes implementation of the projects provided a favorable Chief of Engineers' Report is completed no later than December 31, 2010.

ES.2 Problems, Need for, Opportunities, and Objectives of Action for the MDWD Project

The altered supply and distribution of freshwater, lack of sediments, marsh subsidence and human development in the White Ditch area have resulted in rapid loss of marsh habitat in the MDWD project area over the past century. Various human activities have resulted in degraded and unbalanced distribution of freshwater, brackish, and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, and altered hydrology changed salinity regimes. The threat of increasing relative sea level rise is compounding these problems.

Wetlands in the project area are deteriorating for several reasons: 1) subsidence, 2) lack of sediment and nutrient deposition, 3) erosion via tidal exchange, 4) channelization, 5) saltwater intrusion and 6) lack of freshwater. Recent hurricanes and tropical storms have also caused significant damage to the project area. These activities have resulted in the loss of several thousand acres of solid, vegetated marsh. It is expected that the project area will lose thousands of acres of marsh over the 50-year planning horizon. Deterioration will continue and the system is vulnerable to complete collapse unless preventative measures are taken.

Based on the available data and the outcome of public scoping meetings, a series of potential desired futures exists that require consideration by the study team, sponsor, collaborating agencies and citizens. Early in the planning process a Desired Future Condition was identified as a no net loss of marsh acres consistent with LCA Planning Goal 2. It should be noted that no net loss was what the Project Delivery Team (PDT) felt was achievable and desirable given the uncertainty associated with sea level rise and the constraints of time and availability of information.

Study goals, objectives, and constraints were developed to comply with the study authority and to respond to study area problems and opportunities. In consultation with the non-Federal sponsor and other interested parties, Goals and Objectives were developed in the first quarter of 2009. They are:

Goals and Objectives

Overarching System Goal	Objective
Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the nation.	A. Maintain the current area of marsh habitat, of all types (41,206 acres), that provide life requisite habitat conditions for native coastal marsh fish and wildlife. B. Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained. C. Restore sediment inputs into the project area equivalent to an average of approximately 1,300,000 cubic yards of sediment per year.

ES.3 Alternatives

Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including prior studies, the NEPA public scoping process, and the multidisciplinary, interagency project delivery team (IPDT).

The development of *alternative plans* is described extensively in Chapter 3. Multiple structural measures and management measures were assessed. Five diversion locations were considered. These were repeatedly screened to develop the final array.

The alternatives in the Final Array are:

No Action (Future Without-Project Conditions). Over a 50-year period of analysis, if nothing were done, we would see significant losses of all marsh types throughout the study area. More major storms could accelerate this loss. As a result open-water habitats would continue to grow allowing for further intrusion of saltwater into the marsh.

Alternative 1 – 5,000 cfs diversion at Location 3. This alternative involves construction of a structure capable of diverting up to 5,000 cfs consisting of three 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The diversion would be operated fully open only during March and April and run at up to 1,000 cfs for the rest of the year.

Alternative 2 – 10,000 cfs Max Diversion at Location 3. This alternative involves construction of a structure capable of diverting up to 10,000 cfs consisting of three 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 176 acres of marsh creation utilizing dredged material from an

adjacent 167 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The diversion would be operated fully open only during March and April and run at up to 1,000 cfs for the rest of the year.

Alternative 3 – 15,000 cfs Max Diversion at Location 3. This alternative involves construction of a structure capable of diverting up to 15,000 cfs consisting of ten 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The diversion would be operated fully open only during March and April and run at up to 1,000 cfs for the rest of the year.

Alternative 4 – 35,000 cfs Max Diversion (Recommended Plan) at Location 3. This alternative involves construction of a structure capable of diverting up to 35,000 cfs consisting of ten 15-ft x 15-ft box culverts. Additionally, 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The diversion would be operated fully open only during March and April and run at up to 1,000 cfs for the rest of the year.

Desired Future Condition

The desired future condition established early on in study development was to achieve “no net loss” of marsh acres at the end of the 50-year period of analysis. While it was desirable to maximize the acres of marsh, it was uncertain if that was possible given the various physical and operational constraints. The ERDC-SAND2 model is an engineering spreadsheet that predicts sedimentation in a wetland system. The ERDC-SAND2 model assessed sediment dispersal and was used to generate land creation outputs for the MDWD project area. The ERDC-SAND2 model outputs along with the hydraulic engineering model outputs are the key components in the WVA, which is used to generate habitat units. Based on the ERDC-SAND2 results, Alternative 4 provided the most net acres at the end of period of analysis. By implementing Alternative 4, it is possible that the study area could see a return to historic marsh acreages. Finally, the IC/CE analysis of the final array of alternatives utilized WVA benefits based in part on an operation regime of Open Diversion during March–April with a 1,000 cfs maintenance flow the remainder of the year. Alternative 4 is the most capable at achieving no net loss. Alternative 3 also has the potential to achieve no net loss but requires longer pulse durations. Longer pulse duration was viewed by the PDT and stakeholders as less acceptable.

Relative Sea Level Rise and Sustainability

An analysis of the high sea level rise scenario was conducted utilizing the ERDC-SAND2 model. The model was used to determine whether a net loss or gain of marsh acreage would occur assuming a high sea level rise scenario. Alternative 4 was the most effective at countering the effects of high sea level rise. Alternative 4 could maintain marsh acreage out to approximately year 20 of the analysis which was then quickly followed by a sharp decline and eventual collapse of the marsh and near total conversion to open water. This result was based on the March–April Pulse plus a 1,000 cfs maintenance flow the rest of the year. It should be noted however, that in the event high sea level rise becomes a reality, Alternative 4

alone has the capability (assuming an open diversion) to divert large enough quantities of freshwater, nutrients and sediments to overcome high sea level rise. While not publicly acceptable at present, if the collapse of the marsh within the study areas was imminent, then having the ability to respond accordingly with a year round open diversion would be critical. Alternative 4 is the only alternative capable of providing a sustainable solution to the high sea level rise scenario

Recommendation of the Recommended Plan

The interagency team recommends Alternative Plan 4 (Location 3 – 35,000 cfs) as the Recommended Plan. This alternative best meets the study objectives, is the most flexible, and has the most robust sustainable capability against relative sea level rise over the length of the 50-year planning horizon. Alternative Plan 4 has a primary operating regime of a maximum 35,000 cfs pulse during March–April with a maximum 1,000 cfs maintenance flow throughout the remainder of the 12-month cycle (May–February). The pulse regime was chosen because it capitalizes on sediment availability while minimizing adverse effects to socioeconomic resources. It mimics a natural hydrologic regime.

Alternative 4 meets the four evaluation criteria of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Alternative 4 provides the most robust capability for adapting to future risk and uncertainty. Alternative 4 provides the most flexible management of operations to respond to sea level rise. Based on the ERDC-SAND2 results, Alternative 4 provides the most net acres at the end of period of analysis and it is possible that the study area could see a return to historic marsh acreages. The current cost is $361,606,000, the total first cost of construction is $365,201,000, and the fully funded project cost is $387,620,000. It would result in restoration of natural deltaic processes within the study area. In cooperation with the USFWS, NOAA, and the State of Louisiana, the Corps has planned and would design a project that serves the needs of the nation.

NER Plan

The NER plan reasonably maximizes ecosystem restoration benefits compared to costs, considering the cost effectiveness and incremental cost of implementing other restoration options. Alternative 4 Location 3 – 35,000 cfs, based on all considerations is the NER plan. The NER Plan is supported by the non-Federal sponsor and therefore no locally preferred plan is identified. Additionally, based on the evaluation conducted as part of this EIS, it has been determined that Alternative 4 Location 3 – 35,000 cfs, is the environmentally preferable alternative.

ES.4 Affected Environment

This chapter describes the climate, geomorphic and physiographic setting, and the historic and existing conditions for important resources.

A resource is considered important if it is recognized by statutory authorities including laws, regulations, Executive Orders (EO), policies, rules, or guidance; if it is recognized as important by some segment of the general public; or if it is determined to be important based on technical or scientific criteria. The following sections discuss historic and existing conditions of each important resource occurring within the project area.

Location and Climate

The MDWD project study area is located in LCA Subprovince 1, and comprises part of the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana. Plaquemines Parish is located within the Central Gulf Coastal Plain in southeastern coastal Louisiana. The parish encompasses the current delta of the Mississippi River, which was built up from alluvial silt deposited over centuries when the river was levee-free and overflowed its banks. Elevations range from sea level along the Gulf Coast, to approximately +15 feet above sea level along levee ridges. The project area is located within the Mississippi River Deltaic Plain, with the Mississippi River acting as the primary influence on geomorphic processes in the delta region. The boundary of the project study area encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The climate of the project area is subtropical marine with long humid summers and short moderate winters.

Significant Resources

Significant Resources considered within the development of this Feasibility Report with Integrated SEIS included soils; coastal vegetation; wildlife; fisheries; plankton; benthos; essential fish habitat (EFH); threatened and endangered species; hydrology (including flow and water levels, and sediment); water quality; recreation; public lands; cultural and historic resources; aesthetics; air quality; socioeconomic and human resources (including population; infrastructure; employment and income; navigation; oil, gas, and utilities; pipelines; commercial fisheries; oyster leases; and flood control and hurricane protection). In addition, the characterization of noise and hazardous, toxic, and radioactive waste (HTRW) in the project area are presented.

ES.5 Environmental Consequences

This chapter describes the potential environmental consequences of implementing alternative plans considered for freshwater diversion and marsh restoration in the project study area. The following analysis compares the No Action Alternative to four alternatives carried over for detailed analysis: Alternative Plans 1, 2, 3, and 4. Alternative 4 is the Recommended Plan. Alternatives developed and evaluated in this study are described in Chapter 3. A comparison of the direct, indirect, and cumulative impacts for wetland creation and enhancement is presented. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

No Action Alternative (Future Without Project Conditions)

Direct

The No Action Alternative would have a direct impact on the area between the Mississippi River and River aux Chenes through the continuation of existing degradation of marsh. The absence of a supply of freshwater, sediment, and nutrients combined with the ongoing pressures of wind and wave action, storm surges, and human activities has severely eroded marsh soils and reduced the ability of the project area to maintain a balance of emergent wetland and shallow water. The project area would continue to be isolated from natural riverine processes. No opportunities for beneficial use of dredged material for construction features would occur.

Existing vegetation resources in the project footprint would continue to degrade and convert to intermediate marsh. Wildlife habitat would continue to degrade and switch. The project area is recognized as an important and productive fisheries nursery habitat, and conversion to open water would reduce availability of this habitat. Juvenile fish and invertebrates are important food sources for migratory birds, such as wading birds and waterfowl.

There would be no direct impacts to population and housing, minority populations, infrastructure, tax revenues and property values in the vicinity of the proposed Phoenix diversion site from the No Action Alternative.

Indirect

Without implementation of the proposed diversion, no increase in input of sediment, freshwater and nutrients to the project area would occur. This would result in the persistence of existing conditions including continued erosion of marsh soils, and continued fragmentation and conversion of existing intermediate, brackish and saline marsh to shallow open-water habitats. Both man-induced and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory. Over the next 50 years, approximately 13,750 acres of emergent marsh is projected to be lost, and it is likely that all remaining remnants of bottomland hardwood vegetation would disappear over the same period.

Continued conversion of emergent marsh to open water is expected to have long-term adverse impacts to many fish species that depend on estuarine wetlands. The abundances of aquatic organisms would decrease. The reduction in emergent wetlands would also result in shifts in predator/prey relationships, a decline in fishery productivity, and reduced recreational fishing opportunities. The loss and deterioration of transitional wetland habitats over time could continue to indirectly affect, to an undetermined degree, all Threatened and Endangered species that may potentially utilize the Breton Sound basin including.

In terms of Socioeconomics, there would be no indirect impacts to population and housing, human health, minority or low-income populations, business and industry, traffic and transportation, public facilities and services, infrastructure, tax revenues and property, community and regional growth, land use socioeconomics, water use and supply, or manmade resources. However, there would be indirect impacts to important Socioeconomic natural resources due to no action. Indirect impacts on natural resources and commercial fisheries would occur as a result of continuing loss of emergent wetland and increase in shallow open water. There would be a shift in the populations of fishes and invertebrates, with more saline-dominated species replacing freshwater species. Over the 50-year planning horizon, habitat for many commercial fishery species would likewise decline, leading to a net loss in fisheries population size and diversity. Without implementation of the proposed diversion, indirect impacts on oyster leases would occur as a result of continuing loss of emergent wetland and increase in shallow open water. This would likely result in a shift in oyster population toward the middle and upper reaches of the estuary. At the same time, currently productive oyster leases in the lower portions of the project area would likely degrade in time as salinity shifts above the optimal. Over the 50-year planning horizon, optimal habitat for oyster production would likewise decline, leading to a net loss in oyster lease productivity and harvest.

Alternative 1 – 5,000 cfs max Diversion, Alternative 2 – 10,000 cfs max Diversion, and Alternative 3 – 15,000 cfs max Diversion

The adverse Direct, Indirect, and Cumulative impacts associated with Alternative 1, Alternative 2, and Alternative 3 would be similar to those presented for Alternative 4. The reason for this is that most adverse impacts are associated with construction activities, which would be relatively equivalent regardless of alternative size. Other negative impacts would be associated with freshening of the basin and would be relatively equivalent regardless of alternative size.

Positive Direct, Indirect, and Cumulative impacts associated with Alternative 1, Alternative 2, and Alternative 3 would not equal those provided by Alternative 4. This alternative best meets the study objectives, is the most flexible, is the most robust, and has the most sustainable capability against relative sea level rise over the length of the 50-year planning horizon. It would result in restoration of natural deltaic processes within the study area. Alternative 1, Alternative 2, and Alternative 3 would not fully satisfy the Goal and Objectives of the project.

Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

Direct

Construction of the 35,000 cfs maximum diversion would directly impact approximately 640 acres in the intermediate zone (277 acres of marsh and 363 acres of shallow open water). Approximately 223 acres of marsh and shallow water area would be excavated to enlarge the outfall channel for the structure. This excavated material would be placed on organic marsh soils and aquatic substrates to create approximately 31 acres of ridges lining the outfall channels, and 385 acres of created marsh in locations adjacent to the outfall channels.

The direct impact to hydrology of Alternative 4 would be increased water levels and flows within the project area while the structure is being operated. During operations, Mississippi River water would flow through natural and man-made channels. This would increase the availability of freshwater, sediments, and nutrients. The sediments in the waters would be available to help restore areas of open water that were historically marsh. The areas that would receive the most potential benefits from the sediments would be the open water areas that are adjacent to Bayou Garelle. It is believed that it would be a sufficient amount to keep up with the current rate of marsh loss and have the potential for restoring the marsh back to its historic condition.

Under the 35,000 cfs diversion, no direct impacts to water use and supply or groundwater would occur. However, it could cause short-term adverse impacts to water quality. These impacts would be minimized through best management practices (BMPs). Direct impacts to ambient air quality would be temporary and localized. Construction activities would temporarily cause minor increases in noise levels.

Under the 35,000 cfs diversion alternative, the existing benthic communities in the footprint of the proposed construction and dredging activities would be lost. However, following construction, benthic organisms would likely recolonize aquatic habitats in the project area, and the enhancement of freshwater marsh habitat by the diversion should be beneficial to numerous benthic species. Construction of the 35,000 cfs alternative is expected to have minor short-term impacts to fisheries resources in the immediate vicinity of the outfall management features. Following construction, displaced fish would

likely return to the project area. Direct impacts to EFH would include the disturbance and displacement of managed species in the construction footprint. Construction of the proposed diversion and associated outfall management features would not jeopardize the continued existence of any listed species or destroy or adversely modify critical habitat. Construction of the 35,000 cfs diversion alternative and associated outfall management features would not be expected to adversely affect archaeological sites.

In terms of Socioeconomics, there would be no long-term adverse direct impacts to population and housing, human health, minority or low-income populations, business and industry, traffic and transportation, public facilities and services, infrastructure, tax revenues and property, community and regional growth, agriculture; forestry; public lands; water use and supply; navigation, oil, gas, and utilities; flood control and hurricane protection; fisheries; and oyster leases. Any short-term impacts would be minor and inconsequential.

Indirect

Indirect beneficial impacts of implementing the 35,000 cfs max diversion would include the expected restoration of approximately 20,315 net cumulative acres of emergent marsh soils by year 50 following construction of the project. Indirect impacts to hydrology would be the inundation of lands while the structure is being operated. Lands that would not normally be inundated during the period would become submerged. However, with this submergence there would be an opportunity for the lands to collect beneficial sediments that are being carried by the diverted Mississippi River water, thus renewing historic deltaic processes. Increased sediment introduction into the project area would result in the "filling-in" of open water areas adjacent to Bayou Garelle.

Increased flows from the diversion would also result in changes to the salinity levels in the Breton Sound Basin. Flows of freshwater would result in lower salinities across the project area, and beyond River aux Chenes. These lower salinities would remain for approximately a 3-month period following peak flows from the diversion. No indirect impacts to water use and supply or groundwater would occur. There could be both positive and negative effects to water quality. Creation and protection of emergent wetlands would help to improve local air quality by reducing particulates and gaseous air pollutants. Indirect impacts due to noise are expected to be localized, temporary, and minor in nature. Operation would indirectly provide an inflow of freshwater, sediments and nutrients to the project area and redistribute sediments along existing and created BLH ridges during pulses. An increase in all land types in the project area is expected to occur with this alternative. Additionally, the ERDC-SAND Model land loss calculations conducted in support of the WVA assessment of proposed diversion alternatives projected that the 35,000 cfs diversion would produce an overall gain in land acreage to approximately 59,902 acres by year 50 after project implementation. Operation of the 35,000 cfs diversion is anticipated to result in an increase in SAV coverage in the fresh, intermediate, and brackish zones as a consequence of delivery of nutrients and sediments throughout the project area

There is potential for entrainment of larval and young-of-year (YOY) fish into the marsh and open water of the project area, including individual specimens of federally listed species such as the pallid sturgeon. However, no critical habitat for pallid sturgeon has been identified in the vicinity of the White Ditch project area. While there is a potential for individuals of the species to be adversely affected by entrainment during operation of the diversion, the proposed project is not considered likely to jeopardize the continued existence of pallid sturgeon in the lower Mississippi River.

In terms of Socioeconomics, there would be no distinguishable adverse indirect impacts to population and housing, human health, minority or low-income populations, business and industry, traffic and transportation, public facilities and services, infrastructure, tax revenues and property, community and regional growth, land use socioeconomics, water use and supply, community cohesion, or manmade resources. In the long term the continued existence of these wetlands would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, alligator farming, hunting and fishing guide services, and ecotourism; as well as provide benefits for supporting economic activities such as marinas, bait and tackle shops, and others.

Diversion of river sediment and water with this operating plan is unlikely to substantially increase the potential for sedimentation and shoaling in the Mississippi River downstream of the diversion, or to require additional or increased dredging over the 50-year planning horizon. Indirect effects within the project area resulting from operation of Alternative 4 would include increased water levels within interior distributaries such as River aux Chenes and Bayou Garelle, and increased inundation of low-lying lands, particularly when the diversion is operated at maximum capacity. These hydrologic alterations are expected to distribute and deposit river sediments throughout the project area. No significant adverse effects on existing Federal or non-Federal levees are expected to result from implementation of this alternative.

Over the 50-year planning horizon, implementation of Alternative 4 is expected to have large-scale benefits for commercial fisheries and shellfish operations by restoring and preserving marsh and critical nursery habitat in the project area. Without project implementation most marsh in the project area will be lost based on current rates of loss. Although the long-term, large-scale outlook of implementation would be positive, there would be unavoidable impacts to certain natural resources in the project area. Alternative 4 would have indirect impacts on commercial fisheries by affecting the location of target species. Changes in salinity levels in the project area as a result of project operation could change the distribution of fish and shellfish species based on their salinity tolerance. No broad system-level change in species density, assemblage, or numbers would be expected. Changes in fisheries distribution could impact commercial fishing patterns and locations. There is also a potential for some indirect impact on commercial seafood processing facilities located on the West Bank of Plaquemines Parish if Alternative 4 is implemented. Indirect impacts to oyster leases around this diversion site if Alternative 4 is implemented could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site. This could result in a loss of revenue for commercial oyster harvesters on those leases.

Cumulative

Cumulative impacts would be the synergistic effect of the No Action Alternative with the added combination of similar wetland degradation and wetland loss impacts throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. The Caernarvon Diversion does freshen the White Ditch project area, albeit to an unknown extent, and could potentially impact patterns in and near the study area, but would not likely the study area. The proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch could have impacts on the project area, but conclusive details as to those extents are not available at this time. Other diversions along the Mississippi River would collectively have impacts on Mississippi River stages and possibly sediment and nutrient loads available to the Breton Sound Basin.

ES.6 Public Involvement

A project kick-off meeting was held on December 12, 2008, and a public scoping meeting was organized and hosted in accordance with NEPA on February 5, 2009. A scoping meeting announcement requesting comments on the scope of the MDWD Study was mailed to Federal, State, and local agencies; and interested groups and individuals on January 7, 2009. The media advisory announcing the scoping meeting was provided to 350 media outlets. The open house session provided attendees with an opportunity to visit a series of poster stations staffed by project team members and subject matter experts regarding the following topics: the LCA plan, the NEPA process and milestones, an overview of the study and its goals and objectives, as well as maps of the study area. Approximately 26 people attended the MDWD scoping meeting. A total of 16 multi-part comments were received during the comment period, of which one was received via e-mail and two were copies of letters. Fourteen individuals expressed comments at the scoping meeting. A total of three written comments (letter, email, web site) were received during the comment period. The comments were categorized according to their applicability to the SEIS.

ES.7 Coordination and Compliance

Coordination and compliance efforts were conducted regarding statutory authorities. These include environmental laws, regulations, executive orders, policies, rules, and guidance such as the U.S. Fish and Wildlife Coordination Act, Clean Water Act – Section 401 Water Quality and Section 404(b)(1), Coastal Zone Management Act of 1972, Magnuson-Stevens Fishery Conservation and Management Act of 1996, and the Magnuson-Stevens Act Reauthorization of 2006 (Essential Fish Habitat), Clean Air Act, National Historic Preservation Act of 1966, Farmland Protection Policy Act, Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Louisiana State Rare, Threatened, and Endangered Species, and Natural Communities Coordination, and Executive Orders 13186,12898, and 13112. Full compliance with statutory authorities will be accomplished upon review of the integrated feasibility study and environmental impact statement by appropriate agencies and the public and the signing of a ROD.

ES.8 Areas of Controversy and Unresolved Issues

During the scoping meeting and throughout the alternative identification and evaluation a number of issues have been raised regarding diversions in general and those under consideration in the study area. Every effort has been made to address these concerns and clearly identify the impacts, both beneficial and detrimental of the alternatives considered. Through public review of the document, most of these issues were clarified and resolved. However, it is also likely that if construction and operation of the Recommended Plan were to occur, then these issues would continue to be raised. They are summarized as follows:

- Joint operation of the proposed White Ditch Diversion with the existing Caernarvon Diversion would be key to maintaining the condition of the overall Breton Sound ecosystem. These two projects should not be operated independently of one another. Modeling results and monitoring data suggests that Caernarvon has the ability to substantially freshen the Breton Sound even without freshwater inputs from another source. In order for Breton Sound salinities to rebound after the March–April pulse from the White Ditch Diversion, flow from Caernarvon would have to be closely controlled. This will mean a change to the current operational plan. It will be crucial that future modeling during PED for White Ditch and during Feasibility for the LCA

Modification to Caernarvon investigate joint operation. The LCA 4 Modification to Caernarvon will consider and account for the proposed Medium Diversion at White Ditch project during its analysis. Additionally the existing and proposed operational plans for both White Ditch and Caernarvon are subject to refinement based on any newly acquired data. If significant changes are required, these would be properly disclosed to the public through the NEPA process.

- Potential negative impacts to oysters from over-freshening of the basin. An evaluation of the impacts to the salinity regimes in the study area was conducted and the areas most important to commercial oyster harvesting could experience significant changes as a result of the project, especially if an unfavorable operational regime is implemented. During the PED phase, detailed and extensive aquatic modeling using the fisheries modeling software will be used to thoroughly evaluate the potential impacts to fisheries resources, including commercially important species such as oysters. These results could assist in further refinement of the proposed operational regime.
- Converting the estuary to fresh/intermediate marsh. Fresh and intermediate marsh types are an important habitat type in coastal areas and specifically the study area. The loss of these areas has diminished the ecological integrity of the study area. The restoration of fresh and intermediate marsh types will not exceed historic trends and is not expected to displace significant areas of brackish or saline marsh. Additionally the Recommended Plan has the potential to create new areas of brackish and saline marsh through restoration of the functional processes that create and sustain them.
- Creating 'flotant' marsh that is not anchored and provides no surge protection. The short duration of the pulse (March–April) operating regime has the potential to saturate existing marsh. However, due to the relatively short pulsing season, significant habitat switching is not expected to occur.
- Direct sediment delivery with dredging from the river. The cost of this approach would be excessive. While building marsh directly would have an immediate benefit, it would not restore the processes needed to sustain marsh within the study area.
- Impacts to pallid sturgeon. At this time, surveys are being conducted to determine whether pallid sturgeon are present and if the Recommended Plan will impact the species. Preliminary indications are that the species is not present; however, the USFWS has not yet made a formal determination. That information will be available before a public review draft of the report is completed.
- Creating access and/or land-use problems for private landowners. The Recommended Plan will have immediate impacts in the area being considered for the location of the structure. Access during construction may be limited but this would be temporary.
- Did we pick the best spot on the river to capture sediment? Based on the available information, the supply of sediment at the Phoenix location would be adequate to meet the goals and objectives of the project and operational requirements of the structure. The information used to predict project benefits in the ERDC-Sand2 Model came from data obtained from the Belle Chasse station, which represented the longest continuous dataset from a nearby location. When comparing the ERDC-Sand2 Model inputs to data that have been collected within the project area itself, it is seen that the programs estimates are conservative. Data collected by the USGS in the outfall canal of the existing White Ditch Siphon suggests that more sediment is available to enter

into the project area than represented by the Belle Chasse Data. Using the Belle Chasse Data, it is expected that the Recommended Plan will deliver approximately 16,600 tons of sediment per day into the project area during the March–April Pulse. Using the USGS sediment loads and the same pulse operation, approximately 17,900 tons of sediment per day could enter the project area. This results in a potential 8% increase in sediment loads from what are currently being projected.

Current research being done by the University of Texas in conjunction with the State of Louisiana also suggests that there will be further increased sediment concentrations specifically at the Phoenix site. The Phoenix location of the Recommended Plan was selected because there is a "back-current" in flows on the Mississippi River. This will enhance the amount of sediment available in the area of the diversion as the back-current will continually pull sediments into the diversion.

Additional analysis will be conducted during PED to determine the best orientation and placement of the structure within close proximity of its presently proposed location. The project would not move from the Phoenix location.

- Relative Sea-Level Rise (RSLR). Extensive consideration of RSLR occurred during formulation. Further, the impacts of the moderate and high sea-level rise scenarios on the Recommended Plan were evaluated but it should be noted that no evaluated alternative is able to entirely offset the high rate of sea-level rise.
- Induced shoaling effects and other effects to the navigation/shipping industry. No impacts are expected to the day-to-day activities of the navigation/shipping industry. A qualitative analysis of induced shoaling effects is included in Appendix N. Further analysis is recommended during design to accurately assess and minimize, through the diversion structure design, potential impacts.
- The Recommended Plan for this project exceeds the cost authorization presented in the 2004 LCA Report. The District Commander recommends seeking additional authorization in order to construct the Recommended/NER plan; however, the need to request additional authorization has the potential to impact the project construction schedule.
- Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the USACE for the PED Phase. At this time, a SOW is being developed as part of the Donaldsonville to the Gulf project to look at various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project.
- If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.
- The impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (September 2010). The impacts of the oil spill as well as the various emergency actions taken to address oil spill impacts (e.g., use of oil dispersants, creation of sand berms, use of Hesco baskets, rip rap, sheet piling and other actions) could potentially impact USACE water resources projects and studies within the Louisiana coastal area, including the MDWD project. Potential impacts could include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. The USACE will

continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact project implementation. Supplemental planning and environmental documentation may be required as information becomes available. If at any time petroleum or crude oil is discovered on project lands, all efforts will be taken to seek clean up by the responsible parties, pursuant to the Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.).

Ongoing documentation of the impacts associated with the Deepwater Horizon Oil spill can be found in several governmental sources. The USFWS Situation Report for August 2, 2010 (http://www.fws.gov/home/dhoilspill/pdfs/MondayAugust22010.pdf) indicates the following environmental-related Deepwater Horizon oil spill information: 563 personnel are actively engaged in the response, working to protect wildlife and their habitats, including 36 national wildlife refuges. They are also assessing the damage from the oil spill in preparation for the work that will be needed to restore the Gulf of Mexico. Some 1,643 visibly oiled birds have been collected alive by the U.S. Fish and Wildlife Service, the states and our partners in response to the Deepwater Horizon oil spill. Of those, 594 birds have been rehabilitated and released. Another 1,451 visibly oiled birds have been collected dead. Aerial operations over Louisiana observed an oil sheen covering 300 acres in the northeastern portion of Barataria Bay. A heavily oiled coastline covering about one-half mile was found at Bayou Chalond and heavy oil and tar balls were observed on landfall east of Point-Au-Fer and along Timbalier Island. Beached bird surveys were conducted in Texas, Louisiana, Mississippi, Alabama and Florida. Aerial missions are scheduled for Southwest Pass, Chandeleur Islands, Biloxi Marsh, Barataria Bay, Terrebonne, Marsh Islands, Atchafalaya Delta, Point-Au-Fer and Timbalier Bay.

- Overall number of personnel responding: approximately 30,100
- Total vessels responding: more than 4,500
- Total boom deployed: more than 2,155 miles
- Boom available: more than 856 miles
- Oily water recovered: more than 34.7 million gallons
- Estimated 11.14 million gallons of oil burned
- Estimated total of more than 1.84 million gallons of dispersant used including:
  - Estimated more than 1.07 million gallons surface dispersant used
  - Estimated more than 771,000 gallons of sub-sea dispersant used:
- Estimated approximately 632 miles of Gulf Coast shoreline is currently oiled-approximately 365 miles in Louisiana, 111 miles in Mississippi, 68 miles in Alabama, and 88 miles in Florida.

The USACE, New Orleans District Regulatory Branch, has considered and responded to approximately 55 emergency permits related to the Deepwater Horizon oil spill. In addition, the State of Louisiana is permitted to dredge and fill to construct a six sand berm reaches along the shoreline of the Chandeleur Islands/Breton National Wildlife Refuge westward to Baptiste Collette Bayou and along the seaward shoreline of Timbalier Island eastward to Sandy Pont. Material to construct the berms would be dredged from Ship Shoal, South Pelto, the Mississippi

River Offshore Disposal Site, Pass a Loutre, St. Bernard Shoal and Hewes Point. Emergency permits have the following clause that provides for removing, relocating or altering permitted structures if necessary and upon due notice from the Corps. The clause would pertain to future actions by the United States, such as proposed Louisiana Coastal Area restoration projects:

> *The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee shall be required upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.*

As is evident from the numerous ongoing actions, the dynamic nature of the impacts associated with the Deepwater Horizon oil spill will likely require additional consideration in the near future for USACE Civil Works projects.

ES.9 Conclusions and Recommendations

The Recommended Plan will restore degraded marsh habitat and impaired deltaic processes that sustain them between the Mississippi River and River aux Chenes. This will be accomplished by reconnecting the study area to the supplies of freshwater, nutrients and sediment that have been isolated within the Mississippi River by the MR&T levee. These benefits are represented by the 13,355 Average Annual Habitat Units expected from the NER plan at an estimated fully funded cost of $387,620,000 (Appendix L). When compared to the FWOP in 50 years, the Recommended Plan yields a Net Increase of approximately 35,000 acres under the current rate of sea level rise. The Recommended Plan is the plan that best meets the Louisiana Coastal Area goals and objectives as well as those identified for the study area in partnership with the State of Louisiana. The Recommended Plan is also the plan that best meets the P&G's four criteria of completeness, effectiveness, efficiency, and acceptability, as well as the Environmental Operating Principles of environmental sustainability, interdependence, balance and synergy, accountability, knowledge, respect, and assessing and mitigating cumulative impacts.

The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies, the Non-Federal Sponsors, and the public and has determined that the Recommended Plan presented in this report is in the overall public interest and a justified expenditure of Federal funds.

1.0 STUDY INFORMATION

1.1 STUDY AUTHORITY

Title VII of the Water Resources Development Act (WRDA) 2007 authorizes the Louisiana Coastal Area (LCA) ecosystem restoration program. Included within that authority are requirements for comprehensive coastal restoration planning, program governance, a Science and Technology Program, a program for the beneficial use of dredged material, feasibility studies for restoration plans, project modification investigations, and restoration project construction, in addition to other program elements. This authorization was recommended by the Chief of Engineer's Report, dated January 31, 2005.

> ***SEC. 7003. LOUISIANA COASTAL AREA.***
>
> *(a) IN GENERAL.-The Secretary may carry out a program for ecosystem restoration, Louisiana Coastal Area, Louisiana, substantially in accordance with the report of the Chief of Engineers, dated January 31, 2005.*
>
> *(b) PRIORITIES.—*
>
> *(1) IN GENERAL.—In carrying out the program under subsection a), the Secretary shall give priority to—*
>
> *(A) any portion of the program identified in the report described in subsection (a) as a critical restoration feature;*
>
> *(B) any Mississippi River diversion project that—*
>
> *(i) will protect a major population area of the Pontchartrain, Pearl, Breton Sound, Barataria, or Terrebonne basins; and*
>
> *(ii) will produce an environmental benefit to the coastal Louisiana ecosystem;*
>
> *(C) any barrier island, or barrier shoreline, project that—*
>
> *(i) will be carried out in conjunction with a Mississippi River diversion project; and*
>
> *(ii) will protect a major population area;*
>
> *(D) any project that will reduce storm surge and prevent or reduce the risk of loss of human life and the risk to public safety; and*
>
> *(E) a project to physically modify the Mississippi River-Gulf Outlet and to restore the areas affected by the Mississippi River-Gulf Outlet in accordance with the comprehensive plan to be developed under section 7002(a) and consistent with sections 7006(c)(1)(A) and 7013.*

Under the 2007 WRDA Section 7006, the LCA program has authority for feasibility-level reports of six near-term critical restoration features. The excerpt below from WRDA outlines the project authority for this report for the Medium Diversion at White Ditch project:

SEC. 7006. CONSTRUCTION.

(3) PROJECTS SUBJECT TO REPORTS.—

(A) FEASIBILITY REPORTS.—Not later than December 31, 2008, the Secretary shall submit to Congress feasibility reports on the following projects referred to in the restoration plan:

(i) Multipurpose Operation of Houma Navigation Lock at a total cost of $18,100,000.

(ii) Terrebonne Basin Barrier Shoreline Restoration at a total cost of $124,600,000.

(iii) Small Diversion at Convent/Blind River at a total cost of $88,000,000.

(iv) Amite River Diversion Canal Modification at a total cost of $5,600,000.

***(v) Medium Diversion at White's Ditch at a total cost of $86,100,000**.*

(vi) Convey Atchafalaya River Water to Northern Terrebonne Marshes at a total cost of $221,200,000.

(B) CONSTRUCTION.—The Secretary may carry out the projects under subparagraph (A) substantially in accordance with the plans and subject to the conditions, recommended in a final report of the Chief of Engineers if a favorable report of the Chief is completed by not later than December 31, 2010.

(4) CONSTRUCTION.—No appropriations shall be made to construct any project under this subsection if the report under paragraph (2) or paragraph (3), as the case may be, has not been approved by resolutions adopted by the Committee on Environment and Public Works of the Senate.

This report is an integrated Feasibility Study and Supplemental Environmental Impact Statement (SEIS) conducted for the Medium Diversion at White Ditch (MDWD) project. This report fulfills the reporting requirement to Congress of Section 7006(e)(3), which directs the Secretary of the Army to submit feasibility reports on the six projects included in that section by December 31, 2008, and authorizes implementation of the projects provided a favorable Chief of Engineer's Report is completed no later than December 31, 2010.

1.2 PURPOSE AND SCOPE

In November 2008, the U.S. Army Corps of Engineers (USACE) and the State of Louisiana represented through the Coastal Protection and Restoration Authority (CPRA), executed a single Feasibility Cost-Share Agreement (FCSA) covering six LCA near-term plan elements listed in Section 7006(e) of the Water Resources Development Act (WRDA), 2007. The six features will each go through a separate feasibility analysis and environmental compliance review culminating in a single master feasibility document. The cost-share during this feasibility phase is 50% Federal and 50% Non-Federal in total. However, the individual elements have been divided so that each entity has lead responsibility for preparing three of the six report components. This means that at the end of the feasibility phase the total cost will be shared on a 50/50 basis, yet for work on each individual element during the feasibility phase

the ratio of funds expended by either the Federal or non-Federal sponsor will be higher depending upon their level of responsibility. Although three of the projects will be lead by state teams, each individual feasibility component will be conducted and written to meet USACE planning and technical standards for a feasibility level document.

This document serves as the Final Feasibility Report for the LCA MDWD project. This project was identified as a Near-term Critical Restoration Feature Recommended for Study and Future Congressional Authorization in the LCA Main Report dated January 21, 2005. In November 2007, WRDA passed, authorizing this and other projects from the LCA Main Report. The MDWD feasibility study is anticipated to result in a Chief's Report containing a Recommended Plan to construct a Mississippi River diversion in the vicinity of White Ditch for the purposes of introducing freshwater, sediments, and nutrients into the study area.

1.3 STUDY AREA

The MDWD project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana (Figure 1.1). The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the Forty-Arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound basin.

There are two discreet project locations that will be considered for the purposes of the feasibility study: The area along the Mississippi River where a freshwater diversion structure might be located; and the project area that could be influenced and benefited by the diverted freshwater. The footprint of both of these areas will be dependent upon the overall size and capacity of the diversion structure recommended in the report.

The area of interest where a diversion structure could be located occurs on the left descending bank of the Mississippi River, between Bertrandville to the north (river mile 69) and the community of Davant to the south (river mile 51). An area of particular interest for this study is the stretch between White Ditch (river mile 64.4) and Phoenix (river mile 59.7). This 4.7-mile stretch is unique in that there is no hurricane protection levee (back levee) on the marsh side that protects existing homes and infrastructure from elevated water levels (tidal or storm surge). The Mississippi River levee is the only flood protection structure that keeps river water from entering the project study area. This situation minimizes the amount of infrastructure that could be affected by construction of a diversion structure and allows for a broader array of measures to be considered in addressing problems in the project area. The project study area has been heavily influenced by both man-made and natural processes. Channel construction, subsidence, erosion, saltwater intrusion, and storm-related damages have all significantly altered the natural environment, causing extensive losses of wetland habitats.

1.4 HISTORY OF INVESTIGATION

The MDWD feasibility study is designed to address coastal restoration problems and opportunities in the project area based on guidance from the LCA Ecosystem Restoration Study completed in 2004. The LCA effort identified numerous projects that were classified by immediacy of need in order to prioritize efforts undertaken to eventually achieve Congressional appropriation for construction. An additional nine projects are identified in WRDA 2007 section 7006 and all projects are scheduled to be included in a Chief's Report to be completed by 31 December 2010.

Given the magnitude of Louisiana's coastal land losses and ecosystem degradation, it has become apparent that a systematic approach involving larger projects to restore natural geomorphic structures and processes, working in concert with smaller projects, will be required to effectively deal with a physical problem of such large proportions (LCA 2004).

A siphon capable of diverting Mississippi River water up to 250 cubic feet per second (cfs) currently exists at White Ditch. It was constructed in 1963 to improve oyster and muskrat habitats, but has not been operated since 1991 except for brief modeling studies and other temporary durations. In addition to the LCA authority, both the State-developed Louisiana Comprehensive Master Plan for a Sustainable Coast and the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program have diversion projects identified for further evaluation at White Ditch.

1.5 PRIOR REPORTS AND EXISTING PROJECTS

A number of prior water resources development efforts have been identified as relevant to the MDWD study. Prominent existing efforts are detailed in Sections 1.5.1, 1.5.2, 1.5.3, 1.5.4, and Attachment B. The relevance of these reports is reflected in Table 1.1.

1.5.1 Federal

Several comprehensive planning efforts have significance to the MDWD Feasibility Study, including the Coast 2050 Plan; LCA Ecosystem Restoration Study; Louisiana's Comprehensive Master Plan for a Sustainable Coast; and the LACPR technical report. These comprehensive planning efforts are described below.

Coast 2050 Plan, 1999. In 1998, Federal and State agencies, local governments, academia, numerous non-governmental groups, and private citizens participated in developing the Coast 2050 Plan, a conceptual plan for restoration of the Louisiana coast. The Plan was a direct outgrowth of lessons learned from implementation of restoration projects through the CWPPRA and other programs, and reflected a growing recognition that a more comprehensive "systemic" approach to restoring coastal wetlands was needed. The Plan formed the basis for the May 1999 905(b) reconnaissance report that preceded the LCA Ecosystem Restoration Study that recommended the MDWD project.

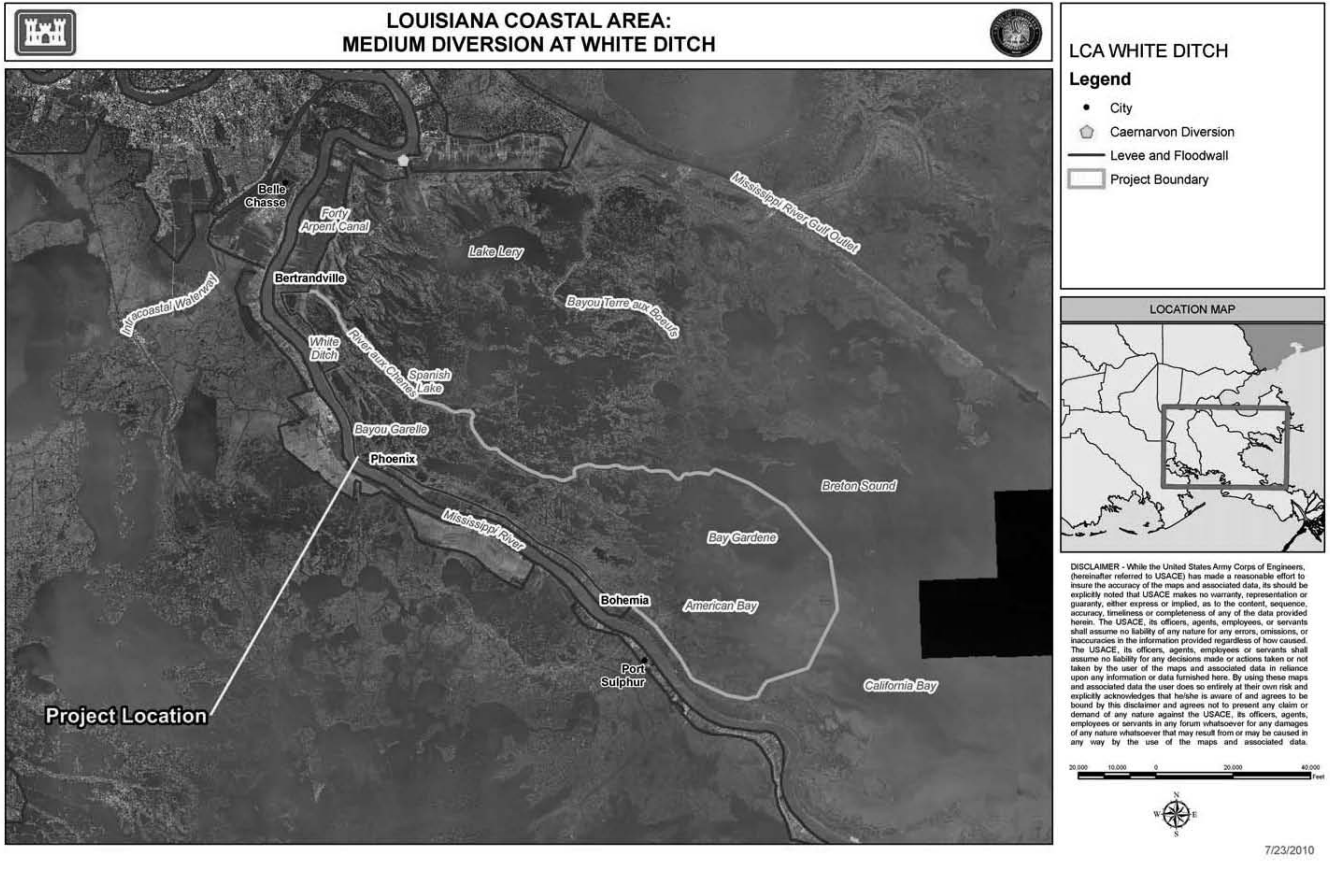


Figure 1.1: Study Area Map

This page intentionally left blank.

Table 1.1: Relevance of Prior Studies, Reports, Programs, and Water Projects to the MDWD Feasibility Study

Prior Studies, Reports, Programs, and Water Projects	Relevance to Medium Diversion at White Ditch				
	Data Source	Consistency	Structural Measurements	Non-Structural Measures	Future Without Project Condition
Mississippi River and Tributaries (MR&T), 1928	X	X	X		
New Orleans to Venice, Louisiana Hurricane Protection, 1962	X	X	X		
Hydrologic and Geologic Studies of Coastal Louisiana, LSU 1973	X				X
Deep-Draft Access to the Ports of New Orleans and Baton Rouge, Louisiana, 1981		X			
Louisiana's Eroding Coastline: Recommendations for Protection, EPA 1982	X	X	X	X	X
Mississippi Deltaic Plain Region Ecological Characterization, USFWS 1982	X				X
Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options, 1982	X				X
Mississippi and Louisiana Estuarine Areas, 1984	X				X
Louisiana Coastal Area, Hurricane Protection, 1988 (Draft)	X	X			
Louisiana Coastal Wetlands Conservation, Restoration and Management Act, Act 6 1989	X	X			X
The Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), 1990	X	X	X	X	X
White's Ditch Diversion Siphon – Outfall Management Plan Feasibility Report (1992)	X		X	X	X
An Environmental- Economic Blueprint for Restoring the Louisianan Coastal Zone: The State Plan for the Wetlands Conservation and Restoration Authority, 1994	X	X	X	X	X
A White Paper- The State of Louisiana's Policy for Coastal Restoration Activities, 1995	X	X			X
Coast 2050, 1999	X	X	X	X	X
Mississippi River Sediment, Nutrient and Freshwater Redistribution Feasibility Study, 2000	X				X
LCA Ecosystem Restoration Study, 2004	X	X	X	X	X
Act 8 of the First Extraordinary Session of 2005		X			
Drawing Louisiana's New Map: Addressing Land Loss in Coastal Louisiana, 2006	X				X
Louisiana's Comprehensive Master Plan for a Sustainable Coast, 2007	X	X	X	X	X

Table 1.1, concluded

Prior Studies, Reports, Programs, and Water Projects	Relevance to Medium Diversion at White Ditch				
	Data Source	Consistency	Structural Measurements	Non-Structural Measures	Future Without Project Condition
Louisiana Coastal Protection and Restoration (LACPR), 2009	X	X	X	X	X
Bonnet Carré Spillway	X	X	X	X	
CWPPRA Projects Constructed or Authorized for Design	X	X	X	X	X
Greater New Orleans Hurricane and Storm Damage Risk Reduction System (GNOHSDRRS)	X	X	X	X	
Various Environmental Assessments (EAs) Prepared by the USACE	X	X	X	X	X

Louisiana Coastal Area (LCA), 2004. In 2000, the USACE and State of Louisiana initiated the Louisiana Coastal Area Ecosystem Restoration Study to address Louisiana's severe coastal land loss problem. The goal of LCA is to achieve and sustain a coastal ecosystem that can support and protect the environment, economy, and culture of coastal Louisiana and thus, contribute to the economy and well-being of the nation. The LCA study focused on "lessons learned" from previous Louisiana coastal restoration efforts, the Coast 2050 restoration strategies, and the best available science and technology to develop a plan addressing the most critical coastal ecological needs. This study recommended the MDWD project.

Louisiana's Comprehensive Master Plan for a Sustainable Coast, 2007. The Louisiana Legislature, through Act 8 of the First Extraordinary Session of the 2005 Louisiana Legislature, established the Coastal Protection and Restoration Authority (CPRA) to develop, implement, make reports on, and provide oversight for a comprehensive coastal protection master plan and annual coastal protection plans. A diversion at White Ditch is identified as a restoration concept for restoring natural processes in the Delta Plain and maintaining critical landscape features.

Louisiana Coastal Protection and Restoration (LACPR), 2009. The Louisiana Coastal Protection and Restoration technical report includes analysis and design for coastal restoration and "Category 5" hurricane risk reduction. The USACE submitted a Preliminary Technical Report to Congress in July 2006 and a draft final report is now in Independent External Peer Review. The LACPR report identifies the MDWD area as a key location for marsh creation though it does not recommend a Mississippi River diversion in the area.

Prior Studies, Reports, and Projects

In addition to the comprehensive planning efforts described above, the studies, reports, and projects listed in Table 1.1 have been identified as potentially relevant to the MDWD study. A brief description of

relevant prior studies and reports and National Environmental Policy Act (NEPA) documents is provided below.

Related Laws and Programs

Over the past three decades, both the Federal Government and the State of Louisiana have established policies and programs that are intended to halt and reverse the loss of coastal wetlands and to restore and enhance ecosystem function.

Federal Laws and Programs

Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), 1990. The CWPPRA of 1990 was the first Federal statutory mandate for restoration of Louisiana's coastal wetlands. The CWPPRA Task Force is composed of five Federal agencies: U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), USACE, National Marine Fisheries Service (NMFS), and Natural Resources Conservation Service (NRCS); and the State of Louisiana. The initial priority of the task force was to prepare a comprehensive restoration plan that would coordinate and integrate coastal wetlands restoration projects to ensure the long-term conservation of coastal wetlands of Louisiana. The plan was adopted in 1993.

The task force is also required to prepare an annual Project Priority List (PPL). CWPPRA provides funds annually for coastal restoration planning and the construction of coastal protection and restoration projects. As of April 2009, 146 active CWPPRA projects have been approved, 77 have been constructed, 17 are under construction, and 30 have been de-authorized or transferred to other programs. The CWPPRA program anticipates receiving $84 million in Federal funds for Fiscal Year 2009 (FY 2009). The CWPPRA program has authorized the White Ditch Resurrection and Outfall Management project for Phase I funding as part of PPL-14.

1.5.2 State

Coastal resource management in Louisiana formally evolved once Louisiana adopted and began participating in the Federal Coastal Zone Management (CZM) program in 1978. Shortly thereafter, the State developed a coastal zone management plan. One of the primary objectives of this plan was to ensure that future development activities within the coastal area would be accomplished with the greatest benefit and the least amount of environmental damage. The Plaquemines Parish Government operates its own CZM program in accordance with State and Federal regulations and adheres to the policy of minimizing environmental damages from approved projects. Any final MDWD project recommendations must be in compliance with the Parish and State CZM program.

Louisiana Coastal Wetlands Conservation, Restoration and Management Act, 1989. In 1989, the constitution of the State of Louisiana was amended with passage and voter approval of Act 6 (LA. R.S. 49:213 *et seq.*), also known as the Louisiana Coastal Wetlands Conservation, Restoration and Management Act. Act 6 designated the Louisiana Department of Natural Resources (LDNR) as the lead State agency for the development, implementation, operation, maintenance, and monitoring of coastal restoration projects. LDNR had the lead for the development and implementation of State-sponsored coastal restoration projects.

Act 6 also created the Wetlands Conservation and Restoration Fund (WCRF), which dedicates a portion of the State's revenues from severance taxes on mineral production (e.g., oil and gas) to finance coastal restoration activities and projects. Currently, the WCRF provides approximately $25 million per year to support coastal restoration activities and projects. Act 6 requires the State to prepare and annually update a "Coastal Wetlands Conservation and Restoration Plan." This plan provides location-specific authorizations for the funding of coastal restoration projects from the WCRF.

Act 8 of the First Extraordinary Session of 2005. In November 2005, Act 8 of the First Extraordinary Session of 2005 created the CPRA and charged it with coordinating the efforts of local, State, and Federal agencies to achieve long-term and comprehensive coastal protection and restoration. The CPRA created a Master Plan to integrate what had previously been discrete areas of activity: flood control and wetland restoration. The Master Plan identifies a diversion at White Ditch in several of its concept alternatives.

1.5.3 Local

Non-governmental organizations (NGOs) have also participated in various coastal restoration projects. Public and private parties involved in wetlands preservation or restoration activities in coastal Louisiana include Coastal America, Corporate Wetlands Restoration Partnership, Gulf Coast Joint Venture, Audubon Society, National Fish and Wildlife Foundation, The Nature Conservancy, and the National Wildlife Federation. These efforts are primarily concerned with preservation. The restoration activities of these organizations may support the overall goals of the MDWD project; however, these efforts are small in scale and will not appreciably influence plan formulation.

The Lake Pontchartrain Basin Foundation (LPBF) and the Coalition to Restore Coastal Louisiana (CRCL) are both active and prominent NGOs that have taken an interest in the development of the MDWD study. The LPBF has developed several plans that rely on alternatives that could be constructed in the White Ditch area.

- Multiple Lines of Defense Strategy
- Pontchartrain Coastal Lines of Defense Plan
- Comprehensive Habitat Management Plan

Public scoping comments were also received from both organizations that propose a large spillway-type structure that is capable of delivering significant amounts of freshwater and sediments to the project area (see Appendix A).

Related Water Projects

Several existing and authorized navigation, river flood control, hurricane storm surge risk reduction and coastal restoration projects are related to the MDWD Feasibility Study. These projects are briefly described below.

River Flood Control Projects

Mississippi River and Tributaries (MR&T), 1928. The MR&T is a comprehensive project for flood control on the lower Mississippi River below Cape Girardeau, Missouri. The MR&T has four major elements: levees, floodways, channel improvement and stabilization, and tributary basin improvements.

The MR&T system controls and confines the river system before it reaches the coastal area. Any location for a diversion from the Mississippi River in the vicinity of White Ditch will be situated on the MR&T levee.

Bonnet Carré Spillway, 1931. The Bonnet Carré Spillway is located at the site of an old crevasse, and contains a flood control structure at the Mississippi River that was completed in 1931. The facility is designed to convey a maximum of 250,000 cfs of floodwater to Lake Pontchartrain to relieve flood conditions downstream. The spillway could serve as a guide in the design of the MDWD project and this concept was submitted for consideration during the public scoping process.

Hurricane Storm Surge Risk Reduction Projects

Greater New Orleans Hurricane and Storm Damage Risk Reduction System. The Hurricane and Storm Damage Risk Reduction System (HSDRRS) for Greater New Orleans consists of more than 200 projects forming a comprehensive system of levees, floodwalls, gates, internal drainage and pumping stations and other structures, integrated into a single system designed to reduce the risk of hurricane and storm damage to the Greater New Orleans area. It is located in southeastern Louisiana and includes all or a portion of six parishes: Jefferson, Orleans, St. Bernard, St. Charles, Lafourche and Plaquemines. The HSDRRS is integrated with the Mississippi River flood system along the main stem of the Mississippi River which protects against riverine flooding. The HSDRRS is designed to perform as an integrated system when completed.

Coastal Restoration Projects

Bonnet Carré Freshwater Diversion. In the 1984 *Mississippi and Louisiana Estuarine Areas: Freshwater Diversion at Lake Pontchartrain Basin and Mississippi Sound* feasibility study, various alternative locations were considered for diverting river water into the Basin at Bonnet Carré and Violet, both alone and in combination with other diversions. The diversion at Bonnet Carré was selected as the preferred alternative, largely due to cost considerations. The Assistant Secretary of the Army for Civil Works [ASA(CW)] transmitted the final feasibility report and Environmental Impact Statement (EIS) to Congress in September 1989. The Design Memorandum was submitted to USACE headquarters in October 1990, approved in November 1991, and the ASA(CW) concurred in January 1993. An Environmental Assessment (EA) evaluating water quality impacts to Lake Pontchartrain was developed following a re-assessment of the project, and a Finding of No Significant Impact (FONSI) was signed in July 1996. The State of Louisiana replied to USACE in July 1996, declining to participate further in the project due to concerns about adverse impacts to water quality in Lake Pontchartrain.

Davis Pond Freshwater Diversion. The Davis Pond diversion structure is located on the west bank of St. Charles Parish and is capable of diverting up to 10,650 cfs of Mississippi River water into a large ponding area to help control salinity levels in the Barataria Bay hydrologic basin. Construction of the project began in 1997 and it began operations in 2002. The project was authorized by the Flood Control Act of 1965 and modified by WRDA in 1974, 1986, and 1996. The Davis Pond project, like Caernarvon, fits within the MDWD authorized project capacity of 5,000 to 15,000 cfs. Davis Pond is currently experiencing design modifications that could serve as a reference in designing the MDWD project.

Caernarvon Freshwater Diversion and Outfall Management. The *Freshwater Diversion to the Barataria and Breton Sound Basins* report and subsequent technical appendices (USACE 1984),

recommended diverting Mississippi River water into the Breton Sound Basin near Caernarvon to increase habitat quality and improve fish and wildlife resources. The Caernarvon Freshwater Diversion was completed in 1991 with a design discharge of 8,000 cfs. Since its construction, the Caernarvon structure has been operated as a salinity control measure. The design and operation of this project served as a reference for development of the MDWD project.

The Water Resources Development Act of 2007, Section 7006(e)(1)(C), authorized a study to identify changes in the operation of the Caernarvon project to increase wetland creation and restoration outputs for this structure. The introduction of additional freshwater would facilitate organic and sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. The present structure, constructed in 1991, can divert up to 8,000 cfs of freshwater; however, the actual amount of diverted flow depends on a detailed annual operational plan which correlates with projected river stages and hunting/migrating seasons. The proposed restoration feature study would assess changes in the operation of the Caernarvon project to increase wetland creation and restoration outputs for this structure. Modified operation of this structure would allow an increase in the freshwater introduction rate, perhaps 5,000 cfs (178 cms) on average, to accommodate the wetland building function of the system. This study would identify any changes to this feature's operation that would increase restoration outputs. The proposed project will also investigate the economical effects of commercial fisheries and the environmental impacts of aquatic wildlife and vegetation due to the possible deviating operational schedule. A Chief of Engineers report is scheduled for completion by November 2011.

Bertrandville Siphon. The Bertrandville Siphon project was recently authorized for Phase I engineering and design under the CWPPRA program in January 2009. This project is located to the north of the MDWD project on the eastbank of Plaquemines Parish and proposes to construct a siphon to divert water from the Mississippi River into surrounding wetlands. The capacity of the structure is proposed at 1,000 cfs and it is under development by the USEPA and the State of Louisiana.

Naomi Siphon and Outfall Management. The Naomi Siphon and Outfall Management project is comprised of two separable elements: the siphon, which is capable of diverting up to 2,100 cfs; and hydrologic control features consisting of two fixed crest rock weirs to retain sediments in the system and help prevent saltwater intrusion into the project area. The siphon was completed in 1992 and the outfall management features were completed in 2002. Although this project is located on the westbank of Plaquemines Parish, its location is near where the MDWD could be located. The Naomi Siphon could serve as a guide for design and implementation of the MDWD project.

White Ditch Resurrection and Outfall Management. A siphon built in 1963 at White Ditch to deliver freshwater for oyster and muskrat habitat has ceased operation due to age and various other complications. The rehabilitation or replacement of the existing siphon at White Ditch and the construction of an additional siphon of similar size is proposed through CWPPRA. Phase I engineering and design funds have been appropriated and the NRCS and the State of Louisiana are developing project details. The project's proposed strategies also include installing a water control structure in the White Ditch outfall channel at the junction with River aux Chenes to force water into interior marshes. The MDWD project team and NRCS are coordinating the development of both projects.

West Pointe à la Hache Siphon and Outfall Management. The existing siphon consists of eight 72-inch siphon tubes capable of diverting up to 2,144 cfs of freshwater from the Mississippi River into the ~17,000 acre project area. Outfall management measures consist of earthen plugs, rock weirs, and spoil

bank maintenance. The project area is suffering from significant loss of wetland habitat due to a variety of factors including subsidence, the absence of freshwater and sediments, canal dredging, and saltwater intrusion. Construction of the project features will help to re-establish *Spartina patens*, the target plant species, in the project area. This project is located on the westbank of the Mississippi River in Plaquemines Parish and could serve as a guide for design of the MDWD project.

Bohemia Mississippi River Reintroduction. The Bohemia Mississippi River Reintroduction project was authorized for Phase I engineering and design funding under the CWPPRA program in October 2007. This project seeks to connect an existing canal to the Mississippi River allowing up to 10,000 cfs to flow through the uncontrolled diversion. A gap would be cut through the natural bank of the River and maintenance dredging would take place in the canal to facilitate the increased flow of freshwater. The project is located south of the MDWD project on the eastbank of the Mississippi River in Plaquemines Parish and could be used as a reference source for data and design considerations.

Bayou Lamoque Freshwater Diversion. Two large freshwater diversion structures are located at Bayou Lamoque on the eastbank of the Mississippi River in Plaquemines Parish: one built in 1955 capable of diverting 4,000 cfs of river water and one built in 1978 capable of diverting 8,000 cfs. These structures were operated periodically by the Louisiana Department of Wildlife and Fisheries (LDWF) until 1994. Neither structure is officially managed because of repair and operation issues and the lack of an interagency management plan. Improvements to the structures were proposed through CWPPRA, and are currently being developed with Coastal Impact Assistance Program (CIAP) funding. The structures could be used as a data and design reference in developing the MDWD project.

Delta Building Diversion North of Fort St. Philip. The wetlands in the area are deteriorating from erosion, subsidence, and insufficient sediment input. Some delta building is occurring in the downstream end of the project area from Mississippi River overbank flow. However, most of the project area is deteriorating from a lack of sediment. The proximity of open, shallow, estuarine water to the Mississippi River, coupled with the low level of development and infrastructure at this site, presents a rare opportunity to construct a sediment diversion project for a reasonable construction cost. The size of the diversion channel was designed to allow enough sediment through to create about 624 acres of marsh over the project life. This project has significantly increased sediment input into the benefited wetlands through the diversion of about 2,500–5,000 cfs of Mississippi River water. This project could serve as a guide for design and operation for the MDWD.

Benney's Bay Sediment Diversion. The objective of the project is to restore vegetated wetlands in an area that is currently shallow open water. The project would divert sediments in an effort to create, nourish, and maintain approximately 5,828 acres of fresh to intermediate marsh in the Benney's Bay area over the 20-year project life. The project consists of a conveyance channel for the large-scale diversion of water and sediments from the river. The conveyance channel would be constructed in two phases: (1) construction of an initial channel with an average discharge of 20,000 cfs; (2) after a period of intensive monitoring, enlargement of the channel to a 50,000 cfs discharge. Material from the construction of the channel would be used to create wetlands in the diversion outfall area. This project is currently being designed. This project could serve as a guide for design of the MDWD.

West Bay Diversion. The diversion site is located on the west bank of the Mississippi River, in Plaquemines Parish, Louisiana, 4.7 miles above Head of Passes. The project diverts Mississippi River water and sediments into West Bay. The project consists of a conveyance channel for the large-scale

diversion of sediments from the river. Material from the construction of the initial channel was used to create wetlands in the diversion outfall area. This project could serve as a guide for design of the MDWD despite recent developments by the CWPPRA Task Force that mandate its closure in 2011 due to negative induced shoaling effects on a nearby anchorage area.

Myrtle Grove Diversion. The 2004 LCA Ecosystem Restoration study considered diversions of various sizes (5,000 cfs, 15,000 cfs, 38,000 cfs with sediment enrichment, 75,000 cfs with sediment enrichment, and 150,000 cfs with sediment enrichment) at Myrtle Grove for inclusion in the near-term restoration plan. The 2005 Report of the Chief of Engineers recommended that a diversion with a capacity between 2,500 and 15,000 cfs with dedicated dredging be authorized for construction at Myrtle Grove contingent upon approval of a feasibility level of detail report by the Secretary of the Army. The project was authorized for construction contingent on preparation of a construction report in section 7006(c) of the WRDA 2007. A diversion at Myrtle Grove was approved for study under the CWPPRA program in 2001 and deauthorized in 2008. The State of Louisiana has continued to conduct hydrologic modeling of the proposed diversion. The diversion would provide additional sediment and nutrients to nourish highly degraded existing fresh to brackish wetlands in shallow open-water areas of mid- and lower Barataria Basin. Dedicated dredging (from the Mississippi River) at the rate of approximately 2 million cubic yards/year for several years with the new structure would provide for the projected creation of up to 19,700 acres of new wetlands over the project life. The LCA White Ditch team has coordinated modeling of the White Ditch diversion with the state's Myrtle Grove modeling team because the two diversions may be located across from one another on the Mississippi River. A feasibility study on the Myrtle Grove diversion was initiated under the LCA program in July 2010.

Existing Studies

A summary of studies and analyses performed on other projects is described in Table 1.2 and shown on Figure 1.2. Information gleaned from these studies was used as a basis for determining measurable metrics in the project objectives and for ensuring assumptions made regarding inputs to the hydraulic model and the ERDC-SAND2 model were sound. Not all studies listed in the table played a significant role in project development, but they were considered and applied where appropriate.

1.6 PLANNING PROCESS AND REPORT ORGANIZATION

The Medium Diversion at White Ditch project follows the USACE's six-step planning process specified in Engineering Regulation (ER) 1105-2-100. The planning process identifies and responds to problems and opportunities associated with the Federal objective and specified State and local concerns. This integrated report includes elements of both the planning process and sections specific to the NEPA review of the project.

The chapter headings and order in this report generally follow the outline of the required NEPA documentation for an EIS. Chapters of the report relate to the six steps of the planning process in ER 1105-2-100 as follows:

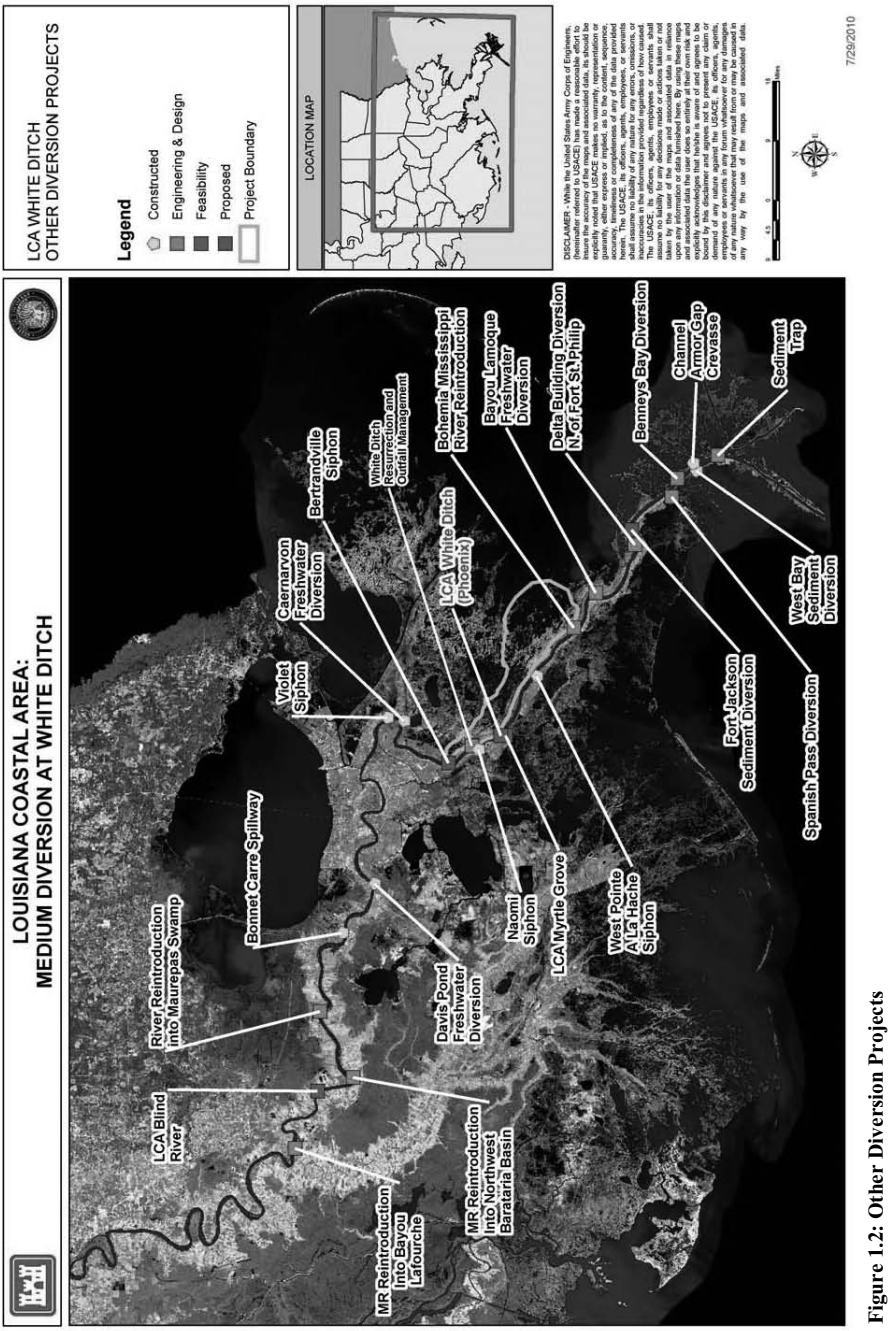


Figure 1.2: Other Diversion Projects

This page intentionally left blank.

Table 1.2: Related Studies That Played a Role in MDWD Project Development

Study Name	Study Focus	Relevant Information	How Used?
River Diversions and Shoaling (Letter, Jr. et al.)	Mississippi River	Examines the effects of how freshwater and sediment diversions affect shoaling rates and subsequent dredging in the lower Mississippi River.	This study was referenced as a supplement to the qualitative shoaling analysis (Appendix N).
Defining Restoration Targets for Water Depth and Salinity in Wind-Dominated Spartina Patens Coastal Marshes (Nyman, et al.)	South-central and southwest Louisiana intermediate marshes	Discusses the effects of predicted vs. observed water levels and salinities on the productivity of marshes dominated by Spartina patens.	This study was considered in conjunction with the MDWD pulsing scheme and maintenance flow scenarios.
The Decline in the Suspended Load of the Lower Mississippi River and its Influence on Adjacent Wetlands (Kesel)	Lower Mississippi River and the Mississippi River Delta	Analyzes the relatively recent trends of decreasing sediment loads in the Mississippi River due to factors such as reservoir construction upriver and land-use changes.	Data was considered as inputs were determined for use in ERDC-SAND2 model runs.
The Effect of Environmental Forcing on the Suspended Sediment Within the Naomi Wetlands as Reflected in Turbidity Data (McGraw)	Marshes surrounding the Naomi Siphon	Analyzes the forcing functions that affect the input and distribution of sediment in a system from a freshwater diversion.	Data was used to consider outfall channel and management arrangements as well as pulsing strategies.
Mississippi River Sediment, Nutrient, and Freshwater Redistribution Study (CWPPRA)	Mississippi River Deltaic Plain and tributaries	Evaluates numerous diversion structures and locations in addition to sediment and nutrient load in the Mississippi River.	This study was used both in developing an array of diversion alternatives and the qualitative shoaling analysis (Appendix N).
Pulsed River Flooding Effects on Sediment Deposition in Breton Sound Estuary, Louisiana (Wheelock)	Upper Breton Sound estuary and Caernarvon diversion	Sediment accretion rates were documented at and around the diversion structure and analysis looked at how to operate diversions to capture as much sediment as possible.	The study was used to assess input assumptions for the ERDC-SAND2 model, consider different pulsing techniques, and distribute flows throughout the study area.
Abatement of Wetland Loss in Louisiana Through Diversions of Mississippi River Water Using Siphons (Roberts et al.)	Central River aux Chenes sub-area of the Breton Sound basin	The existing White Ditch siphon was studied to determine sediment accretion rates and spatial distribution of introduced sediments.	Study was referenced for known sediment loads in the Mississippi River, pulsing schemes, and outfall channel arrangements.
Current and Historical Sediment Loads in the Lower Mississippi River (Thorne et al.)	Lower Mississippi River	Observed sediment loads (with variability) in the Mississippi River were documented for current and historic trends.	The study was considered as a source of sediment inputs, capacity needs for land-building, and when to focus pulsing events.

Table 1.2, cont'd

Study Name	Study Focus	Relevant Information	How Used?
The Impacts of Pulsed Reintroduction of River Water on a Mississippi Delta Coastal Basin (Day et al.)	Upper Breton Sound estuary and Caernarvon diversion	Relates the importance of diversion discharge timing, over-marsh sheet flow, and water distribution to maximize effectiveness.	The study was used to assess input assumptions for the ERDC-SAND2 model, consider different pulsing techniques, and distribute flows throughout the study area.
The Use of Large Water and Sediment Diversions in the Lower Mississippi River (Louisiana) for Coastal Restoration (Allison et al.)	Lower Mississippi River	Focuses on river-side mechanics including analyzing sediment loads and the importance of structure location for maximizing restoration opportunities.	Data utilized in coordination with Myrtle Grove diversion development, sediment suspension in the river and diversion potential.
Sediment Discharge into a Subsiding Louisiana Deltaic Estuary Through a Mississippi River Diversion (Snedden et al.)	Upper Breton Sound Estuary and Caernarvon diversion	Report stresses the importance of timing pulsed diversions to maximize sediment introduction and also examines the distribution of sediments within the system.	Study was considered in conjunction with proposed pulsing operations and design of the distribution network.

Chapter 2: Need For and Objectives of Action. This chapter addresses the first step in the planning process. In the first step of the planning process, the study area problems and opportunities are defined in addition to the constraints, goals, and objectives. An initial statement of problems and opportunities was developed for the 2004 LCA report which reflected the priorities and preferences of the Federal Government, non-Federal sponsor, and other stakeholders. This report presents an updated problem identification that includes enhanced understanding of the process and problems of the study area.

Chapter 3: Alternatives. The third chapter of this report addresses the third, fifth, and sixth steps in the planning process. Step three of the planning process is the formulation of alternative plans. During this step, the plans developed in the 2004 LCA report were reevaluated. The fifth step in the planning process addresses comparisons of the alternative plans with emphasis on the outputs and affects each alternative. During the sixth step of the planning process, the selection of the Recommended Plan is made based upon the comparison of the alternative plans.

Chapter 4: Affected Environment. The fourth chapter of this report addresses the second step of the planning process which requires an inventory and forecast of resources within the study area. The inventory and forecast of the study area provides the without project condition and is the basis of comparison for the alternatives.

Chapter 5: Environmental Consequences. The fifth chapter of this report covers the fourth step of the planning process which evaluates the effects of the proposed alternative plans in terms of ecosystem benefits. The evaluation criteria are based on the overall goals and objectives of the LCA program and specific planning objectives and purposes of the near-term critical restoration projects recommended in the 2005 Chief of Engineer's Report.

1.7 USACE CAMPAIGN PLAN

The USACE has developed a Campaign Plan with a mission to "provide vital public engineering services in peace and war to strengthen our nation's security energize the economy and reduce risk from disasters." This Campaign plan is shaping USACE command priorities, focusing transformation initiatives, measuring and guiding progress, and helping the USACE adapt to the needs of the future.

USACE Campaign Plan Goals and Objectives Summary

- Goal 1: Deliver USACE support to combat, stability and disaster operations through forward deployed and reach back capabilities.
  - Objective 1a: USACE is ready, responsive and reliable in delivering high performance, all hazard, contingency mission execution in a world-wide theater of operations.
  - Objective 1b: Prepare Theater Engineer Commands (TEC) to support Combatant Commanders throughout the spectrum of operations.
  - Objective 1c: Establish human resources and family support programs that promote readiness and quality of life.
  - Objective 1d: Institutionalize USACE capabilities in interagency policy and doctrine.

- Goal 2: Deliver enduring and essential water resource solutions through collaboration with partners and stakeholders.
  - Objective 2a: Deliver integrated, sustainable, water resources solutions.
  - Objective 2b: Implement collaborative approaches to effectively solve water resource problems.
  - Objective 2c: Implement Streamlined and Transparent Regulatory Processes to Sustain Aquatic Resources.
  - Objective 2d: Enable Gulf Coast recovery.

- Goal 3: Deliver innovative, resilient, sustainable solutions to the Armed Forces and the nation.
  - Objective 3a: Deliver sustainable infrastructure via consistent and effective military construction and real estate support to customers.
  - Objective 3b: Improve resilience and lifecycle investment in critical infrastructure.
  - Objective 3c: Deliver reliable infrastructure using a risk-informed asset management strategy.
  - Objective 3d: Develop and apply innovative approaches to delivering quality infrastructure.

- Goal 4: Build and cultivate a competent, disciplined, and resilient team equipped to deliver high quality solutions.
  - Objective 4a: Identify, develop, maintain, and strengthen technical competencies in selected Communities of Practice (CoP).
  - Objective 4b: Communicate strategically and transparently.

- Objective 4c: Standardize business processes.
- Objective 4d: Establish tools and systems to get the right people in the right jobs, then develop and retain this highly skilled workforce.

This project addresses two points of the USACE Campaign Plan. The second goal of the USACE Campaign Plan is addressed by this project since it is an element of the LCA ecosystem restoration plan on the Gulf Coast. This project also addresses the third goal through the application of the planning process to formulate, analyze, and evaluate alternative designs in pursuit of a sustainable, environmentally beneficial, and cost-effective ecosystem restoration design.

2.0 NEED FOR AND OBJECTIVES OF ACTION

2.1 NATIONAL OBJECTIVES

The USACE planning process is based on the economic and environmental Principals and Guidelines (P&G) promulgated in 1983. The P&G provide for development of reasonable plans that are responsive to National, State, and local concerns. Planning project benefits are quantified in this process as national economic development (NED) output, national ecosystem restoration (NER) output, or a combination of NED/NER output.

For water and land resources planning, the Federal objective is to contribute to NED while protecting the nation's environment and adhering to national environmental statutes, executive orders, and Federal planning requirements. NED contributions are increases in the net value of the national output of goods and services, expressed in monetary units. These NED outputs are the direct net benefits that accrue in the planning area and the rest of the nation. Contributions to NED may include increases in the net value of marketed and non-marketed goods and services.

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 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 shall be formulated and evaluated in terms of their net contributions to increases in NER output. Multipurpose plans that include ecosystem restoration shall contribute to both NED outputs and NER outputs. For multipurpose projects, a plan that trades off NED and NER benefits to maximize the sum of net contributions to NED and NER is usually recommended.

NED and NER contributions were considered in the alternatives analysis for this project. However, under Title VII of WRDA 2007, any project or separable project element under LCA may be justified by the environmental benefits alone and economic justification is not required if the Secretary determines that the project or activity is cost-effective. This exemption does not apply for any project that is not predominately related to the protection, preservation, and restoration of the coastal Louisiana ecosystem.

2.2 SIGNIFICANCE OF THE MDWD PROJECT AREA

The benefits of ecosystem restoration and protection projects are difficult to measure in monetary terms. When determining Federal interest, it is important that the significance of the resources being studied for restoration by clearly identified. Under Title VII of WRDA 2007, any project or separable project element under LCA may be justified by the environmental benefits alone and economic justification is not required if the Secretary determines that the project or activity is cost-effective. The USACE's P&G defines significance in terms of institutional, public, and technical recognition of the resources. For years, the Federal Government, the State of Louisiana and other agencies have been engaged in activities that clearly demonstrate the institutional, public, and technical recognition of the resources of the MDWD project area.

Institutional

The formal recognition of coastal Louisiana in laws, adopted plans, and other policy statements of public agencies and private groups illustrate the significance of the Breton Sound Basin to a variety of institutions. At the Federal level, the MDWD project area's importance as an environmental and economic resource has long been recognized by congressional action and through the activities of several agencies. The U.S. Congress recognized the significance of coastal Louisiana by the passage of the CWPPRA (PL-101-646, Title III, CWPPRA), which provided authorization and funding for the Louisiana Coastal Wetlands Conservation and Restoration Task Force to begin actions to curtail wetland losses. Table 2.1 is a list of CWPPRA projects in the Breton Sound Basin.

Table 2.1: CWPPRA's Restoration Projects in the Breton Sound Basin

PPL	Number	Agency	Project Name
2	BS-03a	NRCS	Caernarvon Diversion Outfall Management
10	BS-10	COE	Delta Building Diversion North of Fort St. Philip
10	BS-11	USFWS	Delta Management at Fort St. Philip
14	BS-12	NRCS	White Ditch Diversion Restoration and Outfall Management
15	BS-13	COE	Bayou Lamoque Freshwater Diversion (Transferred to CIAP)
17	BS-15	EPA	Bohemia Mississippi River Reintroduction
17	BS-16	USFWS	Caernarvon Outfall Management/Lake Lery Shoreline Restoration
18	BS-18	EPA	Bertrandville Siphon

While CWPPRA is an ongoing program, it is comprised of relatively small projects that only partially restore the coastal ecosystem, and has proven that given the magnitude of Louisiana's coastal land losses and ecosystem degradation, a systematic approach involving larger projects, working in concert with smaller projects is necessary to reverse the trend of degradation and restore coastal wetlands in Louisiana. Congress reaffirmed the significance of coastal Louisiana by authorizing the LCA Program through Title VII of the WRDA (Public Law 110-114). The MDWD project is specifically categorized as a near-term critical project. This conditional authorization and accelerated schedule to ensure swift action, demonstrates the importance and necessity of taking immediate and bold measures to reduce the rate of degradation that has been allowed to progress in coastal Louisiana for decades. The FY 2011 presidential budget for the USACE provides $35.6 million for Gulf Coast restoration, including $19 million for wetlands construction projects and $16.6 million for wetlands pre-construction studies. The FY 2011 presidential budget for the USFWS provides $5 million for Gulf Coast restoration.

Public

Coastal Louisiana is significant based on wide public recognition of the environmental resources present in the coastal wetlands. Louisiana's coastal wetlands and barrier island systems enhance protection of an internationally significant commercial-industrial complex from the destructive forces of storm-driven waves and tides. Population for Plaquemines Parish, location of the MDWD study area, was estimated at approximately 21,540 in 2007 (U.S. Census Bureau, 2009). Between 60% and 70% of Louisiana's population lives within 50 miles of the coast. Louisiana's coast is a "working coast," supporting critical infrastructure such as highways, ports, pipelines and navigational waterways of national economic

significance. Without coastal restoration, people and businesses that power the nation will be forced to retreat from coastal Louisiana, resulting in severe economic consequences to the nation.

Excluding Alaska, Louisiana produced the nation's highest commercial marine fish landings (about $343 million) excluding mollusk landings such as clams, oysters, and scallops (NMFS 2003). The State of Louisiana also leases thousands of sites throughout the basin for the production and harvesting of oysters. Data from the USFWS show expenditures on recreational fishing (trips and equipment) in Louisiana to be nearly $703 million, and hunting expenditures were $446 million for 2001 (USFWS, 2002).

Technical

Numerous scientific analyses and evaluations of the MDWD project area have documented its significant ecological resources. Louisiana contains one of the largest expanses of coastal wetlands in the contiguous U.S., and accounts for 90 percent of the total coastal marsh loss occurring in the nation. While many studies have been conducted to identify the major contributing factors (e.g., Boesch et al., 1994; Turner 1997; Penland et al., 2000), most studies agree that land loss and the degradation of the coastal ecosystem are the result of both natural and human induced factors, producing conditions where wetland vegetation can no longer survive and wetlands are lost. The natural processes of subsidence, saltwater intrusion, and erosion of wetlands, and the human effects of river levee construction and the oil and gas industry, have caused major impacts to the Breton Sound Basin in recent decades. The two major wetland problems resulting from the natural processes and human intervention in this basin are sediment deprivation and saltwater intrusion.

The MDWD project area contains an extraordinary diversity of habitats that range from narrow natural levees to expanses of forested swamps and freshwater, intermediate, brackish, and saline marshes. Taken as a whole, the unique habitats of wetland areas and the Gulf of Mexico, with their hydrological connections to each other, and migratory routes of birds, fish and other species, combine to place the coastal wetlands of the project area among the nation's most productive and important natural assets. In human terms, these coastal wetlands have been a center for culturally diverse social development.

The commercial harvest of alligator eggs is important economically in the basin. The alligator population in the Breton Sound estuary is surveyed annually by the LDWF via aerial nest inventories conducted in late June or early July after nesting is complete.

Approximately 70 percent of all waterfowl that migrate through the U.S. use the Mississippi and Central flyways, which are located directly over (within) the MDWD project area. With over 5 million birds wintering in Louisiana, the Louisiana coastal wetlands are a crucial habitat to these birds, as well as to neo-tropical migratory songbirds and other avian species that use them as crucial stopover habitat. These economic and habitat values, which are protected and supported by the coastal wetlands of Louisiana, and the MDWD project area specifically, are significant on a national level.

2.3 PUBLIC CONCERNS

A number of public concerns have been identified during the course of the study. Initial concerns were expressed in the study authorization. Additional input was received through coordination with the sponsor, coordination with other agencies*, public review of draft and interim products*, *and through workshops* and public meetings. A discussion of public involvement is included in Chapter 6, Public

Involvement, Review and Consultation. The public concerns that are related to the establishment of planning objectives and planning constraints are:

- Potential negative effects from the diversion on oyster habitats
- Potential negative effects from the diversion on alligator egg collecting
- Potential negative effects from the diversion on the proliferation of invasive species
- Potential negative effects from the diversion on the Mississippi River shipping and navigation industry
- Excessive changes in the salinity gradient that converts existing estuarine habitats into purely freshwater and intermediate types
- Making the project area more susceptible to storm surge by creating 'flotant' marsh
- Not having a rigorous and comprehensive operational scheme
- Proliferating the range and extent of invasive species (water hyacinth)
- Increasing costs associated with maintenance dredging in the Mississippi River due to induced shoaling effects
- Uncertainty about effects of the diversion on commercial and recreational fisheries species
- Coordinating the operational scheme with the Myrtle Grove diversion that could be located directly across from the White Ditch diversion location

2.4 PROBLEMS, NEEDS, AND OPPORTUNITIES

The first step in the planning process is the identification of problems and opportunities. Problems are undesirable, negative conditions that the study will address. Opportunities are desirable conditions that could be achieved in the future. Study area problems and opportunities were drawn from prior comprehensive planning studies and from public input and interagency information exchange.

System-wide problems and opportunities were used to identify and define more geographically specific problems and opportunities throughout the study area. Through the NEPA public scoping process, the study team solicited input on problems and opportunities from members of the public, government resource agencies, and other stakeholders. A discussion of general study area problems and opportunities follows.

2.4.1 General Problem Statement

The altered supply and distribution of freshwater, lack of sediments, marsh subsidence and human development in the MDWD area have resulted in degraded and unbalanced distribution of freshwater, brackish, and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, altered hydrology changed salinity regimes.

Installation of the existing White Ditch diversion siphon was completed in 1963 with the objective of enhancing muskrat and oyster habitat. In the absence of an outfall management plan, the surrounding

marsh received limited benefits from the diverted river water. Two 50-inch steel pipes divert water from the Mississippi River through the White Ditch, into the Belair Canal and then into the River aux Chenes, where it continues south and out of the project area. Usage of the siphons was abandoned for many years and they degraded into a non-usable condition. The siphons were recently refurbished and water was diverted into White Ditch as part of research efforts.

Wetlands in the project area are deteriorating for several reasons: 1) subsidence, 2) lack of sediment and nutrient deposition, 3) erosion via tidal exchange, 4) channelization, 5) saltwater intrusion, 6) lack of freshwater, and 7) sea level rise. Recent hurricanes and tropical storms have also caused significant damage to the project area. These activities have resulted in the loss of several thousand acres of solid, vegetated marsh. Deterioration will continue unless preventative measures are taken.

Along the Louisiana coast, both changes in water level and changes in land elevation are occurring. Relative sea level change is the term applied to the difference between the change in eustatic sea level and the change in land elevation (also referred to as relative subsidence). Land elevations decrease due to subsidence from compaction and consolidation of sediments, faulting, and groundwater depletion, and increase due to sediment accretion from riverine and littoral sources as well as organic deposition from vegetation. For most of coastal Louisiana, sediment accretion is insufficient to offset subsidence, so land elevations are decreasing. Taking into account changes in land elevation and water levels, the average rate of relative sea level change along coastal Louisiana is currently estimated to be between 3.4 to 3.9 feet/century (1.03 and 1.19 meters/century).

In the absence of supplemental freshwater and sediment from the Mississippi River, subsidence, sea-level rise, wave erosion, and saltwater intrusion will continue to be problems. Protection and enhancement of this area are dependent on providing a hydrologic and sediment regime that minimizes the physiological stress to wetland vegetation from saltwater intrusion and tidal energy and is conducive to the retention of locally provided freshwater and sediments

The historic hydrology of the project area indicates that the current course of the Mississippi River has remained the same for the last 700 years and has directly influenced the development of the entire area. The project area is located on the east side of the Mississippi River and was formed between two natural levee ridge systems, River aux Chenes on the east and the Mississippi River on the west. There are also two unnamed bayou ridges found within the project area. These ridges formed along the old natural bayous which were distributary channels for the Mississippi River. These natural bayous once carried sediments and nutrients into the project area during high river stages when the natural ridges were seasonally overtopped.

In the historical setting, floodwater from the river would recede and sediments and nutrients would be deposited in the inter-distributary basins located between ridges. During normal or low river stages, the ridges along the distributary channels served like levees and buffered the basin areas from the daily tidal influence. This buffering effect created a low energy freshwater environment in the inter-distributary basins, forming deep organic soils. Drainage to the area was provided by a high water event breaching the River aux Chenes ridge in the southern part of the project area. This event caused the development of the Bayou Garelle tributary channel.

The present day hydrology of the project area has been altered and no longer functions in a historically natural pattern. Historically, water moved very slowly through the system. Freshwater slowly exited the

system through meandering pathways in the marsh and saltwater was slow to intrude. Presently, changes in the marsh allow water to rapidly pass through the system and saltwater is able to quickly intrude. The hydrologic balance within the marsh has been disturbed due to the following man-made changes:

1. The Mississippi River can no longer overflow its banks into the project area due to the Mississippi River protection levee. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns.
2. Channels have been dredged through natural ridges, which have increased drainage and tidal exchange and exposed the soil to erosive forces.

2.4.2 Study Area Opportunities

Opportunities exist to naturalize the distribution of freshwater and sediments, improve hydrologic distribution of freshwater, improve topographic diversity, reduce the negative impacts of Gulf storm events and inhibit invasive species.

- Freshwater Supply – Re-introduction of freshwater supplies is an opportunity to restore a degraded and impaired deltaic forming process. Further, freshwater introduction has the potential to balance the altered salinity regime, improve the viability of freshwater marsh plant life and therefore restore fish and wildlife habitats.
- Hydraulic Distribution – Human induced habitat fragmentation (canals) has resulted in a degraded condition whereby the limited existing freshwater supplies are directed towards River aux Chenes and into the Gulf. Opportunities exist to improve the internal distribution of freshwater to restore and improve the sustainability of freshwater marsh habitats.
- Sediment Supply and Distribution – The lack of sediments from the Mississippi River has accelerated the degradation of all marsh types. Opportunities exist to re-introduce sediments from the river and use on site sediments displaced by Gulf storm events to create new marsh area. Based on the available survey data, the average depth of open water in the study area is 2 feet, with approximately 1 foot of soil structure above water required to support healthy marsh. This total of 3 feet of soil structure is assumed to be needed to support healthy marsh in the future.
- Topographic Diversity – As the freshwater marshes in the area degrade, niche habitats on ridges are lost, particularly forest resources such as oaks. Opportunities exist to restore ridge type features with both sediment introduction and targeted placement of materials.
- Sustainability – As marsh degradation has accelerated, seasonal Gulf events have a magnified impact on the remaining marsh areas. Opportunities exist through freshwater supply and distribution and sediment supply and distribution to create a healthier marsh which will be more resistant to the normal range of Gulf events.
- Invasive Species – Hyacinth is a common invasive species in the Breton Sound Basin. Freshwater introduction has the potential to improve conditions for its growth. Opportunities exist to control this incursion through effective diversion flexible management, prescribed burns of marsh grass and chemical control.

2.4.3 Desired Future Conditions

In order to more clearly articulate restoration goals and objectives for the project and understand how they fit into the large coastal system and the knowledge gained through the 2004 LCA Study; it is useful to outline potential desired future ecological conditions. Desired future conditions represent the restoration need of the project area. The restoration need in the case of White Ditch is the difference between a fully functioning and sustainable marsh community and the future habitat conditions (future without project). As an "ideal" ecological condition is difficult to determine for the project area due to a lack of reference conditions, the desired future condition is somewhat conceptual and reflects the value of the resource placed upon it by stakeholders. Project objectives will be refined based on the desired future. Finally, it is a useful way of establishing the upper bounds to restoration goals, objectives, and ultimately alternatives.

Based on the available data and the outcome of public scoping meetings, a series of potential desired futures exists that require consideration by the study team, sponsor, collaborating agencies and citizens. Figure 2.1 illustrates five potential desired future conditions. They are:

- **Louisiana Coastal Area Study (2004) 1**: Increase of marsh acres 50% over no net loss.
- **Louisiana Coastal Area Study (2004) 2**: Maintain no net loss of marsh acres.
- **Louisiana Coastal Area Study (2004) 3**: Reduce loss rate by 50%.
- **Desired Future 1**: Historic Condition (1985).
- **Desired Future 2**: Other proposed target?

At this time a Desired Future Condition has been identified as a no net loss of marsh acres consistent with LCA 2. It should be noted that no-net-loss was what the Project Delivery Team (PDT) felt was achievable and desirable given the uncertainty associated with sea level rise and the constraints of time and availability of information. Given the severe loss of marsh from over the last 25 years exceeding the current marsh areas would be beneficial to both the project area but also the larger ecosystem of the Breton Sound. The annual loss rate of marsh of 274.5 acres per year is equivalent to approximately 1.3 million cubic yards of sediment. The 1.3 million cubic yards figure is the quantity of sediment required to offset the loss of 274.5 acres per year. Based on the available survey data, the average depth of open water in the study area is 2 feet with approximately 1 foot of soil structure above water required to support healthy marsh. This total of 3 feet of soil structure is assumed to be needed to support healthy marsh in the future. The 1.3 million cubic yards figure is the volume of sediment needed to fill the 274.5 acres to an average depth of 3 feet.

2.5 PLANNING OBJECTIVES

Study goals, objectives, and constraints were developed to comply with the study authority and to respond to study area problems and opportunities.

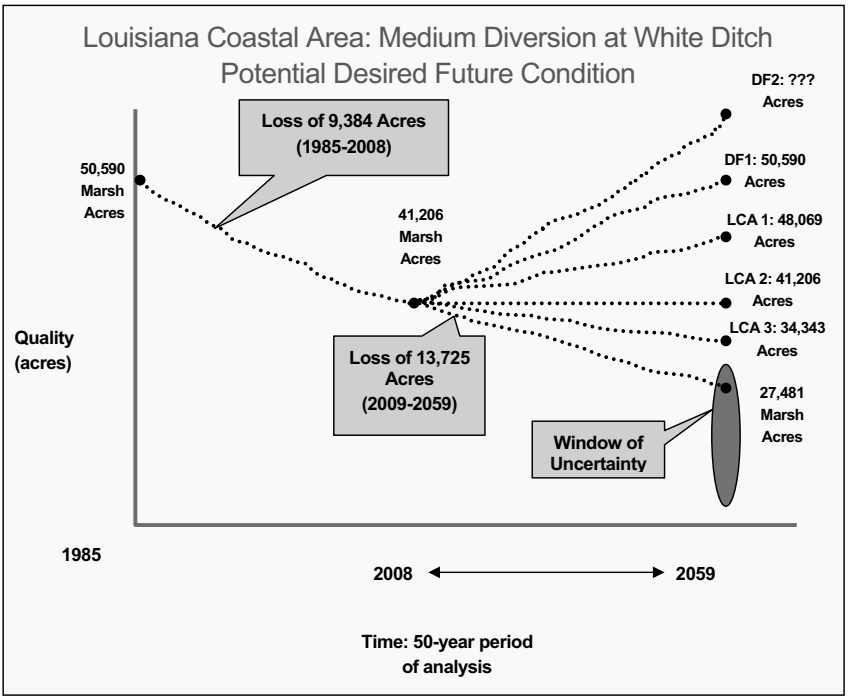


Figure 2.1: Potential Desired Future Condition

2.5.1 Goals and Objectives

In consultation with the non-Federal sponsor and other interested parties, Goals and Objectives were developed in the first quarter of 2009. They are:

Table 2.2: Goals and Objectives

Overarching System Goal	Objective
Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the nation.	A. Maintain the current area of marsh habitat, of all types (41,206 acres) that provide life requisite habitat conditions for native coastal marsh fish and wildlife. B. Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained. C. Restore sediment inputs into the project area equivalent to an average of approximately 1,300,000 cubic yards of sediment per year.

2.6 PLANNING CONSTRAINTS

Development and evaluation of restoration alternatives for the proposed project are constrained by a number of factors. These factors are generally divided into two categories:

- Project design constraints- Limitations to the scope and functionality of specific project features because of issues regarding project effects on other projects or infrastructure in the study area; and
- Ecosystem constraints- Constraints imposed upon the project design by existing conditions within the study area's ecosystem.

These categories and their constituent constraints are discussed separately below.

Project Design Constraints. Identified project design constraints for the MDWD project include the following:

- The current authorization identifies a 5,000–15,000 cfs diversion with the ultimate size to be determined by the PDT. The 2004 LCA report determined based on limited information, a medium diversion would be sufficient to meet the goals and objectives of the overall LCA project. Existing conditions may have changed and we will investigate all reasonable alternatives for achieving the goals and objectives, even if they include larger diversions.
- Flood Damage Protection – The MDWD restoration measures must accomplish its goals while avoiding and/or minimizing significant impacts to the existing level of flood protection.
- Drainage Infrastructure – The current arrangement of canals and water bodies would likely need to be altered to support the goals of the project. The project should permit reasonable access to the local waterways for all prospective users.
- General Infrastructure – A State highway and several local roads, as well as a few residences are found in the study area. Adverse effects to the existing infrastructure will be minimized to the extent practicable. Numerous gas and oil pipelines exist that are not mapped and may limit the design or restrict the use of some potential restoration measures. The risk and uncertainty associated with any project feature must be evaluated as it relates to buried utilities.
- Potential impacts such as induced shoaling or increased Operations and Maintenance of the authorized Mississippi River Navigation Project should be avoided but if necessary mitigation measures and costs will be evaluated and included as part of the Recommended Plan.

Ecosystem Constraints. Identified ecosystem constraints for the MDWD project included the following:

- It may be likely that the restoration of marsh habitats may still not occur fast enough to compensate for the losses due to Gulf storm events and potential sea level rise.
- Water Quality – Planning objectives of the proposed project include the introduction of water and sediments from the Mississippi River. Restoration measures cannot introduce water, nutrient or sediment flows that would violate established state water quality standards.
- Pallid Sturgeon – In 2008 the Bonnet Carré Diversion, north of New Orleans was opened for the first time in 15 years. A number of pallid sturgeons were entrained in the diversion. At this time it

is not known if pallid sturgeons are in the lower river near the MDWD study area. Monitoring will need to be done to determine its presence and if so this will need to be coordinated closely with USFWS.

- River aux Chenes – River aux Chenes, while disconnected from the Mississippi River, still conveys flows from the Breton Sound Basin to the Gulf. Overtopping of the natural levees or banks of the River aux Chenes from a diversion could potentially result in loss of those diversion flows to the Gulf. This effect could serve as an upper constraint on the size of flows that can be diverted. Further Hydrology and Hydraulic modeling will need to be done to better understand these conditions.
- Estuarine Access – Diversion features need to be designed to allow the continuance of ecologically important exchanges of water, nutrients, food sources and fish between the project area and River aux Chenes, as well as navigation access, while achieving project objectives for marsh restoration.

3.0 ALTERNATIVES

3.1 PLAN FORMULATION RATIONALE

3.1.1 Plan Formulation Rationale

Alternatives for the proposed action were formulated in consideration of study area problems and opportunities, as well as study goals, objectives and constraints. As specified in ER 1105-2-100, four criteria were considered during alternative plan screening: completeness, effectiveness, efficiency, and acceptability.

3.1.2 Plan Formulation Criteria

3.1.2.1 Completeness

Completeness is the extent that an alternative provides and accounts for all investments and actions required to ensure the planned output is achieved. These criteria may require that an alternative consider the relationship of the plan to other public and private plans if those plans affect the outcome of the project. Completeness also includes consideration of real estate issues, O&M, monitoring, and sponsorship factors. Adaptive management plans formulated to address project uncertainties also have to be considered.

3.1.2.2 Effectiveness

Effectiveness is defined as the degree to which the plan will achieve the planning objective. The plan must make a significant contribution to the problem or opportunity being addressed.

3.1.2.3 Efficiency

The project must be a cost-effective means of addressing the problem or opportunity. The plan outputs cannot be produced more cost-effectively by another institution or agency.

3.1.2.4 Acceptability

A plan must be acceptable to Federal, state, and local government in terms of applicable laws, regulation, and public policy. The project should have evidence of broad-based public support and be acceptable to the non-Federal cost sharing partner.

3.1.3 Environmental Operating Principles

In 2002, the USACE formalized a set of Environmental Operating Principles applicable to decision-making in all programs. The principles are consistent with NEPA; the Army Strategy for the Environment; other environmental statutes, and the WRDAs that govern USACE activities. The Environmental Operating Principles inform the plan formulation process and are integrated into all project management processes. Alternatives were formulated for this project consistent with the Environmental Operating Principles.

The USACE Environmental Operating Principles are:

- Strive to achieve environmental sustainability, and recognize that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life;
- Recognize the interdependence of life and the physical environment, and proactively consider environmental consequences of USACE programs and act accordingly in all appropriate circumstances;
- Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another;
- 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;
- Seek ways and means to assess and mitigate cumulative impacts to the environment and bring systems approaches to the full life cycle of our processes and work;
- Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work; and
- 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.

3.1.4 White Ditch Study Area Land Loss

The loss of coastal marsh within the White Ditch study area has been profound. The data available and shown in Table 3.1 depicts habitat change over time from the earliest time period of 1956 through 2008 including the aftermath of the 2005 hurricanes that affected the study area. From 1956 to 2008, approximately 12,762 marsh acres of all types have been converted to open water.

This loss of marsh habitat is accounted for in a variety of one time or short term events and the alteration of systemic marsh building processes. These contributors to marsh conversion include:

- Gas and Oil Pipeline Construction
- Extreme 2005 Gulf Storm Events
- Altered Deltaic Process
  - Subsidence
  - Diminished Sediment Inputs
  - Diminished Fresh Water Inputs
  - Diminished Nutrient Inputs
- Sea Level Rise

Table 3.1: Study Area, Medium Diversion at White Ditch

Date	Julian	Data	Land Area (acres)	Water (acres)	Total (acres)	Land Area (mi^2)	Water (mi^2)	Total (mi^2)	% Land	% Water
1956	1956.8	habitat	53,968	44,361	98,329	84.3	69.3	153.6	54.9%	45.1%
1978	1978.8	habitat	46,904	51,425	98,329	73.3	80.4	153.6	47.7%	52.3%
1/9/1985	1985.0	TM	50,590	47,739	98,329	79.0	74.6	153.6	51.4%	48.6%
1/28/1988	1988.1	TM	50,792	47,537	98,329	79.4	74.3	153.6	51.7%	48.3%
1988	1988.8	habitat	47,202	51,127	98,329	73.8	79.9	153.6	48.0%	52.0%
11/1/1990	1990.8	TM	47,114	51,215	98,329	73.6	80.0	153.6	47.9%	52.1%
2/24/1998	1998.2	TM	47,996	50,333	98,329	75.0	78.6	153.6	48.8%	51.2%
11/18/1999	1999.9	TM	45,407	52,922	98,329	70.9	82.7	153.6	46.2%	53.8%
10/1/2000	2000.8	TM LCA Desktop	46,325	52,004	98,329	72.4	81.3	153.6	47.1%	52.9%
10/30/2001	2001.8	TM	45,829	52,500	98,329	71.6	82.0	153.6	46.6%	53.4%
2/27/2002	2002.2	TM	46,728	51,601	98,329	73.0	80.6	153.6	47.5%	52.5%
11/7/2004	2004.9	TM	45,538	52,791	98,329	71.2	82.5	153.6	46.3%	53.7%
10/25/2005	2005.8	TM	40,831	57,498	98,329	63.8	89.8	153.6	41.5%	58.5%
10/28/2006	2006.8	TM	42,057	56,272	98,329	65.7	87.9	153.6	42.8%	57.2%
10/1/2008	2008.8	TM	41,206	57,123	98,329	64.4	89.3	153.6	41.9%	58.1%

The short time frame events include large oil and gas pipeline construction during the 1950s and 1960s. Also, the 2005 hurricane season proved devastating in both the intensity of the storm and the storm track of Katrina through the Breton Sound Basin. Alterations in the deltaic processes that build and sustain marsh are primarily related to the disruption of freshwater, nutrient and sediment inputs that result from the isolation of the study area from the Mississippi River. Sea level rise also has contributed to the loss of marsh habitat to open water. The marsh loss in 2005 compared to historic areas of loss is illustrated in Figure 3.1. The map depicts areas converted from marsh to open water from 1956–2005, not inclusive of Hurricane Katrina. The areas in red indicate those areas of marsh lost to open water as a result of Hurricane Katrina.

In consultation with the U.S. Geological Survey (USGS) and taking into consideration the quality of the available data sets, the loss rates were calculated for the period 1985–2008. With respect to the older data (1956 and 1978), there are issues with using those data points quantitatively in calculating land loss rates. These issues relate primarily to the consistency of data collection methodology and classification of landscape features. They can be looked at qualitatively in terms of what the trends are for an area, but should not be used in calculating the slope of the land loss line. Figure 3.2 shows the 1985–2008 loss rates.

3.1.5 Future Study Area Loss Rates

The future loss rate for the study area is what the PDT in partnership with the sponsor and the public have set goals and objectives against and have measured action alternatives against to determine relative benefits. However, it is important to discuss the assumptions, risk and uncertainty involved with predicting the future rate of marsh conversion to open water.

The available information indicates that a continued loss rate of approximately 274.5 acres +/- per year throughout the 50-year period of analysis would be reasonable. This would yield a loss of an additional 13,725 acres of marsh of various types to open water within the study area. Figure 3.3 illustrates both the historic loss rate and extrapolates that decline out to the end of our period of analysis. The result is 27,481 acres of marsh of all types remaining compared to the 2008 measure of 41,206 acres, or a 33.3% decline in marsh acres.

In Figure 3.3 this concept is expressed as a window of uncertainty.

The two major areas of uncertainty related to the future without project condition are hurricane and storm damage and sea level rise. Seasonal hurricanes and storm damages are reflected in the proposed loss rate as they reflect the inclusion of these events in the historic average. Large catastrophic events similar to Katrina are not included in the future without project condition for the following reasons:

- A storm of the magnitude of Katrina equates to a 425-year storm. While there is always a probability in any given year that a damaging storm of this magnitude could occur, for the period of analysis it is not included.

- One reason the damage to the study area from Katrina was so extensive is the storm track maximized the storm surge into the study area. It is unlikely that another storm would take the same track through the study area during the period of analysis.

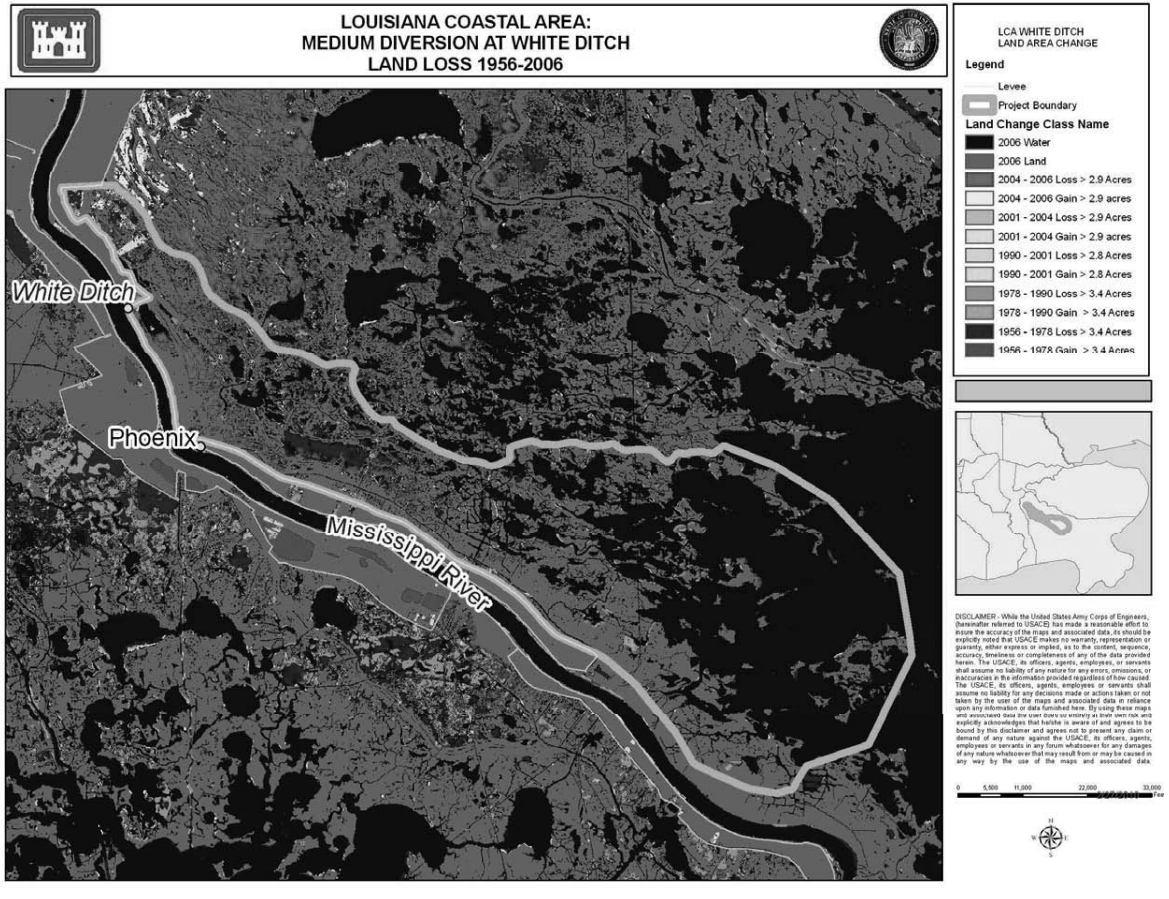


Figure 3.1: Land Area Change in Coastal Louisiana after the 2005 Hurricanes (1956–2005) (USGS)

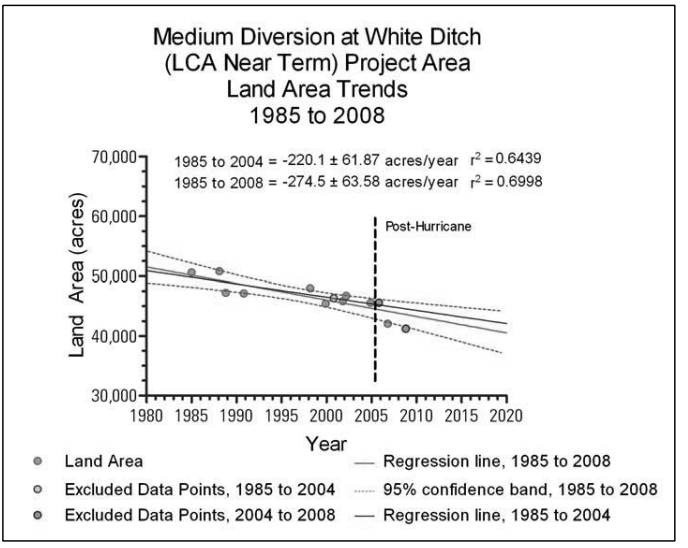


Figure 3.2: Land Area Trends

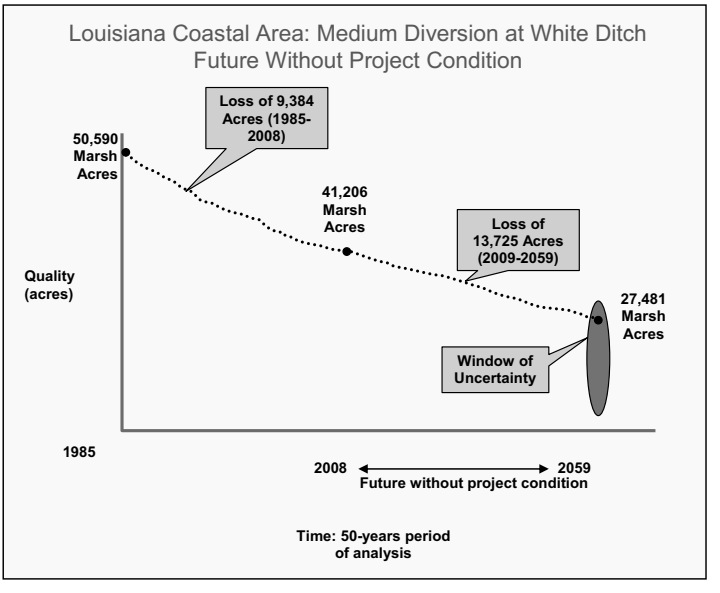


Figure 3.3: Future Without-Project Condition

USACE guidance on sea level rise is found in EC1165-2-211 which directs the consideration of three different scenarios for sea level rise into the planning process. A regional historic rate for the study area has been determined to be 10.2 millimeters per year (mm/yr) or 1.8 feet over the 50-year period of analysis. This is based on the historic average and is already reflected in the 274.5 acres +/- loss rate, which is also based on historic trends. Intermediate and high rates of sea level rise are projected to be 2.3 and 3.7 feet, respectively. The average elevation of marsh within the study area ranges from 1 to 3 feet with exceptions being remnant ridges and terraces. The inclusion of the intermediate scenarios (2.3 feet) and the high sea level rise scenario (3.7 feet) results in a significant decline in marsh habitat of all types. The high rate of sea level rise would likely result in a total collapse of the marsh habitat within the study area. To reflect this uncertainty the impacts of the high rate sea level rise scenario on the future without project condition are shown on in Figure 3.4

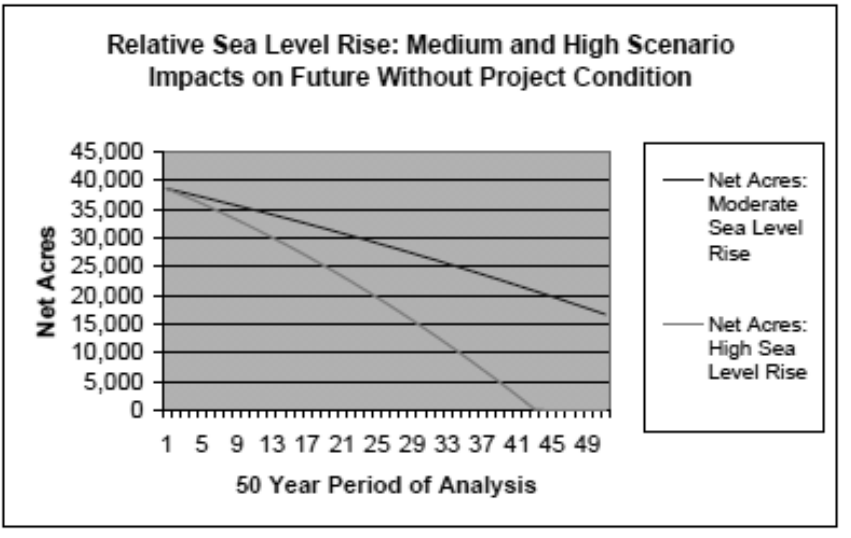


Figure 3.4: Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without-Project Condition

3.2 MANAGEMENT MEASURES

3.2.1 Value Engineering Study

A Value Engineering (VE) workshop was conducted on May 18–22, 2009, for the U.S. Army Corps of Engineers (USACE), New Orleans District, by Value Management Strategies, Inc. The subject of the study was a group of three Louisiana Coastal Area (LCA) ecological restoration projects: Small Diversion at Convent/Blind River, Amite River Diversion Canal Modification, and Medium Diversion at White Ditch. This study was conducted at the Feasibility Scoping Report/Preliminary Draft EIS, an early stage of project development, and as such is the beginning of plan formulation.

VE Study Results

The VE team developed alternative concepts that are intended to assist the USACE in better formulating plans to carry forward into the next phase of project development. These recommendations are categorized per subject project, as well as those that pertain to general plan formulation.

Major findings of the workshop are summarized as follows:

Presently, loss of area in the marsh allows water to rapidly pass through the system and saltwater is able to quickly intrude. The absence of an outfall management plan related to the White Ditch diversion siphon results in the surrounding marsh receiving limited benefits from the diverted river water. Also, the lack of marsh-forming sediments from the Mississippi River has accelerated the degradation of all marsh types. Sediment needs in the project area are extensive and plan strategies that increase diversion flows to provide required sediment transport may not be sufficient to provide the necessary sediment. Key VE alternatives identified to address these issues are as follows:

- Design diversion structures to maximize sediment introduction
- Optimize quantity of freshwater diverted at White Ditch in combination with other proposed diversion projects
- Construct diversion structure approximately 7 miles south of Phoenix
- Construct a combination spillway with capacity controls to medium diversion levels
- Install sediment introduction system into White Ditch diversion structure
- Optimize flow conveyance in White Ditch
- Identify and incorporate impacts effects of subsidence due to fluid withdrawal into project analysis

General/Plan Formulation

- Develop Plan Strategies that account for much higher levels of global sea level (GSL) rise
- Provide clarification and address the Water Resources Development Act of 2007 (WRDA 2007) regarding specified authorized funding limits and the extent of planning development of LCA projects

Many of these comments and recommendations were adopted and considered by the MDWD PDT during alternative formulations process. The Recommended Plan incorporates most of the suggestions developed by the VE team.

3.2.2 Development of Management Measures

A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a nonstructural action) that can be combined with other management measures to form alternative plans. Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources including

prior studies, the NEPA public scoping process, and the multidisciplinary, interagency project delivery team (IPDT).

Before alternative plans were formulated, the first step taken was to identify general locations and categories of potential improvements that would satisfy the goals and objectives established previously. The process began with several discussions concerning the management goals and objectives discussed in the previous section. This yields an array of *general measures* from which *specific measures* were developed. The formulation of these specific measures involved an assessment of the measures as to whether they met the goals and objectives of the study and how likely they were to produce measurable habitat benefits. This is a subjective process requiring further trade-off analysis and habitat evaluation procedures of alternative plans; however, the depth of professional experience and first-hand management knowledge by many members of the team was invaluable in defining specific measures.

Finally, during this process, several specific measures were screened for a variety of reasons. They are not included as specific measures but are described in the screening section below, along with the necessary justification for their elimination from consideration. Upon finalization of specific measures, alternatives were developed through combinations of specific measures. This development of *alternative plans* is described in 3.3 and 3.4.

3.2.3 Description of Management Measures

As each potential category of measures was developed, a corresponding list of criteria related to each potential measure was also developed. Below are listed the categories of actions to adequately address the ecosystem objectives. Measures are loosely defined in five categories that seek to address deficiencies in or unbalanced deltaic forming processes. They are:

F – Freshwater Supply

F1) Uncontrolled Diversion (Levee Removal)
F2) Uncontrolled Diversion (Large Spillway)
F3) Uncontrolled Diversion (Multiple Spillways)
F4) Gated Diversion Structure (Single)
F5) Gated Diversion Structure (Multiple)
F6) Siphon (Large Multiple)
F7) Siphon (Medium Multiple)
F8) Siphon (Small Multiple)

H – Hydraulic Distribution

H1) Culverts and/or Weirs
H2) Canal Reconfiguration
H3) Construct New Canals
H4) Modify Existing Ridges to Redistribute Flow

S – Sediment Supply and Distribution

S1) Canal Dredging and Placement
S2) Dredging and Placement of local Mississippi River Sediments

S3) Importation and Placement of Regional Sediments
S4) Construct Seed Wetlands

P – Protection and Sustainability (Existing Marshes)

P1) Barrier Islands
P2) Rock Dikes
P3) Construct Ridges
P4) Construct Terraces

I- Invasive Species Management

I1) Prescribed Burning
I2) Chemical Control

3.2.3.1 Freshwater Supply

The 2004 LCA Study identified reduction of freshwater inputs to coastal marsh areas as a critical impediment to higher functioning and quality marsh habitats. The disconnect between riverine freshwater sources and the adjacent floodplain marshes has allowed saltwater to intrude into historically freshwater habitat types. The salinity intrusion damages existing vegetation which then dies or begins conversion to saltwater tolerant species. This transition weakens the soil structure and makes it vulnerable to seasonal Gulf storm events. This category of measures includes both controlled and uncontrolled introduction of freshwater to the MDWD area. Potential measures include removing portions of the MR&T levee not required for flood damage reduction, variously sized spillways in the existing MR&T levee, gated diversion structures, and siphons or pumps.

3.2.3.2 Hydraulic Distribution

Existing canal configurations, storm damage and a generally fragmented landscape impede the effective distribution of existing and planned freshwater within the site. This category of measures includes culverts within existing ridges, notched weirs in existing canals, canal reconfiguration or construction of new canals and modifying existing ridges to redistribute freshwater flows within the MDWD area.

3.2.3.3 Sediment Supply and Distribution

Sediment deposition is as least as important as freshwater supply and distribution. In the current configuration, the availability of sediments has been completely eliminated from the project site. While it is likely that the MDWD area would be in a stage of natural degradation, the unavailability of riverine sediments has accelerated this process, resulting in large-scale subsidence and land loss from Gulf storm events. The reintroduction of freshwater discussed above will provide necessary seasonal sediment inputs required for a more sustainable marsh area. However, the large sediment depositional events that historically occurred with an unconfined Mississippi River could be difficult to replicate, despite their importance to marsh creation and sustainability. Further, opportunities exist to strategically place sediment in order to capture what may be introduced along with supplies of freshwater. This category of measures includes dredging existing canals and beneficial placement of material, dredging and placement of Mississippi River sediments, importing and placement of regional sediment resources, and the construction of seed wetlands.

3.2.3.4 Protection (Existing Marshes)

As the MDWD area has degraded, the effects of seasonal and extreme Gulf storm events has led to large scale land loss, particularly since 2005. Opportunities exist to create structures that provide not only habitats similar to barrier islands present in other areas of the Louisiana coast but also to provide protection to the MDWD study area from storm events while other long term measures such as freshwater and sediment reintroduction and distribution take effect. This category of measures includes construction of barrier islands, rock shoreline protection, restoration of historical ridges and associated terraces.

3.2.3.5 Invasive Species Management

Hyacinth is a common invasive species in the Breton Sound Basin. Freshwater introduction has the potential to improve conditions for its growth. Hyacinth can out-compete native marsh grasses for resources resulting in conversion to a monoculture. Measures have been considered to control the proliferation of invasive species that could result from sustained freshwater introduction.

Specific Measures

Management measures that were carried forward for further evaluation are consistent with Administration budget policy, specific USACE policies for ecosystem restoration, and Federal laws, regulations, and Executive Orders.

Reflecting the criteria outlined above and the constraints present at the project site, specific measures were developed within the broad categories of potential measures. These measures are intended to satisfy the objectives and reach the goals of the project study (see Section 2.5.1)

3.2.3.6 Freshwater Supply

- **F1** *Uncontrolled Diversion (MR&T Levee Removal)* – The current MR&T levee between White Ditch and Phoenix, Louisiana, is approximately 4.7 miles in length and provides protection from the river to the community of Carlisle, though there is very little existing infrastructure or developed area. Portions of the levee could be removed to provide a constant connection to the Mississippi River and the corresponding ranges of flood events. The size of the diversion would need to be determined based on hydraulic criteria and the potential biological response to the freshwater diversion. Other considerations include the need to bridge Louisiana State Highway 39 (LA 39) over any created gap in levee protection.
- **F2** *Uncontrolled Diversion (Large Spillway)* – Based on hydraulic and biologic analysis, a large spillway that would convey certain Mississippi River flows into the study area could be constructed on the MR&T levee. A minimum flood frequency of 0.5 would be a starting point for analysis. Other considerations include the need to bridge any potential gap in levee protection for LA 39. Also, the non-Federal back-levee that protects the communities of Belair and Bertrandville to the north would need to be raised because the potential for induced flooding exists with the measure. Finally, the likelihood of the navigation channel migrating during large flood events through the levee opening could increase. A risk analysis would need to be conducted and an adequate structural response would need to be incorporated.
- **F3** *Uncontrolled Diversion (Multiple Spillways)* – A single diversion presents limitations on freshwater distribution within the project site. This measure involves construction of several

small spillways placed along the 4.7-mile length of the MR&T levee to better distribute incoming freshwater. The individual spillways could also be notched or sized differently to allow a variety of flows into the site.

- **F4** *Gated Diversion Structure (Single)* – This measure features a single structure with gates that pass flows ranging from 5,000 to 100,000 cfs. The gates could be electrically controlled similar to Caernarvon. Another option would be a stop log type structure with several bays similar to the Bonnet Carré structure. Stop logs could be placed or removed with truck mounted winches.
- **F5** *Gated Diversion Structure (Multiple)* – A single gated diversion presents limitations on freshwater distribution within the project site. Multiple gated structures that collectively pass 5,000 to 100,000 cfs could be more effective at distributing freshwater throughout the project site.
- **F6** *Siphon (Large Multiple)* – A siphon is a continuous tube that would allow freshwater to drain from the Mississippi River through the MR&T levee into the MDWD area. The flow being driven only by the difference in hydrostatic pressure between the river side and the study area without any need for pumping. Currently, a siphon capable of diverting water up to 250 cfs exists at White Ditch. It was constructed in 1963 by the Parish and the NRCS to improve oyster and muskrat habitats, but has not been operated since 1991 except for brief episodes. To achieve a minimum diversion of 5,000 cfs several large siphons could be required to achieve the desired flow rates.
- **F7** *Siphon (Medium Multiple)* – Several smaller siphons could be constructed in combination with other freshwater measures to achieve the desired cfs.
- **F8** *Siphon (Small Multiple)* – Several smaller siphons could be constructed in combination with other freshwater measures to achieve the desired cfs.

3.2.3.7 Hydraulic Distribution

- **H1** *Culverts and/or Weirs* – Due to storm events and canal construction many areas of existing marsh do not receive adequate distribution of existing freshwater resources. Culverts would be placed, based on existing conditions and alternative hydraulic modeling, to allow for a more even distribution of freshwater throughout the site. Weirs could also be placed in existing waterways to help direct the flow of freshwater and sediments to target areas.
- **H2** *Canal Reconfiguration* – Existing canals for gas, oil and utilities have the effect of fragmenting the marshes and altering the distribution of existing freshwater. This results in degraded areas becoming more susceptible to saltwater intrusion and Gulf storm damage. Existing canals could be altered to better redistribute flows. These alterations could include cutting spoil banks to facilitate sheet flow, filling of abandoned canals and creation of distributaries.
- **H3** *Construct New Canals* – Where appropriate and in conjunction with other measures, new canals could but cut to facilitate freshwater dispersion to degraded freshwater areas.
- **H4** *Modify Existing Ridges to Redistribute Flow* – Remnant historical ridges serve a vital purpose in creating niche habitats for tree species. They also present an opportunity to direct freshwater inputs from proposed diversions. Existing ridges near proposed freshwater sources could be restored to more historical dimensions. The restored ridges would also act to channel introduced sediments to areas needing nourishment.

3.2.3.8 Sediment Supply and Distribution

- **S1** *Canal Dredging and Placement* – Canals that are still needed to support commerce but that have filled in due to storm surge could be dredged to improve their ability to circulate freshwater. The dredged material would be placed in adjacent marshes where pockets of open water exist, thereby decreasing marsh fragmentation and increasing overall marsh acreage.
- **S2** *Dredging and Placement of local Mississippi River Sediments* – Diversion of freshwater does provide opportunities to introduce sediment. However the decades of isolation from wetland forming river flows has resulted in a significant deficit in sediments. This measure entails large scale importation of suitable riverine sediments from dredging nearby Mississippi River reaches. Dredging and placement could be both mechanical and hydraulic. Additionally innovative dredging and placement technologies tested in 2004 could be used to place material in sensitive marsh habitats. These include concrete pumps on floating platforms and conveyor belts.
- ***S3*** *Importation and Placement of Regional Sediments* – The loss of land within the Breton Sound Basin and in particular the MDWD study area has been dramatic. The large quantities of sediment required for a holistic restoration of marsh habitats in the area could justify large scale importation of sediment from areas other than the immediate MDWD reach of the Mississippi River. It is possible to make use of USACE New Orleans District (MVN) channel maintenance material for beneficial use as well as long range transport of suitable sediments from USACE Mississippi Valley Division (MVD) ecosystem projects that are being dredged from critical backwater habitats and where removing the sediment from a given donor study area is preferable in ecosystem terms to placement on site. Placement could be both mechanical and hydraulic. Additionally innovative dredging and placement technologies tested in 2004 could be used to place material in sensitive marsh habitats. These include concrete pumps on floating platforms and conveyor belts.
- **S4** *Construction of Seed Wetlands* – Certain areas that will be subject to increased sediment load from freshwater introduction could be constructed to create immediate marsh habitat while being configured to trap additional sediments from freshwater diversions. An example would be a perched wetland with an elevated perimeter and transitional (habitat) interior. As water levels fluctuate sediments would become trapped in the center and drop out, resulting in marsh creation.

3.2.3.9 Protection (Existing Marshes)

- **P1** *Barrier Islands* – Currently, a complex of barrier islands exists on the extreme south-east of the Breton Sound basin that is being addressed through other efforts. However, the MDWD area and Breton Sound in general have reached a point where the marsh is no longer able to recover from seasonal storm events due to saltwater intrusion and conversion of marsh to open water. A series of smaller constructed barrier islands aligned along high probability hurricane tracks and on the south-east edge of the study area would serve to disrupt storm surge and damage to project features. In addition to the habitat value of the barrier islands they would provide protection of the study area over the long term (>50 years), while freshwater and sediment measures restore the marshes themselves and make them more resilient to Gulf storm damage.
- **P2** *Rock Dikes* – Areas of existing high quality marsh could be made more resilient to seasonal Gulf events by construction of rock shoreline protection.

Table 3.2: Summary of the Problems, Opportunities, Goals, Objectives and Measures to this Point in the Planning Process

Problems and Opportunities	Overarching System Goal	Objective	Potential General Measures
Problem: The altered supply and distribution of freshwater, lack of sediments, marsh subsidence and human development in the White Ditch area have resulted in a degraded and unbalanced distribution of freshwater, brackish and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, altered hydrology changed salinity regimes. Opportunities: Opportunities exist to naturalize the distribution of freshwater and sediments, improve hydrologic distribution of freshwater, improve topographic diversity, reduce the negative impacts of Gulf storm events and inhibit invasive species.	Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the nation.	A. Maintain the current area of marsh habitat, of all types (41,206 acres) that provide life requisite habitat conditions for native coastal marsh fish and wildlife. B. Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained. C. Restore sediment inputs into the project area equivalent to an average of approximately 1,300,000 cubic yards of sediment per year.	**F1)** Uncontrolled Diversion (Levee Removal) **F2)** Uncontrolled Diversion (Large Spillway) **F3)** Uncontrolled Diversion (Multiple Spillways) **F4)** Gated Diversion Structure (Single) **F5)** Gated Diversion Structure (Multiple) **F6)** Siphon (Large Multiple) **F7)** Siphon (Medium Multiple) **F8)** Siphon (Small Multiple) **H1)** Culverts **H2)** Canal Reconfiguration **H3)** Construct New Canals **H4)** Modify Existing Ridges to Redistribute Flow **S1)** Canal Dredging and Placement **S2)** Dredging and Placement of local Mississippi River Sediments **S3)** Importation and Placement of Regional Sediments **S4)** Construct Seed Wetlands **P1)** Barrier Islands **P2)** Rock Dikes **P3)** Construct Ridges **P4)** Construct Terraces **I1)** Prescribed Burns **I2)** Chemical Control

- **P3** *Construct Ridges* – In areas where historical ridges have been degraded due to Gulf storm damage or subsidence, new ridges could be constructed using local sediments. The short term sustainability of such features can be enhanced with practices such as stone-toe protection or construction utilizing geo-textile fabrics (textile tubes). Stone-toe protection is a practice whereby rock is placed along the active erosion line (toe) of a bankline, thereby inhibiting undercutting of the bank. Long-term sustainability is dependent on other measures to build healthy marshes through freshwater and sediment supplies.
- **P4** *Construct Terraces* – Terraces could be constructed in open-water habitats to help trap sediments that move through the area.

3.2.3.10 Invasive Species Management

- **I1** *Prescribed Burning* – Fire is a natural disturbance regime in coastal marshes. Habitat fragmentation has limited the effectiveness of this regime at controlling invasive plant species. Prescribed burns at locations susceptible for non-native species invasion will control the species and improve the overall health of the marsh habitat.
- **I2** *Chemical Control* – In areas where hyacinth is dominant or the spatial extent is small and isolated, chemical means may be employed to control invasive species. These measures would be likely combined with other measures to improve overall habitat quality.

3.2.4 Screening / Evaluation of Alternative Plans

Screening of measures is a process whereby various criteria are evaluated to better characterize a specific measure and the likelihood that it can achieve cost effective restoration. The outcome of this process can result in specific measures being dropped from further consideration. Reasons (screening criteria) for elimination of specific measures can include:

- Objectives Supported – Each measure can support some or all of the ecosystem objectives. Those that support more objectives represent more holistic solutions.
- Timeframe for Marsh Creation – Measures have variable timeframes for creating acres of marsh habitat; some immediate, others long term.
- Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRR&R) – The complexity and cost of operations and maintenance of measures was discussed.
- Lands, Easements, Rights-of-Way, Relocations of Utilities or Other Existing Structures, and Disposal Areas (LERRDs) – While acquisition of LERRDs is a sponsor responsibility, the likelihood that the lands can be acquired or that impacts to oil, gas, oyster and alligator leases generate excessive costs or risks must be considered.
- Navigation – Measures that have the potential to introduce navigational hazards or increased Operation and Maintenance (O&M) costs were identified.
- Flooding – Measures that increase base and flood event water elevations on the existing Mississippi River & Tributaries levee or the non-Federal back-levee were identified. Measures that would require significant raising of the non-Federal back levee were also identified.

A workshop was held in April 2009 with the sponsor and other resource managers to screen the preliminary list of specific measures. Appendix L also provides additional information. The table below details measures that were eliminated from further consideration and why.

3.2.5 Alternative Plans not Carried Forward for Further Analysis

Table 3.3: Specific Measures Screened from Further Consideration

Category	Specific Measure	Symbol	Justification for Elimination from Further Consideration
Freshwater Supply	Uncontrolled Diversion (Levee Removal)	**F1**	Uncontrolled diversions would not allow for targeted management of water inflows to account for seasonal variation. Also, as the flows on the Mississippi River are highly altered this measure would not fulfill the objective of naturalizing freshwater and nutrient flow into the study area. This alternative would not allow flexibility needed for cooperative management with other existing and future diversion projects in the region. The cost to relocate or elevate the State highway would be high. This measure would necessitate at a minimum the raising of the non-Federal back levee to the north of MDWD and possibly require the raising of the back levee protecting Phoenix.
	Uncontrolled Diversion (Large Spillway)	**F2**	Uncontrolled diversions would not allow for targeted management of water inflows to account for seasonal variation. Also, as the flows on the Mississippi River are highly altered this measure would not fulfill the objective of naturalizing freshwater and nutrient flow into the study area. This alternative would not allow flexibility needed for cooperative management with other existing and future diversion projects in the region. The cost to relocate or elevate the State highway would be high.
	Uncontrolled Diversion (Multiple Spillways)	**F3**	Uncontrolled diversions would not allow for targeted management of water inflows to account for seasonal variation. Also, as the flows on the Mississippi River are highly altered this measure would not fulfill the objective of naturalizing freshwater and nutrient flow into the study area. This alternative would not allow flexibility needed for cooperative management with other existing and future diversion projects in the region. The cost to relocate or elevate the State highway would be high.
	Controlled Diversion (Single Gates)	**F4**	Engineering analysis concluded that a single gate structure would be inadequate to pass the minimum flows necessary to meet project goals and objectives.

Table 3.3, cont'd

Category	Specific Measure	Symbol	Justification for Elimination from Further Consideration
	Siphon (Large Multiple	**F6**	The use of large siphons was evaluated. The first cost of construction and O&M costs were higher than comparably sized (CFS) gated box culverts, while the habitat benefits were identical. Further discussion and analysis can be found in the Engineering Appendix.
	Siphon (Medium)	**F7**	The use of medium siphons was evaluated. The first cost of construction and O&M costs were higher than comparably sized (CFS) gated box culverts, while the habitat benefits were identical. Further discussion and analysis can be found in the Engineering Appendix.
	Siphon (Small-Multiple)	**F8**	The use of small siphons (less than 1,000 cfs) would require multiple crossing of the MR&T levee, the State highway and utilities. The operation of numerous (>5) sites would pose operation and maintenance issues for the sponsor. The need to cut multiple new outfall canals through healthy marsh to distribute freshwater is undesirable.
Hydraulic Distribution	Construct New Canals	**H3**	Construction of new canals would require cutting through existing healthy marsh and result in immediate loss of wetlands in the study area. It would also result in additional habitat fragmentation. The distribution of freshwater throughout the site can be achieved through other measures. These types of measures are envisioned as stand-alone new canals and distinct from an outfall canal necessary to move water directly from the diversion structure.
Sediment Supply and Distribution	Dredge and Place Mississippi River Sediments	**S2**	Upon further analysis it was determined that the diversion structures themselves were far more efficient at capturing needed sediments for marsh creation.
	Importation of Regional Sediments	**S3**	Upon further analysis it was determined that the diversion structures themselves were far more efficient at capturing needed sediments for marsh creation.
	Construct Seed Wetlands	**S4**	After further discussion and engineering analysis this measure was effectively combined with measure S1 for each of the final array of diversion alternatives.

Table 3.3, cont'd

Category	Specific Measure	Symbol	Justification for Elimination from Further Consideration
Protection	Barrier Islands	**P1**	Based on costs and efforts associated with recent projects, the level of effort to construct barrier islands as part of the MDWD project would likely be cost prohibitive, especially in light of the primary goal of the project. This is primarily due to the large amount of construction and associated material that would likely be required to effectively accomplish this task. This measure alone would not accomplish the goals of the project and could impair the ability to implement other necessary associated measures.
Invasive Species Management	Prescribed Burning	**I1**	After further discussion among the state and Federal resource managers, it was concluded that burning, though practiced widely for marsh vegetation propagation, was ineffective as a tool for controlling the spread of invasive species. (Will be considered as future adaptive management actions where determined necessary and appropriate).
	Chemical Control	**I2**	Large scale application of chemicals could have as much detrimental effect to healthy marsh as to invasive species. Further, the use of chemicals to control invasive species could present problems when applied over large swaths of private property. (Will be considered as future adaptive management actions where determined necessary and appropriate).

3.3 PRELIMINARY ALTERNATIVE PLANS

3.3.1 Development of Alternative Plans

Alternative plans are combinations of management measures that collectively meet study goals and objectives within the defined study constraints. Alternative plans are assembled and compared against one another using performance outputs and costs. Alternative plans and their component management measures will be assessed relative to the objective of National Ecosystem Restoration (NER). As alternative plans are evaluated, implementation roles for other Federal and non-Federal agencies will be considered and developed in detail for the Recommended Plan.

Alternatives were developed that combine the best measures to provide a broad range of alternatives. All of the action alternatives have freshwater diversions as the base option with additional measures added as more data became available in later stages of the feasibility study. Based on discussions with the sponsor and a study team review of goals and objectives the following conceptual alternatives have been defined:

1. **Conceptual White Ditch (CWD) 1: No Action.** Over a 50-year period of analysis, if nothing were done, we would see significant losses of all marsh types throughout the study area. More major storms could accelerate this loss. As a result open-water habitats would continue to grow allowing for further intrusion of saltwater into the marsh.
2. **CWD 2: LCA Plan**. This alternative involves construction of a 15,000 cfs maximum diversion structure. No other measures would be evaluated as part of this alternative. The need for a managed diversion was previously established as part of the screening of uncontrolled diversion measures. Therefore the design would allow for control of freshwater and sediment delivery (based on flow) at a 5,000 cfs minimum.
3. **CWD3: LCA Plan Enhanced**. This alternative involves construction of a 15,000 cfs maximum diversion structure. The design would allow for control of freshwater and sediment delivery (based on flow) at a 5,000 cfs minimum. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S), and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
4. **CWD4: 45,000 CFS Freshwater Diversion.** This alternative involves construction of a structure capable of diverting up to 45,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S), and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
5. **CWD5: 75,000 CFS Freshwater Diversion.** This alternative involves construction of a structure capable of diverting up 75,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
6. **CWD6: 100,000 CFS Freshwater Diversion.** This alternative involves construction of a structure capable of diverting up to 100,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

After defining the desired future condition, following the feasibility scoping meeting, the objectives for the project were refined. The freshwater, sediment and nutrient requirements needed to maintain existing acres of marsh habitat while improving the distribution of marsh types, necessitated a reevaluation of all large diversion (>15,000 cfs) alternatives. Additionally, the Diversion Project at Myrtle Grove on the opposite bank of the Mississippi River completed hydraulic evaluation of the same range of diversions (45k, 75k and 100k) and identified significant issues with impacts to MR&T and back levees; a situation very similar to the White Ditch study area. Table 3.4 below lists the alternatives eliminated from further consideration and why.

Table 3.4: Conceptual Alternatives Screened from Further Consideration

Alternative	Symbol	Justification for Elimination from Further Consideration
45,000 CFS Freshwater Diversion.	**CWD5**	Significant impacts were identified at Myrtle Grove in evaluating the 45,000 diversion option. Sustained water levels in excess of 3 feet were identified. Similar water levels could be expected within the White Ditch project site. These sustained water depths indicate the need for toe armoring of significant portions of the levee system as well as the potential to raise non-Federal back levees. Finally, an important design criterion was the desire for all diversions not to exceed the natural levees of River aux Chenes. When this occurs, freshwater and nutrients discharge to the Gulf via River aux Chenes and their benefits are lost.
75,000 CFS Freshwater Diversion.	**CWD5**	Significant impacts were identified at Myrtle Grove in evaluating the 75,000 diversion option. Sustained water levels in excess of 3 feet were identified. Similar water levels could be expected within the White Ditch project site. These sustained water depths indicate the need for toe armoring of significant portions of the levee system as well as the potential to raise non-Federal back levees. Finally, an important design criterion was the desire for all diversions not to exceed the natural levees of River aux Chenes. When this occurs, freshwater and nutrients discharge to the Gulf via River aux Chenes and their benefits are lost.
100,000 CFS Freshwater Diversion.	**CWD6**	Significant impacts were identified at Myrtle Grove in evaluating the 100,000 diversion option. Sustained water levels in excess of 3.5 feet were identified. Similar water levels could be expected within the White Ditch project site. These sustained water depths indicate the need for toe armoring of significant portions of the levee system as well as the potential to raise non-Federal back levees. Finally, an important design criterion was the desire for all diversions not to exceed the natural levees of River aux Chenes. When this occurs, freshwater and nutrients discharge to the Gulf via River aux Chenes and their benefits are lost.

Ecohydraulic modeling of the project alternatives was utilized to compare the effects of one alternative to another. Modeling of this type is a difficult and computationally intensive analysis. For a detailed description of the methodology and results of the analysis, see Appendix L. The initial screening of alternatives was conducted to narrow down the number of alternatives to be run for the WVA Analysis based on time constraints. These simulations were setup to examine a hypothetical spring pulse period and allow for the comparison of results between all 660 runs. Each simulation was to run for a 1-month duration with "maximum" flows from the proposed new diversion as well as from the existing Caernarvon diversion (8,000 cfs). By assuming maximum flow from Caernarvon, it was possible to examine the potential extremity of events. Other parameters were as follows:

- Average spring (March–May) tidal conditions.
- Average spring (March–May) wind forcing conditions for Plaquemines Parish, Louisiana.
- Average spring (March–May) rainfall inputs.
- An average evaporation constant of 5 mm/day.
- Starting salinity over the entire grid of 7 ppt.

The results of this round of modeling clearly demonstrated that any diversion alternative will greatly freshen the project area, particularly if the diversion is operated in conjunction with Caernarvon. The smaller diversions freshen the sound more slowly, but are just as effective as the larger diversions. Other conclusions that were drawn from this initial modeling are that the larger diversions, 70,000 cfs and 100,000 cfs, will overtop the River Aux Chenes ridge.

After the screening of the larger-sized diversions, it was decided by the PDT that in order for a full array of alternatives to be evaluated, a diversion that went beyond the 2005 LCA report description was needed. Since the original concepts for an alternative over the 2005 15,000 cfs project (45,000–100,000 cfs) proved unacceptable, the PDT developed and discussed a 30,000 cfs diversion because it was the next logical increment up from 15,000 cfs that did not encounter the problems with the 45,000 cfs or larger diversions. As we progressed through our hydrology and hydraulics assessment we developed a minimum operating condition for all of the structures such that they could operate at design flows at any time during a typical year with a minimum of 1 foot of head differential on the Mississippi River which is an average low stage. The structure design for the 15,000 cfs diversion (ten 15-x-15-foot box culverts) is physically capable of passing a maximum flow of 35,000 cfs based on a 7-foot head differential on the Mississippi River which is an average yearly stage. Further, H&H modeling determined that 35,000 cfs was the maximum diversion that would not exceed River aux Chenes natural levees. Therefore a 35,000 cfs diversion alternative was developed for both locations 2 and 3. See Appendix L for additional information on the H&H analysis.

3.3.2 Location for Diversion Structure(s)

The various conceptual alternatives are all centered on diversion structures as the primary means by which wetland forming processes are restored. The location of one or multiple diversion structures within the study area is a critical piece to quantifying the benefits of various increments of diversion size ranging from 5,000 to 35,000 cfs. The remaining non-diversion measures formulated in Section 3.2 were then combined and optimized based on the variety of diversion sizes and locations to most effectively and efficiently distribute diverted freshwater, nutrients and sediments so as to maximize marsh creation.

Preliminary investigations identified five potential locations for diversion structures. These areas are shown on Figure 3.5

Negative and positive aspects of each of these sites are evaluated based on best professional judgment and an evaluation of known and collected data.

Location 1

Location 1 is at the north end of the White Ditch study area. It is a populated residential area interspersed with orchards, pastures, and bottomland hardwoods. The west border is the Mississippi River and MR&T levee and the east border is the Plaquemines Parish non-Federal back levee. The distance between the MR&T levee and the back levee ranges from approximately 1,900 to 2,700 feet.

The Value Engineering Study team suggested this as a potential location for a diversion structure. This area was identified because it is located on a point bar of the Mississippi River giving it greater potential to deliver sediment into the study area. This location would provide the greatest benefit to the extreme northern end of the study area.



Figure 3.5: Potential Diversion Structure Locations

Benefits of this location include:

- It would deliver benefits to the northern section of the study area.

Drawbacks of this location include:

- The presence of a back levee introduces additional construction challenges and costs. Flood protection measures such as coffer dams would have to be maintained on two levees instead of one during construction. Water would have to be transported approximately 2,000 feet in pipes or culverts to reach the marsh.
- It would be difficult to convey sediment, freshwater, and nutrients to the southeast portion study area. Therefore, it would be difficult to satisfy the goals and objectives throughout the entire study area. An alternative at this location would likely not be independently viable.
- The vast majority of water and sediments introduced at this location would travel into the Forty Arpent Canal and away from the study area. It would be difficult to prevent this because the canal is not a natural feature and does not have a spoil terrace to restrict overland flow. It is likely that potential benefits would never be maximized due to the difficulty in maintaining water in the system.
- Due to the proximity of River aux Chenes, less flow would be required to exceed the riverbank compared to a diversion that was located further away. If less flow is allowed into the study area, less sediment and nutrients would be put into the system.
- Location 1 contains private development between the MR&T levee and the back levee. Construction at this location would require removal of homes and relocations would likely be necessary. There is one potential area in location 1 that would not impact homes, but would require clearing of approximately 30 acres of bottomland forest.

Location 2

Location 2 is at the existing siphons at White Ditch. There are no residences in the potential construction footprint. There are several small recreational buildings and an electrical substation nearby. Additionally, several oil/gas pipelines run through the diversion study area. The length of this location runs from the existing White Ditch down the MR&T levee for 9,000 feet. It is considered a good location for sediment.

Benefits of this location include:

- The most important characteristic of this site is the lack of a back levee. The absence of a back levee simplifies construction efforts and minimizes construction costs.
- There are existing internal infrastructure features, such as channels and levees, which could be modified to convey diverted water within the marsh.
- The location is centrally located within the overall study area. It could independently provide environmental benefits and meet project objectives throughout the study area. An alternative at this location would be independently viable.

- There are minimal residences to impact and potentially no relocations would be necessary. Real estate issues would be substantially less complicated compared to other areas because there are very few land owners to acquire ROEs from.

Drawbacks of this location include:

- There could be a need to elevate an existing electrical substation within this location.
- There are a few residences in the vicinity of the location that might need to be elevated

Location 3

Location 3 is just north of Phoenix, Louisiana. There are no known structures within the footprint of this area. It runs from the junction of the MR&T levee and the Federal back levee to a point approximately 9,200 feet north on the MR&T levee. The White Ditch Value Engineering team identified this area as a good location to intake sediment because it is on a point bar. Point bars are locations where sediments drop out of the water column and settle. It is centrally located within the study area and could yield benefits to the north and south.

Benefits of this location include:

- The most important characteristic of this site is the lack of a back levee. The absence of a back levee would greatly simplify construction and would minimize construction costs.
- There are existing internal features, such as channels, ridges, and historic distributaries, which could be used to convey diverted water within the marsh.
- The location is centrally located within the overall study area. It could provide environmental benefits and meet project objectives throughout most of the study area, rather than just in a specific section.
- There are no residences to directly impact and no relocations would be necessary. Real estate issues would be substantially less complicated compared to other areas because there are very few land owners to acquire ROEs from.

Drawbacks of this location include:

- There is not an existing channel to directly convey diverted flows.
- There are a few residences in the vicinity of the location that would likely need to be elevated.
- Marsh would have to be excavated to create the outfall channel.

Location 4

Location 4 is in the central portion of the White Ditch study area. It is near commercial and residential areas. The distance between the MR&T levee and the Federal back levee is approximately 2,200 feet. The White Ditch Engineering team identified this area as a good location to intake sediment because it is near a channel crossing in the river. It is centrally located within the study area and could yield benefits to the north and south.

Benefits of this location include:

- The location is centrally located within the overall study area. It could provide environmental benefits and meet project objectives throughout most of the study area, rather than just in a specific section.
- The location is centrally located within the overall study area. It could provide environmental benefits and meet project objectives throughout most of the study area, rather than just in a specific section.
- There are existing internal infrastructure features, such as channels and levees, which could be used to convey diverted water within the marsh.

Drawbacks of this location include:

- The presence of a back levee introduces additional construction challenges and costs. Flood protection measures such as coffer dams would have to be maintained on two levees instead of one during construction. Water would have to be transported approximately 2,200 feet in pipes or culverts to reach the marsh.
- The existing canal between the levees would need to be widened to convey appropriate flows. Numerous oil and natural gas lines on the bottom of the channel could create difficulties in dredging.
- There is an anchorage area on the Mississippi River side of this location that might have to be relocated.
- Location 4 contains some private development between the MR&T levee and the back levee. Construction at this location might require removal of homes, depending upon the configuration of the outfall canal.

Location 5

Location 5 is located in the central portion of the White Ditch study area between Phoenix and Pointe à la Hache, Louisiana. It is a populated residential and business area with multiple land owners. The distance between the MR&T levee and the Federal back levee ranges from approximately 1,800 to 2,900 feet. This area was recommended for consideration in the Value Engineering Study. It was identified as a good location to intake sediment and deliver environmental benefits to the southern end of the study area.

Benefits of this location include:

- There are existing internal infrastructure features, such as channels and levees, which could be used to convey diverted water.
- There are existing internal infrastructure features, such as channels and levees, which could be used to convey diverted water.

Drawbacks of this location include:

- The presence of a back levee introduces additional construction challenges and costs. Flood protection measures such as coffer dams would have to be maintained on two levees instead of

one during construction. Water would have to be transported up to 2,900 feet in pipes or culverts to reach the marsh.

- The location contains a substantial amount of private development. Construction at this location could require removal of homes and relocations might be necessary.
- It would be difficult to convey sediment, freshwater, and nutrients to the northwest portion study area. Therefore, it would be difficult to meet objectives for entire study area. An alternative at this location would likely not be independently viable.

Discussion and Conclusions

A screening process was used to determine which of the locations were most suitable for further evaluation in combination with increments of diversion size. Criteria evaluated include:

- Back Levee Cost: Several locations would need to cross residential areas with back levees. The cost of crossing two levees would be high.
- Lack of Beneficial Sediment: Certain locations have high sediment load along the Mississippi River and would be better suited for capturing river sediments.
- Hydrology and Hydraulics: The flow of water to the Gulf in a north-west to south-east fashion indicates that diversion located towards the lower "downstream" end of the project sites would be less effective at distributing the requisite freshwater, sediment and nutrients. See Appendix H for additional information on Hydrology and Hydraulics.
- Infrastructure Cost: All locations have infrastructure in addition to the levees. Locations that have higher densities of infrastructure relative to one another and therefore higher relocation costs were identified.
- Capacity Limitation: Not all locations are able to accommodate the full range of diversion structure capacities.
- New Outfall Canals: Locations that would require new outfall canal construction as opposed to those locations with existing outfall available were identified.

Table 3.5 aligns the locations with the criteria that limit the sites overall suitability as a location for diversion.

Table 3.5: Diversion Location Screening

Louisiana Coastal Area: Medium Diversion at White Ditch Diversion Location Matrix					
	Back Levee Cost	H&H	Infrastructure Cost	Capacity Limitations	New Outfall Canals
Location					
1	X		X	X	X
2					
3					X
4	X	X	X	X	
5	X	X	X	X	X

There are numerous disadvantages to placing alternatives at Locations 1, 4, or 5. Most of these disadvantages are directly related to the existence of a back levee. From an engineering standpoint, these sites are more complicated for construction and would be more costly to construct. The distance between the MR&T and back levee at these locations averages around 2,000 feet. Long trenches would need to be excavated to a depth of ~20 feet between the two levees. Once excavated, this distance would need to be spanned by concrete box culverts or pipes to carry water from the river to the marsh. Long-term O&M of these features would be difficult. Coffer dams would have to be constructed on the MR&T and the back levee.

By comparison, Locations 2 and 3 do not have a back levee and therefore lack the engineering disadvantages associated with 1, 4, and 5. Water and sediment could move directly from the river into the marsh through a box culvert structure beneath the MR&T levee, which would be approximately 350 feet. Only one coffer dam would have to be constructed. Diversions at Locations 2 or 3 would be much simpler to construct and less costly than at Locations 1, 4, and 5.

Locations 2 and 3 also have the advantage of being centrally located and directly adjacent to much of the most degraded marsh within the project boundary. These locations could independently provide positive influences on most of the study area. Location 4 is also centrally located and could provide benefits to most of the study area. However, locations 1 and 5 are at the fringe of the area of severe degradation. It would be very difficult for either site to independently provide benefits to the entire study area.

Because of the back levee and the protection it provides, Locations 1, 4, and 5 have numerous real estate and relocation concerns. There are several homes, businesses, and farms at each of these locations. Removal and relocations of homes and businesses would be unavoidable. By comparison, Locations 2 and 3 have minimal real estate concerns. There are far fewer landowners and very few homes or business in the footprint of either. The few impacts that potentially exist would be indirect.

In summation, no justifiable reason exists to continue consideration of any area outside of the 4.7-mile stretch between White Ditch and Phoenix where there is no back levee. It is believed that the goals and objectives of the project can be fully and effectively addressed from Location 2 and 3. Locations 1, 4, and 5 have been removed from further consideration.

3.3.3 Description of Alternative Plans

The remaining conceptual alternatives from Section 3.3.1 have been integrated with the remaining suitable locations for diversion structures to yield an array of alternatives that meet the goals and objectives of the project and are likely to restore the impaired deltaic processes. The alternatives are:

1. **White Ditch (WD) 1: No Action.** Over a 50-year period of analysis, if nothing were done, we would see significant losses of all marsh types throughout the study area. More major storms could accelerate this loss. As a result open-water habitats would continue to grow allowing for further intrusion of saltwater into the marsh.

2. **White Ditch (WD) 2: Location 2 – 5,000 cfs.** This alternative involves construction of a structure capable of diverting up to 5,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S), and protection and sustainability (P) will be refined to

improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

3. **White Ditch (WD) 3: Location 2 – 10,000 cfs.** This alternative involves construction of a structure capable of diverting up to 10,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

4. **White Ditch (WD) 4: Location 2 – 15,000 cfs.** This alternative involves construction of a structure capable of diverting up to 15,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

5. **White Ditch (WD) 5: Location 2 – 35,000 cfs.** This alternative involves construction of a structure capable of diverting up to 35,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

6. **White Ditch (WD) 6: Location 3 – 5,000 cfs.** This alternative involves construction of a structure capable of diverting up to 5,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

7. **White Ditch (WD) 7: Location 3 – 10,000 cfs.** This alternative involves construction of a structure capable of diverting up to 10,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

8. **White Ditch (WD) 8: Location 3 – 15,000 cfs.** This alternative involves construction of a structure capable of diverting up to 15,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

9. **White Ditch (WD) 9: Location 3 – 35,000 cfs.** This alternative involves construction of a structure capable of diverting up to 35,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

3.3.4 Screening / Evaluation of Alternative Plans

3.3.4.1 The ERDC-SAND2 Model

The ERDC-SAND2 model was originally known as the Boustany Model. The Boustany Model was developed for evaluating the marsh creation potential. ERDC modified and refined the Boustany model to specifically measure the marsh creation potential of diversion structures. The modified version became known as the SAND model. The SAND was refined further and became the SAND2. The ERDC-SAND2 model was the tool used by the MDWD team to predict changes in marsh acreages for all alternatives over a 50 year planning horizon. It is an ecohydraulic engineering model specifically designed to assess the effectiveness of potential diversion projects on restoration of land in the coastal marsh. The ERDC-SAND2 model is fundamentally based on three processes impacting marsh accretion:

1) Historical land loss rates are applied to account for marsh loss due to all negatively impacting system processes (e.g. sea level rise, compaction, subsidence, etc.) along with background processes existing prior to the diversion operation (e.g. marsh nutrient cycling, net tidal and groundwater inputs, etc.).

2) Inorganic benefits of flow diversion from the addition of sediment.

3) Organic benefits of flow diversion due to plant growth, mortality, and burial stimulated by addition of the limiting nutrient (nitrogen).

The model applies these processes to assess Future With Project (FWP) and Future Without Project (FWOP) conditions for alternative comparison. Since the FWOP condition is without diversion, FWOP marsh acreage is a function of land loss only. The model processes these categories and projects acres of marsh within a specified project area. With some slight modifications, the model can also project acreages with accelerated sea level rise rates. More extensive information concerning the ERDC-SAND2 model can be found in Appendix L.

The outputs (net and average annual acres) from the ERDC-SAND2 model became a key component of the WVA ecosystem model. A defined operating plan had yet to be evaluated, so three such operating schemes were proposed to begin to characterize the potential range of benefits of various operating regimes for each diversion and the ability of each alternative to achieve the goals and objectives of the project. The Open Diversion reflects the upper threshold in terms of potential impacts. The other two regimes focus on maximizing sediment capture during the highest sediment load in the River based on available information. They are:

- Open Diversion Year Round
- A March 1–May 30 Maximum Pulse with no Maintenance Flow
- A March only pulse with a 1,000 cfs Monthly Maintenance Flow

Finally, the likelihood existed that these large diversion alternatives may have impacts beyond the immediate study area. Therefore the ERDC-SAND2 Model was run on the original study area as well as the entire Breton Sound Basin. The Institute for Water Resources (IWR) Planning Suite was used for the analysis.

Table 3.6 displays the costs and net acres of marsh created at the end of the 50-year period of analysis in order to compare alternatives that can achieve no net loss of marsh acres. The most cost effective alternatives and operating schemes that achieve a no net loss or desired future condition are highlighted in green. The desired future condition would be equivalent to the current marsh acres (2009) of 41,206. The Location 3 – 10,000 cfs alternative achieves this at the end of the period of analysis only for the year round open diversion operating regime. It does this more cost effectively than the same size diversion at Location 2. The Location 3 – 15,000 alternative achieves the desired future condition at the end of the period of analysis for the year round open diversion and the March–May Pulse. It does this more cost effectively than the same size diversion at Location 2. The Location 3 – 35,000 alternative achieves the desired future condition at the end of the period of analysis for all three operating regimes and more cost effectively than the same size diversion at Location 2. The 35,000 cfs diversion also achieves a no net loss of marsh within the expanded Breton Sound Basin if operated at full capacity year round.

It should be noted that the major difference in cost between Location 2 alternatives and Location 3 is the length of conveyance channels needed to move freshwater, nutrients and sediments. While Location 2 has an existing conveyance channel (White Ditch) Hydrologic and Hydraulic modeling indicated that it requires considerably more dredging and placement of material to make it effective at moving diversion flows to the majority of the study area. Location 3, while it does involve dredging of new conveyance channels, they are much shorter and more efficient at distributing diversion flows of freshwater, nutrients and sediments. A complete discussion of this can be found in the Engineering Appendix L.

Table 3.6: LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1a

Alternative	Total First Cost*	Annualized Cost**	Operating Regimes Gross/Net Acres (Original Study Area) Year 50: Original Study area - Open Diversion	Original Study area - March–May Pulse	Original Study area - March Pulse + 1,000 CFS	Operating Regimes Gross Acres (Expanded Study Area) Year 50: Expanded Study area Open Diversion	Expanded Study area March–May Pulse
Location 2 - 5,000 CFS Box	$181,800,000	$9,013,128	35,241/ –5,965	32,676/ –8,530	34,484/ –6,722	69,251	64,481
Location 2 - 10,000 CFS Box	$230,000,000	$11,402,748	43,448/ 2,242	38,071/ –3,135	36,318/ –4,888	80,924	70,298
Location 2 - 15,000 CFS Box	$398,600,000	$19,761,458	51,445/ 10,239	43,327/ 2,121	38,111/ –3,095	92,668	76,099
Location 2 - 35,000 CFS Box	$493,400,000	$24,461,373	76,174/ 34,968	59,670/ 18,464	44,364/ 3,155	139,965	98,909
Location 3 - 5,000 CFS Box	$140,600,000	$6,970,549	35,241/ –5,965	32,676/ –8,530	34,484/ –6,722	69,251	64,481
Location 3 - 10,000 CFS Box	$165,000,000	$8,180,232	**43,448/ 2,242**	38,071/ –3,135	36,318/ –4,888	80,924	70,298
Location 3 - 15,000 CFS Box	$229,400,000	$11,373,001	**51,445/ 10,239**	**43,327/ 2,121**	38,111/ –3,095	92,668	76,099
Location 3 - 35,000 CFS Box	$334,800,000	$16,598,435	**76,174/ 34,968**	**59,670/ 18,464**	**44,364/ 3,155**	**139,965**	98,909

*Excludes Real Estate and O&MRRR

**FY 2010 Discount Rate 4 3/8%

Table 3.7: LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1b

Alternative	Incremental Cost/Cost Effectiveness Analysis Open Operation				Incremental Cost/Cost Effectiveness Analysis March–May Pulse			
	Open Diversion (Average Annual Acres)	Incremental Cost	Incremental Acres	Incremental Cost per Acre	Mar–May Pulse (Average Annual Acres)	Incremental Cost	Incremental Acres	Incremental Cost per Acre
Location 2 - 5,000 CFS Box	5,276				2,715			
Location 2 - 10,000 CFS Box	11,553		Non-Cost Effective Plans		5,853		Non-Cost Effective Plans	
Location 2 - 15,000 CFS Box	17,860				8,984			
Location 2 - 35,000 CFS Box	42,731				21,282			
Location 3 - 5,000 CFS Box	5,276	$6,970,549	5,276	$1,321	2,715	$6,970,549	2,715	$2,567
Location 3 - 10,000 CFS Box	11,553	$1,209,683	6,277	$193	5,853	$1,209,683	3,138	$385
Location 3 - 15,000 CFS Box	17,860	$10,163,318	11,583	$877	8,984	$10,163,318	5,846	$1,739
Location 3 - 35,000 CFS Box	**42,731**	**$6,435,117**	**31,148**	**$207**	**21,282**	**$6,435,117**	**15,436**	**$417**

*Excludes Real Estate and O&MRRR

**Discount Rate 4 3/8%

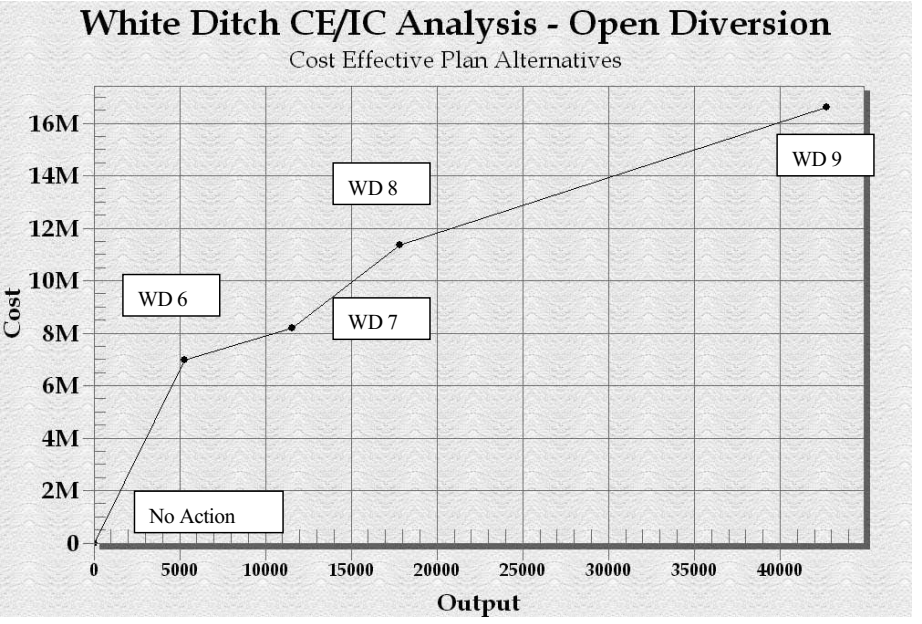


Figure 3.6: White Ditch CE/IC Analysis—Open Diversion

3.3.4.2 CE/IC Analysis

In order to refine the preliminary alternatives further, a two-step Cost Effectiveness & Incremental Cost (CE/IC) Analysis was utilized. The first step used preliminary cost estimates developed for each action alternative and outputs from the ERDC-SAND2 model. Table 3.7 displays the CE/IC analysis of the action alternatives. Average Annual Acres of Marsh is compared against the annualized first cost of the action alternatives. Average Annual Acres of Marsh produced by each size of diversion structure is the same for each location. All of the alternatives at location 2 were not cost effective while the 5, 10 and 15 thousand cfs diversions at location 3 were found to be cost effective. The 35,000 cfs diversion was considered a best buy.

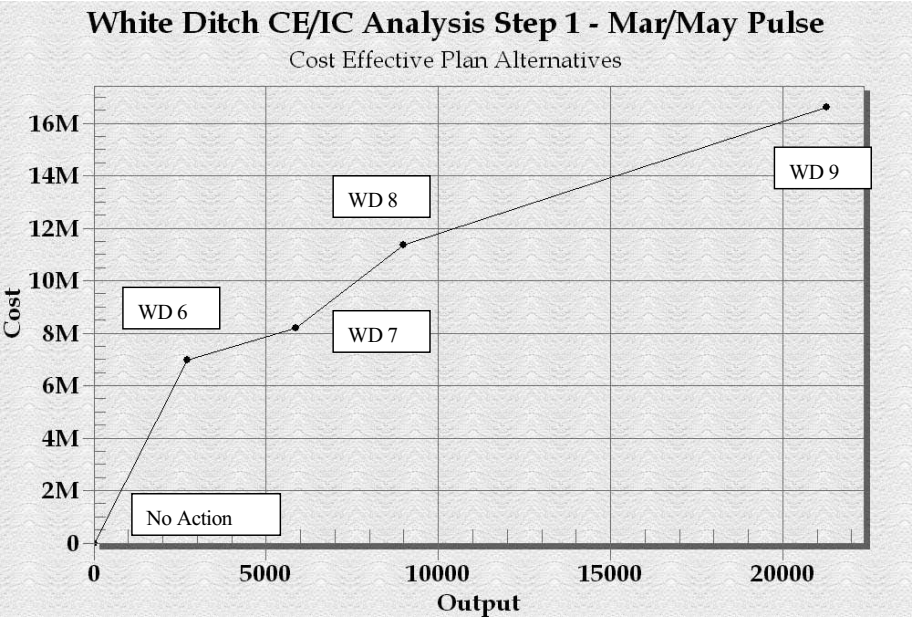


Figure 3.7: White Ditch CE/IC Analysis Step 1—March–May Pulse

3.3.5 Alternative Plans not Carried for Further Analysis

Based on the above analysis, it was determined that the following alternatives would not be further evaluated:

- White Ditch (WD) 2: Location 2 – 5,000 cfs
- White Ditch (WD) 3: Location 2 – 10,000 cfs
- White Ditch (WD) 4: Location 2 – 15,000 cfs
- White Ditch (WD) 5: Location 2 – 35,000 cfs

3.4 FINAL ARRAY OF ALTERNATIVES

3.4.1 No Action (Future Without Project Conditions)

No Action. The future without project condition for White Ditch will continue to see declines in overall wetland acres of all types (Figure 3.8). The current altered deltaic process will result in the lack of freshwater, nutrients and sediments in the project are that are critical to sustain existing marsh and build additional areas. Overall the study area is expected to see an average loss of 274.5 acres of marsh per year. This land loss will, during the 50-year period of analysis, result in a further loss of 13,725 acres of marsh from the 2009 acreage of 41,206.

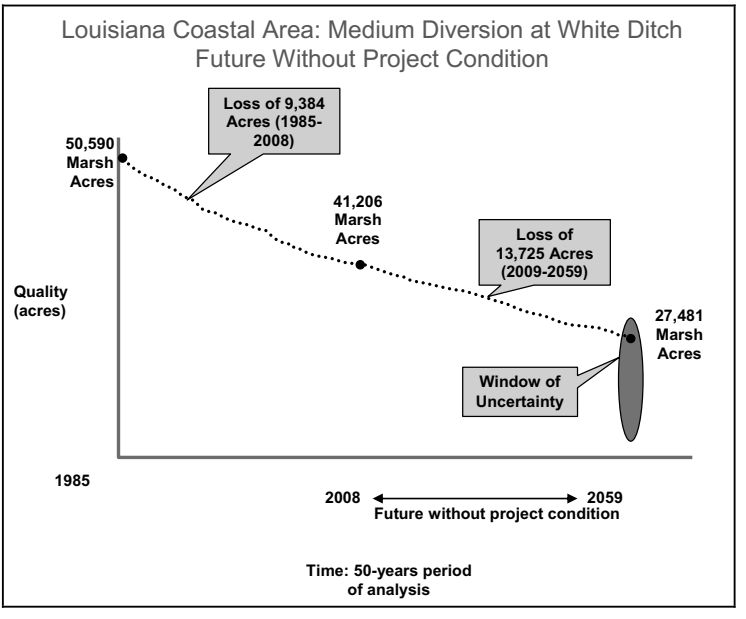


Figure 3.8: LCA: Medium Diversion at White Ditch Future Without Project Condition

Waterbodies would grow larger and wave erosion would accelerate causing further land loss, making remaining marsh lands in the project area and the larger Breton Sound Basin more vulnerable to tropical storms. The Future Without Project Condition will likely see the existing marsh persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses. The study area will likely see additional saltwater intrusion and conversion of the remaining intermediate and brackish marsh to saline marsh types with the associated salt-tolerant or marine fauna.

The remaining marsh acreage of 27,481 does not account for any losses that may be incurred by moderate or high rates of sea level rise. Figure 3.9 below depicts the impacts of both the moderate and high rates of sea level rise on the project area.

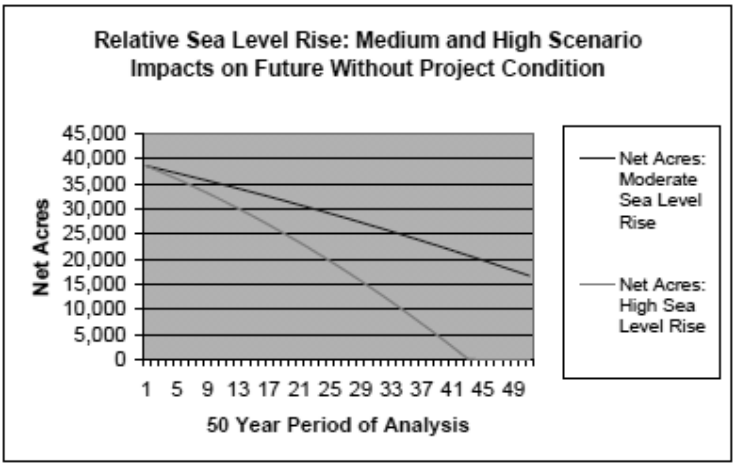


Figure 3.9: Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without Project Condition

Marsh acres are the result of a variety of physical structure and functions within the larger ecosystem. Some of these components include soils and waterbottoms, sediment, subsidence, salinity, riparian vegetation, benthics and fishery resources. Summaries of the future without project condition for these resources are below with more details provided in Section 4.

Soils and Waterbottoms. No direct alteration of soils or substrate would occur under the No Action Alternative and associated water management features. No conversion of prime or unique farmland would occur, and the No Action Alternative would have no direct impact on these resources.

The indirect impacts of the No Action Alternative, would be that the existing patterns of soil erosion and land loss would continue into the future. Organic soils in the project area would not be able to maintain their elevations due to subsidence, decreased plant productivity, wave erosion, and relative sea level rise. Net primary productivity within the project area would continue to decline and existing wetland vegetation would continue to diminish. The ongoing conversion of existing fragmented emergent wetlands to shallow open water would continue with associated indirect impacts on coastal vegetation, fish and wildlife resources, EFH, recreation, aesthetic, and socioeconomic resources. In the future, if no actions are taken to restore and protect marsh habitat within the project area, any prime and unique farmland that remains outside of the protection of existing Federal and non-Federal back levees would continue to be subject to further degradation and possible loss.

Sedimentation and Erosion. The No Action Alternative (i.e., not implementing a sediment and freshwater diversion in the White Ditch Study Area) would have a direct impact on sedimentation or erosion within the area between the Mississippi River and River aux Chenes through the continuation of

existing degradation of marsh. The absence of a supply of freshwater, sediment, and nutrients combined with the ongoing pressures of wind and wave action, storm surges, and human activities has severely eroded marsh soils and reduced the ability of the project area to maintain a balance of emergent wetland and shallow water.

Indirect impacts of the No Action Alternative, not implementing the diversion, are the persistence of existing conditions. Consequences would include further degradation of the existing marsh from saltwater intrusion due to short circuited hydrologic processes present in the basin; as well as the continued lack of sediments, nutrients, and freshwater River aux Chenes and the Mississippi River. With the absences of these features, the marsh would not be able to sustain itself against subsidence and prolonged inundation from sea level rise. The No Action Alternative would cause the existing marsh to persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses.

Subsidence. The Future Without Project Condition will likely see the existing marsh to persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses.

Salinity. Under the No Action Alternative, no direct impacts to salinity levels of the Mississippi River or the White Ditch project area would occur.

Indirect impacts of not implementing restoration features would result in the persistence of existing conditions for the Mississippi River and continued degradation of the White Ditch project area.

Vegetation Resources. Direct impacts under the No Action Alternative, no construction of diversion structure or associated outfall management features would occur, and no BLH would be cleared or filled by construction activities. No opportunities for beneficial use of dredged material for construction features would occur. Existing BLH in the project footprint would continue to degrade and convert to intermediate marsh. No direct impacts to existing wetland vegetation resulting from construction of the proposed diversion and associated features would occur. No opportunities for beneficial reuse of marsh soil and substrate excavated for construction would be realized. No direct impacts to Submerged Aquatic Vegetation (SAV) would occur. Baseline SAV coverage was estimated at approximately 15% of open water areas in the vicinity of the proposed construction footprint (25% in the overall project area). Existing SAV in the project footprint would continue to degrade and die off as increased salinities enter the study area and marsh continues to decrease in acreage.

Without implementation of the proposed diversion, no input of sediment, freshwater and nutrients to the project area would occur. This would result in indirect impacts including the continued erosion of marsh soils and continued fragmentation and conversion of BLH to intermediate and brackish marsh habitats. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, and increased water velocities. Over the next 50 years, the remaining BLH species in the Study Area would experience continued subsidence, sea level rise, and salinity increases. The BLH would eventually diminish and convert to

marsh. Over the next 50 years, approximately 13,750 acres of emergent marsh is projected to be lost, and it is likely that all remaining remnants of bottomland hardwood vegetation would disappear over the same period. Over the next 50 years, SAV is projected to be reduced from the estimated baseline of 25% of open water areas to approximately 15% as the area deteriorates.

Benthics. The Future Without Project Condition will likely see marine (saltwater) influences continue to take hold and convert freshwater wetlands into intermediate, brackish, and saline marsh. As freshwater inputs continue to decline and allow marine influences to predominate over riverine influence, salinity levels rise, resulting in the conversion of low-lying vegetated areas to open water and the redistribution of marine sediment. These actions eventually lead to conditions that expedite interior marsh loss and the benthic community and benthic processes would shift from that of an estuarine community to a more open water marine community. Over the long term, without renewed inputs of freshwater, sediment, and nutrients to restore and maintain emergent marsh habitat, the project area is likely to convert from a predominately estuarine habitat to a predominately marine habitat. The benthic community that supports the estuarine system processes would be adversely affected by the reduction and eventual loss of this habitat.

Essential Fish Habitat. The No Action Alternative (no construction of river diversion structure or associated outfall management features) would have no direct impact on Essential Fish Habitat (EFH).

Indirect impacts of not implementing wetland creation/nourishment and shoreline protection features would result in the persistence of existing conditions resulting in the conversion of categories of EFH, such as estuarine marsh and SAV, to marine water column and mud, sand, or shell substrates is expected to continue. Over time, the No Action Alternative would result in the conversion of an estimated 13,724 acres of emergent marsh to open water. Substantial decreases in the quality of EFH in the project area would reduce the area's ability to support federally managed species.

3.4.2 Alternative 1 – 5,000 cfs diversion

Location 3 – 5,000 cfs. This alternative involves construction of a structure capable of diverting up to 5,000 cfs consisting of three 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater, nutrient and sediments (Figure 3.10).

The locations of secondary features, such as notched weirs, were determined from best professional judgment. Notched weirs are rock structures designed to increase the retention time of the diverted water within the project area by restricting flow into the River Aux Chenes. Hydraulic modeling clearly demonstrated that River aux Chenes drains the project area and that once water enters it is quickly carried away from the desired benefit area. Major outfalls into River aux Chenes would be restricted in order to retain water in the benefit area and create a greater retention time. A greater retention time would allow for more sediment to fall in the project area versus being lost to River Aux Chenes. Placing notched weirs in outfall canals would create a smaller cross-section and result in smaller outflow capacity from the project area into River Aux Chenes. Notched weirs were chosen because they would not restrict navigational traffic, nor would they restrict the ingress/egress of aquatic organisms. The structures would be constructed of 400-pound rip rap with a geotextile and geogrid bedding. A typical cross-section of a notched weir and plans showing their potential locations can be found in Section L7.5.

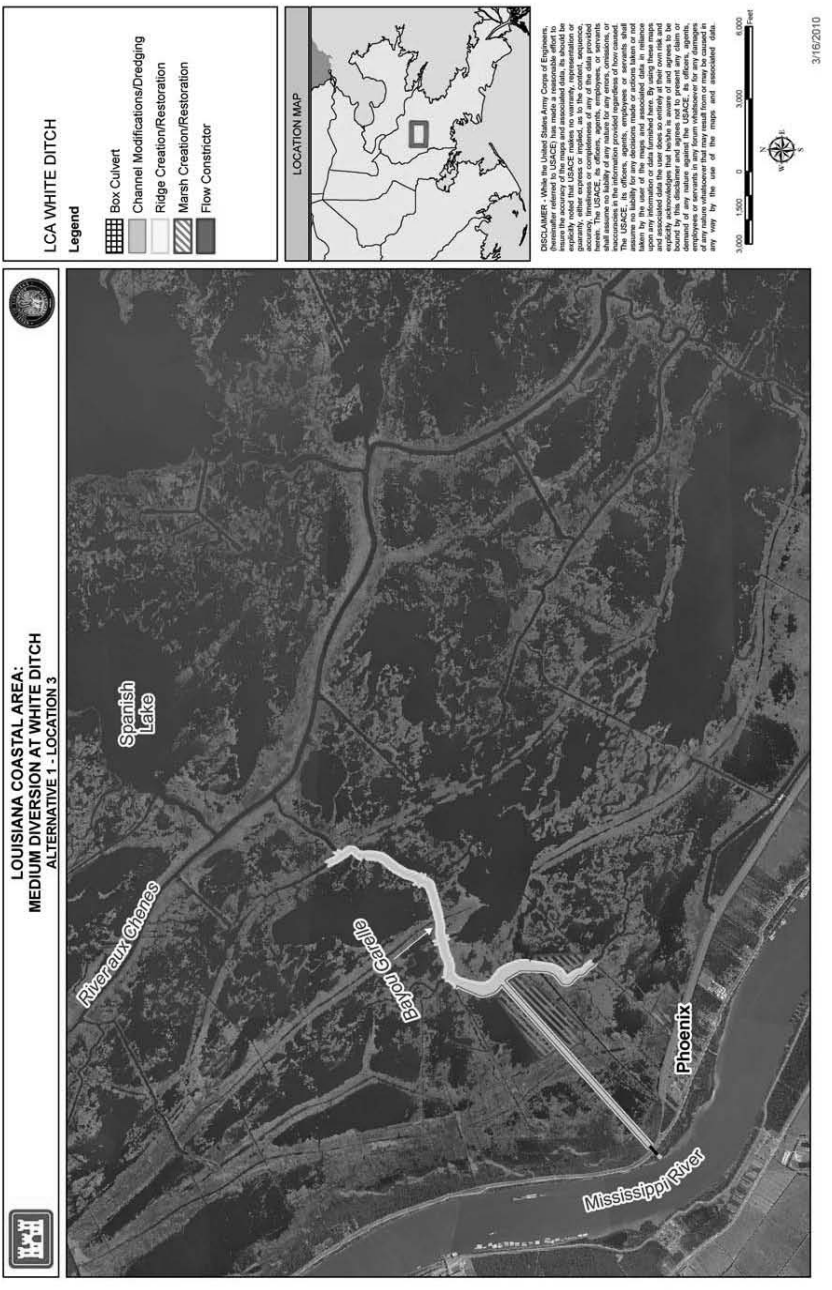


Figure 3.10: Alternative 1 – Location 3

3.4.3 Alternative 2 – 10,000 cfs Max Diversion

Location 3 – 10,000 cfs. This alternative involves construction of a structure capable of diverting up to 10,000 cfs consisting of three 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 176 acres of marsh creation utilizing dredged material from an adjacent 167 acres of canal being reconfigured to convey freshwater, nutrient and sediments (Figure 3.11).

The locations of secondary features, such as notched weirs, were determined from best professional judgment. Notched weirs are rock structures designed to increase the retention time of the diverted water within the project area by restricting flow into the River Aux Chenes. Hydraulic modeling clearly demonstrated that River aux Chenes drains the project area and that once water enters it is quickly carried away from the desired benefit area. Major outfalls into River aux Chenes would be restricted in order to retain water in the benefit area and create a greater retention time. A greater retention time would allow for more sediment to fall in the project area versus being lost to River Aux Chenes. Placing notched weirs in outfall canals would create a smaller cross-section and result in smaller outflow capacity from the project area into River Aux Chenes. Notched weirs were chosen because they would not restrict navigational traffic, nor would they restrict the ingress/egress of aquatic organisms. The structures would be constructed of 400-pound rip rap with a geotextile and geogrid bedding. A typical cross-section of a notched weir and plans showing their potential locations can be found in Section L7.5.

3.4.4 Alternative 3 – 15,000 cfs Max Diversion

Location 3 – 15,000 cfs. This alternative involves construction of a structure capable of diverting up to 15,000 cfs consisting of ten 15-ft x 15-ft box culverts. Additionally, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal being reconfigured to convey freshwater, nutrient and sediments (Figure 3.12).

The locations of secondary features, such as notched weirs, were determined from best professional judgment. Notched weirs are rock structures designed to increase the retention time of the diverted water within the project area by restricting flow into the River Aux Chenes. Hydraulic modeling clearly demonstrated that River aux Chenes drains the project area and that once water enters it is quickly carried away from the desired benefit area. Major outfalls into River aux Chenes would be restricted in order to retain water in the benefit area and create a greater retention time. A greater retention time would allow for more sediment to fall in the project area versus being lost to River Aux Chenes. Placing notched weirs in outfall canals would create a smaller cross-section and result in smaller outflow capacity from the project area into River Aux Chenes. Notched weirs were chosen because they would not restrict navigational traffic, nor would they restrict the ingress/egress of aquatic organisms. The structures would be constructed of 400-pound rip rap with a geotextile and geogrid bedding. A typical cross-section of a notched weir and plans showing their potential locations can be found in Section L7.5.



Figure 3.11: Alternative 2 – Location 3



Figure 3.12: Alternative 3 – Location 3

3.4.5 Alternative 4 – 35,000 cfs Max Diversion (Recommended Plan)

Location 3 – 35,000 cfs. This alternative involves construction of a structure capable of diverting up to 35,000 cfs consisting of ten 15-ft x 15-ft box culverts. Additionally, 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments (Figure 3.13).

The locations of secondary features, such as notched weirs, were determined from best professional judgment. Notched weirs are rock structures designed to increase the retention time of the diverted water within the project area by restricting flow into the River Aux Chenes. Hydraulic modeling clearly demonstrated that River aux Chenes drains the project area and that once water enters it is quickly carried away from the desired benefit area. Major outfalls into River aux Chenes would be restricted in order to retain water in the benefit area and create a greater retention time. A greater retention time would allow for more sediment to fall in the project area versus being lost to River Aux Chenes. Placing notched weirs in outfall canals would create a smaller cross-section and result in smaller outflow capacity from the project area into River Aux Chenes. Notched weirs were chosen because they would not restrict navigational traffic, nor would they restrict the ingress/egress of aquatic organisms. The structures would be constructed of 400-pound rip rap with a geotextile and geogrid bedding. A typical cross-section of a notched weir and plans showing their potential locations can be found in Section L7.5.

3.5 COMPARISON OF ALTERNATIVE PLANS

This section describes the alternative plans and the process used to determine the potential costs, habitat benefits, incremental cost/cost effectiveness, and other factors leading to a recommended plan. Once the final array was determined, a second round of ecohydraulic modeling was conducted. These runs analyzed how salinities would encroach back into the Breton Sound with “maintenance” flows coming from the proposed diversion (1,000 cfs) and Caernarvon (800 cfs). For these runs, simulations started following the final results of the initial screening of alternatives using the salinities that were estimated there. These results fed into the WVA analysis. These simulations were for a 3-month period with the following parameters:

- Average summer (June–August) tidal conditions.
- Average summer (June–August) wind forcing conditions for Plaquemines Parish, Louisiana.
- Average summer (June–August) rainfall inputs.
- An average evaporation constant of 5 mm/day.

3.5.1 Incremental Cost/Cost Effectiveness Analysis Process.

Cost effectiveness analysis was used to determine what project features should be built, based on habitat benefits (outputs) that meet the goals and objectives of the project and at the same time are the most cost effective. The Corps has incorporated cost effectiveness analysis into its planning process for all ecosystem restoration planning efforts. A cost effectiveness analysis is conducted to ensure that least cost



Figure 3.13: Alternative 4 – Location 3

alternatives are identified for various levels of output. After the cost effectiveness of the alternatives has been established, incremental cost analysis is conducted to reveal and evaluate changes in cost for increasing levels of environmental output.

Cost effectiveness and incremental analysis is a three step procedure: (1) calculate the environmental outputs of each alternative; (2) determine a cost estimate for each alternative; (3) combine the alternatives to evaluate the best overall project alternative based on habitat benefits and cost. While cost and environmental outputs are necessary factors, other factors such as the ability to construct, schedule, likelihood to achieve projected results, immeasurable environmental benefits, ancillary benefits etc., are very important in deciding on the preferred alternative.

Environmental outputs were calculated as Average Annual Habitat Units (AAHUs). The annualized costs were calculated by applying a 4-3/8% annual interest rate to the construction costs over the 50-year period of analysis. What is described below is the second step of the process introduced in Section 3.3.4 above.

3.5.2 Wetland Value Assessment (WVA)

The Wetland Value Assessment (WVA) methodology is a quantitative habitat-based assessment methodology developed for use in determining wetland benefits of project proposals submitted for funding under the CWPPRA. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited or enhanced by the project and the net acres of habitat protected/restored. See Appendix B for a complete description of the WVA and its application to this project.

The WVA was developed in 1991 by the Environmental Work Group (EnvWG) assembled under the Planning and Evaluation Subcommittee of the CWPPRA Technical Committee; the EnvWG includes members from each agency represented on the CWPPRA Task Force and members of the Academic Assistance Subcommittee. The WVA was designed to be applied, to the greatest extent possible, using only existing or readily obtainable data. The WVA models have been revised several times since they were developed in 1991. WVA has been used to evaluate 50–60 projects CWPPRA coastal restoration projects over the last 2 years. WVA has also been used to evaluate proposed impacts for approximately 200 permit applications and 30–40 mitigation areas. For these reasons, and because it was developed specifically for use in Louisiana coastal environments, this methodology was selected for use in evaluating MDWD and other LCA projects.

The WVA is a modification of the Habitat Evaluation Procedures (HEP) developed by the USFWS (USFWS 1980). HEP is widely used by the USFWS and other Federal and State agencies in evaluating the impacts of development projects on fish and wildlife resources. A notable difference exists between the two methodologies, however, in that HEP generally uses a species-oriented approach, whereas the WVA utilizes a community approach.

The WVA has been developed for application to several habitat types along the Louisiana coast and community models have been developed for fresh marsh, intermediate marsh, brackish marsh, saline marsh, fresh swamp, barrier islands, and barrier headlands. Two other habitat assessment models for

bottomland hardwoods and coastal chenier/ridge habitat were developed outside of the CWPPRA arena and are periodically used by the EnvWG. A WVA Procedural Manual was prepared by the EnvWG to provide guidance to project planners in the use of the various community models.

Habitat types impacted by construction of the MDWD outfall management features (channel enlargement, marsh creation, and ridge creation) are intermediate marsh and open water in the intermediate salinity zone. Habitat types impacted by operation of the MDWD are intermediate, brackish, and saline marsh, and open water in the intermediate, brackish, and saline zones. Project implementation will create two habitat types found historically but not currently present in the impacted area: fresh marsh and ridge. Consequently, the WVA assessment for MDWD utilized community models for fresh/intermediate marsh, brackish marsh, saline marsh, and coastal chenier/ridge habitat.

WVA Model Certification

The WVA model is completing model certification in accordance with EC 1105-2-407, May 2005 Planning Models Improvement Program:

Model Certification. The model has undergone external review which is documented in the July 8, 2009, Draft Model Certification Review Report for the Wetland Value Assessment Models prepared by the Battelle Memorial Institute for the U.S. Army Corps of Engineers, Ecosystem Planning Center of Expertise. The WVA revision documentation and spreadsheets have been submitted to the ECO-PCX. The ECO-PCX has reviewed the revisions and will forward a recommendation to certify the model for use in the LCA projects.

Since the WVA was still in the process of being certified, the projects using the WVA model were required to respond to specific comments related to the ongoing certification process and the use of WVA on the specific project. The specific comments and responses for the WVA as it relates to the LCA-MDWD Modification project can be found in Appendix K. Based on satisfactory responses to these comments, Planning Center of Expertise for Ecosystem Restoration has cleared the WVA model for use in evaluating the alternatives considered in this report.

WVA Concept

The WVA operates under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland habitat type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of community models developed specifically for each habitat type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values, and 3) a mathematical formula that combines the Suitability Index for each variable into a single value for habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI. The output of each model (the HSI) is assumed to have a linear relationship with the suitability of a coastal wetland system in providing fish and wildlife habitat.

The WVA models have been developed for determining the suitability of Louisiana coastal wetlands in providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. The models have been designed to function at a community level and therefore attempt to define an optimum combination of habitat conditions for common fish and wildlife species utilizing a given

habitat type. Earlier attempts to capture other wetland functions and values such as storm-surge protection, flood water storage, water quality functions, and nutrient import/export were abandoned due to the difficulty in defining unified model relationships and meaningful model outputs for such a variety of wetland benefits. However, the ability of a Louisiana coastal wetland to provide those functions and values may be generally assumed to be positively correlated with fish and wildlife habitat quality as predicted through the WVA.

Community Model Variable Selection

Habitat variables considered appropriate for describing habitat quality in each wetland type were selected according to the following criteria:

- The condition described by the variable had to be important in characterizing fish and wildlife habitat quality in the wetland type under consideration;
- Values had to be easily estimated and predicted based on existing or readily obtainable data (e.g., aerial photography, habitat classification data, water quality monitoring stations, interviews with knowledgeable individuals, etc.); and
- The variable had to be sensitive to the types of changes expected to be brought about by typical wetland restoration projects proposed under the CWPPRA.

The marsh community models used in the WVA assessment for the MDWD (fresh/intermediate, brackish, and saline) all utilize the same habitat variables. These are: 1) percent of wetland (marsh) covered by emergent vegetation; 2) percent of open water covered by submerged and floating-leaved aquatic vegetation; 3) Marsh edge and interspersion with open water; 4) percent of open water less than or equal to 1.5 feet deep in relation to marsh surface; 5) salinity; and 6) aquatic organism access. Baseline values assigned to these variables are listed and explained in the WVA Assessment appendix (pages 17–74) included with the USFWS Coordination Act Report attached to this document as Appendix B.

Suitability Index Graphs

A suitability index graph is a graphical representation of how fish and wildlife habitat quality or "suitability" of a given habitat type is predicted to change as values of the given variable change, and allows the model user to numerically describe, through a Suitability Index, the habitat quality of a wetland area for any variable value. Each Suitability Index ranges from 0.1 to 1.0, with 1.0 representing the optimal condition for the variable in question. Suitability Index (SI) graphs were constructed for each variable. While the three marsh community models used for the MDWD utilize the same six variables, the suitability graphs for each variable differ according to the marsh community type (fresh/intermediate, brackish, or saline).

Habitat Suitability Index Formula

The final step in model development was to construct a mathematical formula that combines all Suitability Indices into a single Habitat Suitability Index value. Because the Suitability Indices range from 0.1 to 1.0, the HSI also ranges from 0.1 to 1.0, and is a numerical representation of the overall or "composite" habitat quality of the particular wetland area being evaluated. The HSI formula defines the aggregation of Suitability Indices in a manner unique to each wetland type depending on how the formula is constructed.

Within an HSI formula, any Suitability Index can be weighted by various means to increase the power or "importance" of that variable relative to the other variables in determining the HSI. Additionally, two or more variables can be grouped together into subgroups to further isolate variables for weighting.

Benefit Assessment

The net benefits of a proposed project are estimated by predicting future habitat conditions under two scenarios: future without-project and future with-project. Specifically, predictions are made as to how the model variables will change through time under the two scenarios. Through that process, HSIs are established for baseline (pre-project) conditions and for future without- and future with-project scenarios for selected "target years" throughout the expected life of the project. Those HSIs are then multiplied by the study area acreage at each target year to arrive at Habitat Units (HUs). Habitat Units represent a numerical combination of quality (HSI) and quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with-project scenarios are annualized, averaged over the project life, to determine AAHUs. The "benefit" of a project can be quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference in AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality. The starting point for the WVA 50-year period of analysis was assumed to be 2015 based upon the current schedule to complete Plans & Specifications and Construction. This 2015 date differs slightly from the 2009 used in the previous iterations of the planning process. While the starting point of the analysis has changes between steps (2015 compared to 2009) the entire final array of alternatives was evaluated on equal terms and therefore the comparison of alternatives and their respective benefits is valid.

The WVA assessment for the MDWD utilized habitat and land-water data generated by the USGS for the project area, aerial photography, monitoring and hydrodynamic modeling data (for salinity) and also used field survey data collected for WVAs recently conducted for other, smaller CWPPRA projects within and adjacent to the MDWD project area. Separate WVA analyses were conducted for each marsh type and each diversion size alternative, and for each outfall management feature type. Target year 0 (TY0) was assumed to be 2015. The WVA analyses conducted for the future-without-project (FWOP) condition used two target years: 1 (TY1) and 50 (TY50) to assess changes in the project area over the 50-year planning horizon. Analyses of the future-with-project (FWP) condition also used TY1 and TY50, but added a target year 5 (TY5) within the 50-year planning horizon. TY5 was used in the FWP analyses because review of hydrodynamic modeling outputs projecting salinities indicated that a portion of the intermediate marsh area would transition to fresh marsh within a few years following the start of project operation. More-detailed information concerning data sources, variable assumptions, anticipated habitat changes, and performance of the diversion alternatives over time is presented in an appendix to the USFWS Coordination Act Report at Appendix B.

MDWD Summary

Following the multiple operating regimes analyzed as part of Step 1 described previously, an optimal operating regime was established based on the best available supplies of freshwater, nutrients and sediments while avoiding the negative impacts of open diversions on the public, oyster and alligator resources. A March–April Open Pulse with a 1,000 cfs maintenance flow the rest of the year would achieve these ends. The WVA values for the MDWD project are summarized below:

Table 3.8: Direct Footprint Acreage Impacts

	Ridge Creation	Marsh Creation	Channel Enlargement
Alternative 1: Location 3 – 5,000 cfs Diversion	32	139	153
Alternative 2: Location 3 – 10,000 cfs Diversion	32	176	167
Alternative 3: Location 3 – 15,000 cfs Diversion	32	235	182
Alternative 4: Location 3 – 35,000 cfs Diversion	31	385	223

Table 3.9: Benefits Summary*

Outfall Management Features				
Feature	**5,000 cfs**	**10,000 cfs**	**15,000 cfs**	**35,000 cfs**
Marsh Creation	54.59	72.52	92.19	155.20
Channel Enlargement	-15.99	-19.08	-21.89	-31.25
Ridge Footprint	-11.33	-11.33	-11.33	-11.37
Ridge Creation	28.24	28.24	28.24	27.36
Net AAHUs	**55.51**	**70.35**	**87.21**	**139.94**
Diversion Benefits				
Marsh Type	**5,000 cfs**	**10,000 cfs**	**15,000 cfs**	**35,000 cfs**
Fresh/Intermediate	3,505.05	3,862.13	5,650.28	8,802.11
Brackish	1,359.93	1,655.31	1,656.16	3,965.54
Saline	276.26	347.78	347.97	447.42
Net AAHUs	**5,141.24**	**5,865.22**	**7,654.41**	**13,215.07**
Total Net AAHUs	**5,196.75**	**5,935.57**	**7,741.62**	**13,355.01**

* The WVAs were updated during the review process. The updated AAHUs and acres are in Appendix B. There was no significant change in these values.

Table 3.10: Acreage Summary

MDWD Final Array of Alternatives		
	WVA AAHUs March–April Open + 1,000 cfs Maintenance Flow Year 0 = 2015	Gross/Net Acres March–April Open + 1,000 cfs Maintenance Flow Year 0 = 2015 No Net Loss Acres = 39,587
Location 3 – 5,000 cfs	5,197	35,638 / –3,949
Location 3 – 10,000 cfs	5,936	40,419 / 562
Location 3 – 15,000 cfs	7,742	45,046 / 5,459
Location 3 – 35,000 cfs	13,355	59,902 / 20,315

Note: The WVA assessment was updated during the review process. The updated AAHUs and acres affected can be found in Appendix B. There was no significant change in these values as a result of the update.

Cost Estimates for Habitat Improvement Measures

Rough cost estimates were developed to conduct the cost effectiveness and incremental cost analysis of the various alternative plans. Items included in the first cost construction estimated are mobilization, dredging, placement, demobilization, contingency, Engineering and Design during Construction (EDC), Supervision & Administration (S&A), Real Estate and Operations and Maintenance. Table 3.11 summarizes the costs associated with each alternative plan. Following selection of the Recommended Plan, the design will be refined and a feasibility level cost estimate prepared. Therefore, the cost of the Recommended Plan may differ from the numbers used during IC/CE analysis. Further details can be found in the Engineering and Cost Appendices (Appendix L).

Table 3.11: LCA: White Ditch Cost Estimates

Alternative	Total First Cost*	Annualized O&MRRR	Annualized First Cost**	Total Annualized Cost
Location 3 – 5,000 CFS Box	$152,900,000	$781,804	$7,580,348	$8,362,152
Location 3 – 10,000 CFS Box	$174,200,000	$871,463	$8,636,342	$9,507,805
Location 3 – 15,000 CFS Box	$241,700,000	$1,131,044	$11,982,801	$13,113,845
Location 3 – 35,000 CFS Box	$329,300,000	$1,467,836	$16,325,760	$17,793,596

*Includes Real Estate
**FY 2010 Discount Rate 4-3/8%

3.5.3 Results of the Incremental Cost/Cost Effectiveness Analysis

The analyses showed that alternative plans 1, 2, 3, and 4 are cost effective. Aside from the No Action Alternative, Alternative 4 exhibited the lowest cost per Unit of all alternatives, $1,332 per AAHU. Alternative 3 exhibited the highest cost per Unit at $1,694 per AAHU.

Table 3.12: White Ditch Incremental Cost/Cost Effectiveness Step 2

Alternative	Total Annualized Cost	WVA AAHU	Average Cost per AAHU
Location 3 – 5,000 CFS Box	$8,362,152	5,197	$1,609
Location 3 – 10,000 CFS Box	$9,507,805	5,936	$1,602
Location 3 – 15,000 CFS Box	$13,113,845	7,742	$1,694
Location 3 – 35,000 CFS Box	$17,793,596	13,355	$1,332

* Includes Real Estate
** Discount Rate 4⅜%

Overall, alternative 4 was considered a best buy plan. However, as the plans are linear in benefits and costs, a CE/IC analysis was conducted on all of the alternatives. These plans provide the greatest increase in benefits for the least increase in cost.

The No Action Alternative (FWOP) is cost effective; however, it provides no improvement in habitat quality resulting in steep declines in marsh. Alternative plan 1 provides 5,197 AAHUs over and above the No Action Alternative (FWOP) at an annualized incremental cost of $8,362,152 (tables 3.12 and 3.13). Alternative plan 2 provides 739 additional AAHUs, at an annualized incremental cost of $1,145,653. Alternative plan 3 provides 1,806 additional AAHUs, at an annualized incremental cost of $3,606,040. Alternative Plan 4 provides 5,613 additional AAHUs at an annualized incremental cost of $4,679,752. Alternative 4 has the lowest incremental cost per AAHU of $834.

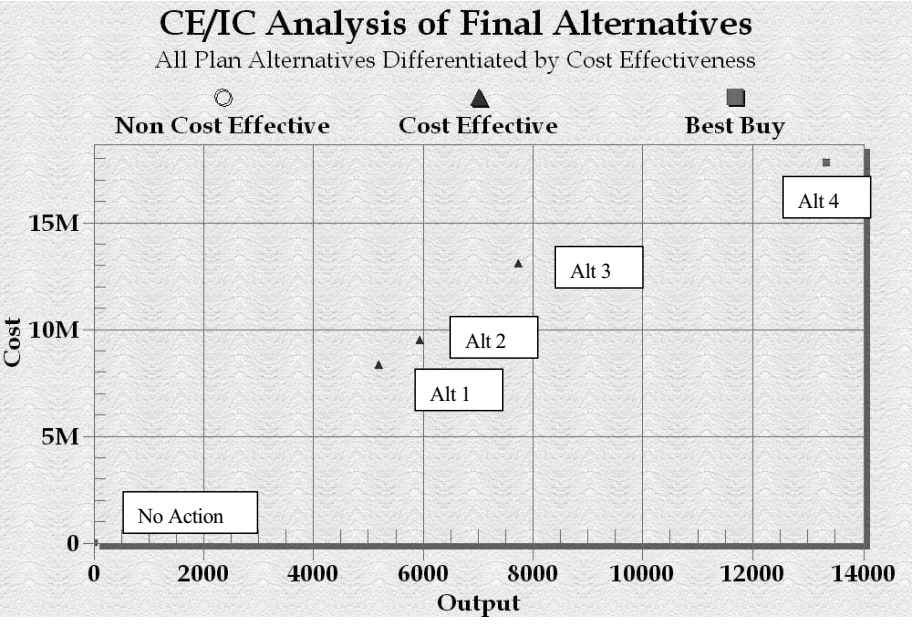


Figure 3.14: CE/IC Analysis of Final Alternatives

Table 3.13: White Ditch Incremental Cost/Cost Effectiveness Step 2

			Incremental Cost/Cost Effectiveness Analysis of Cost Effective Plans		
Alternative	Total Annualized Cost	WVA AAHU	Incremental Cost	Incremental AAHU	Incremental Cost per AAHU
Location 3 – 5,000 CFS Box	$8,362,152	5,197	$8,362,152	5,197	$1,609
Location 3 – 10,000 CFS Box	$9,507,805	5,936	$1,145,653	739	$1,550
Location 3 – 15,000 CFS Box	$13,113,845	7,742	$3,606,040	1,806	$1,997
Location 3 – 35,000 CFS Box	$17,793,596	13,355	$4,679.752	5,613	$834

* Includes Real Estate

** Discount Rate 4⅜%

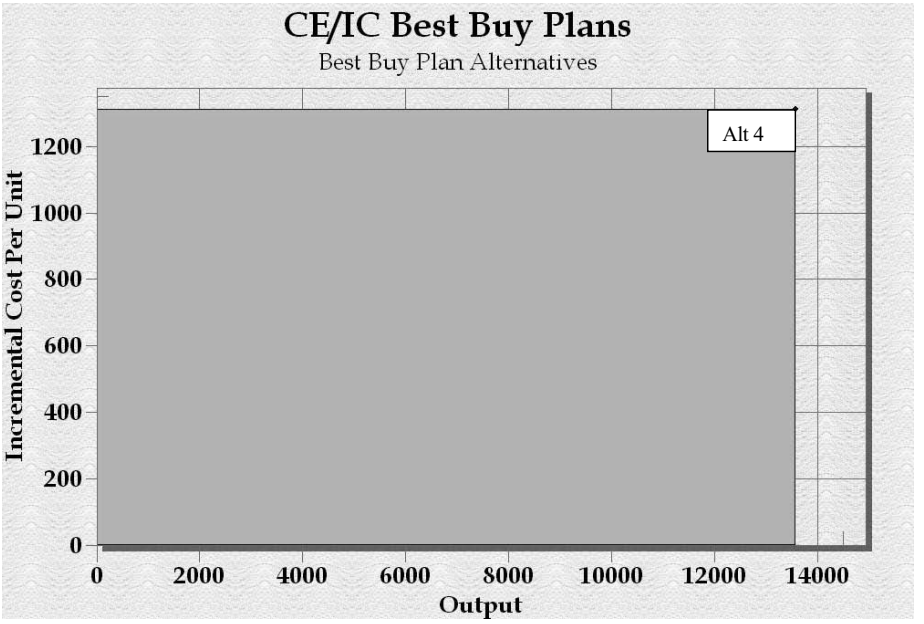


Figure 3.15: CE/IC Best Buy Plans

3.5.4 Other Factors

As part of the process to determine whether additional increments of ecosystem investment are worth the cost, other factors were considered.

3.5.4.1 Recreational Benefits

The primary purpose of the White Ditch Study is to determine a cost effective ecosystem restoration plan, however there are potential ancillary benefits to recreation. Recreation benefits are not being claimed to justify the project but are useful in discerning among the final alternatives. A complete analysis can be found in the Recreation Benefits Analysis Annex to Appendix K.

Given that the study area has 90,109 unit days per year and that each unit day is valued at $8.99, the total annual monetary value of the recreational resource that would be affected by the White Ditch project is $810,256. Given that the likelihood at success with fishing will increase and that environmental factors will improve over time if the proposed project is implemented, the total annual monetary value of the recreational resource will increase in the future compared to the annual monetary value of the recreational resource should the proposed project not be implemented.

To better understand the economic impact of the proposed project on recreation, the analysis considered effects over a 50-year period. The analysis uses the Federal discount rate for 2009 of 4 3/8%. The following table summarizes the potential net present value of recreational resources for each alternative.

Table 3.14: Net Increase in Recreation Benefits

	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Net Present Value of Benefits over 50 years	$0	$1,206,000	$1,278,000	$1,421,000	$853,000
Annualized Benefits	$0	$57,284	$60,704	$67,496	$40,517

3.5.4.2 Desired Future Condition

The desired future established early on in the study was to achieve a no net loss of marsh acres at the end of the 50-year period of analysis. While it was desirable to maximize the acres of marsh, it was uncertain if that was possible given the various physical and operational constraints. The outputs of the ERDC-SAND2 model are one of the key components in the WVA. Based on the ERDC-SAND2 results, Alternative 4 provided the most net acres at the end of period of analysis. It is possible that the study area could see a return to historic marsh acreages. Finally, the IC/CE analysis of the final array of alternatives utilized WVA benefits based in part on an operation regime of Open Diversion during March–April with a 1,000 cfs maintenance flow the remainder of the year. As can be seen in the figure below, under a variety of operating regimes, Alternative 4 is the most capable at achieving no net loss.

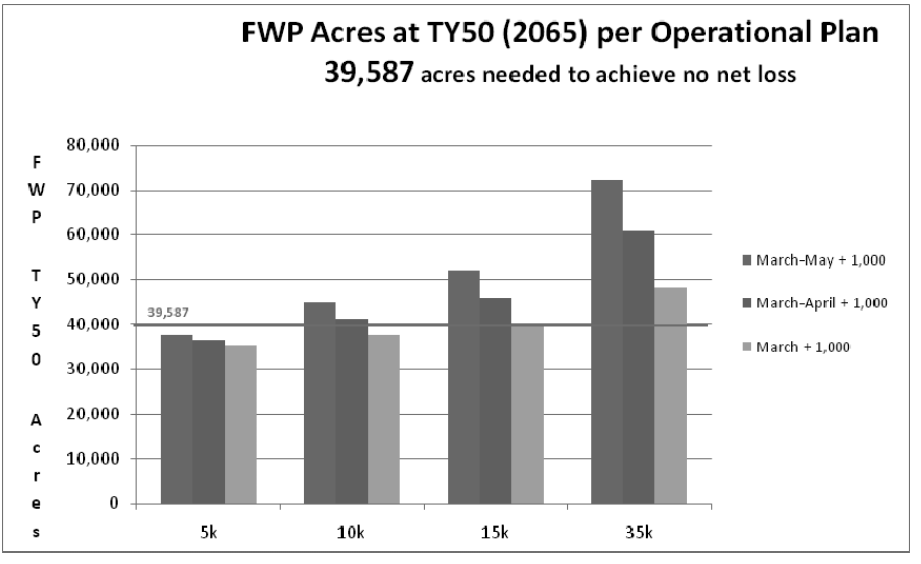


Figure 3.16: FWP Acres at TY50 per Operational Plan

3.5.4.3 Relative Sea Level Rise

An analysis of the high sea level rise scenario was conducted utilizing the ERDC-SAND2 model. The model was used to determine whether a net loss or gain of marsh acreage would occur assuming a high sea level rise scenario. Alternative 4 was the most effective at countering the effects of high sea level rise. Alternative 4 could maintain marsh acreage out to approximately year 20 of the analysis which was then quickly followed by a sharp decline and eventual collapse of the marsh and near total conversion to open water. This result was based on the March–April Pulse plus a 1,000 cfs maintenance flow the rest of the year. Tables 3.15 and 3.16 display these details. It should be noted however, that in the event high sea level rise becomes a reality, Alternative 4 alone has the capability (assuming an open diversion) to divert large enough quantities of freshwater, nutrients and sediments to overcome high sea level rise. Longer term pulses of freshwater may result in large scale habitat switching to predominately freshwater types. Further, long term freshwater pulses can saturate marsh vegetation and soils such that they are less resilient to storm surge from seasonal events resulting in marsh displacement and conversion to open water. There is strong public feeling that the prolonged operation of Caernarvon prior to Katrina contributed to the severe loss of marsh. While not publicly acceptable at present (due to the anticipated negative consequences of over-freshening the basin), if the collapse of the marsh within the study areas was imminent, then having the ability to respond accordingly with a year round open diversion would be critical.

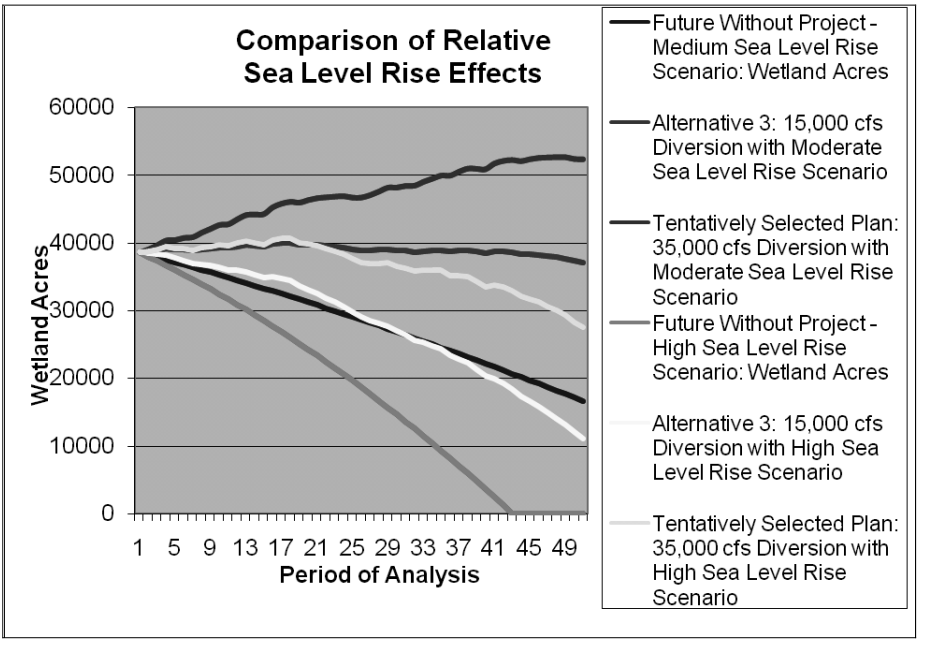


Figure 3.17: The Recommended Plan as Compared to Evaluated Alternatives and Different Rates of Projected Sea-Level Rise

Table 3.15: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area Under Historical Sea Level Rise Rates

	Gross Acres of Marsh					
Project Life Years:	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	36,000	33,300	30,500	27,800	25,000
5,000 cfs Diversion Alternative	38,700	38,300	37,800	37,000	36,600	35,600
10,000 cfs Diversion Alternative	38,700	39,300	39,900	39,900	40,700	40,400
15,000 cfs Diversion Alternative	38,700	40,300	41,900	42,700	44,600	45,000
35,000 cfs Diversion Alternative	38,700	43,800	48,800	52,200	57,300	59,900

Note: the total project area for the Medium Diversion at White Ditch is 98,000 acres.

Table 3.16: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area Under the Intermediate and High Sea Level Rise Rates

	Gross Acres of Marsh					
Project Life Years:	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	34,900	30,900	26,500	21,800	16,900
35,000 cfs Diversion Alternative	38,700	42,800	46,600	48,500	51,800	52,400
No Action Alternative (FWOP)	38,700	31,500	23,700	14,000	2,900	0
35,000 cfs Diversion Alternative	38,700	39,500	39,600	36,300	33,800	27,600

Note: the total project area for the Medium Diversion at White Ditch is 98,000 acres.

3.5.4.4 Breton Sound Benefits

During the initial ERDC-SAND2 evaluation of alternatives in Step 2, it was determined that Alternative 4 has the capability to create marsh in the larger Breton Sound basin (i.e., beyond the MDWD project boundary) through nutrient transfer. The modification of the Caernarvon Diversion is currently being evaluated in an effort to investigate ways to enhance the capture of sediment. It may be possible, with further analysis, to claim benefits to the Caernarvon study area as a result of implementing Alternative 4. This may lead to cost savings for the Caernarvon project.

3.5.4.5 Adaptive Management

Alternative 4 provides the most robust capability for adapting to future risk and uncertainty. As discussed above, Alternative 4 provides the most flexible management of operations to respond to sea level rise. The difference between alternatives 3 and 4 is the outfall canals, ridges and flow notched weirs that are responsible for distributing flows at 15,000 and 35,000 cfs, respectively. Just as sea level rise represents uncertainty at one end of the spectrum, it is also possible that the sea level rise will not be any more pronounced than historic levels. Also, as the science of operating large diversion structures is refined throughout the period of analysis, it is possible to maximize environmental outputs with smaller diversions. Finally, it is expected that as the project is actually operated and benefits are achieved, it will be of value for the Federal, state and local partnership to revisit the goals and objectives associated with

the study area. If the project is proving to be very successful at creating marsh it may no longer necessary to maintain a 35,000 cfs diversion capability. To achieve this, O&M could be reduced resulting in outfall canals, ridges and notched weir structures necessary to support a decreased diversion flow.

3.5.4.6 Acceptability, Completeness, Effectiveness, and Efficiency.

Alternative 4 meets the four evaluation criteria of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Special consideration is also given to these criteria within the larger context of the LCA Report (2004). The four criteria are acceptability, completeness, effectiveness, and efficiency.

***Acceptability*.** The plan is acceptable to Federal, state, tribal, local entities, and the public. It is compatible with existing laws, regulations, and policies.

Completeness. The plan is complete. Realization of the plan does not depend on implementation of actions outside the plan.

Effectiveness. The plan is effective. It addresses all the project objectives. It improves marsh habitat by restoring deltaic process related to freshwater, nutrient and sediments. It does this by introducing the quantities of freshwater, nutrients and sediments required (objectives) to achieve no net loss of marsh during the period of analysis.

Efficiency. The plan is efficient. It is a cost-effective solution to the stated problems and objectives. No other plan produces the same level of output more cost effectively. The plan is cost effective and provides the greatest increase in benefits for the least increase in costs.

3.5.4.7 Selection of the Recommended Plan

The interagency team selected Alternative Plan 4 as the Tentatively Selected Plan. After approval by the Civil Works Review Board, the Tentatively Selected Plan became known as Recommended Plan. It would result in restoration of deltaic processes within the study area. In cooperation with the USFWS, NOAA, and the State of Louisiana, the Corps has planned and would design a project that serves the needs of the nation. The Recommended Plan best meets the study objectives, is the most flexible, and has the most robust sustainable capability against relative sea level rise over the length of the 50-year planning horizon. Once the Recommended Plan was determined, a year-long hydraulic model scenario was run to analyze the effects of the plan over an annual cycle and these results are available in Appendix L.

3.6 NER PLAN

The NER plan reasonably maximizes ecosystem restoration benefits compared to costs, considering the cost effectiveness and incremental cost of implementing other restoration options. Alternative 4 Location 3 – 35,000 cfs, based on all considerations is the NER plan as well as the Recommended Plan. This alternative involves construction of a structure capable of diverting up to 35,000 cfs consisting of ten 15-x-15-foot box culverts. Additionally, there would be 31 acres of ridge and terrace creation, and 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal construction. The Recommended Plan has a primary operating regime of up to a maximum 35,000 cfs pulse during March–April with up to a maximum 1,000 cfs maintenance flow throughout the remainder of the 12-month cycle (May–February).

The pulsed operational scheme is as important to the Recommended Plan as the proposed structure itself. This combination of structure operation and size represents an optimization of desirable impacts and a minimization of undesirable impacts. The pulse regime was chosen because it minimizes adverse effects to natural socioeconomic resources and mimics a natural hydrologic regime. The March–April timeframe is specifically meant to target sediment loads that are typically high in the Mississippi River during that time of year. Although the Recommended Plan would be authorized to run up to 35,000 cfs during the March–April timeframe, it does not necessarily mean it always would. If conditions were unfavorable, flow through the structure could be reduced. For example, if the river was falling and sediment concentrations were low, the structure could be closed. Conversely, it could be reopened when water started rising and sediment levels in the river become elevated. Additionally, the 1,000 cfs maintenance flow that is authorized from May–February does not mean that it would continuously operate at 1,000 cfs. It is possible that the structure would be completely shut down during much of the year in order to encourage stabilization of estuarine salinity gradients. This flexibility to actively and adaptively manage the operation within the recommended framework is a critical aspect of the Recommended Plan.

All of the diversion alternatives that were considered during the planning process resulted in freshening of the Breton Sound basin to a comparable degree. The performance obtained by coupling a 35,000 cfs structure with the March–April pulse regime is what makes the Recommended Plan unique among the alternatives considered. It can attain project objectives while minimizing adverse impacts to natural and manmade resources. It is the length of operation that makes the effect of a diversion on salinity regimes either large or small, not the cubic-feet-per-second capacity of the diversion. From this perspective, a large diversion achieves objectives while having negligible long-term effect on salinities and the associated ecosystems. Although somewhat counterintuitive, it is important to note that a larger diversion is in fact smaller when measuring the effect on balance of the estuarine system. For comparison's sake, consider that smaller diversions would require a much longer run time in order to get close to achieving similar sediment input results as the Recommended Plan. Longer runs could potentially disturb desirable estuarine salinity gradients and create conditions unfavorable to vital natural socioeconomic resources while also potentially creating favorable conditions for nuisance invasive plant species. There is also a limit on how big a diversion can be dictated by the conditions of the project area. At the Phoenix location, there is a limit on effectiveness of size because diversions larger than 35,000 cfs would exceed the containment capacity of the River aux Chenes ridges. The Recommended Plan is the optimization point between achieving project objectives and preserving estuarine balance.

The Recommended Plan is capable of achieving no-net-loss of marsh acreages during the period of analysis (2015–2065). Estimated total marsh acreage at the end of the period of analysis is estimated to be 59,000 acres with approximately 32,000 net acres of new marsh created from the primary operating regime. Further, the Recommended Plan is robust enough to achieve benefits through the period of analysis taking into account both the intermediate and high rates of relative sea level rise. The Recommended Plan is capable of achieving no-net-loss of marsh acres accounting for the intermediate relative sea level rise rate. In summary, the Recommended Plan has the potential to reverse the decline of marsh habitats occurring now and in the future within the project area and provides sustainability in the face of uncertainty surrounding relative sea level rise.

The Recommended Plan will restore degraded marsh habitat and impaired deltaic processes between the Mississippi River and River aux Chenes. This will be accomplished by reconnecting the study area to the supplies of freshwater, nutrients and sediment that have been isolated within the Mississippi River by the

MR&T levee. These benefits are represented by the 13,355 AAHUs expected from the Recommended Plan at an estimated fully funded cost of $387,620,000 (Appendix L).

3.7 PLAN SELECTION – RECOMMENDED PLAN

3.7.1 Budget and Reauthorization

Section 902 of the WRDA of 1986 legislates a maximum total project cost. Projects to which this limitation applies and for which increases in costs exceed the limitations established by Section 902 require further authorization by Congress raising the maximum cost established for the project. No funds may be obligated or expended nor any credit afforded that would result in the maximum cost being exceeded, unless the House and Senate committees on Appropriations have been notified that Section 106 of the Energy and Water Development Appropriations Act of 1997 will be utilized. The maximum project cost allowed by Section 902 includes the authorized cost (adjusted for inflation), the current cost of any studies, modifications, and actions authorized by the WRDA of 1986 or any later law, and 20 percent of the authorized cost (without adjustment for inflation).

The authorized cost for the MDWD project in WRDA 2007 is $86,100,000. After Section 902 guidance is applied, the adjusted budget (including inflation and adaptive management costs) of the project is $126,686,400, projected to April 2014 dollars. The first cost of construction estimate for the Recommended Plan is $365,201,000 and the fully funded Recommended Plan cost estimate is $387,620,000 (mid-point of construction).

In order to proceed to the next phases of the proposed project, including Preconstruction, Engineering and Design (PED) and construction, a Congressional reauthorization of the project that accounts for the increase in project costs must be implemented. This could either happen with the enactment of a new WRDA, perhaps as early as 2011, or with the enactment of other amending language that adjusts the project as authorized in WRDA 2007 to account for the increase in the construction cost estimate.

3.7.2 Components

This alternative involves construction of a structure capable of diverting up to 35,000 cfs which involves excavating a section of levee and constructing 10 each, sized 15 feet x 15 feet, box culverts with hydraulic operated sluice gates, replacing the roadway, and constructing an outfall channel to carry freshwater and sediment to the desired locations in the marsh. The plan also includes 31 acres of ridge and terrace creation and 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being excavated and reconfigured to convey freshwater, sediments, and nutrients. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area.

Table 3.17: Medium Diversion at White Ditch Authorized, Adjusted, and Recommended Plan Cost Table

Authorized cost in WRDA 2007 Title VII, Section 7006 (e)(3)(A):	**$86,100,000**
* Cost Index Used: EM 1110-2-1304 (Revised 31 Mar 2010)	CWBS Feature Code 15 Floodway Control & Diversion Structure
Cost Index Ratio: 1Q FY07 to 3Q FY14	**1.15**
** Current Project Cost Estimate: (Inflation applied from 10/2006 to 4/2014)	**$99,015,000**
20% of Authorized Cost:	**$17,220,000**
*** Monitoring & Adaptive Management: (per WRDA 2007 Section 2039)	$11,143,400 – $692,000 = **$10,451,400**
Maximum Cost Limited by Section 902 B:	$99,015,000 + $17,220,000 + $10,451,400 = **$126,686,400**
Recommended Plan cost	**$387,620,000**

Notes:

* The cost index applied to the current estimate through PED is derived from: EM 1110-2-1304, March 31, 2000, Civil Works Construction Cost Index System (CWCCIS).

** For the purposes of applying the Cost Index to the WRDA Authorized Cost, each project was adjusted for inflation from October 2006 price identified in WRDA 2007 to the mid-point of construction.

*** This is the cost of any modifications required by law. This is derived from section 8.0 of each projects Monitoring and Adaptive Management Plan minus the project monitoring cost found on the LCA Cost Summary Worksheet – October 2004 Price Levels modified study cost December 20, 2004.

3.7.3 Design, Environmental, and Construction Considerations

Major Project Considerations

- Ensure that stability of the Mississippi River Levee will not be compromised during construction.
- Continued access of LA 39, a major evacuation route, will be maintained during construction.
- Construction of the diversion will be done in accordance with industry standards.
- Construction of the channel conveyance systems will be done in accordance with industry standards.
- Ridge restoration features will make use of beneficial spoil from the channel conveyance systems and will be done in accordance with industry standards.
- Any excess spoil from the channel conveyance systems, beyond the ridge restoration features, will go into marsh creation. These marsh creation features will be built to industry standards.

3.7.4 Real Estate Requirements

The White Ditch study area is located in the Breton Sound estuary and covers the area extending north and south from just south of Belair, Louisiana to the coastline of Louisiana and extending east and west from the Mississippi River to River aux Chenes. This area extends about 50 km in the NW-SE directions and about 30 km in the SW-NE direction. Subsidence, erosion, channelization, saltwater intrusion, storm damage and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch study area resulting in extensive wetland loss and ecosystem degradation. There is an existing siphon at the mouth of White Ditch that was built in 1963 and has not been in operation since 1991, except for brief episodes.

This restoration project would reverse the trend of habitat degradation between the Mississippi River and the River Aux Chenes Ridges through Mississippi River re-introduction. This will be accomplished by re-connecting the Mississippi River to the study area through the use of a river diversion. The material obtained through deepening/widening of the outfall channel will be used to stabilize ridges on either side of the channel acting as containment. Dredge material will also be placed in strategic locations to build marsh. Any excess dredged material is to be used for beneficial marsh creation.

Although the White Ditch diversion would increase the frequency of inundation in the interior marshes during the March–April pulse, the project would not interfere with economically viable uses of the property. Therefore, flowage easements are not necessary within the project area. In addition, there is no acquisition of real estate interests proposed specifically to protect the benefits area of the project. Any activity that may have a detrimental effect to the benefits area of the project is regulated. Therefore, the risks over time would be minimal, aside from uncontrollable forces such as nature (hurricanes, etc.).

There is a total of 1,161.2 acres required for this project. The diversion structure will require approximately 7.2 acres. Approximately 317.7 acres are necessary for the dredging of channels and improvement/enhancement of associated channel ridges needed to maximize the conveyance of freshwater and sediment. Approximately 381 acres are required to accommodate marsh restoration efforts. Approximately 3 acres are needed to install notched weirs to redirect and restrict a certain level of flow entering surrounding marshlands from the freshwater diversion. The additional 452.3 acres is required for temporary work area. A more-detailed discussion regarding real estate requirements is in Appendix J, Real Estate Plan.

3.7.5 Operations and Maintenance Considerations

For purposes of analysis, it was assumed that the diversion would operate at maximum capacity during March–April with a 1,000 cfs “maintenance” flow for the remainder of the year. Although the Recommended Plan would be authorized to run up to 35,000 cfs during the March–April timeframe, it does not necessarily mean it always would. Additionally, the 1,000 cfs maintenance flow that is authorized from May–February does not mean that it would continuously operate at 1,000 cfs.

With the proposed diversion there will be needs for channel maintenance dredging and sluice gate maintenance. It is estimated that there will need to be significant channel dredging every 10 years on the proposed channel enhancement features. It is also assumed that there will be annual maintenance and lubrication needs provided to the sluice gates. The project is not anticipated to induce shoaling in the Mississippi River. However, if further analysis determines that the project increases maintenance

dredging requirements for the Mississippi River, Baton Rouge to the Gulf of Mexico Project by inducing shoaling, the incremental costs of any additional maintenance dredging would be a 100 percent non-Federal responsibility.

More-detailed information on the operations and maintenance of the proposed diversion can be found in the engineering Appendix L.

Table 3.18: O&MRRR Annualization

	Annualized Operations-Culver Operations & Gate Maintenance	Channel Maintenance Dredging Present Value	Rip Rap Replacement Present Value	Structural Rehabilitation Present Value	Annualized Cost of Present Value Components	Total Annualized O&MRRR
Location 3 – 5,000 CFS Box	**$27,138**	**$7,760,630**	**$6,151,522**	**$1,309,900**	**$754,666**	**$781,804**
Year 9		3,064,984	2,429,483			
Year 19		1,996,436	1,582,490			
Year 24				975,770		
Year 29		1,300,416	1,030,785			
Year 39		847,051	671,421			
Year 49		551,743	437,343	334,130		
Location 3 – 10,000 CFS Box	**$27,138**	**$9,418,113**	**$6,302,499**	**$1,309,900**	**$844,325**	**$871,463**
Year 9		3,719,591	2,489,110			
Year 19		2,422,826	1,621,329			
Year 24				975,770		
Year 29		1,578,154	1,056,083			
Year 39		1,027,961	687,900			
Year 49		669,582	448,077	334,130		
Location 3 – 15,000 CFS Box	**$50,003**	**$11,985,939**	**$6,372,738**	**$3,446,525**	**$1,081,040**	**$1,131,044**
Year 9		4,733,728	2,516,850			
Year 19		3,083,404	1,639,398			
Year 24				2,567,384		
Year 29		2,008,434	1,067,853			
Year 39		1,308,231	695,566			
Year 49		852,141	453,070	879,141		
Location 3 – 35,000 CFS Box	**$50,003**	**$18,403,436**	**$6,748,546**	**$3,446,525**	**$1,417,833**	**$1,467,836**
Year 9		7,268,256	2,665,272			
Year 19		4,734,316	1,736,075			
Year 24				2,567,384		
Year 29		3,083,787	1,130,826			
Year 39		2,008,683	736,585			
Year 49		1,308,394	479,788	879,141		

3.7.6 Monitoring Plan and Adaptive Management

For the Medium Diversion at White Ditch project, there are a number of uncertainties associated with ecosystem function and how the ecosystem components of interest will respond to the restoration project. In addition, there are associated uncertainties about the best design and operation for the project. Using an adaptive management approach during project planning provided a mechanism for building flexibility into project design and for providing new knowledge to better define anticipated ecological responses. This also enabled better selection of appropriate design and operating scenarios to meet the project objectives. Additionally, an adaptive management approach will help define project success and identify outcomes that should realistically be expected for the project.

In order to utilize an adaptive management approach throughout project implementation, an effective monitoring program will be required. Monitoring results will be used through an assessment process to determine whether the project outcomes are consistent with original project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project management, where periodic assessments are performed using monitoring data and reported back to the LCA Adaptive Management Planning Team. This team will review the assessment reports and make recommendations to the LCA Program Management Team for adaptive management actions. A carefully designed monitoring program is central component of the White Ditch diversion adaptive management program.

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 following discussion outlines key components of a monitoring plan that will support the LCA Medium Diversion at White Ditch Adaptive Management Program. The plan identifies performance measures along with desired outcomes and monitoring designs in relation to specific project goals and objectives. Additional monitoring is identified under Supporting Information Need to help further understand and corroborate project effects.

Objective 1: Maintain the current area of marsh habitat, of all types, that provide life requisite habitat conditions for native coastal marsh fish and wildlife.

Performance Measure: Habitat and land:water classification

Desired Outcome: Reduce the rate of land loss (10 year post-construction trend) compared to the pre-project condition (1985–2012).

Desired Outcome: Maintain and/or increase acreage of marsh habitats from pre-construction estimates (41,206 acres)

Monitoring Design: Habitats will be classified using Landsat TM scenes collected in 3 pre- and 10 post-project years and Digital Orthophoto Quadrangles for 1 pre- and 2 post-project years, as well as any available field data in the study area to assess land:water trends and habitat distribution.

Supporting Information Need: Finfish and shellfish status and trends will be assessed by increasing the number of LDWF finfish and shellfish sampling sites in the White Ditch project area.

Objective 2: Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained.

Performance Measure: Plant diversity and cover

Desired Outcome: Enhance floristic quality of marsh vegetation communities

Monitoring Design: Permanent vegetation monitoring stations will be established for assessing project area vegetation communities. These stations will be sampled 3 years prior to project completion to assess pre-project conditions and 10 years post-construction.

Supporting Information Need: Salinity and hydroperiod will be assessed by establishing nine hydrologic sites in project and reference areas

Risk Endpoint: Nutrient loading

Desired Outcome: Nutrient introductions do not contribute to reduced biomass of belowground plant material when compared to pre-construction estimates

Monitoring Design: Belowground biomass will be sampled quarterly at the nine vegetation sites. These stations will be sampled for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction. Nutrients (TN, Ammonia, Nitrate+Nitrite, TP), Metals, Agro-chemicals, and Dissolved Oxygen will be measured every 2 months in the immediate project outfall channel and at the nine hydrologic sites for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

Desired Outcome: Nutrient introductions do not contribute to expansion of floating aquatic vegetation (water hyacinth) in project area when compared to pre-construction estimates

Monitoring Design: The distribution of water hyacinth throughout the project area will be tracked by visual assessment of water hyacinth cover from overflights during summer.

Objective 3: Restore sediment inputs into the into the project area equivalent to an average of approximately 1,328,580 cubic yards of sediment per year.

Performance Measure: Annual sediment discharge

Desired Outcome: Deliver 1.328 million cubic yards (equivalent to 1.422 million tons) of sediment through the White Ditch diversion each year.

Monitoring Design: Hourly turbidity recorder will be deployed in the outfall channel and at nine hydrologic sites and correlated to TSS to investigate this measure. The sites will be measured for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

Performance Measures: accretion and subsidence

Desired Outcome: Maintain marsh elevation within tidal frame (relative sea level rise = 0 cm yr^{-1}).

Monitoring Design: SET/feldspar stations will be sampled at nine hydrologic sites for assessing project area accretion and marsh elevation changes for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

An Adaptive Management Program for the Medium Diversion at White Ditch project is needed to ensure the project achieves the desired outcomes. The Program will also facilitate coordination of projects within the LCA Program and coordination among PDTs, the LCA S&T, and LCA Program Management. The LCA Adaptive Management Planning Team will lead all LCA project and program adaptive management recommendations and actions. This team is responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision making process. If this team determines that adaptive management actions are needed, the team will coordinate a path forward with project planners and project managers. Other PDT members may be solicited as needed; for instance, if the adaptive management measure is operational, Operations and Hydraulics representatives might be asked to participate.

The costs associated with implementing these monitoring and adaptive management plans were estimated based on currently available data and information developed during plan formulation as part of the feasibility study. Because uncertainties remain as to the exact project features, monitoring elements, and adaptive management opportunities, the costs estimates will be need to be refined in PED during the

development of the detailed monitoring and adaptive management plans. The current total estimate for implementing the monitoring, assessment, and adaptive management program is $9,363,400. Costs to be incurred during PED and Construction include drafting of the detailed monitoring plan, monitoring site establishment and pre-construction and construction data acquisition to establish baseline conditions. Cost calculations for post construction monitoring were calculated for a 10-year (maximum) period post construction. If ecological success is determined earlier (prior to 10 years post construction), the monitoring program will cease and costs will decrease accordingly.

For further details on the Monitoring and Adaptive Management Plan, please refer to Appendix I.

3.7.7 Effectiveness of Recommended Plan in Meeting Goals and Objectives

The Recommended Plan is the most effective alternative at meeting the Goals and Objectives of the alternatives evaluated. It achieves no net loss of marsh acres and provides the requisite freshwater, nutrients and sediments to sustain them. The Recommended Plan restores the functional wetland building processes that have been impaired resulting in a degraded condition of the marsh. For each objective, the Recommended Plan achieves the following:

- *Maintain the current area of marsh habitat, of all types (41,206 acres) that provide life requisite habitat conditions for native coastal marsh fish and wildlife.*

  The Recommended Plan is capable of achieving no net loss of marsh acreages during the period of analysis (2015–2065) resulting in the maintenance of the current area of marsh habitat (41,206 acres). Estimated marsh acreage at the end of the period of analysis is estimated to be 48,000–73,000 acres, depending on the operating regime with approximately 60,000 total acres of marsh resulting from the primary operating regime (Figure 3.16). Further, the Recommended Plan is robust enough to achieve benefits through the period of analysis taking into account both the intermediate and high rates of Relative Sea Level Rise. The Recommended Plan is capable of achieving no net loss of marsh acres accounting for the intermediate Relative Sea Level Rise rate.

- *Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained.*

  Based on the availability of nutrient and freshwater supplies available in the Mississippi River in the vicinity of Recommended Plan's location (USGS Gages data) the Recommended Plan will provide adequate supplies of both to maintain current areas of marsh. The pulsed operation of the Recommended Plan will result in the maintenance of the overall distribution of marsh types within the study area.

- *Restore sediment inputs into the project area equivalent to an average of approximately 1,300,000 cubic yards of sediment per year.*

  The Recommended Plan is designed, relative to the sediment column in the Mississippi River, to capture sufficient sediments to achieve the required to offset the projected loss rate over the 50-year period of analysis.

3.7.8 Effectiveness of Recommended Plan in Meeting Environmental Operating Principles

The formulation of all of the alternatives considered for implementation was done in accordance with the Environmental Operating Principles.

3.7.9 Compensatory Mitigation Measures

The project will provide positive ecosystem benefits to the study area. Temporary negative marsh impacts associated with excavation of outfall canals and management structures will be compensated for by creation of new marsh of better quality as a result of the reintroduction of freshwater, nutrients and sediments into the study area. No mitigation measures are needed.

3.8 RISK AND UNCERTAINTY

3.8.1 Induced Shoaling

A complete qualitative analysis can be found in Appendix N. The diversion of significant quantities of river sediments and water typically leads to unintended consequences, in that the diverted water and sediment concentrations are not in the same proportion as in the river. The typical response is sedimentation and shoaling in the main river downstream of the diversion. In the receiving diversion channel, sedimentation or erosion could take place, depending on a variety of factors.

An additional consideration will be the sedimentation that may take place in interior distribution channels after the flow is diverted. The March–April discharge will be directed into marsh and open water areas and the portion of the diverted sediment load that is sand will settle quickly when the flow velocity decreases. If it is desired for the sand load to be carried well away from the diversion point, the diversion channel(s) must be carefully designed to maintain the velocity necessary to keep the sand load in suspension. Similarly, silts and clays will begin depositing as velocities approach zero, so the diversion channel design should minimize the creation of eddies or areas of low velocity.

The current operating plan for the Recommended Plan is limited to a diversion pulse of 35,000 cfs in March–April of each year during the normal high flow period of the Mississippi River and a diversion of 1,000 cfs the rest of the year. This flow rate may not be experienced over the full 60-day period. The proposed 35,000 cfs diversion will be the largest man-made diverted flow for wetland building on the Lower Mississippi River, but the 1- to 2-month duration will be a modifying factor. The diversion should approximate 5 percent or less of the main channel flow for most years. Although some deposition in the downstream channel could occur, the 1- or 2-month duration should result in minimal shoaling, especially in the navigation channel. Although the peak monthly sediment concentration normally occurs in March, the peak monthly water discharge occurs in April with high flows typically continuing into May and later. When the diversion is reduced to 1,000 cfs, some of this deposition could be resuspended by the Mississippi flow and carried on downstream in the following months. On an annual basis, the net gain in downstream deposition could be minimal. Specific sediment transport studies for the White Ditch Diversion are required to better address the amount of deposition expected. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative. Specific sediment transport studies to better address the amount of deposition expected will be conducted during PED. If further

analysis determines that the project increases maintenance dredging requirements for the Mississippi River, Baton Rouge to the Gulf of Mexico Project by inducing shoaling, the incremental costs of any additional maintenance dredging would be a 100 percent non-Federal responsibility.

3.8.2 Relative Sea Level Rise

An analysis of the high sea level rise scenario was conducted utilizing the ERDC-SAND2 model. The model was used to determine whether a net loss or gain of marsh acreage would occur assuming a high sea level rise scenario. Alternative 4 was the most effective at countering the effects of high sea level rise. Alternative 4 could maintain marsh acreage out to approximately year 20 of the analysis which was then quickly followed by a sharp decline and eventual collapse of the marsh and near total conversion to open water. This result was based on the March–April Pulse plus a 1,000 cfs maintenance flow the rest of the year. It should be noted however, that in the event high sea level rise became a reality, Alternative 4 alone has the capability (assuming an open diversion) to divert large enough quantities of freshwater, nutrients and sediments to overcome high sea level rise. While not publicly acceptable at present, if the collapse of the marsh within the study area was imminent, having the ability to respond accordingly with a year-round open diversion would be critical.

3.8.3 ERDC-SAND2 Model Background

The ERDC-SAND2 model was used to calculate acres of marsh created over the life of the project by predicting accretion rates across the project area. Several sites were initially considered for the proposed diversion; however, equivalent data for each site was not available. Ideally, data from each individual potential diversion site could have been used to make this prediction. In an attempt to fairly compare each site, the known water level data for the Mississippi River were taken from the Tarbert's Landing gage, which has daily records for the past 25 years. Sediment load data were obtained from the Belle Chasse gage site, which is very close to the project area and representative of that section of the river. Together, river level data and sediment load data were used to fairly and evenly compare one potential site to another. There is some uncertainty associated with not using site-specific data for the analysis. However the risk is minimal because the sediment data being used came from nearby stations and the site(s) that were selected, especially those of the Final Array, appear to occur in areas of higher sediment concentration than the location used in the model.

Verification of the ERDC-SAND2 model was conducted by simulating the effects of the freshwater diversions (siphons) at Naomi and West Pointe à la Hache, both of which began operating in 1993, and the larger Caernarvon Freshwater Diversion Project, which began operating in 1991. The model verification work and other work with the model indicates that it is most applicable in interior marsh systems. When applied to open bays or large lakes, it appears to substantially overestimate land-building. This may be related to resuspension and export of deposited sediments, a process the model does not address. The MDWD measures, however, are all generally interior locations which are handled well by the model. Unfortunately, no examples of freshwater introductions without sediment are available to verify the application of the ERDC-SAND2 model for nutrient-only situations.

The ERDC-SAND2 model uses the average water depth of the project area along with the sediment load introduced into the area from the river to project future acres of marsh created. If the assumed average water depth is greater or the introduced sediment load is less than what was assumed, a decrease in the projected benefits could occur. It is uncertain as to the accuracy of the average water depth or actual

sediment loads for the project area. The risk of encountering lower sediment loads than what was used in the ERDC-SAND2 calculation is minimal. In fact, it is likely that the site will encounter heavier sediment loads than what was used in the model due to the location selected. This would in turn likely increase project benefits. For more information surrounding the ERDC-SAND2 equations used, see Appendix L.

3.8.4 Real Estate

Although the White Ditch diversion would increase the frequency of inundation in the interior marshes during the March–April pulse, the project would not interfere with economically viable uses of the property. The benefited area consists of low-lying marsh and shallow open water accessible only by boat and vulnerable to tidal surges. The area was once subject to inundation by the Mississippi River during spring high-water events, until levees were constructed along the river by the Mississippi River and Tributaries project. The White Ditch diversion is formulated to mimic these natural, land-building flood events by reintroducing freshwater, sediment and nutrients to the marshes in the project area. Over the 50-year period of analysis, the project is anticipated to prevent the loss of approximately 13,750 acres of emergent marsh in the project area and could potentially lead to a net gain in marsh acres. Economically viable uses of the private property in the project area include recreational and commercial fishing and hunting, as well as alligator farming. These uses are likely to be enhanced through operation of the diversion because it will improve fish and wildlife values in the benefited area. All existing viable uses of the marshlands are not expected to be detrimentally affected by the periodic change in water elevation. Therefore, flowage easements are not necessary within the project area.

The benefited area of the White Ditch diversion is approximately 98,000 acres, nearly all of which is marshlands. Any activity that may have a detrimental effect to the benefits area of the project is regulated. Therefore, the risks over time would be minimal, aside from uncontrollable forces such as nature (hurricanes, etc.). The types of activities that could be considered risks (oil/gas surface exploration, excavation and fill activities, etc.) are currently regulated by the Louisiana Department of Natural Resources, Office of Coastal Management, under Title 43, Chapter 7 of the Louisiana Administrative Code. Specifically, Subchapter C, Section 723.A.2 requires permits for dredging or filling, urban developments, energy development activity(exploration and transmission of oil/gas), mining activities(surface & subsurface), surface water control, shoreline modification, recreational developments, industrial development, drainage projects and “any other activities or projects that would require a permit or other form of consent or authorization from the U.S. Army Corps of Engineers, the Environmental Protection Agency, or the Louisiana Department or Natural Resources.” Additionally, activities in the marshes (wetlands) are regulated by Section 404 of the Clean Water Act under the purview of the USACE. Certain other activities are regulated by the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the U.S. EPA, and the Louisiana Department of Environmental Quality.

More-detailed information regarding real estate is in Appendix J, Real Estate Plan.

3.8.5 Sediment Modeling

Sediment modeling of the Mississippi River was not conducted as part of this study due to time constraints. Modeling is anticipated as part of PED to refine the diversion orientation and determine whether intake structures would benefit the project. The uncertainty associated with the project outputs in the absence of this information is small. The information used in the ERDC-Sand2 Model came from data obtained from the Belle Chasse station, which represented the longest continuous dataset from a nearby

location. When comparing the ERDC-Sand2 Model inputs to data that have been collected within the project area, it is seen that the program's estimates are conservative. Data collected by the USGS in the outfall canal of the existing White Ditch Siphon suggests that more sediment is available to enter into the project area than represented by the Belle Chasse Data. Using the Belle Chasse Data, it is expected that the Recommended Plan will deliver approximately 16,600 ton of sediment per day into the project area during the March–April Pulse. Using the USGS sediment loads and the same pulse operation, approximately 17,900 tons of sediment per day could enter the project area. This results in a potential 8% increase in sediment loads from what are currently being projected.

Current research being done by the University of Texas in conjunction with the State of Louisiana also suggests that there will be further increased sediment concentrations specifically at the Phoenix site. The Phoenix location of the Recommended Plan was selected because there is a "back-current" in flows on the Mississippi River. This will enhance the amount of sediment available in the area of the diversion as the back-current will continually pull sediments into the diversion.

All available information points to the proposed location as a suitable location to capture Mississippi River Sediments. However this will be evaluated further during the PED phase.

3.8.6 Reauthorization

The Recommended Plan for this project exceeds the cost authorization presented in the 2004 LCA Report. The Recommended Plan exceeds the maximum project cost authorized in section 7006(e)(3) of the WRDA 2007. The District Commander recommends seeking additional authorization in order to construct the Recommended Plan/NER plan; however, the need to request additional authorization has the potential to impact the project construction schedule.

3.8.7 Other Diversions

Some uncertainty exists as to the potential for future diversion on the Mississippi River to come online during the period of analysis for the White Ditch Project. To the extent possible based on the available information, the alternatives were formulated so as to produce benefits independent of other diversions. However, as other regional diversions are planned or come online, operational coordination will need to occur not only with White Ditch but in a systemic fashion. Joint operation of the proposed White Ditch Diversion with the existing Caernarvon Diversion would be key to maintaining the condition of the overall Breton Sound ecosystem. These two projects should not be operated independently of one another. Modeling results and monitoring data suggests that Caernarvon has the ability to substantially freshen the Breton Sound even without freshwater inputs from another source. In order for Breton Sound salinities to rebound after the March–April pulse from the White Ditch Diversion, flow from Caernarvon would have to be closely controlled. This will mean a change to the current operational plan. It will be crucial that future modeling during PED for White Ditch and during Feasibility for the LCA Modification to Caernarvon investigate joint operation. The LCA 4 Modification to Caernarvon will consider and account for the proposed Medium Diversion at White Ditch project during its analysis. Additionally the existing and proposed operational plans for both White Ditch and Caernarvon are subject to refinement based on any newly acquired data. If significant changes are required, these would be properly disclosed to the public and additional NEPA documents prepared as appropriate.

3.8.8 Water Quality

In preparation of the Water Quality sections, the best available data was used to characterize existing conditions, and best professional judgment was used to predict the project's impacts. During PED, more data will be collected in receiving basin. Water quality parameters will be modeled as part of the hydrologic modeling effort conducted during the PED phase. If the results of these modeling efforts suggest that the project's water quality impacts will differ from those currently anticipated, then a supplemental NEPA document may be prepared as appropriate. If further analysis during PED indicates that the project is likely to have significant adverse impacts to water quality, then the project's features and/or operation will be refined to mitigate the adverse impacts to the fullest extent possible, consistent with the project's overall goals of creating marsh and restoring natural deltaic processes. The project will also be adaptively managed post-construction to maximize the project's ability to meet its goals and objectives and minimize adverse impacts. Appendix I details the Water Quality monitoring that would occur pre- and post-project implementation.

3.8.9 Fisheries

In preparation of the Fisheries sections, the best available data was used to characterize existing conditions and best professional judgment was used to predict the project's impacts. During PED, an aquatic model will be used to further analyze the project's potential impacts on fisheries resources. If the results of the modeling effort suggest that the project's impacts will differ from those currently anticipated, then a supplemental NEPA document may be prepared as appropriate. Although maximizing productivity of fisheries is not an objective of the project, fish populations may be monitored before and after project completion if additional aquatic modeling suggests this is warranted. If further analysis during PED indicates that the project is likely to have significant adverse impacts to fisheries resources, then the project's features and/or operation will be refined to mitigate the adverse impacts to the fullest extent possible, consistent with the project's overall goals of creating marsh and restoring natural deltaic processes. The project will also be adaptively managed post-construction to maximize the project's ability to meet its goals and objectives and minimize adverse impacts.

3.9 IMPLEMENTATION REQUIREMENTS

3.9.1 Milestone Schedule

Milestones	Schedule
Final Report	August 2010
Division Engineer Notice	August 2010
Washington Level Review	August 2010
State and Agency Review	October 2010
Execute Cost-Sharing Agreement for PED	November 2010
Chief of Engineers Report	November 2010
Begin Preconstruction Engineering and Design	2010
ASA and OMB Review	2011
ASA Report to Congress	2011
Execute PPA	November 2011

Milestones	Schedule
Receive Reauthorization from WRDA 2011**	November 2011
Request Construction Funding per Reauthorization**	November 2011
Complete Design Documentation Report	June 2012
Complete Plans and Specifications	July 2012
Complete Real Estate Acquisition	July 2012
Advertise Construction	August–September 2013
Start Construction	November 2013
Complete Construction	November 2016
Turnover Project to Local Sponsor	2016
Initiate Monitoring and Adaptive Management	During PED
Complete Monitoring and Adaptive Management	2026

3.9.2 Implementation Responsibilities

The non-Federal sponsor shall, prior to implementation, agree to perform all of the local cooperation requirements and non-Federal obligations. Local cooperation requirements and non-Federal sponsor obligations include, but are not necessarily limited to:

a. Provide a minimum of 35 percent of total project costs as further specified below:

   (1) Enter into an agreement which provides, prior to execution of the project partnership agreement, 25 percent of design costs;

   (2) Provide, during the first year of construction, any additional funds needed to cover the non-Federal share of design costs;

   (3) 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 improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material that the Government determines to be necessary for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project;

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

b. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project;

c. Not use funds provided by a Federal agency under any other Federal program, to satisfy, in whole or in part, the non-Federal share of the cost of the project unless the Federal agency that provides the funds determines that the funds are authorized to be used to carry out the study or project;

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

e. For as long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the project, or functional portions of the project, including mitigation, 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;

f. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-Federal sponsor of responsibility to meet the non-Federal sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

g. Hold and save the United States 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 United States or its contractors;

h. 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), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, periodic nourishment, 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 investigations 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;

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

j. Agree that, as between the Federal Government and the non-Federal sponsor, 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, and repair the project in a manner that would not cause liability to arise under CERCLA;

k. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstruction or encroachments) which might reduce ecosystem restoration benefits, hinder operation and maintenance, or interfere with the project's proper function, such as any new developments on project lands or the addition of facilities which would degrade the benefits of the project;

l. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as would properly reflect total costs of construction of the project, 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 Code of Federal Regulations (CFR) Section 33.20;

m. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213), which provides that the Secretary of the Army shall not commence the 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;

n. 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, as well as Army Regulation 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 and 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.); and

o. 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 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

3.9.3 Cost Sharing

The State of Louisiana, acting through the CPRA, will be the non-Federal sponsor for the LCA MDWD project. In November 2008, the USACE and CPRA executed a single Feasibility Cost-Share Agreement covering six Louisiana Coastal Area near-term plan elements listed in Section 7006(e) of the Water Resources Development Act of 2007. The six features each underwent a separate feasibility analysis and environmental compliance analysis culminating in a single master feasibility document. The cost-share during the feasibility phase was 50% Federal and 50% non-Federal, however, the individual elements have been divided so that each entity has lead responsibility for preparing three of the six report components. At the end of the feasibility phase the total cost for all elements will have been shared on a 50/50 basis, yet for work on each individual element during the feasibility phase the ratio of funds expended by either the Federal or non-Federal sponsor will be higher depending upon their level of responsibility. The Corps has the technical planning lead for this particular LCA project element. Following the feasibility phase, the cost share for the planning, design and construction of the project will be 65% Federal and 35% non-Federal. The CPRA must provide all lands, easements, rights-of-way, utility or public facility relocations, and disposal areas (LERRDs) required for the project. Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) of the project would be a 100%

CPRA responsibility. Additionally, project monitoring and any Adaptive Management deemed necessary will be cost shared at 65/35 for the first 10 years of the project life.

Under current law, authority for the non-Federal sponsor to receive credit for construction activities is limited. Section 7007(a) of WRDA 2007 authorizes the Secretary to credit, "toward the non-Federal share of the cost of a study or project under this title the cost of work carried out in the coastal Louisiana ecosystem by the non-Federal interest for the project before the date of the execution of the partnership agreement for the study or project." In addition, section 7007(a) incorporates the requirement of section 221 of the Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) that the Government and non-Federal sponsor must enter into a separate agreement for any work that will be carried out prior to execution of the partnership agreement. In other words, work undertaken by the non-Federal sponsor prior to (but not after) execution of the project partnership agreement (PPA) is eligible for credit subject to execution of a separate agreement covering such work before it is undertaken. For design work that the non-Federal sponsor proposes to undertake, the Design Agreement will serve as the required separate agreement. For construction work that the non-Federal sponsor proposes to undertake, an In-Kind Memorandum of Understanding will be required. Opportunities to enter into an In-Kind MOU for construction activities will depend on the schedule for entering into the PPA for a project.

Section 7007(d) provides that credit afforded under section 7007 that is in "excess" of the non-Federal cost share for a study or project authorized in Title VII of the Water Resources Development Act of 2007 may be applied toward the non-Federal cost share of any other study or project under that title. "Excess" credit will be applied only toward another study or project involving the same sponsor. In addition, "excess" credit will be applied within project phases (i.e., study to study, design to design, and construction to construction). At this time, it is anticipated that that there are limited opportunities for the application of "excess credit" from other Title VII projects toward these projects.

Table 3.19 provides the distribution of costs for the fully funded project cost estimate. The fully funded cost of implementing the Recommended Plan is estimated to be $387,620,000 (Engineering Appendix L). The Federal Government would provide 65% of the first cost of implementing the Recommended Plan including PED, construction, and construction management, which is estimated to total $251,953,000. The State of Louisiana would be responsible for providing 35% of the First Cost of implementing the Recommended Plan. The 35% share of the project cost includes the State of Louisiana's responsibility for providing all LERRDs. The estimated costs are $135,667,000 in cash with $508,000 in LERRD credit.

The State of Louisiana also would be responsible for OMRR&R of project features. The operation and maintenance costs are anticipated to be minimal over the 50-year period of analysis at an average annual cost of $1,467,836.

3.9.4 Environmental Commitments

Mitigation measures are proposed to avoid or minimize impacts that would otherwise occur as a result of the implementation of the preferred alternative. These environmental and related commitments would be implemented by construction contractors or management authorities. Some commitments, such as monitoring or adaptive management would continue beyond completion of construction of facilities.

Table 3.19: Cost Sharing

Project Feature	Total Cost	Non-Federal		Federal	
		%	Cost	%	Cost
Total first cost of construction[1]	$365,201,000	35	$127,820,000	65	$237,381,000
LERRD credit	$494,000	100	$494,000	0	$0
Monitoring & adaptive management	$11,143,000	35	$3,900,000	65	$7,243,000
OMRR&R[2]	$1,468,000	100	$1,468,000	0	$0

[1] Total first cost of construction is based on the sum of the PED; construction management (i.e., supervision and administration); LERRDs; and monitoring and adaptive management and is based on October 2010 price levels.

[2] Average annual cost based on October 2010 price levels.

Throughout the planning process, efforts have been made to avoid impacts to the extent practicable. If avoidance could not be achieved, mitigation measures were developed to reduce the magnitude and extent of the impact. The Recommended Plan would impact approximately 277 acres of intermediate marsh and 363 acres of shallow open water for construction of the diversion. Approximately 223 acres of intermediate marsh and shallow open water would be excavated for the outfall channel. However, creation of approximately 385 acres of intermediate marsh habitat, nourishment of 35,000 cumulative acres of emergent marsh habitat, and creation of 31 acres of ridge habitat would mitigate for wetland impacts resulting from construction activities.

Best management practices would be included in construction specifications and they would be employed during construction activities to minimize environmental effects. Many of these best management measures are required by Federal, State, or local laws and regulations, regardless of whether they are specifically identified in this document or not. Project implementation would comply with all relevant Federal, State, and local laws, ordinances, regulations, and standards during the implementation of the preferred alternative. Implementation of the environmental commitments would be documented to track execution and completion of the environmental commitments.

Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the USACE for the PED Phase. At this time a SOW is being developed as part of the Donaldsonville to the Gulf project to look a various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project.

A summary of the environmental and related commitments made during the planning process and incorporated into the proposed project plan include the following:

- Ensure construction contractors limit ground disturbance to the smallest extent feasible.
- Use accepted erosion control measures during construction.

- Conduct a search for bald eagle, other raptors and colonial nesting wading bird active nests within three-quarters of a mile from proposed disturbance activities prior to construction. Appropriate protective measures and no-work distance restrictions would be implemented to avoid or minimize nest disturbance if active nests are identified
- Contact pipeline and gas well companies prior to construction activities to identify and avoid existing hazards.
- Implement best management practices and measures contained in erosion control guidelines to control soil erosion from construction areas.
- Implement measures to control fugitive dust during construction.
- Implement a program to compensate for losses of archaeological sites (if any) that would occur as a result of construction and operation of the proposed project.
- Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the USACE for the PED Phase. At this time a SOW is being developed as part of the Donaldsonville to the Gulf project to look at various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project.
- An operating plan will be developed based on a maximum of a 2-month pulse. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.
- The USACE will follow the "Reasonable and Prudent Measures" and "Terms and Conditions" as described in the USFWS Biological Opinion for Pallid sturgeon which can be found in Appendix A and summarized in Section 5.11.5. The USACE is aware that the reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take (i.e., the habitat acreage amount described herein) is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take shall cease pending reinitiation.

3.9.5 Financial Requirements

3.9.5.1 Sponsorship Agreement

Prior to the start of construction, the State of Louisiana will be required to enter into a Project Partnership Agreement (PPA) with the Federal Government and satisfy State laws and all applicable regulations. In general, the items included in the PPA have been outlined in the previous paragraphs.

3.9.5.2 Financial Requirements

It is expected that the CPRA will have the capacity to provide the required local cooperation for the Recommended Plan. A project schedule and cost estimate will be provided to the CPRA so that it may develop a financing plan. A standard cost share percentage of 65% Federal and 35% non-Federal would be applied to the total first cost of the project. The 35% share of the project cost includes the State of Louisiana's responsibility for providing all LERRDs.

Section 7007(b) of WRDA 2007 provides that "The non-Federal interest may use, and the Secretary shall accept, funds provided by a Federal agency under any other Federal program, to satisfy, in whole or part, the non-Federal share of the cost of the study or project if the Federal agency that provides the funds determines that the funds are authorized to carry out the study or project." If the Mineral Management Services determines in writing that funds it provides to the non- Federal sponsor under the Energy Policy Act of 2005 (Coastal Impact Assistance Program - CIAP) and the Gulf of Mexico Energy Security Act of 2006 (GOMESA) are authorized to be used to carry out the Medium Diversion at White Ditch project, the non-Federal sponsor can use those funds toward satisfying its local cooperation for the project, including the non-Federal sponsor's acquisition of Lands, Easements, Relocations, Rights of-way and Disposals (LERRDs) required for the project.

By letters dated July 2, 2009, and December 18, 2009, the Minerals Management Service and the USACE established a process for the Minerals Management Service to provide its written determination regarding the acceptability of the use of CIAP funds for LCA studies, projects, and programs. That process provides that the Minerals Management Services' written determination for a specific study, project, or program will take the form of the grant award document for that activity.

3.9.5.3 Local Cooperation

The CPRA provided a letter of intent to serve as the non-Federal sponsor for the project on August 9, 2010. A copy of the letter can be found in Attachment 2.

3.9.5.4 Project Management Plan

A Project Management Plan (PMP) for implementation of the Recommended Plan will be prepared. The PMP will describe activities, responsibilities, schedules, and costs required for the Plans and Specifications phase and construction of the project. The Plans and Specifications phase will last for an estimated 24 months at a total cost of $36,980,000.

3.9.5.5 Procedures for Project Implementation

Under the 2007 WRDA Section 7006, the LCA program has authority for feasibility-level reports of six near-term critical restoration features. Project construction is contingent upon a favorable Chief's report by December 31, 2010. The excerpt below from WRDA outlines the project authority for this report for the Medium Diversion at White Ditch project.

SEC. 7006. CONSTRUCTION.

(3) PROJECTS SUBJECT TO REPORTS.-

. . .

(B) CONSTRUCTION.-The Secretary may carry out the projects under subparagraph (A) substantially in accordance with the plans and subject to the conditions, recommended in a final report of the Chief of Engineers if a favorable report of the Chief is completed by not later than December 31, 2010.

. . .

The Recommended Plan for the Medium Diversion at White Ditch project exceeds its total authorized cost authorized under Section 7006(e)(3)(A)(v) of WRDA 2007 and Section 902 of WRDA 1986 as amended. As such, additional authority must be enacted to enable the Recommended Plan to be carried out with these increased costs. Future actions necessary for project approval and implementation are summarized as follows:

1. The U.S. Army Corps of Engineers Mississippi Valley Division Commander will review the final report and then issue a public notice announcing completion of the final report. This is referred to as the Division Engineer's Notice, or DE's Notice.

2. The report will then be submitted to Headquarters, U.S. Army Corps of Engineers (HQUSACE), and the Office of the Assistant Secretary of the Army for Civil Works (ASA (CW)) for concurrent Washington level review.

3. The 30-day State and agency review and coordination of the EIS will be ongoing concurrently during the HQUSACE review.

4. Concurrent Washington level review by HQUSACE and ASA(CW) will conclude with a HQUSACE staff assessment, the 30-day State and agency review, review input by the ASA(CW), HQUSACE final assessment, a field visit and meeting, if necessary, and the documentation of report review prepared by HQUSACE.

5. The Washington level decision-making process will follow the decision-making sequence of HQUSACE and ASA(CW), once the documentation of report review has been completed. There will be a briefing, if necessary, for the Designated Senior Representatives of Decision-Makers to resolve any outstanding issues. The Chief of Engineers will provide his recommendations on the report to the ASA(CW), who will provide the report and proposed recommendations to the Office of Management and Budget (OMB) to obtain their views and comments on whether the proposed recommendations are consistent with Administrative policies. Prior to the transmittal of the report to the Congress, the Non-Federal Sponsor, the State of Louisiana, interested Federal agencies, and other parties will be advised of any significant modifications made to the recommendations and will be afforded an opportunity to comment further.

6. The report will then be transmitted to Congress for project authorization with the Chief of Engineer's report, ASA(CW) report, State and agency comments, and Office of Management and Budget comments.

7. Congress will have to enact law to increase the authorized cost of the project.

8. Funds could be provided, when appropriated in the budget, for Preconstruction Engineering and Design (PED) upon issuance of the Division Engineer's public notice, announcing the completion of the final report and pending project funding authorization. A Design Cooperation Agreement will need to be developed and executed between the Federal Government and the State of Louisiana, whereby the sponsor will provide 25% of the cost of PED studies.

9. The U.S. Army Corps of Engineers will complete final design and plans and specifications for project construction.

10. Subsequent to appropriation of construction funds by Congress, formal assurances of local cooperation in the form of a Project Partnership Agreement (PPA) will be required from the State of Louisiana.

11. The State of Louisiana will be required to provide all real estate requirements for project implementation.

12. Bids for construction will be advertised and contracts awarded.

13. Upon completion of construction, the Corps' acceptance from the contractor and notice of construction completion for the project (or a functional portion of the project) to the non-Federal sponsor will proceed or be concurrent with the delivery of an O&M manual and as-built drawings. The State of Louisiana will be responsible for OMRR&R of the project in accordance with guidelines provided by the U.S. Army Corps of Engineers.

3.9.6 Views of Non-Federal Sponsor

CPRA, the non-Federal sponsor, has expressed the desire for implementing the LCA MDWD project and sponsoring the project construction in accordance with the items of local cooperation that are set forth in the recommendations chapter of this report. In addition, CPRA supports the NER/Recommended Plan since this plan has the greatest potential to restore the study area to historic conditions for marsh acreage in addition to being able to offset effects from the range of potential sea-level rise. The plan is also cost-effective and provides the most benefits of all the best-buy plans in the final array. However, due to authorized cost limitations in WRDA 2007, the project may require additional Congressional authorization to increase funding and allow the implementation of the NER/Recommended Plan to fully address the ecosystem needs identified in this report.

The State of Louisiana fully supports the project. The state recognizes that the USACE's position is that Section 7007 does not authorize credit for work carried out after the date of a partnership agreement. However, the State disagrees with the USACE's position and intends to continue to seek a change in law that would allow in-kind contribution credit for work carried out after the date of a Project Partnership Agreement and that would allow for such in-kind contributions credit to carry over between LCA Program components (i.e., "excess" credit for work undertaken after signing of the project partnership agreement for one project may be carried over for credit to another project). Nevertheless, while the State is of the opinion that its view is consistent with the authority and Congressional intent under WRDA 2007, the State fully intends to proceed with the project under the Corp's interpretation of current law and to meet all non-Federal financial and other obligations outlined by the USACE in this report until such time as the law is changed.

4.0 AFFECTED ENVIRONMENT

This chapter describes the climate, geomorphic and physiographic setting, and the historic and existing conditions for the following important resources: soils; coastal vegetation; wildlife; fisheries; plankton; benthos; essential fish habitat (EFH); threatened and endangered species; hydrology (including flow and water levels, and sediment); water quality; recreation; public lands; cultural and historic resources; aesthetics; air quality; socioeconomic and human resources (including population; infrastructure; employment and income; navigation; oil, gas, and utilities; pipelines; commercial fisheries; oyster leases; and flood control and hurricane protection). In addition, the characterization of noise and hazardous, toxic, and radioactive waste (HTRW) in the project area are presented.

A resource is considered important if it is recognized by statutory authorities including laws, regulations, Executive Orders (EO), policies, rules, or guidance; if it is recognized as important by some segment of the general public; or if it is determined to be important based on technical or scientific criteria. The following sections discuss historic and existing conditions of each important resource occurring within the project area.

4.1 ENVIRONMENTAL SETTING OF STUDY AREA

The MDWD project study area is located in LCA Subprovince 1, and comprises part of the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana. Plaquemines Parish is located within the Central Gulf Coastal Plain in southeastern coastal Louisiana. The parish encompasses the current delta of the Mississippi River, which was built up from alluvial silt deposited over centuries when the river was levee-free and overflowed its banks. Elevations range from sea level along the Gulf Coast, to approximately +15 feet above sea level along levee ridges. The project area is located within the Mississippi River Deltaic Plain, with the Mississippi River acting as the primary influence on geomorphic processes in the delta region.

4.1.1 Location

The boundary of the project study area encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the Forty-Arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the beneficial effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound Basin.

4.1.2 Climate

The climate of the project area is subtropical marine with long humid summers and short moderate winters. The climate is strongly influenced by the water surface of many sounds, bays, lakes and the Gulf of Mexico and seasonal changes in atmospheric circulation. During the fall and winter, the study area experiences cold continental air masses which produce frontal passages with temperature drops. During

the spring and summer, the study area experiences tropical air masses which produce a warm, moist airflow conducive to thunderstorm development (LACPR 2008).

The study area is also subject to periods of drought, flood, tropical waves, tropical depressions, tropical storms and hurricanes. These weather systems can cause considerable property and environmental damage and loss of human life. Historical data from 1899 to 2007 indicate that 30 hurricanes and 41 tropical storms have made landfall along the Louisiana coastline (NOAA 2009). The largest recent hurricanes were Katrina and Rita in 2005, which caused considerable damage in the study area. Hurricane Gustav, while much smaller and less intense, caused additional damage in the study area. Hurricane Ike, which made landfall in Galveston, Texas in 2008, caused flooding and wind damage in coastal areas as it passed the Louisiana Coast.

Average annual temperature in the area is 67° (F), with monthly temperatures varying from the mid-90°s (F) in July and August, to the mid-30°s (F) in January and February. Average annual precipitation is 57.0 inches, varying from a monthly average of 7.5 inches in July, to an average of 3.5 inches in October.

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level.

4.1.3 Geomorphic and Physiographic Setting

The project study area is located within the Plaquemines-Balize delta complex, one of six such complexes that make up the Mississippi River Deltaic Plain. The primary geomorphic influence in this region is the natural hydrologic process referred to as the delta cycle. The delta cycle is a dynamic and episodic process alternating between periods of seaward progradation of deltas (regressive deposition) and the subsequent landward retreat of deltaic headlands as deltas are abandoned, reworked, and submerged by marine waters (transgressive deposition). The Plaquemines-Balize complex is in the latter phase of the cycle. More detailed information on the delta cycle was provided in the LCA Final Programmatic Environmental Impact Statement (FPEIS).

4.2 SIGNIFICANT RESOURCES

4.2.1 Soils and Waterbottoms

This resource is institutionally significant because of the Council on Environmental Quality (CEQ) memorandum of August 11, 1980, entitled, “Analysis of Impacts on Prime or Unique Agricultural Lands in Implementing the National Environmental Policy Act (NEPA);” Executive Order 11990 – Protection of Wetlands; and the Agriculture and Food Act of 1981 (Public Law 97-98) containing the Farmland Protection Policy Act (P.L. 97-98; 7 U.S.C. 4201 *et seq.*). Coastal land loss is directly and inextricably linked to the five factors of soil formation (parent material; climate; plants and other organisms; relief; and time). These factors are discussed in detail in the FPEIS for the 2004 LCA report.

4.2.1.1 Soils and Waterbottoms

4.2.1.1.1 Historic Conditions

The soils in the Louisiana coastal zone formed in either alluvial sediments or loess, and many have accumulations of organic material in the upper part. Some soils are organic throughout, and some, nearest to the coast, formed in marine sediments. Deltaic processes have played a significant role in the types of soil present in the project area. The dynamic and episodic deltaic building processes alternates between periods of seaward progradation of deltas (regressive deposition) and the subsequent landward retreat of deltaic headlands as deltas are abandoned, reworked, and submerged by marine waters (transgressive deposition). The types of soils present today in much of the project area are characterized by the depositional environments associated with both of these phases of the deltaic cycle.

4.2.1.1.2 Existing Conditions

The feasibility report for the White's Ditch Diversion Siphon Outfall Management Plan (United States Department of Agriculture, Soil Conservation Services (USDA-SCS, 1992)) noted that there are several different soils mapped in the project area. These are Commerce, Sharkey, Clovelly, Lafitte, and Gentilly. Commerce and Sharkey soils are poorly drained, firm mineral soils formed in loamy or clayey alluvium. Gentilly soils are very poorly drained, very slowly permeable, semi-fluid, mineral soils formed in clay alluvium. Clovelly and Lafitte soils are both level, very poorly drained, semi-fluid, organic soils formed in accumulation of herbaceous plant material in brackish marshes. The Commerce and Sharkey soil series are classified as prime farmland soils where rarely flooded and adequately drained, while the Gentilly, Clovelly, and Lafitte soil series are classified as hydric soils.

4.2.2 Hydrology

This resource is institutionally important because of the Clean Water Act of 1977 (CWA), as amended. The Mississippi River is technically important because it provides habitat for various species of wildlife, finfish and shellfish. The Mississippi River is publicly important because of its use as a major navigational channel and it recreational use for fishing, boating and bird watching.

4.2.2.1 Flow and Water Levels

4.2.2.1.1 Historic Conditions

Over geologic history, the course of the Mississippi River has changed several times through the delta-switching process. Formation of a new delta lobe occurred roughly once every 1,000 years in response to changes in the flow path of the Mississippi River into the Gulf over the past 5,000-6,000 years; the modern delta consequently consists of smaller delta complexes formed over the past 8,000 years (Fisk 1944; Frazier 1967; Penland and Boyd, 1985; Autin et al., 1991, Saucier 1994). Major distributaries over this period have included Bayous Lafourche, Terrebonne, Des Families, Barataria, and to a lesser extent, the Atchafalaya River (USACE 2000).

Historically, the Lower Mississippi River was prone to frequent spring floods that caused catastrophic damage and loss of life post-settlement (Davis 1993, USACE 2009). Federal flood control and navigation measures that began in earnest with the authorization of the MR&T Project by the Flood Control Act of 1928 have since regulated the river's stage and flow and mitigated damage (USACE 2009). These actions

have channelized the Lower Mississippi River and prevented the abandonment of the current flow path. Operation of the Old River Control Structure (ORCS) has strictly regulated Mississippi River flows since 1977 to prevent capture by the Atchafalaya River: 30 percent of flows are allocated to the Atchafalaya and 70 percent to the Mississippi River (USACE 2009).

4.2.2.1.2 Existing Conditions

The MDWD project area is part of the Breton Sound estuary system. The Breton Sound estuary is located in southeastern Louisiana, and is bounded on the west by the Mississippi River, on the north by Bayou la Loutre, on the east by the south bank of the Mississippi River-Gulf Outlet (MRGO), and on the south by Baptiste Collette Bayou and Breton Island. The estuary consists of about 430 square miles of fresh and brackish coastal wetlands that comprises shallow-water ponds, lakes, bays, and a man-made canal system. Major natural streamcourses within the estuary are the Oak River (also known as River aux Chenes) and Bayou Terra aux Boeufs. These functioned as distributary channels of the Mississippi River into the estuary prior to construction of the MR&T mainstem levee. Other large water bodies are Big Mar, Lake Leary, Spanish Lake, Grand Lake, and Little Lake.

Flood control measures and flow management have resulted in relatively consistent flows and water levels in the Lower Mississippi River from 1978 to present in the study area. The flow and water level of the Lower Mississippi River are directly related and exhibit a seasonal pattern that is presumably linked to snowmelt runoff and spring rains. High flows and water levels are characteristic of spring months (March 1–May 31), while low flows and low water levels are typical from mid-summer to mid-fall (August 16–November 15). Based on USGS data from their Tarberts Landing gage from 1978 to 2008, the average annual, spring, and summer–fall discharge rates are 566,123 + 306,846; 813,333 + 283,377; and 283,925 + 113,984 cfs (Mean + SD), respectively. Stage and flow are more variable in the spring than summer–fall months.

Other factors influencing the stage and flow of the Lower Mississippi River in the study area are astronomical and meteorological tides, which have the greatest effect during periods of low stage and flow (USACE 2000). Astronomical tides have been observed as far upstream as the head of ship navigation in Baton Rouge, Louisiana. Strong south and southeasterly winds can cause rapid rise and northwesterly winds rapid decline in the river's stage (USACE, 2000). Seasonally, tides tend to be highest in late summer through mid fall (August–November) and lowest in the winter and early spring (December–March). Storm surges can also raise tidal levels in the summer and fall months. These levels can vary greatly depending on the strength and location of the storm.

4.2.2.2 Sedimentation and Erosion

4.2.2.2.1 Historic Conditions

Prior to development of the current mainstem Mississippi River levee system in the mid-twentieth century, seasonal high river stage events periodically replenished the Breton Sound Basin with sediments and nutrients that acted to maintain the area as a functioning estuary.

Extensive research and data exist on the historic and existing sediment dynamics of the Lower Mississippi River. Historically, the Lower Mississippi River transported extremely high sediment loads to the Gulf in association with deltaic processes. When it was a classical meandering alluvial river that was aggrading

its channel throughout much of its length, the suspended sediment and bed loads of the Mississippi River have been estimated to have been as high as 270 x 106 m^3/hr (353 x 106 yd^3/hr) and 130 x 106 m^3/yr (170 x 106 yd^3/yr), respectively (Kesel et al. 1992). The Lower Mississippi River has experienced significant changes in sediment transport dynamics over its more recent history, with a general trend of decreased sediment transport from historic to present times. Kesel (1988) estimated a 43 percent reduction in sediment loading from historic (prior to 1900) to predam periods (1930–1952) and a 51 percent decline from predam to postdam periods (1963–1982). Increased land development along the Mississippi River during the 1800s would have contributed to higher sediment loading, and thus this period may provide an inappropriate reference time frame for long-term trend analysis (USACE 2000). Consequently, there is uncertainty as to how current sediment loads of the Lower Mississippi River compare to historic levels.

4.2.2.2.2 Existing Conditions

The absence of a supply of freshwater, sediment, and nutrients combined with the ongoing pressures of wind and wave action, storm surges, and human activities have eroded marsh soils and reduced the ability of the project area to maintain a balance of emergent wetland and shallow water.

The USGS station at Tarbert Landing, Mississippi, maintains an extended record of sediment data for the Lower Mississippi River Period of record for daily measurements extends from 1975 to present. Sediment loading patterns suggest that daily-suspended sediment loads are above average from January through May and below average from August through November (USGS 1999, 2009). Based on water year 2002 through 2008, the average daily measured suspended sediment load at this location was 334,000 tons/day; the daily measured suspended sediment load varies from 39,000 to 119,000 tons/day (USGS 2009). The sand to silt ratio of suspended sediment is typically 20% sand to 80% silt (USGS 1999). Mashriqui and Kemp (1996) reported the mean sediment load of the Mississippi River at Tarbert Landing to be 226 mg/L, of which about 26% was sand, with silts and clays each contributing between 30% and 40%.

In 1995 the USACE derived the long-term relative subsidence rates from radiocarbon dating of buried peat deposits for all of southeast Louisiana. It was determined that the MDWD project area is subsiding at a rate of approximately 0.50 foot per century. Just beyond the project boundary toward Head of Passes, the rate increases to 1.0–4.0 feet per century.

4.2.2.3 Water Use and Supply

4.2.2.3.1 Historic Conditions

Fresh ground and surface water is abundant in southern Louisiana. Prior to the 1900s, water used for most purposes was from surface sources. Many households collected rainwater for domestic uses and farmers generally relied on rainfall and irrigation ditches to provide water to their crops. During the late 1800s, water wells began to come into common usage and quickly proliferated in areas where fresh groundwater was available. The use of groundwater allowed farmers to plant crops in areas where sources of fresh surface water were unreliable or unavailable. In coastal areas of southeastern Louisiana, groundwater supplies are generally limited and surface water is primarily used. Large amounts of fresh groundwater are generally available and groundwater is used for most purposes.

4.2.2.3.2 Existing Conditions

During 2000, about 3,000 million gallons per day (Mgal/d) (11,370 million liters per day [Ml/d]) of freshwater were withdrawn for various uses in the LCA Study area. Of this water, about 97 percent was from surface sources and about 3 percent was from groundwater sources. Most of this use was in southeastern Louisiana in parishes that border or straddle the Mississippi River.

The Mississippi River and some of its distributaries were the largest sources of surface water, contributing 96 percent (2,800 Mgal/d [10,612 Ml/d]) of the total surface withdrawals. Withdrawals for power generation and industry were primarily from the Mississippi River and used for once-through cooling and much of the water was returned to the source. Industrial withdrawals were primarily for petroleum refining and chemical manufacturing.

4.2.2.4 Groundwater

4.2.2.4.1 Historic Conditions

Southern Louisiana generally has very abundant fresh groundwater supplies. However, aquifers along the coast typically contain saltwater that extends inland as a wedge along the base of the aquifer. Coastward, the saltwater wedge typically thickens and the overlying freshwater thins until the entire thickness of the aquifer contains saltwater. Salty groundwater is often defined as water containing a chloride concentration greater than 250 mg/L or a dissolved solids concentration greater than 1,000 mg/L. Saltwater can move into freshwater parts of the aquifer by lowering freshwater levels through pumping. Such movement of saltwater or the saltwater wedge is known as saltwater encroachment. Saltwater can move laterally or vertically in an aquifer.

4.2.2.4.2 Existing Conditions

The water table is at or near the surface throughout most of the coastal zone. The silt- and sand-rich depositional environments such as point bar, intradelta, natural levee, beach, and near shore gulf are generally connected hydraulically to the adjacent water body (i.e., river, lake, distributary channel) and the elevation of the water table in these deposits reflects the level/stage of the adjacent water body. This is especially true in deposits adjacent to the Mississippi and Atchafalaya Rivers.

4.2.3 Water Quality and Salinity

4.2.3.1 Historic Conditions

Historic water quality issues for the project area are similar to existing issues addressed below. Mean salinities in the Breton Sound Basin range from fresh (0–2 parts per thousand [ppt]) in the upper basin to saline (>10 ppt in the middle and lower portions of the basin.

4.2.3.2 Existing Conditions

Historic and current water quality issues for the waters within the White Ditch project include the transport of nutrients, pesticides, synthetic organic compounds, trace elements, suspended sediment, and bacteria. The database for sampling stations on the Mississippi River near the diversion site is extensive, with comprehensive water quality datasets beginning in the mid-1970s. Historically, sites have been

operated in cooperation with the USACE and the Louisiana Department of Environmental Quality (LDEQ). The database for the Mississippi River is extensive enough that several general conclusions can be made concerning its suitability for coastal restoration efforts: Trace elements, including heavy metals, are generally not considered a water quality issue in the Mississippi River.

1. Nitrate concentrations average around 1.4–1.6 mg/L in the lower Mississippi River. This is the result of natural and human inputs, particularly agricultural fertilizers in the mid-continent. Nitrate at these concentrations can cause excessive algal growth and eutrophication in coastal water bodies and contribute to the hypoxia problem in the Gulf of Mexico.
2. Fecal coliform bacteria in the lower Mississippi River have declined dramatically with more effective sewage treatment at Baton Rouge and New Orleans since the mid to late 1980s.
3. The primary pesticides detected in the Mississippi River are the herbicides atrazine, metolachlor, and acetochlor.
4. Per LDEQ's database[2], organic compounds are typically not detected in the Mississippi River.
5. For conventional parameters in LDEQ's database[2], there is essentially no difference in water quality spatially along the length of the Mississippi River between Pointe à la Hache and the Louisiana state line.

The most common individual designated uses within proximity to the White Ditch Project Area include primary contact recreation, secondary contact recreation, fish and wildlife propagation, shellfish propagation, and drinking water supply. Primary contact recreation is defined by LDEQ as any recreational activity that involves or requires prolonged body contact with the water, such as swimming, water skiing, tubing, snorkeling, and skin-diving. Secondary contact recreation is defined as any recreational activity that may involve incidental or accidental body contact with the water and during which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, and recreational boating. Fish and wildlife propagation is defined as the use of water for preservation and reproduction of aquatic biota such as indigenous species of fish and invertebrates, as well as reptiles, amphibians, and other wildlife associated with the aquatic environment. This also includes the maintenance of water quality at a level that prevents contamination of aquatic biota consumed by humans. Shellfish propagation is the use of water to sufficiently maintain biological systems that support economically important species of oysters, clams, mussels, or other mollusks so that their productivity is preserved and the health of human consumers of these species is protected.

The Louisiana Department of Health and Hospitals (LDHH) coordinates with LDEQ, the LDWF, and the Louisiana Department of Agriculture and Forestry (LDAF) to issue water body advisories aimed at protecting the public's health. These include fish and shellfish consumption advisories and swimming advisories. Fish and shellfish consumption advisories employ a risk-based method to advise the public to limit or avoid the intake of certain species of fish and shellfish that have unsafe contaminant levels in their tissues. Swimming advisories may be issued for a water body due to fecal coliform or other types of contamination. This information comes from the LDEQ's 2008 305(b)/303(d) Integrated Report. The water bodies within the White Ditch project area are currently meeting their designated uses. The Mississippi River in proximity of the project was fully supporting the designated uses of secondary

[2] LDEQ performs collection and analysis for 29 conventional parameters and fecal coliform through the Surface Water Monitoring Program with a priority pollutant scan quarterly at the Mississippi River site near the White Ditch Project Area.

contact recreation and drinking water supply; however, was assessed as not supporting primary contact recreation or fish and wildlife propagation. The suspected causes of impairment include nitrogen, phosphorus, and total fecal coliform from suspected sources of municipal point source discharges and upstream sources. The Mississippi River Basin Coastal Bays and gulf waters were assessed as not supporting fish and wildlife propagation due to mercury from atmospheric deposition. The Mississippi River within the project area was not assessed for the other designated uses due to insufficient data.

For the White Ditch WVA assessment, baseline salinity values for the project area were determined using 2008–2009 data from Coastal Reference Monitoring stations located within or near the project area. Baseline values determined for intermediate marsh were representative of the mean values during the growing season (March–November), which ranged from 3.7 to 5.7; the mean baseline was calculated as 4.0. Baseline salinity for brackish and saline marsh was representative of the mean annual salinity recorded in 2008–2009. Baseline values of 6.6 for the brackish marsh zone was determined using station data that ranged from 5.0 to 9.9 ppt. A baseline value of 13.0 was estimated for the saline zone by extrapolating data from a single monitoring station in an isolated area of marsh to the larger open-water areas at the lower end of the estuary, where salinities were believed to be higher. Figure 4.1 shows the existing salinity gradients that could be found in a typical July.

4.2.4 Air Quality

This resource is institutionally significant because of the Clean Air Act of 1963 (CAA), as amended, and the Louisiana Environmental Quality Act of 1983 (LEQA), as amended. Air quality is technically significant because of the status of regional ambient air quality in relation to the National Ambient Air Quality Standards (NAAQS). It is publicly significant because of the desire for clean air expressed by virtually all citizens.

4.2.4.1 Historic Conditions

Historic air quality conditions in the project area are similar to those described in Section 4.2.5.2 below.

4.2.4.2 Existing Conditions

The EPA *Green Book Nonattainment Areas for Criteria Pollutants* (Green Book) maintains a list of all areas within the United States that are currently designated nonattainment areas with respect to one or more criteria air pollutants. Nonattainment areas are discussed by county or metropolitan statistical area (MSA). MSAs are geographic locations, characterized by a large population nucleus, that are comprised of adjacent communities with a high degree of social and economic integration. MSAs are generally composed of multiple counties. Review of the Green Book indicates that Plaquemines Parish is in attainment for all Federal NAAQS pollutants (http://www.epa.gov/oar/oaqps/greenbk/multipol.html) (http://www.deq.louisiana.gov/portal/Default.aspx?tabid=112)

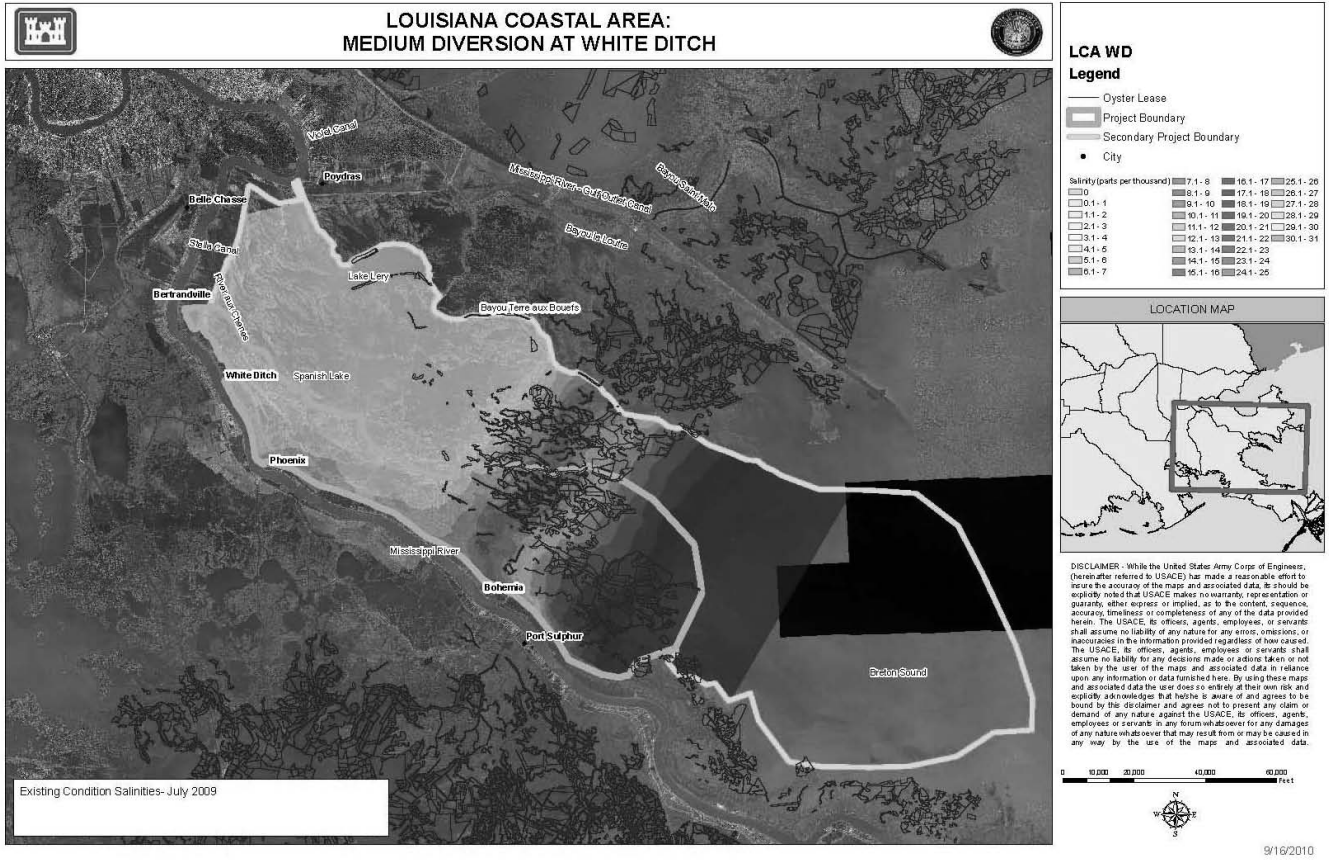


Figure 4.1: LCA White Ditch Existing Condition Salinities – July 2009

This page intentionally left blank.

4.2.5 Noise

Noise is institutionally significant because of the Noise Control Act of 1972 that declares the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare; and the Occupational Safety and Health Standards (29 CFR, part 1910) regarding protection against the effects of noise exposure. Noise is technically significant because noise can negatively affect the physiological or psychological well-being of an individual (Kryter, 1994) ranging from annoyance to adverse physiological responses, including permanent or temporary loss of hearing, and other types of disturbance to humans and animals, including disruption of colonial nesting birds. Noise is publicly significant because of the public's concern for the potential annoyance and adverse effects of noise on wildlife and humans.

4.2.5.1 Historic Conditions

Noise is typically associated with human activities and habitations, such as operation of commercial and recreational boats, water vessels, air boats, and other recreational vehicles; operation of machinery and motors; and human residential-related noise (air conditioner, lawn mower, etc.). However, the project area is a remote marsh only sparsely populated on its perimeter. The noise from distant urban areas surrounding the project area has little if any impacts on the area.

4.2.5.2 Existing Conditions

The MDWD study area contains a wide array of land use activities that vary throughout the entire project corridor. The dominant land use category located within the project area, as described under the Federal Highway Administration's (FHWA) Noise Abatement Criteria (NAC), is Activity Category C, which includes developed and undeveloped lands. The project area also contains a moderate amount of elements described in Activity Category B, which consists of playgrounds; active sports areas; parks, residences; motels; schools; churches; libraries; and hospitals. The dBA ranges for Activity Categories B and C were calculated by the FHWA using two different noise descriptors (L_{eq} and L_{10}). According to FHWA NAC, the estimated dBA ranges that are typically present for Activity Categories B and C are 67 dBA to 70 dBA and 72 dBA to 75 dBA, respectively (FHWA-2).

4.2.6 Vegetation Resources

Coastal vegetation resources attain institutional significance through the following Federal statutes: the Coastal Barrier Resources Act of 1982; the Coastal Zone Management Act of 1972; the Emergency Wetlands Resources Act of 1986; the Estuary Protection Act of 1968; the Fish and Wildlife Conservation Act of 1980; the Fish and Wildlife Coordination Act of 1958, as amended; the Migratory Bird Conservation Act; the Migratory Bird Treaty Act; the Endangered Species Act of 1973 (ESA); the Magnuson Fishery Conservation and Management Act 1990; the NEPA of 1969; the North American Wetlands Conservation Act; the Water Resources Development Acts of 1976, 1986, 1990, and 1992; and Executive Order 13186—Responsibility of Federal Agencies to Protect Migratory Birds. Coastal vegetation resources are technically significant because they are a critical element of the coastal habitats. In addition, coastal vegetation resources serve as the basis of productivity, contribute to ecosystem diversity, provide various habitat types for fish and wildlife, and are an indicator of the health of coastal habitats. Coastal vegetation resources are publicly significant because of the high priority that the public places on their aesthetic, recreational, and commercial value.

Vegetation in coastal Louisiana is inextricably linked to coastal hydrology. Two of the major mechanisms of vegetation change in the region, which includes the project area, are flooding and salinity. Hydrologic alterations such as levee building, channel construction, and drainage activities have substantially contributed to the vegetation changes in the project area over the past 50 years. A more-detailed discussion of the relationship between regional hydrology and vegetation regimes in the region was provided in the Final Programmatic EIS for the LCA Ecosystem Restoration Study (LCA 2004).

4.2.6.1 Riparian Vegetation

4.2.6.1.1 Historic Conditions

Historically, the Mississippi River had a riparian zone that transitioned from bottomland hardwood (BLH) forested ridges, transitioning through a mixed woodland community, to a swamp habitat between the ridges and eventually into marshland. The study area formed by a crevasse of the Mississippi River, forming River aux Chenes (Oak River) which transported water to the marshes during seasonal high water events, mainly during the late winter and early spring. The Mississippi River protection levee was constructed and reduced the spatial extent of the riparian zone while eliminating the natural flow of river water into the basin. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns. In addition, numerous channels have been dredged through natural ridges which increased drainage and tidal exchange. Composite coastal habitat mapping conducted by the USGS's National Wetlands Research Center in 2000 indicated that 839 acres of wetland forest, 460 acres of wetland shrub-scrub, and 0 acre of swamp were present in the project area at that time. Comparable survey data for the post-Katrina period was not available; however, local reports and visual observation suggest that storm damage has further reduced riparian forested acreage.

4.2.6.1.2 Existing Conditions

This resource is institutionally important because of Section 906 of the Water Resources Development Act of 1986 and the Fish and Wildlife Coordination Act of 1958, as amended. BLH forest is technically important because: it provides necessary habitat for a variety of species of plants, fish, and wildlife; it often provides a variety of wetland functions and values; it is an important source of lumber and other commercial forest products; and it provides various consumptive and non-consumptive recreational opportunities. BLH forest is publicly important because of the high priority that the public places on its aesthetic, recreational, and commercial value. BLH provides necessary habitat for a variety of species of plants, fish, and wildlife, and provides a variety of wetland functions and values. Seasonal flooding occurs over portions of the forests.

BLH provides necessary habitat for a variety of species of plants, fish, and wildlife, and provides a variety of wetland functions and values. Existing BLH in the study area is limited to small remnants of forested ridges adjacent to the Mississippi River, Oak River, and numerous oil and gas exploration canals. The BLH species along the Mississippi River batture include Drummond red maple (*Acer drummundii*), sugarberry (*Celtis laevigata*), Chinese tallow (*Sapium sebiferum*) sweet gum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), and black willow (*Salix nigra*). Shrubs and vines include buttonbush (*Cephalanthus occidentalis*), dew berry (*Rubus* sp.), and green briar (*Smilax* sp.)

The species found along Oak River include live oak trees (*Quercus virginiana*), black willow, sugarberry, and scattered baldcypress (*Taxodium distichum*) on the northern end. A lot of the oak trees have died

leaving remnant snag trees on the subsiding ridge. Scrub/shrub species include palmetto (*Sabal minor*), elderberry (*Sambucus canadensis*), eastern baccharis (*Baccharis haemifolia*) locally called mung bushes, and wax myrtle (*Myrica cerifera*), and marshhay cordgrass (*Spartina patens*). The Bayou Garelle ridges have subsided to mostly a scrub/shrub habitat with the same species as above.

Canal dredging for oil and gas exploration has created numerous man-made ridges. The species on the banklines include sugarberry, Chinese tallow, and black willow. Shrubs and vines include palmetto, elderberry, mung bushes, and dewberry. Strong southeasterly winds associated with storms causes seasonal flooding over portions of the banklines and ridges.

4.2.6.2 Wetland Vegetation

4.2.6.2.1 Historic Conditions

Historically, there was a basin with wide and gradual salinity transition zones that supported a healthy, natural, and sustainable estuary and fisheries. The 1956 habitat map was used for target land and vegetation distribution. The 1956 USGS analysis divided marsh between fresh (fresh and intermediate) and non-fresh (brackish and saline). According to the 1956 USGS Habitat Analysis, there was 10,716 acres of fresh marsh and 40,130 acres of non-fresh marsh (Figure 4.2).

4.2.6.2.2 Existing Conditions

The following Federal laws recognize the national significance of marshes as a natural resource: the Clean Water Act of 1977, as amended; Executive Order 11990 of 1977, Protection of Wetlands; Coastal Zone Management Act of 1972, as amended; and the Estuary Protection Act of 1968. Marshes are ecologically important because they: 1) provide necessary habitat for various species of plants, fish, and wildlife; they serve as ground water recharge areas; 2) provide storage areas for storm and flood waters; 3) serve as natural water filtration areas; 4) provide protection from wave action, erosion, and storm damage; and 5) provide various consumptive and non-consumptive recreational opportunities. Marshes are significant to the public because of the high value the public places on the ecological functions and human benefits that marshes provide. The basic marsh habitats within the MDWD study area are intermediate, brackish, and saline marsh with an addition of fresh marsh in the extended influence area (Figure 4.3).

There are approximately 2,000 acres of fresh marsh (0–3 ppt salinity) in the extended influence area. There are two basic types of fresh marsh in the area, flotant emergent and attached emergent. The flotant marsh is actually not attached to the underlying soil although the marsh plants form a dense mat that appears to be solid. The flotant marshes contain primarily maiden cane, coastal arrowhead, and Baldwin's spikerush. The attached emergent fresh marsh is attached to the underlying soil and also contains predominantly maiden cane and coastal arrowhead, along with spikerush, alligatorweed, common reed, coastal water-hyssop, penny-wort, and saltmeadow cordgrass.

Intermediate marsh (2–8 ppt salinity) habitat lies between fresh marsh and brackish marsh and the species of vegetation are not much different from fresh marsh, however, the dominance of the species is different. Marshhay cordgrass (*Spartina patens*) is the dominant species, with coastal arrowhead (*Sagittaria falcata*), roseau cane (*Phragmites australis*), coastal water-hyssop (*Bacopa monnieri*), seashore paspalum

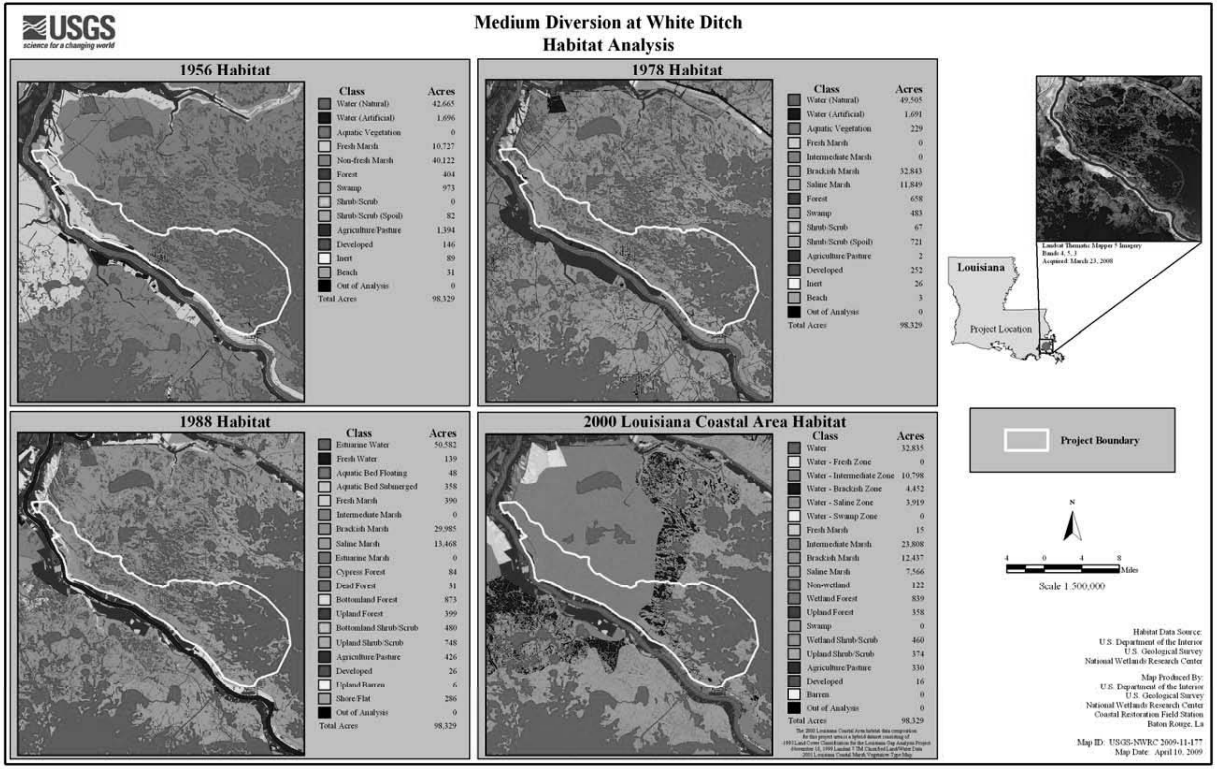


Figure 4.2: Historic Habitat Analysis of the White Ditch Project Area

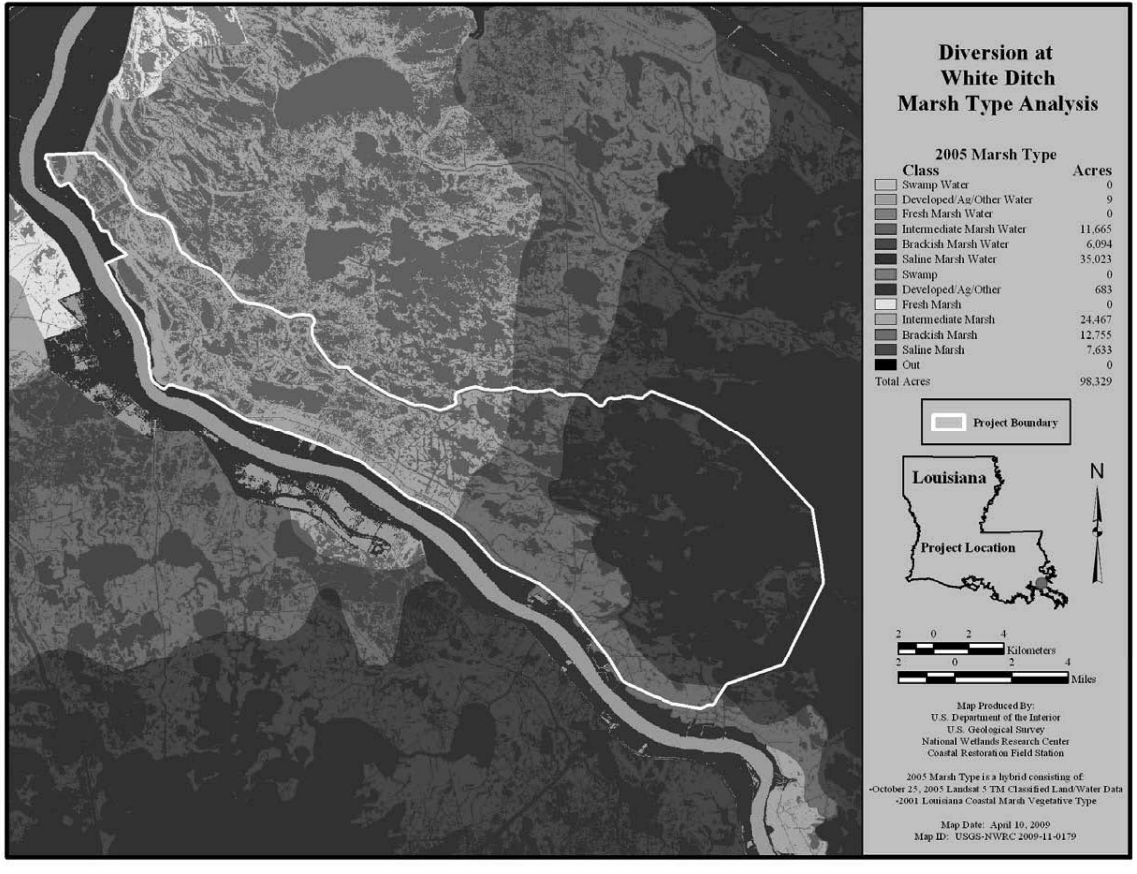


Figure 4.3: Marsh Types in the White Ditch Project Area

(*Paspalum vaginatum*), spikerush (*Eleocharis parvula*), eastern baccharis (*Baccharis halimifolia*) smartweed (*Polygonum* sp.), deerpea (*Vigna repens*), marsh morning glory (*Ipomoea sagittata*), and leafy three-square (*Scirpus robustus*) also common. There are approximately 32,000 and 90,000 acres of intermediate marsh in the MDWD study area and the extended influence areas, respectively.

Brackish marsh (4–18 ppt salinity) habitat lies between intermediate marsh and saline marsh. The dominant brackish marsh plant is marshhay cordgrass, comprising about one-half of the plants (Gosselink 1984: Conner and Day 1987). Other important species include seashore saltgrass (*Distichlis spicata*), camphorweed (*Pluchea camphorata*), and coastal water-hyssop (Conner and Day 1987). There are approximately 17,500 and 11,500 acres of brackish marsh in the MDWD study area and the extended influence areas, respectively.

The saline marsh (8–29 ppt salinity) community typically has the lowest plant species diversity of any marsh type. The dominant species in the salt marshes of the project area is oystergrass (*Spartina alterniflora*). There are approximately 7,500 and 5,000 acres of saline marsh in the MDWD study area and the extended influence areas, respectively.

4.2.6.3 Upland Vegetation

4.2.6.3.1 Historic Conditions

Historically, upland vegetation in the project study area, if present, would have been limited to the highest natural levee areas.

4.2.6.3.2 Existing Conditions

Upland vegetation in the project study area is limited to the highest elevation developed areas such as the Federal levee and landscaping around home sites.

4.2.6.4 Submerged Aquatic Vegetation (SAV)

4.2.6.4.1 Historic Conditions

Fresh and intermediate marshes often support diverse communities of submerged aquatic plants that provide important food and cover to a wide variety of fish and wildlife species. Brackish marshes also have the potential to support aquatic plants that serve as important sources of food and cover for several species of fish and wildlife. Although brackish marshes generally do not support the amounts and kinds of subaquatic plants that occur in fresh/intermediate marshes, certain species, such as widgeon-grass (*Ruppia maritima*), and coontail (*Ceratophyllum demersum*) and Eurasian watermilfoil (*Myriophyllum spicatum*) in lower salinity brackish marshes, can occur abundantly under certain conditions. Those species, particularly widgeon-grass, provide important food and cover for many species of fish and wildlife. The saline marshes typically do not contain an abundance of aquatic vegetation as often found in fresh/intermediate and brackish marshes.

4.2.6.4.2 Existing Conditions

Little to no up-to-date field information is available on the current composition and extent of submerged aquatic vegetation (SAV) in the White Ditch project area. For purposes of the WVA analysis, existing

SAV in the intermediate marsh zone was assumed to be 25% of the total area. That value is the mean of the SAV cover values from the Monsecour Siphon Project (2009), Bertrandville Siphon Project (2008), and White Ditch Siphon Project (2004) WVAs prepared by CWPPRA. Those WVAs encompass the majority of the intermediate marsh zone in the project area. No SAV cover data has been collected in the brackish marsh zone and there are no previous project WVAs that have been conducted in this portion of the project area. It is assumed that SAV cover would be somewhat less in this area (15% assumed) as compared to the intermediate area. Similar to the brackish marsh zone, no SAV cover data has been collected in the saline marsh zone and there are no previous project WVAs that have been conducted in this portion of the project area. SAV cover is typically very low or non-existent within saline marshes and this area contains very large open water areas, which typically contain no SAV. However, it is assumed that SAV cover may exist in some of the more isolated bodies of water (2% coverage assumed).

4.2.6.5 Invasive Species – Vegetation

4.2.6.5.1 Historic Conditions

Invasive plant species often increase and spread rapidly because the new habitat into which they are introduced is often free of insects and diseases that are natural controls in their native habitats. In coastal Louisiana, Chinese tallow, water hyacinth, alligator weed and hydrilla are well-known invasive plants. More recently, common salvinia, giant salvinia, and variable-leaf milfoil also have become invasive, displacing native aquatic species and degrading water quality and habitat quality (LACPR 2008).

4.2.6.5.2 Existing Conditions

Of the invasive plant species occurring or potentially occurring within the White Ditch project area, water hyacinth is currently the species most identified as problematic by local property owners. No information on the existing occurrence or coverage within the project area is available; however, the reported proliferation of this species in canals and water bodies within the Caernarvon subbasin is commonly attributed to the fresher water conditions resulting from operation of that existing diversion.

4.2.7 Wildlife and Habitat

This resource is institutionally significant because of the Fish and Wildlife Conservation Act of 1980, the Fish and Wildlife Coordination Act of 1958, as amended, the Migratory Bird Conservation Act, the Migratory Bird Treaty Act, the ESA, and Executive Order 13186, Migratory Bird Habitat Protection. Wildlife resources are technically significant because they are a critical element of the various coastal habitats, they are an indicator of the health of coastal habitats, and many wildlife species are important commercial resources. Wildlife resources are publicly significant because of the high priority the public places on their aesthetic, recreational, and commercial value.

4.2.7.1 Historic Conditions

The wetlands and associated habitats of coastal Louisiana are of national importance and provide essential habitat to diverse and abundant wildlife resources, including a wide range of resident and migratory birds as well as critical habitat for the wintering populations of the piping plover. Coastal Louisiana has the Nation's largest concentrations of colonial nesting wading birds and seabirds. Coastal marshes in the state provide habitat to 14 species of ducks and geese (those species for which data is available). Marshes,

swamps, and associated habitats support millions of neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds, and numerous songbirds, providing essential stopover habitat on their annual migration route. Coastal Louisiana has been a leading fur-producing area in North America, and coastal marshes and swamps also support game and small mammals. Louisiana marshes provide abundant habitat for many reptiles, most notably the American alligator, and the swamps and fresh/intermediate marshes also support many amphibians, especially various frog species.

4.2.7.2 Existing Conditions

Existing wetlands in the study area provide important and essential wildlife habitats, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements. The coastal marshes of Louisiana provide winter habitat for more than 50 percent of the duck population of the Mississippi Flyway. Large populations of migratory waterfowl, including gadwalls, blue-winged teal, green-winged teal, wigeons, lesser scaup, shovelers, pintails, and mallards, are present during winter in the MDWD study area. Mottled ducks are present year-round. These waterfowl are highly sought by sportsmen. In addition, coots, gallinules, rails, mourning doves, and snipe are important game species. Dabbling duck and diving duck numbers are increasing in the vicinity of existing freshwater diversions, such as in the Caernarvon area upriver of the study area.

Non-game avian species present in the study area include wading birds, shore birds, and sea birds include egrets, ibis, herons, sandpipers, willets, black-necked stilts, gulls, terns, skimmers, grebes, loons, cormorants, and white and brown pelicans. Various raptors such as barred owls, red-shouldered hawks, northern harriers (marsh hawks), American kestrel, and red-tailed hawks are present. Passerine birds present include sparrows, vireos, warblers, mockingbirds, grackles, red-winged blackbirds, wrens, blue jays, cardinals, and crows. Many of these birds are present primarily during periods of spring and fall migrations.

The study area also contains a great variety of mammals, reptiles, and amphibians. Abundant furbearers, including nutria, muskrat, mink, otter, and raccoon, formerly supported a trapping industry in the nearby Terrebonne Basin. Other species inhabiting the area where suitable habitat is present include white-tailed deer, skunks, rabbits, squirrels, armadillos, and a variety of smaller mammals. The area provides habitat for salamanders, toads, frogs, turtles, and several species of poisonous and nonpoisonous snakes. The American alligator is abundant in fresh to intermediate marsh and is caught commercially for its hides and meat throughout the area.

Numerous terrestrial invertebrates are found throughout the study area. The most notable are insects, which often serve as vectors, transmitting disease organisms to higher animals, including man. Mosquitoes are the most important of the vectors in the area, although other groups, such as deer flies, horseflies, and biting midges are also considered vectors. The area provides suitable breeding habitat for such species as *Aedes sollicitans* (salt-marsh mosquito), *Culex salinarius*, and other species of mosquitoes. Mosquitoes carry the West Nile virus, which has recently caused some illness and even death of both animals and humans in Louisiana.

Native muskrats, once trapped for their valuable fur throughout coastal Louisiana, have been crowded out by invasive South American nutria. Damage by nutria herbivory on marsh vegetation is an ongoing concern in the study area. The first CWPPRA-funded coast-wide survey, conducted in 1998, showed herbivory damage areas totaling approximately 90,000 acres. By 1999 this coast-wide damage had

increased to nearly 105,000 acres. This rapid and dramatic increase in damaged acres prompted LDWF to pursue funding for the Coastwide Nutria Control Program (CNCP) in January 2002.

The project is funded by the CWPPRA through the NRCS and the CPRA with the LDWF as the lead implementing agency. The project goal is to significantly reduce damage to coastal wetlands attributable to nutria herbivory by removing 400,000 nutria annually. This project goal is consistent with the Coast 2050 common strategy of controlling herbivory damage to wetlands. The method chosen for the program is an incentive payment to registered trappers/hunters for each nutria tail delivered to established collection centers. Initially, registered participants were given $4.00 per nutria tail. To encourage participation, the payment was increased to $5.00 per tail in the 2006–2007 season. During the 2007–2008 season, a total of 73,797 tails were harvested in Plaquemines Parish (LDWF annual report, 2008).

4.2.8 Aquatic Resources

4.2.8.1 Historic Conditions

A general description of aquatic resources in the overall LCA study area (plankton and benthos) was provided in Sections 3.9 and 3.10 of the LCA FPEIS and is incorporated here by reference. No information is available on historic conditions of aquatic resources in the specific White Ditch project area.

4.2.8.2 Existing Conditions

Aquatic habitat in the project vicinity is provided by the Mississippi River, oxbow lakes, borrow areas and estuarine wetlands. The main stem of the Mississippi River with an average depth of greater than 5 feet is inherently low in primary productivity on a relative basis because of high turbidity. Poor benthic productivity is characteristic of the shifting substrates and high current velocities in the area. The deep main river channel is the habitat of large predaceous fishes, some plankton feeders and a number of omnivorous species.

Plankton communities serve an important role in the coastal waters of Louisiana. Phytoplankton are the primary producers of the water column, and form the base of the estuarine food web. Zooplankton provide the trophic link between the phytoplankton and the intermediate level consumers such as aquatic invertebrates, larval fish, and smaller forage fish species (Day et al., 1989). Microzooplankton appear to be important consumers of bacterioplankton, which are typically enumerated primarily by culture and microscopic techniques. Culture techniques are selective and invariably underestimate bacterial densities (Day et al., 1989). “The Cooperative Gulf of Mexico Estuarine Inventory and Study, Louisiana,” prepared by the Louisiana Wildlife and Fisheries Commission in 1971 provides a summary of plankton across the coastal estuaries of Louisiana in the late 1960s (Perret et al., 1971). The dominant member of the zooplankton community throughout that study was the copepod *Acartia tonsa*. The greatest concentrations of zooplankton were encountered in Breton Sound. The lowest concentrations were encountered in Chandeleur Sound and Lake Borgne east of the Mississippi River, Lakes Barre and Raccourci, and Terrebonne and Timbalier Bays. Species diversity was greatest in the Breton Sound and Mississippi River, East Bay, Garden Island Bay, and West Bay areas.

Historically, salinity appears to be the chief controlling factor in the number of species present, while temperature, competition, and predation control the number of individuals present (Day et al., 1989). In

addition, the abundance of certain zooplankton may be indicative of good fishing areas. While some zooplankton are euryhaline, others have distinct salinity preferences (Day et al., 1989). Therefore, introduction of river water into estuarine systems may have dramatic short-term impacts on plankton populations in adjacent coastal waters (Hawes and Perry, 1978).

4.2.9 Fisheries

Fishery resources are institutionally significant because of the Fish and Wildlife Coordination Act of 1958, as amended; the ESA; the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Magnuson-Stevens Act), as amended; the Magnuson-Stevens Act Reauthorization of 2006; the Coastal Zone Management Act; and the Estuary Protection Act. Fishery resources are technically significant because: they are a critical element of many valuable freshwater and marine habitats; they are indicators of the health of various freshwater and marine habitats; and many species are commercially important. Fishery resources are publicly significant because of the high priority placed on their aesthetic, recreational, and commercial value.

4.2.9.1 Historic Conditions

Prior to the twentieth century, the tremendous estuarine productivity of coastal Louisiana was sustained by the river's distributaries and periodic floodwaters, which deposited millions of tons of sediments and nutrients on adjacent coastal marshes. The beneficial impact of this alluvial renourishment to fisheries was recognized by early native inhabitants and is documented in formal reports dating back to 1906. Levee construction and subsequent fortification through the twentieth century has resulted in major disruption to the river's natural deltaic cycle. Processes such as subsidence, saltwater intrusion, and wave erosion were no longer offset by accretion, resulting in extensive loss of coastal wetlands (Caffey and Schexnayder 2002). Despite this, Louisiana commercial fishery landings have increased significantly since the early 1900s and recreational harvests have been relatively stable for the past 10 years. At the same time, coastal habitats that support Louisiana fisheries have been increasingly impacted over the last 50 years by subsidence, sea level change, channelization of bayous, dredging of canals, and intensive management of marshes for wildlife and waterfowl.

4.2.9.2 Existing Conditions

The MDWD project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana. The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the Forty-Arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning.

The majority of the MDWD study area is estuarine habitat. Estuarine fishery species may be resident (inhabiting the estuary throughout their life cycle), such as killifishes, or transient (utilizing the estuary for some portion of their life cycle) such as gulf menhaden, blue crab, or shrimp. Marine species are found in offshore waters throughout the gulf coast and generally do not depend on estuaries to complete any part of their life cycle. These species are in some ways dependent on the health and productivity of

coastal estuaries, in that their prey often is made up of estuarine dependent species. In addition, some marine species frequently inhabit the lower reaches of estuaries, where productivity is high. Noted finfish species found in the Breton Sound Basin include speckled trout, red drum, black drum, sheepshead, sand seatrout, Atlantic croaker, spot, gulf menhaden, and spotted seatrout.

Three species of crustaceans — brown shrimp, white shrimp, and blue crab — are of major commercial and recreational importance in the coastal waters of Louisiana. Each of these species follows a circular migration, which encompasses a broad range of estuarine salinities. Because commercial harvesting targets the late juvenile and adult stages, productivity is often incorrectly equated with higher salinities. Though higher salinities tend to favor harvestability, they are not directly linked to absolute productivity (Caffey and Schexnayder 2002).

The American oyster is indigenous to coastal Louisiana and provides a substantial ecological and commercial resource. This organism is notable in that it is sessile and cannot migrate like many other estuarine species. Salinity plays a key role in oyster sustainability (Eastern Oyster Biological Review Team [EOBRT], 2007). Adult oyster can tolerate salinities from 0 to 42 ppt, but the optimal range is 14 to 28 ppt (EOBRT, 2007). Oyster spat can settle out at salinities as low as 3 ppt, but will have difficulty surviving. Fresher waters fail to support biological function, and more saline waters promote disease and predation. The upper two-thirds of the study area and extended influence area are either not conducive for spat settlement or suboptimal for natural oyster reef formation (Figure 4.1). Adult oysters are more prone to impacts from changes in water quality than commercially harvested fishes and crustaceans because they are sessile, and cannot relocate in response to changes in water quality parameters. Production of oysters in Louisiana has been relatively stable for the last 50 years, with harvest from public beds replacing the decreasing harvest from private leases. See Section 4.2.15.15.2 for a discussion of oyster leases. The Louisiana oyster industry has been experiencing many stressors over the past several decades that threaten the long-term sustainability of both the industry and the resource (Coleman, 2003). Increasing coastal land loss is reducing the amount of marsh that provides shelter to reefs, and saltwater intrusion is exacerbating disease and predation. In addition, the industry is faced with changing environmental conditions, fluctuating market demands, public perception issues, and increased competition.

4.2.10 Essential Fish Habitat (EFH)

This resource has statutory significance because of the Magnuson-Stevens Act (P.L. 104-297), which intended to promote the protection, conservation, and enhancement of EFH. The EFH designation is an important component of building and maintaining sustainable marine fisheries through habitat protection. The Magnuson-Stevens Act defines EFH for federally managed fish species as “those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.”

4.2.10.1 Historic Conditions

Emergent wetlands and shallow open water areas in the MDWD project area and adjacent areas of the Breton Sound Basin provide transitional habitat between estuarine and marine environments used by migratory and resident fish and other aquatic organisms for nursery, foraging, breeding and spawning, and other life requirements. The marshes and shallow bays function as nursery grounds for stocks of shrimp, oysters, crabs, and a variety of finfish (Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1993).

4.2.10.2 Existing Conditions

By letter dated February 10, 2009, the NMFS provided information on EFH in the study area in support of the public scoping effort for the project feasibility study and EIS. Aquatic and tidally influenced wetland habitats in portions of the MDWD study area are designated as EFH for various federally managed species, including white shrimp, brown shrimp, red drum, lane snapper, dog snapper, and Gulf stone crab. These species are managed by the Gulf of Mexico Fishery Management Council (GMFMC). Table 4.1 lists life stages and subcategories of EFH for these species that would potentially be benefited or impacted by this project. Primary categories of EFH in the study area include estuarine emergent wetlands; SAV; mud, sand, and shell substrates; and estuarine water column. Detailed information on federally managed fisheries and their EFH is provided in the 2005 generic amendment of the Fisheries Management Plans (FMPs) for the Gulf of Mexico prepared by the GMFMC. The generic amendment was prepared as required by the Magnuson-Stevens Act (P.L. 104-297).

In addition to being designated as EFH for the species listed in Table 4.1, water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, such as striped mullet, Atlantic croaker, gulf menhaden, spotted seatrout, sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the GMFMC (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks). (NOAA 2009)

Table 4.1: Essential Fish Habitat (EFH) for Various Life Stages for Shrimp, Red Drum, Reef Fish, and Stone Crab (NMFS Scoping Correspondence, 2009)

Species	Life Stage	System	EFH
Brown Shrimp	Larvae	Marine	<82 m; planktonic, sand/shell/soft bottom, SAV, emergent marsh, oyster reef
	Juvenile	Estuarine	<18 m; planktonic, sand/shell/soft bottom, SAV, emergent marsh, oyster reef
White Shrimp	Juvenile	Estuarine	<30 m; SAV, soft bottom, emergent marsh
Gulf Stone Crab	Eggs	Estuarine/Marine	<18 m; sand/shell/soft bottom
	Larvae/postlarvae	Estuarine/Marine	<18 m; planktonic/oyster reefs, soft bottom
	Juvenile	Estuarine	<18 m; sand/shell/soft bottom, oyster reef
Red Drum	Larvae/postlarvae	Estuarine	All estuaries planktonic, SAV, sand/shell/soft bottom, emergent marsh
	Juvenile	Estuarine/Marine	GOM <5 m W from Mobile Bay; all estuaries SAV, sand/shell/soft/hard bottom, emergent marsh
	Adults	Marine/Estuarine	GOM 1–46 m W from Mobile Bay; all estuaries SAV, pelagic, sand/shell/soft/hard bottom, emergent marsh
Lane Snapper	Larvae	Estuarine/Marine	4–132 m; reefs, SAV
	Juvenile	Estuarine/Marine	<20 m; SAV, mangrove, reefs, sand/shell/soft bottom
Dog Snapper	Juvenile	Estuarine/Marine	SAV, mangrove, emergent marsh

4.2.11 Threatened and Endangered Species

4.2.11.1 Historic Conditions

In Louisiana, Plaquemines parish has experienced some of the most dramatic environmental changes within the state over the past century. These changes have stressed listed species in Louisiana as their habitats are lost or modified. Some species that historically may have inhabited the area are the red wolf (*Canis rufus*) and the Louisiana black bear (*Ursus americanus luteolus*). Other species that were listed on the Endangered Species List, but have since then been de-listed because population's levels have improved are the bald eagle (*Haliaeetus Leucocephalus*) and the brown pelican (*Pelecanus occidentalis*).

Red wolf (*Canis rufus*). The red wolf is one of the world's most endangered wild canids. Once common throughout the southeastern United States, red wolf populations were decimated by the 1960s due to intensive predator control programs and loss of habitat. A remnant population of red wolves was found along the Gulf Coast of Texas and Louisiana. The USFWS declared red wolves extinct in the wild in 1980 (USFWS 2007). At one time red wolves may have occurred in the project area, but no documented sightings have occurred since they were declared extinct in the wild.

Louisiana Black Bear (*Ursus americanus luteolus*). The Louisiana black bear was listed as a threatened species in 1992. The Louisiana black bear is a subspecies of the American black bear, found in Louisiana, south Mississippi and east Texas. This bear is usually black in color and typically weighs 150 to 300 pounds as an adult (USFWS 2008). The Louisiana black bear was numerous during colonial times and may have inhabited the project area, but no documented cases exist in this area for the twentieth century.

Bald Eagle (*Haliaeetus leucocephalus*). Bald eagles live near rivers, lakes, and marshes where they can find fish, their staple food (USFWS 2009a). The successful recovery of bald eagle populations within the continental United States resulted in the delisting of the species from the Endangered Species List by the USFWS on August 9, 2007. Bald eagles may occur in the project area but no nest trees are documented within the MDWD project area.

Brown Pelican (*Pelecanus occidentalis*). Brown pelicans live in coastal regions along the Gulf and feed primarily of on fish. The successful recovery of the brown pelican population within the continental United States resulted in the delisting of the species from the Endangered Species List by the USFWS on November 17, 2009. Brown pelicans inhabit the area, but do not nest within areas directly affected by the proposed action.

4.2.11.2 Existing Conditions

Within the study area there are several animal and plant species under the Federal jurisdiction of the USFWS and/or the NMFS, presently classified as endangered or threatened. Within Plaquemines Parish, location of the MDWD study area, federally listed species include the pallid sturgeon (*Scaphirynchus albus*), Gulf sturgeon (*Acipenser oxyrhynchus desotoi*), West Indian manatee (*Trichechus manatus*), piping plover (*Charadrius melodus*), green sea turtle (*Chelonia mydas*), Kemp's ridley sea turtle (*Lepidochelys kempii*), and loggerhead sea turtle (*Caretta caretta*)

Gulf Sturgeon (*Acipenser oxyrhynchus desotoi*). The Gulf sturgeon was listed as threatened throughout its range on September 30, 1991. Gulf sturgeon live in the estuaries and coastal shelf regions of the Gulf

of Mexico during the cooler months of the year, from October to March. Distribution of Gulf sturgeon in Louisiana extends from the Mississippi River east to the Pearl River. The majority of sturgeon have their origins in the Pearl River system, where the largest population occurs (Carr, Tatman, & Chapman, 1996).

Green Sea Turtle (*Chelonia mydas*). The green sea turtle was listed as threatened in U.S. waters, except for the Florida breeding population which was listed as endangered, on July 28, 1978. Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherever they occur in U.S. waters. The green sea turtle is one of the largest marine turtles with adult weights averaging between 250 to 450 pounds (Dundee 1989). In the Atlantic and Gulf of Mexico waters, the green sea turtle typically inhabits areas adjacent to the coastline and has been known to have a range spanning from Texas to as far north as Massachusetts (NOAA-1).

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*). The Kemp's ridley sea turtle was listed as endangered throughout its range, on December 2, 1970. The Kemp's ridley sea turtle is the smallest of the sea turtles with adults reaching an approximate length of 2 to 2½ feet and weighing around 110 pounds (Dundee 1989). During the months of May to October, this species can be found in and around the shore line of Louisiana with adults occupying areas around the mouth of Mississippi during the spring and summertime (LDWF 2005).

Loggerhead Sea Turtle (*Caretta caretta*). The loggerhead sea turtle was listed as threatened throughout its range on July 28, 1978. The loggerhead sea turtle is also one the larger marine turtles with average adult lengths ranging from 3 to 7 feet and weighing approximately 300 to 1,100 pounds (Dundee 1989). In Louisiana, this species has been found nesting on the Chandeleur Islands and Grand Isle in Terrebonne Parish (Dundee 1989).

Pallid Sturgeon (*Scaphirynchus albus*). The pallid sturgeon was listed as endangered throughout its range on October 9, 1990. The pallid sturgeon is a bottom oriented, large river obligate inhabiting the Missouri and Mississippi Rivers from Montana to Louisiana and the Atchafalaya River. The pallid sturgeon is adapted to the predevelopment habitat conditions that historically existed in these large rivers (USFWS 2009b).

West Indian Manatee (*Trichechus manatus*). The West Indian manatee was listed as endangered on June 2, 1970. The West Indian manatee is a large gray or brown aquatic mammal. Adults average approximately 10 feet in length and weigh up to 2,200 pounds. Manatees inhabit both salt and freshwater of sufficient depth (5 feet to usually less than 20 feet) throughout their range. A few individuals have been known to stray as far north as the northern Georgia coast and as far west as the coastal waters of Louisiana (USFWS 2001).

Piping Plover (*Charadrius melodus*). The piping plover was listed as threatened and endangered on December 11, 1985. The piping plover is a shorebird that inhabits open beaches, alkali flats, and sandflats of North America. It breeds primarily along the Atlantic coast from North Carolina to southern Canada, along rivers and wetlands of the northern Great Plains from Nebraska to the southern prairie provinces, and along portions of the western Great Lakes. In winter, most individuals are found on coastal beaches and sand flats from the Carolinas to Yucatan; some scatter through the Bahamas and West Indies (Haig, 1992).

4.2.12 Cultural and Historic Resources

This resource is institutionally significant because of the National Historic Preservation Act of 1966 (NHPA), as amended, and the NEPA of 1969. Cultural resources are technically significant because of their association or linkage to past events, to historically important persons, and to design and/or construction values; and for their ability to yield significant information about prehistory and history. Cultural resources are publicly significant because preservation groups and private individuals support their protection, restoration, enhancement, or recovery.

4.2.12.1 Historic Conditions

According to the records at the Louisiana State Division of Archaeology there has only been one previous cultural resource survey in the project area. This survey was a linear inventory for a proposed 24 inch pipeline for Gulf Refining Company (Chance and Associates 1981). No sites were identified by this survey. However this survey was not conducted to today's standards and any buried sites were most likely missed. Besides the possibility of encountering historic and prehistoric period terrestrial sites there is also the possibility of impacting historic period sunken ships in the main channel of the Mississippi River.

4.2.12.2 Existing Conditions

Four archaeological sites are known to exist in or near the project area. These are 16PL16, 16PL15, 16PL193, and 16PL25. One historic period site was thought to be within the project area, 16PL27, Fort De Boulye. The three prehistoric sites were visited and two, 16PL15 and 16PL25 were found to be not eligible to the National Register of Historic Places. 16PL16 has not been evaluated because it is located just outside the Area of Potential Effect. 16PL27 is a National Historic Landmark but is not located where it is shown on Louisiana Division of Archaeology records. By law any effect to a National Historic Landmark has be the subject of consultation with the National Park Service. Consultation with the National Park Service on this issue begin with the DEIS and coordination has occurred since. It is believed that 16PL27, if it does still exist, is located outside the Area of Potential Effect. 16PL193 is a standing structure and also was not found eligible for the National Register of Historic Places. At this time the area along Oak River and the Mississippi River batture has been surveyed for cultural resources. Bayou Garelle remains to be surveyed. A task order for this is in the process of being issued.

4.2.13 Aesthetics

This resource is institutionally important because of the laws and policies that affect visual resources, most notably the 1969 NEPA. Visual resources are publicly and technically important because of the high value placed on the preservation of unique natural and culture landscapes.

4.2.13.1 Historic Conditions

Based on available aerial photography (namely, comparisons between 2008 photography and 1992 photography), the visual conditions of the White Ditch Study Area have seen little change over the past 20 years as it pertains to aesthetic (visual) resources. The same public thoroughfares that are in place today were in place then, along with similar view sheds. Primary view sheds, as they are today, were best taken from atop the local levee system, and, in some instances, LA 39. With limited access to the site, the only other alternative for viewing and enjoying the aesthetic qualities of the land becomes available via

watercraft. Comparisons between the two sets of photography show that areas associated with view sheds from the public thoroughfares have changed little, while areas to be accessed by watercraft have seen dramatic change through land loss and conversion to larger open water areas. Without older aerial photography, ground photographs of the site, or other historical visual data, further analysis of aesthetic (visual) conditions will not be possible.

4.2.13.2 Existing Conditions

The landscape of the region is dominated by fields and marshland with a mixture of water tolerant vegetation and some forestation. The flood side of the levees is moderate to densely vegetated offering some minimal view sheds into the swamps and marshlands. For a significant portion of the study area, view sheds are only offered from atop the levee system. For those who participate in outdoor activities, such as recreational walking, hiking and biking, nature/ ecological study, fishing, and/ or birding the visual characteristics are much more apparent and important when on the levees or the land on the flood side.

The most likely scenario is that the local residents are the primary utilizers of the banks of the levees for recreational purposes and would greatly benefit from an aesthetically pleasing recreational environment.

4.2.14 Recreational Resources

4.2.14.1 Historic Conditions

Due to the somewhat isolated nature of the project area and limited access, consumptive recreational use pressures have been moderate. Historically, primary recreational activities in the study area have been consumptive in nature, including fishing and hunting. Saltwater recreational activities have revolved primarily around saltwater fishing and to a lesser degree recreational shrimping and crabbing. Freshwater based recreational opportunities have primarily been waterfowl hunting and some limited freshwater fishing. Historically, natural ridges in the study area have supported deer and small game hunting.

As throughout much of coastal Louisiana, the study area has experienced substantial coastal erosion, loss of wetlands and increasing salinity levels. Some of the effects were exacerbated by past and recent hurricanes.

Due to increased salinity levels, deterioration of freshwater and intermediate marsh habitats have resulted in decreased opportunities for waterfowl hunting. According to duck hunters, waterfowl hunting flourished in the 1980s when the existing White Ditch siphon operated at full capacity. In recent decades, as marshes and SAV in the area have disappeared, waterfowl have shown less preference for the study area and duck hunting success has decreased.

Similarly, the study area has experienced erosion and subsidence, which has threatened the natural ridges in the area that have traditionally provided opportunities for hunting deer and small game.

The lower reaches of the study area have historically offered quality saltwater fishing opportunities as is the situation today. After the 2005 hurricanes when salinity levels were very high, anglers reported that the area experienced one of the best periods of recreational saltwater fishing.

4.2.14.2 Existing Conditions

The most prominent recreational activities within the study area are consumptive uses, saltwater fishing and waterfowl hunting. Other consumptive recreation uses include recreational crabbing and shrimping with limited deer and small game hunting on natural ridges. Non-consumptive recreational activities appear to be minimal and include wildlife observation.

Recreation resources are publicly significant because of the high value that the public places on fishing, boating, and hunting as measured by the large number of fishing and hunting licenses sold in Louisiana and the large per-capita number of recreational boat registrations in Louisiana. This is particularly important as most of the recreational activities in the study area are only accessible by boat.

There are a variety of water features in the area including canals, tributaries, bayous, wetlands and marshes. Within the study area, recreational walking, nature/ecological study and birding are activities in which residents and visitors may participate. Recreational sport fishing and boating in the waters is available and encouraged where public access is available.

Tables 4-2, 4-3, and 4-4 below show the number of recreational fishing and hunting licenses and boat registrations, respectively, within the study area. The fishing and hunting license and boat registration data are provided by the LDWF (http://www.wlf.louisiana.gov/education/economics/).

Table 4.2: Fishing Licenses Year 2009

	All Resident Fishing Privileges	All Resident Saltwater Privileges	All NR* Fishing Privileges	All NR* Saltwater Privileges
St. Bernard	3,739	3,748	581	570
Plaquemines	3,647	3,678	1,266	1,261
Orleans	6,264	6,238	1,069	1,039
Jefferson	47,645	47,500	9,649	9,296

* Non-Resident

Table 4.3: Hunting Licenses Year 2009

	Hunting Licenses	
Parish	Resident	Non-Resident
St. Bernard	1,335	12
Plaquemines	1,023	24
Orleans	1,858	45
Jefferson	13,681	253

Table 4.4: Boat Registrations
Year 2008

Parish	Boat Registrations
St. Bernard	2,294
Plaquemines	3,340
Orleans	4,157
Jefferson	19,258

There are two boat launches located within the White Ditch project area (Figure 4.4):

- The Belair Pump Station launch provides a gravel ramp approximately 18 feet wide by 15 feet in length. There is parking for 15 vehicles; however, no lighting, power, water or services are available.

- The Pointe à la Hache Marina Boat Launch provides two concrete boat ramps each 15 feet wide by 20 feet in length and an electric boat lift. The launch provides lighting, power, and water along with a fuel station, a small retail store, and bait shop. The marina has a launch as well as in-water slips.

4.2.15 Socioeconomics and Human Resources

This resource is institutionally significant because of the NEPA of 1969; the Estuary Protection Act; the CWA; the River and Harbors Acts; the Watershed Protection and Flood Protection Act; and the Water Resources Development Acts. Of particular relevance is the degree to which the proposed action affects public health, safety, and economic well-being; and the quality of the human environment. This resource is technically significant because the social and economic welfare of the nation may be positively or adversely impacted by the proposed action. This resource is publicly significant because of the public's concern for health, welfare, and economic and social well-being from water resources projects.

Nearly two million people, representing approximately 43 percent of the State's population, reside within the LCA Study area. The rich soil conditions, mild climate, natural waterways, and abundance of water and other natural resources have long attracted and supported economic development in coastal Louisiana. The diversified economy that exists in the region today includes oil and gas production and transportation, navigation, commercial fishing, agriculture, recreation, and tourism. Employment has varied widely with periods of rapid growth and contraction; in 2000 there were more than 800,000 jobs in coastal Louisiana. The most influential industries for the study area's economy include oil and gas; navigation; commercial and recreational fishing and hunting; and agriculture, all of which are essential for supporting Louisiana's economy.

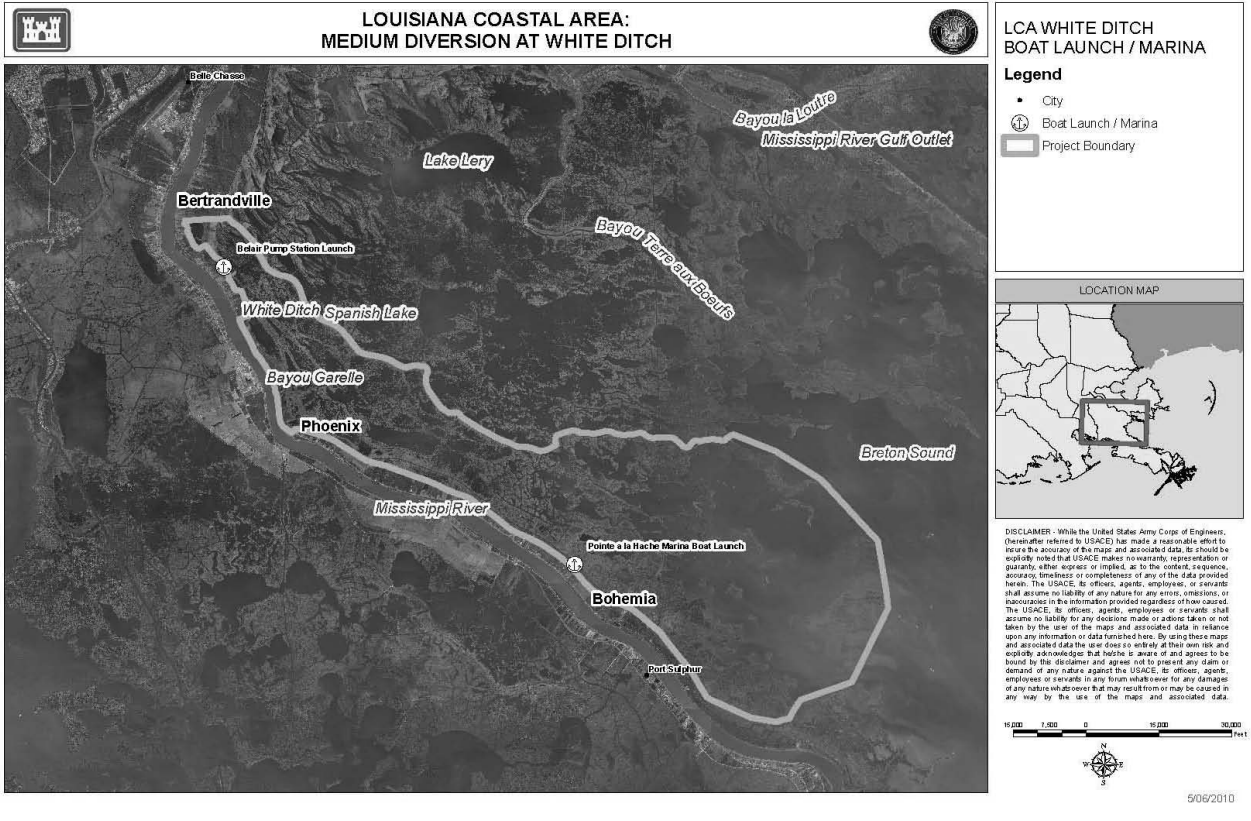


Figure 4.4: LCA White Ditch Boat Launch/Marina

4.2.15.1 Population and Housing

4.2.15.1.1 Historic Conditions

Native American settlement in the area goes back to unknown dates. The earliest European settlement in the area was by the French about 1700.

Phoenix is a rural town of 600 families in Plaquemines Parish on the East Bank of the Mississippi River. It is on the opposite side of the river from Myrtle Grove. It is the closest town to the Fort De La Boulave Site, a National Historic Landmark. In the foot-shaped delta region, locals call Plaquemines Parish “the big toe dat slipped out da boot.”

Pointe à la Hache is a rural community. The name "Pointe à la Hache" is French for "cape of the axe." In 1915 a major hurricane devastated the area, busting levees and flooding the region, and 31 died in the area. The Parish Courthouse was destroyed, but some of its material was salvaged for reuse in the new Courthouse completed the same year. In 1965 Hurricane Betsy damaged the area with severe flooding. The 1930 census showed the Point à la Hache area having a population of 404. The area was again severely damaged by Hurricane Katrina at the end of August 2005. As of mid 2009, only a small number of people have returned to live full time here

The communities of Phoenix and Pointe à la Hache are relatively old communities consisting predominantly of mobile homes and some permanent housing, some dating back to the 1960s. There is a sparse population within the area, with most of the residents residing between LA Hwy 15 and LA Hwy 39.

There is no new residential development, and some of the existing facilities are abandoned and in disrepair. There is a high school in the Phoenix community which services the residents of lower East Plaquemines Parish.

4.2.15.1.2 Existing Conditions

Population for Plaquemines Parish, location of the MDWD study area, was estimated at approximately 21,540 in 2007 (U.S. Census Bureau, 2009). This represents a decline of about 19.5 percent from the 2000 Census. The largest age category was persons between 18 and 64 years old, at approximately 62.7 percent. The White population represented an estimated 70.8 percent of the total population, African Americans 22.2 percent, persons of Hispanic or Latino origin 3.3 percent, Asians 3.1 percent, American Indian and Alaska native persons 2.4 percent, and persons reporting two or more races 1.3 percent. Housing units in the parish were estimated at 8,680 in 2007, and the 2007 median household income was estimated at $44,896.

4.2.15.2 Employment, Business, and Industrial Activity

4.2.15.2.1 Historic Conditions

Employment and businesses operating in the diversion area have been limited due to its remote location and limited population. The area along the East Bank of the Mississippi River in the Phoenix and Pointe à la Hache vicinity has been used as a remote site for commercial storage of chemical and fuel related products. Barges and Ships use the area for mooring and storage.

Prior to the Hurricanes Betsy and Katrina, the area did maintain better employment and business opportunities for the populace, but many of the residents have not returned since these storms devastated the area, and there is very limited opportunity existing for the few residents remaining in the local area.

There are now only two businesses in the project area consisting of a crude material storage facility in the Phoenix area, and a fuel storage facility in the Pointe à la Hache area. There are several barges and some ships that moor along the Mississippi River, but they do not provide sustainable employment opportunities for the residents. There is a small boat harbor located near Pointe à la Hache on the Eastern side of LA Hwy 39. There are very limited small businesses in the area, consisting of older convenience stores servicing the local community. There is one gas station in the area.

4.2.15.2.2 Existing Conditions

The most influential industries for the study area economy, and the ones most likely to be impacted by coastal wetland losses or by restoration efforts, include oil and gas, navigation (transportation); and commercial and recreational fishing and hunting.

Of interest to the coastal degradation issue are those pipelines that exist within the coastal areas that are vitally important as a conveyance means to move oil, gas, or chemical products from point of production to refineries, gas plants, and intrastate and interstate pipelines. Many thousands of miles of pipelines can be found in coastal Louisiana ranging from small gathering lines connecting production wells with storage tanks to larger pipelines carrying very large quantities of gas or oil.

Areas east of the Mississippi River and the Barataria Basin dominate oyster production in Louisiana. St. Bernard and Plaquemines Parishes encompass virtually all of the oyster producing areas east of the river, and Plaquemines Parish also includes part of the Barataria Basin. From 1988 through 1997, these two parishes accounted for approximately 50 percent of the oysters landed in Louisiana, and approximately 47 percent of landings from private leases in Louisiana. Monitoring data from the existing Caernarvon diversion structure has shown that production of both oysters and menhaden has increased.

4.2.15.3 Community Cohesion

Community cohesion refers to the common vision and sense of belonging within a community that is created and sustained by the extensive development of individual relationships that are social, economic, cultural, and historical in nature. The degree to which these relationships are facilitated and made effective is contingent upon the physical and spatial configuration of the community itself: the functionality of the community owes much to the physical landscape within which it is set. The viability of community cohesion is compromised to the extent to which these physical features are exposed to interference from outside sources.

4.2.15.3.1 Historic Conditions

The downstream unincorporated communities of Phoenix and Pointe à la Hache are relatively old. Pointe à la Hache, one of the largest settlements between English Turn and the Gulf during the first half of the nineteenth century, was selected as the parish seat in 1846. The first church in the town was built in 1820, the jail in 1835, and the courthouse in 1890. The first newspaper in the parish, *The Rice Planter*, was published at Pointe à la Hache during the decade preceding the Civil War.

4.2.15.3.2 Existing Conditions

With the exception of a decline in population, existing conditions in the downstream communities of Phoenix and Pointe à la Hache are largely unchanged from the historic condition, consisting predominantly of mobile homes and some permanent housing, some dating back into the 1960s. There has been little employment mobility for the population. There had been, and still remains, a sparse population within the area, with most of the residents residing between LA 15 and LA 39.

4.2.15.4 Environmental Justice

Environmental Justice (EJ) is institutionally significant because of Executive Order 12898 of 1994 (E.O. 12898) and the Department of Defense's Strategy on Environmental Justice of 1995, which direct Federal agencies to identify and address any disproportionately high adverse human health or environmental effects of Federal actions to minority and/or low-income populations. Minority populations are those persons who identify themselves as Black, Hispanic, Asian American, American Indian/Alaskan Native, and Pacific Islander. A minority population exists where the percentage of minorities in an affected area either exceeds 50 percent or is meaningfully greater than in the general population. Low-income populations as of 2000 are those whose income are $22,050.00 for a family of four and are identified using the Census Bureau's statistical poverty threshold. The Census Bureau defines a "poverty area" as a Census tract with 20 percent or more of its residents below the poverty threshold and an "extreme poverty area" as one with 40 percent or more below the poverty level. This is updated annually at http://aspe.hhs.gov/poverty/09poverty.shtml. This resource is technically significant because the social and economic welfare of minority and low-income populations may be positively or disproportionately impacted by the proposed actions. This resource is publicly significant because of public concerns about the fair and equitable treatment (fair treatment and meaningful involvement) of all people with respect to environmental and human health consequences of Federal laws, regulations, policies, and actions.

A potential disproportionate impact may occur when the percent minority (50 percent) and/or percent low-income (20 percent) population in an EJ study area are greater than those in the reference community. For purposes of this analysis, all Census Block Groups within the project footprint are defined as the EJ study area. Plaquemines Parish, of which the LCA Medium Diversion at White Ditch (MDWD) project is located, is considered the reference community of comparison, whose population is therefore considered the EJ reference population for comparison purposes. Parish figures were used for unincorporated areas located within 1 mile of the proposed project footprint. Where applicable, parish figures were used for unincorporated areas (Census Block Groups) located within 1 mile of the proposed project footprint if the block group numbers are so small as to not meet the requirements for further consideration.

The methodology, consistent with E.O. 12898, to accomplish this EJ analysis includes, identifying low-income and minority populations within the LCA-MDWD project area using up-to-date economic statistics, aerial photographs, 2000 U.S. Census records, Environmental Systems Research Institute, Inc. (ESRI) estimates, as well as conducting community outreach activities such as public meetings. Despite the 2000 U.S. Census being 9 years old, it serves as a logical baseline of information and is the primary deciding variable per data accuracy and reliability for the following reasons:

- Census 2000 data is the most accurate source of data available due to the sample size of the Census decennial surveys. With one of every six households surveyed, the margin of error is negligible.
- The Census reports data at a much smaller geographic level than other survey sources, providing a more defined and versatile option for data reporting.
- Census information sheds light upon the demographic and economic framework of the area pre-Hurricane Katrina. By accounting for the absent population, the analysis does not exclude potentially low income and minority families that wish to return home.

Due to the considerable impact of Hurricane Katrina upon the New Orleans metropolitan area, and the likely shift in demographics and income, the 2000 Census data are supplemented with more current data, including 2007 and 2008 estimates provided by ESRI. The 2007 and 2008 estimates are utilized for reference purposes only to show changing trends in population since 2000.

4.2.15.4.1 Historic Conditions

The concept of "environmental justice" is rooted in Title VI of the Civil Rights Act of 1964, which prohibited discrimination based on race, color and national origin, and other nondiscrimination statutes as well as other statutes including the NEPA of 1969, the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970, and 23 U.S.C Section 109 (h). In 1971, the CEQ annual report acknowledged racial discrimination adversely affects the environment of the urban poor. During the next 10 years, activists maintained that toxic waste sites were disproportionately located in low-income and areas populated by "people of color." By the early 1980s, the environmental justice movement had increased its visibility and broadened its support base (Commission for Environmental Equality 2009).

This led to the United Church of Christ (UCC) undertaking a nationwide study and publishing Toxic Waste and Race in the United States (UCC 1987). This eventually gained the attention of the Federal Government and in 1992 the USEPA's Office of Environmental Equity was established. In 1994, EJ was institutionalized within the Federal Government through Executive Order 12898 (EPA 1995a), which focused Federal attention on human-health and environmental conditions in minority and low-income communities (EPA 1995a, 1995b, 1995c, 1995d).

Executive Order 12898 requires greater public participation and access to environmental information in affected communities. The results of early efforts and research (UCC 1987) into EJ suggested that environmental amenities and toxic waste sites were not uniformly distributed among income groups, classes, or ethnic communities. Disparities of this nature may have been and continue to be the result of historical circumstances, lack of community participation, or simply inadequate or inappropriate oversight. Consequently, dialogue with some community groups were not conducted and their concerns not considered in the decision making process on local or Federal actions.

Residential areas and businesses for minority and low-income populations have historically been limited within the White Ditch Diversion study area due to the area being predominantly surrounded by brackish marsh and unsuitable for building. Some areas were drained and later inhabited, but the areas adjacent to the diversion area remain uninhabited.

4.2.15.4.2 Existing Conditions

The total population of this parish, according to the 2000 U.S. Census Bureau is 26,757. Because the area has such a low population density, the Plaquemines Parish and Louisiana state census figures were used to determine whether the White Ditch Diversion area meets the requirements set under Executive Order 12898 for further consideration. For 2008 the U.S. Census Bureau's population estimates were 21,276. This represents a slight population decline possibly due to the effects of Hurricanes Katrina and Rita in 2005.

According to the 2000 U.S. Census, the LCA MDWD project boundary in Plaquemines Parish is located within Census Tract 501, Block Group 1. The 2000 Census demographic profile records indicate that the minority population in Louisiana was 38.7 percent of the total population and the low-income population was 19.6 percent of the total population. The minority population in Plaquemines Parish was 31.8 percent and the low-income population was 18.0 percent in 2000. The 2008 estimates were approximately 32.1 percent minority and 11.2 percent low-income (http://censtats.census.gov, accessed November 11, 2009).

Analyses of the above information show that the percentage of the population that is minority is comparable to that of state figures and low-income populations are lower than state figures. Because there are few residential neighborhoods in the proposed project area, and based on the aforementioned 2000 U.S. Census figures, as well as field visits conducted in November 2009 to the proposed project area, it has been determined that the proposed LCA MDWD project area is not a minority and/or low income population per Executive Order 12898.

4.2.15.5 Infrastructure

4.2.15.5.1 Historic Conditions

Infrastructure in the project area has historically been limited due to the remote and low-elevation location as well as low population in this part of southeastern Louisiana.

4.2.15.5.2 Existing Conditions

Infrastructure in the project area includes the Federal Mississippi River levee, LA 39, and non-Federal back levees to the north and south of the proposed diversion location. An overhead power-line operated by Entergy has three poles that are located in the vicinity of the proposed construction area. A buried telephone cable is also located in the vicinity.

4.2.15.6 Business and Industry

4.2.15.6.1 Historic Conditions

Business and industry had historically been limited within White Ditch Diversion area. The early predominant industries have been trapping and hunting. However, oil production, commercial fishing activities and oyster harvesting have had some impact within the area.

4.2.15.6.2 Existing Conditions

There are no industries located in the inhabited areas adjacent to the White Ditch Diversion area. The two significant business operations consist of a chemical storage facility near Phoenix and a fuel storage operation near Pointe à la Hache. There is also a small boat harbor near Pointe à la Hache. Most other businesses are small operations supporting the local populations. The area adjacent to the White Ditch Diversion area is protected by a levee system. Pipelines and oyster leases exist within the project area.

4.2.15.7 Traffic and Transportation

4.2.15.7.1 Historic Conditions

The communities east of LA Hwy 39 are remote and receive little vehicle traffic. LA Hwy 39 services local residents but is used mostly for commercial vehicles traveling to the two commercial chemical and fuel storage facilities located in the area.

4.2.15.7.2 Existing Conditions

LA Hwy 39 is a two-lane sparsely traveled highway which terminates at Pointe à la Hache. Traffic consists predominately of commercial vehicles traveling to the two commercial chemical and fuel storage facilities located in the area. It also provides egress for the residents of Phoenix and Pointe à la Hache. There is additional recreational traffic from vehicles transiting to the Pointe à la Hache Boat Harbor. The area adjacent to the White Ditch Diversion area is protected by a levee system.

4.2.15.8 Public Facilities and Services

4.2.15.8.1 Historic Conditions

The inhabited area adjacent to the White Ditch project area is sparsely populated with the heaviest concentration of residents residing in the Phoenix and Pointe à la Hache areas. There are few public facilities or services provided within the populated areas. There is a public high school servicing the students in the lower portion of East Plaquemines Parish. There is also a volunteer fire department located in Phoenix.

The community of Pointe à la Hache once contained the Plaquemines Parish Public Courthouse, built in 1915. It was damaged by recurring hurricanes, and was finally burned by arson in 2002.

4.2.15.8.2 Existing Conditions

There are a limited number of public facilities in the vicinity of the proposed Phoenix diversion area. These facilities include a volunteer fire department and the Phoenix High School.

4.2.15.9 Tax Revenues and Property Values

4.2.15.9.1 Historic Conditions

The White Ditch diversion area is an under-developed marsh. The area East of LA Hwy 39 consisted of marsh and bayous, with some man-made canals. The majority of tax revenues have been derived from taxes on oil production and seafood products harvested in the area.

4.2.15.9.2 Existing Conditions

The proposed White Ditch project area is located near Phoenix, Louisiana. No economic data is available for the specific project area, but the nearest available data is at the parish level. Median household income in Plaquemines Parish in 2007 was estimated at $44,896 (statewide average was estimated at $40,866 for the same year). The median value of owner-occupied homes in Plaquemines Parish in 2000 was $110,100 (compared with the state average of $85,000) (Source: U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, Census of Population and Housing, Small Area Income and Poverty Estimates, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits, Consolidated Federal Funds Report, Last Revised November 17, 2009).

4.2.15.10 Community and Regional Growth

4.2.15.10.1 Historic Conditions

The communities adjacent to the White Ditch Diversion area were originally populated by trappers and hunters. Over time, Phoenix and Pointe à la Hache experienced limited economic growth primarily consisting of local small businesses supporting the area's population.

There is little population within the project area. The area is used primarily for recreational activity and there are oil and gas wells and commercial oyster leases existing in portions of the affected area.

4.2.15.10.2 Existing Conditions

Community and regional growth are generally influenced by national trends, but otherwise depend significantly upon relatively local attributes that allow it to be evaluated apart from the national economy. For the purposes of socioeconomic impact analysis, the project area is first described in summary terms with respect to prevailing trends in the growth of population, housing, income, and employment. Against this baseline, the relative effects of the proposed and alternative actions are evaluated.

Data for Plaquemines Parish, East Bank is not easily discernable through census data. The nearest impacted areas with available census data is St. Bernard Parish. According to U.S. Census data from 1990 and 2000 the following trends were observed in St. Bernard Parish: population grew from 66,631 to 67,229; employment grew from 30,738 to 31,267; and median household income grew from $25,482 to $35,939.

Preliminary 2010 Census data will be available in 2011 at the earliest. However, intermediate census estimates reported by the Greater New Orleans Data Center indicated a population in St. Bernard Parish of 19,826 in 2007.

4.2.15.11 Land Use Socioeconomics

4.2.15.11.1 Agriculture

4.2.15.11.1.1 Historic Conditions

Agriculture in Plaquemines Parish (excluding commercial fishing as discussed in Section 4.2.15.15) consists mainly of citrus and nursery crops, as well as livestock (primarily cattle) production. Agriculture on the east bank of the parish is limited by the availability of land suitable for cultivation of crops or livestock. Loss of marsh and marsh land in the project area during the past several decades has limited the potential for agricultural production in the project area. Reports from long-time residents of the east bank of Plaquemines Parish indicate that some portions of the project area may have been used for livestock grazing. No current agricultural production is known to be located within the immediate White Ditch project area, with the exception of alligator farming (egg harvesting), which occurs seasonally in portions of the project area and adjacent parts of the northern Breton Sound Basin under permits issued by the Louisiana Department of Fish and Wildlife.

4.2.15.11.1.2 Existing Conditions

Louisiana's alligator farming program began in the early 1970s, but production did not significantly increase until the early 1990s. In the last few years, production has exceeded 200,000 skins. Nearly all of this production is the result of collecting eggs from nests in the wild. To compensate for the removal of eggs, a proportion of the alligators raised on the farm are returned to the marshland where the eggs were originally collected.

Statewide data collected by the LDWF showed that in 2008 a total of 530,579 eggs were collected, 459,887 were hatched, and 45,578 of these hatchlings were returned to the wild. While statewide estimates indicated an increase in nest production of 3.1 percent over 2007 figures, estimates for southeastern Louisiana (which includes the White Ditch project area) indicated a 0.3 percent decrease from 2007–2008, compared with an estimated 8.7 percent increase for southwestern Louisiana for the same period.

4.2.15.11.2 Forestry

4.2.15.11.2.1 Historic Conditions

None.

4.2.15.11.2.2 Existing Conditions

The MDWD project has no commercial forestry production located within the proposed project area.

4.2.15.11.3 Public Lands

4.2.15.11.3.1 Historic Conditions

None.

4.2.15.11.3.2 Existing Conditions

The MDWD project has no public lands located within the proposed project area.

4.2.15.12 Water Use and Supply

4.2.15.12.1 Historic Conditions

The Mississippi River has historically been the primary source of freshwater in the project area.

4.2.15.12.2 Existing Conditions

The Mississippi River is the primary source of public water supply in Plaquemines Parish. Water use and supply facilities located within the vicinity of the White Ditch project area include a water tower servicing the residents of the Pointe à la Hache and Phoenix communities.

4.2.15.13 Navigation

4.2.15.13.1 Historic Conditions

Annual U.S. port tonnage statistics consistently rank the Ports of New Orleans, South Louisiana, and Baton Rouge fourth, first, and ninth, respectively. Primary inbound cargos at the Port of Baton Rouge are petroleum and chemicals. Outbound cargos are grain, chemicals, and petroleum products. Primary inbound cargos at the Port of South Louisiana are crude oil and petroleum products, while corn, wheat, and animal feed dominate the port's exports. At the Port of New Orleans, principal inbound cargos consist of steel, crude, and refined petroleum products and outbound cargos include grain, forest products, and steel. The river reach adjacent to the MDWD project area is within the Port of Plaquemines. In 2008, U.S. port tonnage statistics ranked the Port of Plaquemines tenth in the nation, with estimated cargos totally over 63,744 million short tons.

4.2.15.13.2 Existing Conditions

The Mississippi River is the major navigable waterway in the vicinity of the proposed project. Commercial navigation is a critical activity in the river bordering the west side of the White Ditch project area. On the east bank of the Mississippi River, the water bodies within the project area have not been used extensively for shallow water navigation, and there is no deep water navigation possible in the area. There are man-made canals once used by oil companies, but commercial use of these canals is limited and they are now used mostly for recreational purposes.

4.2.15.14 Man-Made Resources

4.2.15.14.1 Oil, Gas, Utilities, Pipelines

4.2.15.14.1.1 Historic Conditions

Louisiana is laced with thousands of pipelines conveying oil, gas, and other liquid and gaseous materials for short and long distances. Included are 25,000 miles (40,250 km) of pipe moving natural gas through interstate pipelines, 7,600 miles (12,236 km) of pipe carrying natural gas through intrastate pipelines to users within the state's boundaries, 3,450 miles (5,554 km) of pipe transporting crude oil and crude oil

products, and thousands of miles of flowlines carrying oil and gas from the wellhead to separating facilities.

The petroleum industry in the state accounts for almost 25 percent of the total state revenues and employs more than 116,000 people (about 6 percent of the state's total workforce). These workers earn almost 12 percent of the total wages paid in Louisiana. The oil and gas production industry, and the numerous associated support industries, are an important part of the socioeconomic landscape of the project area (see Employment and Income section). Indirect employment levels in support industries make this economic sector more important than is indicated by the direct employment figures.

Of interest to the coastal degradation issue are those pipelines existing within the coastal areas that are vitally important as a conveyance means to move oil, gas, or chemical products from point of production to refineries, gas plants, and intrastate and interstate pipelines. Pipelines found in coastal Louisiana range from small gathering lines connecting production wells with storage tanks to larger pipelines carrying very large quantities of gas or oil.

4.2.15.14.1.2 Existing Conditions

The MDWD project area contains some pipelines that cross LA Hwy 39. There are utility service lines that traverse the length of LA Hwy 39 servicing the communities located south of the proposed diversion structure. There are no oil refineries or rigs located within the diversion area. State database records show several oil wells in the vicinity of proposed construction features (Figure 4.5). As noted in Appendix J (Real Estate Plan), there are two oil wells located within the proposed channel, and one oil well located within the proposed marsh creation/wetland restoration. All wells located within the right-of-way limits of the project are closed/abandoned and, therefore, not productive or in use. Closed/abandoned wells within the project area are not anticipated to cause real estate issues or delays for the project.

The impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (August 5, 2010). This spill could potentially adversely impact USACE water resources projects and studies within the Louisiana coastal area. Potential impacts could include factors such as changes to existing or baseline conditions, as well as changes to future-without and future with project conditions. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact USACE water resources development projects/studies. This could include revisions to proposed actions as well as the generation of supplemental environmental analysis and documentation for specific projects/studies as warranted by changing conditions.

4.2.15.14.2 Flood Control and Hurricane Protection

4.2.15.14.2.1 Historic Conditions

None.

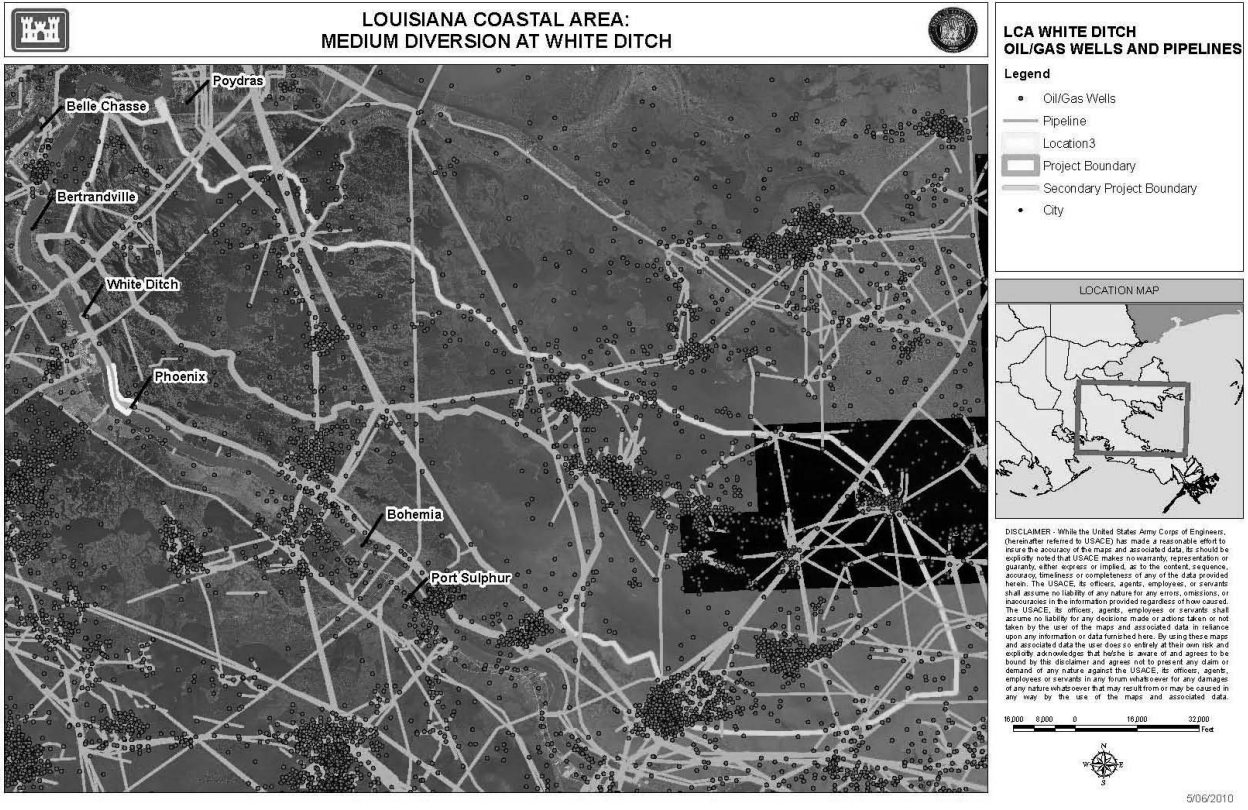


Figure 4.5: LCA White Ditch Oil/Gas Wells and Pipelines

4.2.15.14.2.2 Existing Conditions

Protection from high Mississippi River levels in the vicinity of the proposed project is provided by the Federal levee that runs the length of the western border of the White Ditch project area. Residences and businesses upstream and downstream of the proposed diversion construction site are protected from Gulf storm surges by non-Federal back levees.

4.2.15.15 Natural Resources

4.2.15.15.1 Commercial Fisheries

4.2.15.15.1.1 Historic Conditions

Louisiana's coastal wetlands are the richest estuaries in the country for fisheries production. Commercially and recreationally important species such as brown and white shrimp, blue crabs, eastern oysters, and menhaden are abundant, but these species populations are threatened if land loss continues. Louisiana has historically been an important contributor to the nation's domestic fish and shellfish production, and is one of the primary contributors to the nation's food supply for protein. While Louisiana has long been the nation's largest shrimp and menhaden producer, it has also recently become the leading producer of blue crabs and oysters. Total landings in Louisiana were 1.2 billion pounds (0.54 billion kg) in 2001. The percentage contribution of total landings for the Gulf region was 74 percent and for the nation was 12.5 percent. Dockside revenues for commercial fisheries in coastal Louisiana were $343 million in 2001 (NMFS 2003b). These revenues were the largest for any state in the contiguous United States, second only to Alaska.

4.2.15.15.1.2 Existing Conditions

The MDWD project area along with the larger Breton Sound Basin contains important commercial fishery resources including saltwater fish, shellfish and oysters.

4.2.15.15.2 Oyster Leases

4.2.15.15.2.1 Historic Conditions

Louisiana is the top producer of the eastern oyster in the United States, averaging approximately 13.1 million pounds per year since 2000, with an average value of $34.0 million (NMFS Fisheries Statistics Division, personal communication, 2009). The fishery has two main sources: privately leased grounds and public seed grounds. The State of Louisiana owns the water bottoms and leases out acreage to oyster fishermen. The public grounds are open to harvesting by all licensed fishermen, but are only open during the public season, which runs from September through March. Oysters can be harvested from the private grounds throughout the year.

4.2.15.15.2.2 Existing Conditions

Areas east of the Mississippi River and the Barataria Basin dominate oyster production in Louisiana. St. Bernard and Plaquemines parishes encompass virtually all of the oyster producing areas east of the river. From 1988 through 1997, these two parishes accounted for approximately 50 percent of the oysters landed in Louisiana, and approximately 47 percent of landings from private leases in Louisiana. Oyster

leases in Plaquemines Parish have 15-year terms and are leased from the state for $2 per acre per year. The White Ditch project area contains 311 oyster leases at the Gulf end of the proposed freshwater diversion area. Figure 4.6 below, and also found in Appendix J (Real Estate Plan, Exhibit B) of this report, shows the locations of these oyster leases. When existing conditions salinities are overlaid on the leases, approximately seven of the leases could experience suboptimal salinities for high oyster production.

4.2.16 Hazardous, Toxic, and Radioactive Wastes

4.2.16.1 Historic Conditions

The USACE is obligated under Engineer Regulation (ER) 1165-2-132 to assume responsibility for the reasonable identification and evaluation of all HTRW contamination within the vicinity of the proposed action. ER 1165-2-132 identifies the USACE policy to avoid the use of project funds for HTRW removal and remediation activities. Costs for necessary special handling or remediation of wastes (e.g., those regulated by the Resource Conservation and Recovery Act of 1976 [RCRA]), pollutants and other contaminants, which are not regulated under the CERCLA, will be treated as project costs if the requirement is the result of a validly promulgated Federal, state or local regulation.

HTRW investigations facilitate early identification and consideration of HTRW problems. The Civil Works Project Plan routinely includes a phased and documented review to provide for early identification of HTRW potential at project sites. ER 1165-2-132 requires that viable options to avoid HTRW problems be determined and a procedure for resolution of HTRW concerns be established.

The discharge of dredged material into waters of the U.S. is regulated under the CWA, and the Marine Protection and Sanctuaries Act governs the transportation of dredged material to ocean waters for the purpose of disposal. The RCRA hazardous waste management regulations, promulgated pursuant to RCRA (42 U.S.C. 6905) specifically exempt dredge material from the hazardous waste definition if that material is covered by:

1) a permit issued under Section 404 of the CWA, 33 U.S.C. 1344;

2) a permit issued under Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 33 U.S.C. 1413; or

3) the administrative equivalent of such permits where the work involves an Army Corps of Engineers civil works project, 40 C.F.R. 261.4(g), 63 F.R. 65874, 65921; November 30, 1998. ER1165-2-132 states, dredged material and sediments beneath navigable waters proposed for dredging qualify as HTRW only if they are within the boundaries of a site designated by the EPA or a state for a response action (either a removal or a remedial action) under CERCLA, or if they are a part of a NPL site under CERCLA.

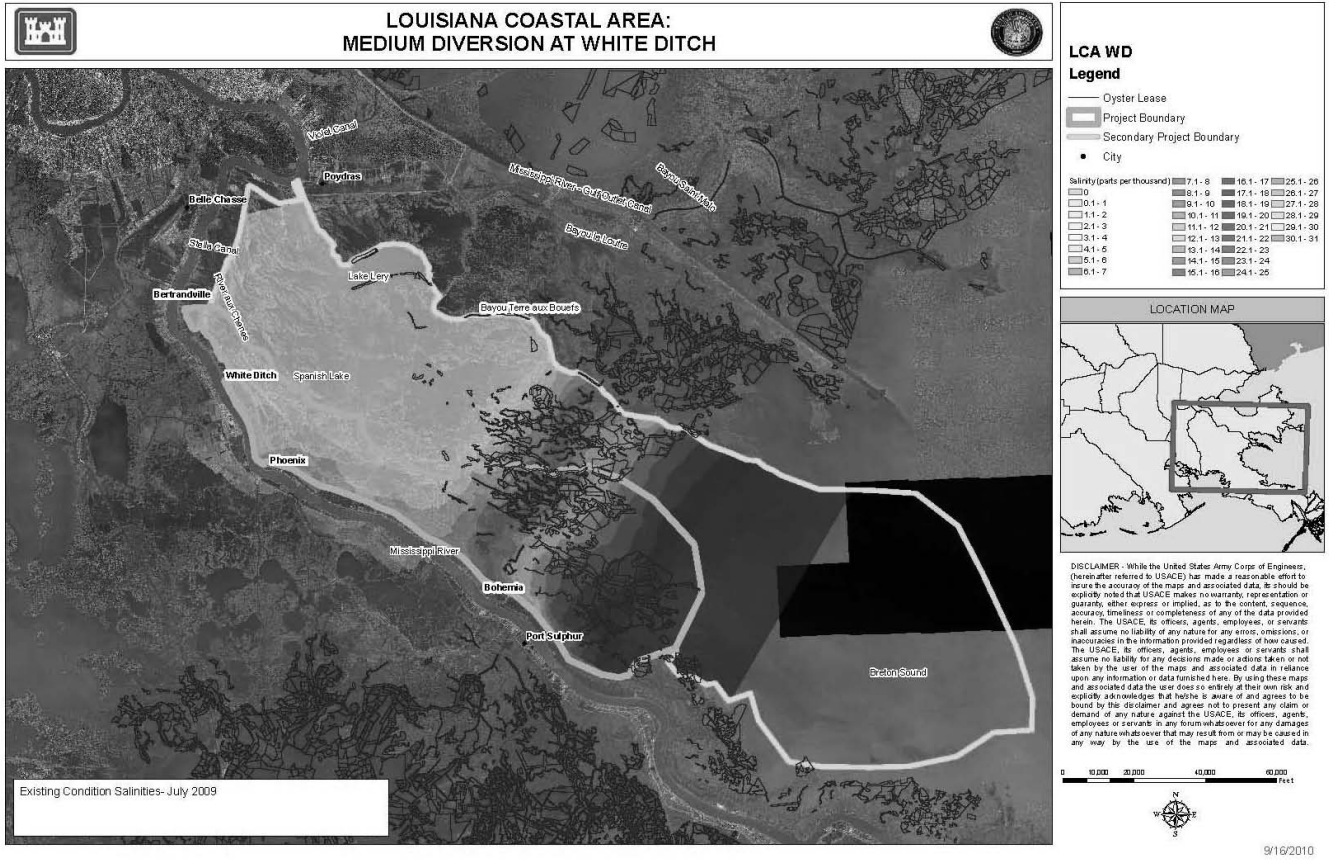


Figure 4.6: LCA White Ditch Existing Condition Salinities – July 2009

This page intentionally left blank.

4.2.16.2 Existing Conditions

As reported in the Phase I ESA, during records research and site reconnaissance it was determined that areas adjacent to some of the project features contained RECs that presented a low to moderate risk of affecting potential project features, albeit that no Recognized Environmental Conditions (RECs) were noted within direct proximity of land associated with any of the potential project features.

Should at anytime during the project HTRW concerns arise, the CEMVN would take immediate actions to investigate the concerns. Should an HTRW issue be determined and the development of a response action required, CEMVN would coordinate with the appropriate Federal and state authorities to implement an approved response action.

This page intentionally left blank.

5.0 ENVIRONMENTAL CONSEQUENCES

This chapter describes the potential environmental consequences of implementing alternative plans considered for freshwater diversion and marsh restoration in the project study area. The following analysis compares the No Action Alternative to four alternatives carried over for detailed analysis: Alternative Plans 1, 2, 3, and 4. Alternative 4 is the Recommended Plan. Alternatives developed and evaluated in this study are described in Chapter 3, Alternatives. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

A comparison of the direct, indirect, and cumulative impacts for wetland creation and enhancement is presented herein. Direct impacts would be those effects that would be caused by the proposed action and occur at the same time and place (Section 1508.8(a) of 40 CFR Parts 1500–1508). For example, the use of excavated material from construction of outfall management features would be used directly to create acres of emergent wetland habitat. Indirect impacts would be those effects that would be caused by the action and would be later in time or further removed in distance, but would be still reasonably foreseeable (Section 1508.8(b) of 40 CFR Parts 1500–1508). For example, shoreline protection features reduce the long-term rate of erosion to interior wetlands. Cumulative impacts would be the aggregate of impacts to the environment resulting from the proposed action in combination with other ongoing actions, and actions being considered within the reasonably foreseeable future. Cumulative impacts would be the effects on the environment that would result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such actions. Cumulative impacts can result from actions that individually would be minor, but collectively result in significant actions taking place over time (Section 1508.7 40 CFR Parts 1500–1508). For example, the incremental impacts of emergent wetland creation at several localized areas could significantly modify an entire basin's habitat diversity. The cumulative impact analysis followed the 11-step process described in the 1997 report by the Council of Environmental Quality entitled "Considering Cumulative Effect Under the National Environmental Policy Act." Section 5.21 summarizes cumulative impacts for all important resources.

This environmental analysis evaluates and compares, from a qualitative and quantitative perspective, the four alternatives carried over for detailed analysis. Impact analysis described in this chapter is based on a combination of scientific and engineering analyses, professional judgment, and previously compiled information.

The operational scenario used in the evaluation of all alternatives, including the Recommended Plan, involves operating the diversion structure at full flow capacity for 2 months each year, and at a reduced "maintenance flow" for the remainder of the year. High river flows (with corresponding high suspended sediment levels) historically occurred in the early spring on the lower Mississippi River, and prior to construction of the Federal levee system would have naturally replenished coastal wetlands in the project study area with freshwater, sediment and nutrients. In addition, both historical information and more recent scientific investigations of freshwater diversions such as the Caernarvon freshwater diversion suggest that potential negative consequences of reintroduction of river inflows in the MDWD project would be more likely to be reduced or minimized if flows would be limited in duration and would be timed to avoid sensitive periods in the annual life cycles of marsh vegetation and associated aquatic organisms.

The impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (August 5, 2010). This spill could potentially adversely impact USACE water resources projects and studies within the Louisiana coastal area. Potential impacts could include factors such as changes to existing or baseline conditions, as well as changes to future-without and future with project conditions. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact USACE water resources development projects/studies. This could include revisions to proposed actions as well as the generation of supplemental environmental analysis and documentation for specific projects/studies as warranted by changing conditions.

5.1 SOILS AND WATERBOTTOMS

5.1.1 Soils and Waterbottoms

5.1.1.1 No Action Alternative (Future Without Project Conditions)

5.1.1.1.1 Direct

No direct alteration of soils or substrate would occur under the No Action Alternative and associated water management features. No conversion of prime or unique farmland would occur, and the No Action Alternative would have no direct impact on these resources.

5.1.1.1.2 Indirect

Under the No Action Alternative, existing patterns of soil erosion and land loss would continue into the future. Organic soils in the project area would not be able to maintain their elevations due to subsidence, decreased plant productivity, wave erosion, and relative sea level rise. Net primary productivity within the project area would continue to decline and existing wetland vegetation would continue to diminish. The ongoing conversion of existing fragmented emergent wetlands to shallow open water would continue with associated indirect impacts on coastal vegetation, fish and wildlife resources, EFH, recreation, aesthetic, and socioeconomic resources. In the future, if no actions would be taken to restore and protect marsh habitat within the project area, any prime and unique farmland that remains outside of the protection of existing Federal and non-Federal back levees would continue to be subject to further degradation and possible loss.

5.1.1.1.3 Cumulative

Under the No Action Alternative, as erosion continued, there would be a continued loss of marsh soils. Waterbodies would grow larger and wave erosion would accelerate causing further land loss, thus making remaining marsh lands in the project area and the larger Breton Sound Basin more vulnerable to tropical storms. In addition to land loss in coastal Louisiana, a large percentage of the nation's wetlands would continue to disappear with accompanying impacts to wildlife, fisheries, coastal communities, and socioeconomic resources.

5.1.1.2 Alternative 1 – 5,000 cfs max Diversion

5.1.1.2.1 Direct

Construction of the 5,000 cfs maximum diversion would directly impact approximately 324 acres in the intermediate zone (136 acres of marsh and 188 acres of shallow open water). Approximately 153 acres of marsh and shallow water area would be excavated to enlarge the outfall channel for the structure. This excavated material would be placed on organic marsh soils and aquatic substrates to create approximately 32 acres of ridges lining the outfall channels, and 139 acres of created marsh in locations adjacent to the outfall channels.

5.1.1.2.2 Indirect

Loss of marsh soils would continue in the project area; however, indirect impacts of implementing the 5,000 cfs max diversion would include reducing the rate of marsh soil loss in the project area compared to the projected rate of loss under the FWOP condition over the 50-year period following construction.

5.1.1.2.3 Cumulative

This alternative would have positive synergistic effects on soil resources when combined with other Federal, state, local, and private restoration efforts, including the nearby Caernarvon diversion. Implementing the 5,000 cfs diversion alternative would contribute to reducing regional rates of marsh soil loss over the 50-year project life.

5.1.1.3 Alternative 2 – 10,000 cfs max Diversion

5.1.1.3.1 Direct

Construction of the 10,000 cfs maximum diversion would directly impact approximately 375 acres in the intermediate zone (155 acres of marsh and 220 acres of shallow open water). Approximately 167 acres of marsh and shallow water area would be excavated to enlarge the outfall channel for the structure. This excavated material would be placed on organic marsh soils and aquatic substrates to create approximately 32 acres of ridges lining the outfall channels, and 176 acres of created marsh in locations adjacent to the outfall channels.

5.1.1.3.2 Indirect

Indirect impacts of implementing the 10,000 cfs max diversion would include substantially reducing the rate of marsh soil loss in the project area compared to the projected loss rate under FWOP conditions over the 50-year period following construction.

5.1.1.3.3 Cumulative

This alternative would have positive synergistic effects on soil resources when combined with other Federal, state, local, and private restoration efforts, including the nearby Caernarvon diversion. Implementing the 10,000 cfs diversion alternative would contribute to reducing regional rates of marsh soil loss over the 50-year project life.

5.1.1.4 Alternative 3 – 15,000 cfs max Diversion

5.1.1.4.1 Direct

Construction of the 15,000 cfs maximum diversion would directly impact approximately 449 acres in the intermediate zone (199 acres of marsh and 250 acres of shallow open water). Approximately 182 acres of marsh and shallow water area would be excavated to enlarge the outfall channel for the structure. This excavated material would be placed on organic marsh soils and aquatic substrates to create approximately 32 acres of ridges lining the outfall channels, and 235 acres of created marsh in locations adjacent to the outfall channels.

5.1.1.4.2 Indirect

Indirect impacts of implementing the 15,000 cfs max diversion would include the expected restoration of emergent marsh soils at a rate that would exceed the projected loss rate under the FWOP condition over the 50-year period following project construction.

5.1.1.4.3 Cumulative

This alternative would have positive synergistic effects on soil resources when combined with other Federal, state, local, and private restoration efforts, including the nearby Caernarvon diversion. Implementing the 15,000 cfs diversion alternative would contribute to reducing regional rates of marsh soil loss over the 50-year project life.

5.1.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.1.1.5.1 Direct

Construction of the 35,000 cfs maximum diversion would directly impact approximately 640 acres in the intermediate zone (277 acres of marsh and 363 acres of shallow open water). Approximately 223 acres of marsh and shallow water area would be excavated to enlarge the outfall channel for the structure. This excavated material would be placed on organic marsh soils and aquatic substrates to create approximately 32 acres of ridges lining the outfall channels, and 385 acres of created marsh in locations adjacent to the outfall channels.

5.1.1.5.2 Indirect

Indirect impacts of implementing the 35,000 cfs max diversion would include the expected restoration of emergent marsh soils at a rate that would substantially exceed the projected loss rate under the FWOP condition over the 50-year period following project construction.

5.1.1.5.3 Cumulative

This alternative would have positive synergistic effects on soil resources when combined with other Federal, state, local, and private restoration efforts, including the nearby Caernarvon diversion. Implementing the 35,000 cfs diversion alternative would provide the highest potential contribution of the four alternatives evaluated in detail in this study to reducing regional rates of marsh soil loss.

5.2 HYDROLOGY

5.2.1 Flow and Water Levels

5.2.1.1 No Action Alternative (Future Without Project Conditions)

5.2.1.1.1 Direct

The No Action Alternative would have no direct impacts on flow or water levels within the surrounding marsh or historic distributaries such as River aux Chenes.

5.2.1.1.2 Indirect

Indirect impacts of the No Action Alternative, not implementing the diversion, would result in the persistence of existing conditions. Consequences would include further degradation of the existing marsh from saltwater intrusion due to short circuited hydrologic processes present in the basin, as well as the continued lack of sediments, nutrients, and freshwater. With the absences of these inputs, the marsh would not be able to sustain itself against subsidence and prolonged inundation from increasing sea level rise rates, Figure 5-1.

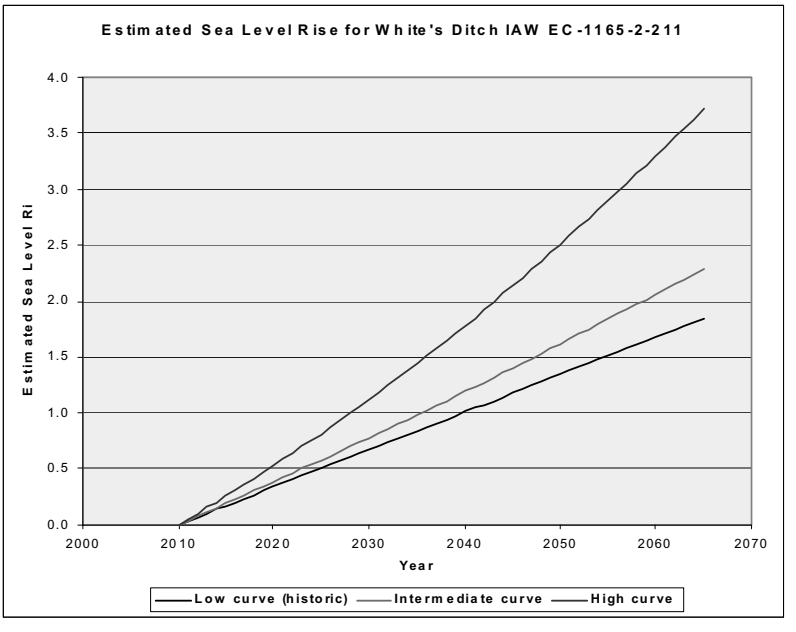


Figure 5.1: Sea Level Rise Rates for the White Ditch Study Area

The No Action Alternative would result in the existing marsh persisting with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities with saltwater, which would induce stress and lead to further degradation.

Current guidance for incorporating the direct and indirect physical effects of projected future sea-level change in all aspects of USACE projects (i.e., managing, planning, engineering, designing, constructing, operating, and maintaining) is established by Circular No. 1165-2-211, dated July 1, 2009. Under this direction, the no action and action alternatives must be evaluated under "low," "intermediate," and "high" projected rates of future sea-level change. Scenarios differ in whether and how eustatic sea-level rise accelerates over time. Accordingly, the low estimate is based on an extrapolation of the historic rate of RSLR for the study area. Against the high sea level rise scenario, all marsh would be gone in approximately 45 years under the No Action Alternative.

5.2.1.1.3 Cumulative

Cumulative impacts would be the synergistic effect of the No Action Alternative on flow and water levels with the added combination of similar wetland degradation and wetland loss impacts to flow and water levels throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. The Caernarvon Diversion does freshen the White Ditch project area, albeit to an unknown extent. It could potentially impact the flow patterns in and near the study area, but would not likely affect water levels. The proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch could have impacts on the project area, but conclusive detail as to those extents would not be available at this time. Other diversion along the Mississippi River would collectively have impacts on Mississippi River stages and possibly sediment and nutrient loads available to the Breton Sound Basin.

5.2.1.2 Alternative 1 – 5,000 cfs max Diversion

5.2.1.2.1 Direct

The direct impact of a diversion with the potential of operating up to 5,000 cfs in the area between River aux Chenes and the Mississippi River would be increased water levels and flows within the project area while the structure is being operated. During operations, Mississippi River water would flow through River aux Chenes, Bayou Garelle, and numerous other natural and man-made channels. Stages would be elevated near the outfalls of where water is leaving the Bayou Garelle and flowing into larger, more open, bodies of water.

The direct impact of the diversion of water from the Mississippi River at the proposed diversion site would be a very small decrease in the flow in the Mississippi River. Based on data from 1978 to 2008, the average spring (March 1 – May 31) flow at Tarbert Landing is 813,333 cfs ± 283,377 cfs (Mean + SD), vs. a diversion rate of 5,000 cfs. The small decrease in flow at this intake location would have no impact on water levels in the Mississippi.

5.2.1.2.2 Indirect

Indirect impacts of a 5,000 cfs diversion would be the slight inundation of lands while the structure is being operated. During operations lands that would not always be inundate during the period would become submerged. With this submergence, there would be an opportunity for the lands to collect sediments that would be carried by the diverted Mississippi River water, thus renewing historic deltaic processes.

The indirect impact of the diversion of water into the project area would be a very small decrease in the flow in the Mississippi River. The small decrease in flow at this intake location should have no impact on water levels in the Mississippi River, particularly during typical spring discharge.

5.2.1.2.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 5,000 cfs diversion with all past, present, and reasonably foreseeable activities causing changes to or maintaining hydrology in and around the project area.

Operations of the White Ditch structure would need to be done in concert with the existing Caernarvon diversion, as well as the proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch. Coordinated operations of all structures would be necessary to optimize potential benefits within the Breton Sound Basin.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 5,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in flow patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sediment levels and flows. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.1.3 Alternative 2 – 10,000 cfs max Diversion

5.2.1.3.1 Direct

The direct impact of a diversion with the potential of operating up to 10,000 cfs in the area between River aux Chenes and the Mississippi River would be increased water levels and flows within the project area while the structure is being operated. During operations, Mississippi River water would flow through River aux Chenes, Bayou Garelle, and numerous other natural and man-made channels. Flows through these channels would have velocities similar to those in the 5,000 cfs diversion due to the proposed channel improvements (i.e. deepening or widening) as described in the Engineering Appendix (Appendix L). Stages would be elevated near the outfalls of where diverted water is leaving the Bayou Garelle and

flowing into larger, more open, bodies of water. Results from hydrodynamic modeling yield that these stages would be higher than those from the 5,000 cfs diversion.

5.2.1.3.2 Indirect

Indirect impacts of a 10,000 cfs diversion would be the slight inundation of lands while the structure is being operated. During operations these lands would be submerged deeper than the 5,000 cfs diversion. Lands that would not always be inundated during the period would become submerged. With this submergence, there would be an opportunity for the lands to collect sediments, more than the 5,000 cfs diversion, that would be carried by the diverted Mississippi River water, thus renewing historic deltaic processes.

5.2.1.3.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 10,000 cfs diversion with all past, present, and reasonably foreseeable activities causing changes to or maintaining hydrology in and around the project area.

Operations of the White Ditch structure would need to be done in concert with the existing Caernarvon diversion, as well as the proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch. Coordinated operations of all structures would be necessary to optimize potential benefits within the Breton Sound Basin.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 10,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in flow patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sediment levels and flows. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.1.4 Alternative 3 – 15,000 cfs max Diversion

5.2.1.4.1 Direct

The direct impact of a diversion with the potential of operating up to 15,000 cfs in the area between River aux Chenes and the Mississippi River would be increased water levels and flows within the project area while the structure is being operated. During operations, Mississippi River water would flow through River aux Chenes, Bayou Garelle, and numerous other natural and man-made channels. Flows through these channels would have velocities similar to those in the 10,000 cfs diversion due to the proposed channel improvements (i.e. deepening or widening) as described in the Engineering Appendix. Stages would be elevated near the outfalls of where diverted water is leaving the Bayou Garelle and flowing into

larger, more open, bodies of water. Results from hydrodynamic modeling yield that these stages would be higher than those from the 10,000 cfs diversion.

5.2.1.4.2 Indirect

Indirect impacts of a 15,000 cfs diversion would be the slight excess inundation of lands while the structure is being operated. During operations these lands would be submerged deeper than those from the 10,000 cfs diversion. Lands that would not always be inundated during the period would become submerged. With this submergence, there would be an opportunity for the lands to collect sediments, more than from the 10,000 cfs alternative, that would be being carried by the diverted Mississippi River water thus renewing historic deltaic processes.

5.2.1.4.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 15,000 cfs diversion with all past, present, and reasonably foreseeable activities causing changes to or maintaining hydrology in and around the project area.

Operations of the White Ditch structure would need to be done in concert with the existing Caernarvon diversion, as well as the proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch. Coordinated operations of all structures would be necessary to optimize potential benefits within the Breton Sound Basin.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 15,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in flow patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sediment levels and flows. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.2.1.5.1 Direct

The direct impact of a diversion with the potential of operating up to 35,000 cfs in the area between River aux Chenes and the Mississippi River would be increased water levels and flows within the project area while the structure is being operated. During operations, Mississippi River water would flow through River aux Chenes, Bayou Garelle, and numerous other natural and man-made channels. Flows through these channels would have velocities similar to those in the 15,000 cfs diversion due to the proposed channel improvements (i.e., deepening or widening) as described in the Engineering Appendix. Stages would be elevated across large portions of the project area surrounding the outfalls of where diverted water is leaving the Bayou Garelle. Results from hydrodynamic modeling yield that these stages would be

higher than those from the 15,000 cfs diversion. Large areas of the marsh (from approximately 1 mile south and west of Bayou Garelle and the main outfall channel, extending to the northern extent of the project boundary, and being contained by the River aux Chenes and Mississippi River ridges) would be inundated on the order of 0.3 to 0.6 foot during maximum diversion operations. The model indicates that these areas would quickly drain to the normally inundated extent on the order of 5 to 7 days when operations would be shifted from maximum flow to the proposed 1,000 cfs maintenance flow at the end of the March–April pulse.

5.2.1.5.2 Indirect

Indirect impacts of a 35,000 cfs diversion would be the slight inundation of lands while the structure is being operated. During operations these lands would be submerged deeper than those from the 15,000 cfs diversion. Lands that would not always be inundated during the period would become submerged. With this submergence, there would be an opportunity for the lands to collect beneficial sediments, more than from the 15,000 cfs diversion, that would be being carried by the diverted Mississippi River water thus renewing historic deltaic processes.

5.2.1.5.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 35,000 cfs diversion with all past, present, and reasonably foreseeable activities causing changes to or maintaining hydrology in and around the project area.

Operations of the White Ditch structure would need to be done in concert with the existing Caernarvon diversion, as well as the proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch. Coordinated operations of all structures would be necessary to optimize potential benefits within the Breton Sound Basin.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 35,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in flow patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sediment levels and flows. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals. See Appendix L for additional information.

5.2.2 Sedimentation and Erosion

5.2.2.1 No Action Alternative (Future Without Project Conditions)

5.2.2.1.1 Direct

The No Action Alternative, i.e., not implementing a diversion in the White Ditch Study Area, would have a direct impact on sedimentation and erosion within the area between the Mississippi River and River aux Chenes through the continuation of existing degradation of marsh. The absence of a supply of freshwater, sediment, and nutrients combined with the ongoing pressures of wind and wave action, storm surges, and human activities would continue to erode marsh soils and reduce the ability of the project area to maintain a balance of emergent wetland and shallow water.

5.2.2.1.2 Indirect

Indirect impacts of the No Action Alternative would result in the persistence of existing conditions. Consequences would include further degradation of the existing marsh from saltwater intrusion due to impaired hydrologic processes present in the basin; as well as the continued lack of sediments, nutrients, and freshwater. With the absences of these processes, the marsh would not be able to sustain itself against subsidence and prolonged inundation from sea level rise.

The No Action Alternative would cause the marsh to continue with minimal inputs of freshwater, nutrients, and sediment. The sediment deficit would continue to result in subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level (i.e., subsidence plus sea level rise) would continue to permanently inundate marsh communities, which would ultimately lead to substantial losses of acreage.

5.2.2.1.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the No Action Alternative with all past, present, and reasonably foreseeable activities causing changes to or maintaining sedimentation and erosion in and around the project area.

5.2.2.2 Alternative 1 – 5,000 cfs max Diversion

5.2.2.2.1 Direct

The direct impact of a diversion with the potential of operating up to 5,000 cfs in the area between River aux Chenes and the Mississippi River would be increased availability of freshwater, sediments, and nutrients. The sediments in the waters would be available to help “fill in” areas of open water that were historically marsh. The areas that would receive the most potential benefits from the sediments would be the open water areas that would be adjacent to the Bayou Garelle. As sediments reach these areas their velocities begin to decrease and particles would begin to fall out.

Assuming the diversion operated at maximum capacity (5,000 cfs) for 2 months in the spring and 1,000 cfs for the remainder of the year, 74,000 tons of sediment would be expected annually. This amount of sediment would be beneficial to the project area, but it would not be a sufficient amount to offset the rate of marsh loss the project area has historically experienced.

Measures would be taken to prevent erosion of existing features. Restoration of historic ridge features as well as armoring of necessary channels would be done to prevent degradation of the project area from erosive hydraulic forces that would result from diverted flows. The sediments that would be deposited from the diversion would be subject to erosive forces due to their lack of cohesion or consolidation. This is not deemed as a negative impact, but rather a natural process.

5.2.2.2.2 Indirect

Increased sediment introduction into the project area would result in the "filling-in" of open water areas adjacent to the Bayou Garelle. With these areas filling in, there would be more opportunity for SAV to establish themselves across the project area. As time progress in the project area, these areas would likely transition from SAVs to emergent vegetation as more sediment is brought into the area.

With the inundation of land from diverted flows, there would be an opportunity for the lands to collect sediments through overland flow. This process would help established marsh keep pace with the relative sea level rise by aiding in accretion.

5.2.2.2.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 5,000 cfs Alternative with all past, present, and reasonably foreseeable activities causing changes to or maintaining sedimentation and erosion in and around the project area.

The Caernarvon Diversion inputs sediments into the Breton Sound Basin. These sediments likely fall out long before they reach River aux Chenes having no impact on the project area. The CWPPRA project for the rehabilitation of the existing siphon at White Ditch would have direct sediment introduction into the project area, specifically in the northern extents.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 5,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in sedimentation and erosion patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sedimentation and erosion. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.2.3 Alternative 2 – 10,000 cfs max Diversion

5.2.2.3.1 Direct

The direct impact of a diversion with the potential of operating up to 10,000 cfs in the project area would be increased availability of freshwater, sediments, and nutrients. The sediments in the waters would be available to help "fill in" areas of open water that were historically marsh. The areas that would receive

the most potential benefits from the sediments would be the open water areas that would be adjacent to the Bayou Garelle. As sediments reach these areas velocities would decrease and particles would fall out.

Assuming the diversion operated at maximum capacity (10,000 cfs) for 2 months in the spring and 1,000 cfs for the remainder of the year, 108,000 tons of sediment would be expected annually. This amount of sediment would be beneficial to the project area and would be sufficient maintain existing acreage against the current rate of loss.

Measures would be taken to prevent erosion of existing features. Restoration of historic ridge features as well as armoring of necessary channels would be done to prevent degradation of the project area from erosive hydraulic forces that would result from increased velocities of diverted flows. The sediments that would be deposited from the diversion would be subject to erosive forces due to their lack of cohesion or consolidation. This is not deemed as a negative impact, but rather a natural process.

5.2.2.3.2 Indirect

Increased sediment introduction into the project area would result in the "filling-in" of open water areas adjacent to the Bayou Garelle. This effect would be roughly twice that of the 5,000 cfs diversion (assuming a March–April Pulse). With these areas filling in, there would be more opportunity for SAV to establish themselves across the project area. As time progress in the project area, these areas would begin to transition from SAVs to emergent vegetation as more sediment would be brought into the area.

With the inundation of land from diverted flows, there would be an opportunity for the lands to collect sediments through overland flow. This effect would be roughly twice that of the 5,000 cfs diversion (assuming similar operational schemes). This process would help established marsh keep up with relative sea level rise by aiding in accretion.

5.2.2.3.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 10,000 cfs Alternative with all past, present, and reasonably foreseeable activities causing changes to or maintaining sedimentation and erosion in and around the project area.

The Caernarvon Diversion inputs sediments into the Breton Sound Basin. These sediments likely fall out long before they reach River aux Chenes having no impact on the project area. The CWPPRA project for the rehabilitation of the existing siphon at White Ditch would have direct sediment introduction into the project area, specifically in the northern extents.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 10,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in sedimentation and erosion patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sedimentation and erosion. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially

undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.2.4 Alternative 3 – 15,000 cfs max Diversion

5.2.2.4.1 Direct

The direct impact of a diversion with the potential of operating up to 15,000 cfs in the project area would be increased availability of freshwater, sediments, and nutrients. The sediments in the waters would be available to help "fill in" areas of open water that were historically marsh. The areas that would receive the most potential benefits from the sediments would be the open water areas that would be adjacent to the Bayou Garelle. As sediments reach these areas velocities would decrease and particles would fall out.

Assuming the diversion operated at maximum capacity (15,000 cfs) for 2 months in the spring and 1,000 cfs for the remainder of the year, 143,000 tons of sediment would be expected annually. This amount of sediment would be beneficial to the project area and would be sufficient maintain existing acreage against the current rate of loss.

Measures would be taken to prevent erosion of existing features. Restoration of historic ridge features as well as armoring of necessary channels would be done to prevent degradation of the project area from erosive hydraulic forces that would result from increased velocities of diverted flows. The sediments that would be deposited from the diversion would be subject to erosive forces due to their lack of cohesion or consolidation. This is not deemed as a negative impact, but rather a natural process.

5.2.2.4.2 Indirect

Increased sediment introduction into the project area would result in the "filling-in" of open water areas adjacent to the Bayou Garelle. This effect would be roughly three times that of the 5,000 cfs diversion (assuming a March–April Pulse). With these areas filling in, there would be more opportunity for SAV to establish themselves across the project area. As time progress in the project area, these areas would begin to transition from SAVs to emergent vegetation as more sediment is brought into the area.

With the inundation of land from diverted flows, there would be an opportunity for the lands to collect sediments through overland flow. This effect would be roughly three times that of the 5,000 cfs diversion (assuming similar operational schemes). This process would help established marsh keep up with the relative sea level rise by aiding in accretion.

5.2.2.4.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 15,000 cfs Alternative with all past, present, and reasonably foreseeable activities causing changes to or maintaining sedimentation and erosion in and around the project area.

The Caernarvon Diversion inputs sediments into the Breton Sound Basin. These sediments likely fall out long before they reach River aux Chenes having no impact on the project area. The CWPPRA project for the rehabilitation of the existing siphon at White Ditch would have direct sediment introduction into the project area, specifically in the northern extents.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 15,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in sedimentation and erosion patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sedimentation and erosion. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.2.2.5.1 Direct

The direct impact of a diversion with the potential of operating up to 35,000 cfs in the project area would be increased availability of freshwater, sediments, and nutrients. The sediments in the waters would be available to help "fill in" areas of open water that were historically marsh. The areas that would receive the most potential benefits from the sediments would be the open water areas that would be adjacent to the Bayou Garelle. As sediments reach these areas velocities would decrease and particles would fall out.

Assuming the diversion operated at maximum capacity (35,000 cfs) for 2 months in the spring and 1,000 cfs for the remainder of the year, 279,000 tons of sediment would be expected annually. This amount of sediment would be sufficient to exceed the current rate of marsh loss and would have potential to recreate acreage comparable to that present in the 1950s.

Measures would be taken to prevent erosion of existing features. Restoration of historic ridge features as well as armoring of necessary channels would be done to prevent degradation of the project area from erosive hydraulic forces that would result from increased velocities of diverted flows. The sediments that would be deposited from the diversion would be subject to erosive forces due to their lack of cohesion or consolidation. This is not deemed as a negative impact, but rather a natural process.

5.2.2.5.2 Indirect

Increased sediment introduction into the project area would result in the "filling-in" of open water areas adjacent to the Bayou Garelle. This effect would be roughly seven times that of the 5,000 cfs diversion (assuming a March–April Pulse). With these areas filling in, there would be more opportunity for SAV to establish themselves across the project area. As time progress in the project area, these areas would begin to transition from SAVs to emergent vegetation as more sediment is brought into the area.

With the inundation of land from diverted flows, there would be an opportunity for the lands to collect sediments through overland flow. This effect would be roughly seven times that of the 5,000 cfs diversion (assuming similar operational schemes). This process would help established marsh keep up with the relative sea level rise by aiding in accretion.

5.2.2.5.3 Cumulative

Cumulative impacts would be the synergistic and combined effect of the 35,000 cfs Alternative with all past, present, and reasonably foreseeable activities causing changes to or maintaining sedimentation and erosion in and around the project area.

The Caernarvon Diversion inputs sediments into the Breton Sound Basin. These sediments likely fall out long before they reach River aux Chenes having no impact on the project area. The CWPPRA project for the rehabilitation of the existing siphon at White Ditch would have direct sediment introduction into the project area, specifically in the northern extents.

The proposed Myrtle Grove diversion, which if constructed would be directly across the river from the proposed White Ditch structure could have cumulative effects with the 35,000 cfs diversion. The combination of the two structures working in proximity to each other on opposite sides of the Mississippi River could potentially create changes in sedimentation and erosion patterns. The risk of this is low due to the relatively small percentage of water actually that would actually be diverted from the river.

Other existing and proposed diversions along the Mississippi River could collectively have impacts on sedimentation and erosion. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole assemblage could have effects on flows and stages. System-wide coordination would be necessary to ensure avoidance of potentially undesirable impacts. An overall operating plan for diversions would allow beneficial use of the river for multiple uses and goals.

5.2.3 Water Use and Supply

5.2.3.1 No Action Alternative (Future Without Project Conditions)

5.2.3.1.1 Direct

Under the No Action Alternative no direct impacts to water use and supply of the project area would occur.

5.2.3.1.2 Indirect

Indirect impacts of not implementing restoration features would result in the persistence of existing conditions for the Mississippi River and White Ditch project area.

5.2.3.1.3 Cumulative

Cumulative impacts would be the synergistic effect on the No Action Alternative for water use and supply with the added combination of similar wetland degradation and wetland loss impacts to water use and supply throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

5.2.3.2 Alternative 1 – 5,000 cfs max Diversion

5.2.3.2.1 Direct

Under the 5,000 cfs diversion, no significant direct impacts to water use and supply of the project area would occur.

5.2.3.2.2 Indirect

Under the 5,000 cfs diversion, no significant indirect impacts to water use and supply of the project area would occur.

5.2.3.2.3 Cumulative

Cumulative impacts would be the synergistic effect on the 5,000 cfs diversion for water use and supply with the added combination of similar wetland degradation and wetland loss impacts to water use and supply throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

5.2.3.3 Alternative 2 – 10,000 cfs max Diversion

5.2.3.3.1 Direct

Under the 10,000 cfs diversion, no direct impacts to water use and supply of the project area would occur.

5.2.3.3.2 Indirect

Under the 10,000 cfs diversion, no indirect impacts to water use and supply of the project area would occur.

5.2.3.3.3 Cumulative

Cumulative impacts would be the synergistic effect on the 10,000 cfs diversion for water use and supply with the added combination of similar wetland degradation and wetland loss impacts to water use and supply throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

5.2.3.4 Alternative 3 – 15,000 cfs max Diversion

5.2.3.4.1 Direct

Under the 15,000 cfs diversion, no direct impacts to water use and supply of the project area would occur.

5.2.3.4.2 Indirect

Under the 15,000 cfs diversion, no indirect impacts to water use and supply of the project area would occur.

5.2.3.4.3 Cumulative

Cumulative impacts would be the synergistic effect on the 15,000 cfs diversion for water use and supply with the added combination of similar wetland degradation and wetland loss impacts to water use and supply throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

5.2.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.2.3.5.1 Direct

Under the 35,000 cfs diversion, no direct impacts to water use and supply of the project area would occur.

5.2.3.5.2 Indirect

Under the 35,000 cfs diversion, no indirect impacts to water use and supply of the project area would occur.

5.2.3.5.3 Cumulative

Cumulative impacts would be the synergistic effect on the 35,000 cfs diversion for water use and supply with the added combination of similar wetland degradation and wetland loss impacts to water use and supply throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

5.2.4 Groundwater

5.2.4.1 No Action Alternative (Future Without Project Conditions)

5.2.4.1.1 Direct

Under the No Action Alternative no direct impacts to groundwater of the project area would occur.

5.2.4.1.2 Indirect

Under the No Action Alternative no indirect impacts to groundwater of the project area would occur.

5.2.4.1.3 Cumulative

Cumulative impacts would be the synergistic effect of the No Action Alternative on groundwater with the added combination of similar wetland degradation and wetland loss impacts to groundwater, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. No cumulative impacts would be anticipated.

5.2.4.2 Alternative 1 – 5,000 cfs max Diversion

5.2.4.2.1 Direct

Under the 5,000 cfs diversion, no direct impacts to groundwater of the project area would occur.

5.2.4.2.2 Indirect

Under the 5,000 cfs diversion, no indirect impacts to groundwater of the project area would occur.

5.2.4.2.3 Cumulative

Cumulative impacts would be the synergistic effect of the 5,000 cfs diversion on groundwater with the added combination of similar wetland degradation and wetland loss impacts to groundwater, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. No cumulative impacts would be anticipated.

5.2.4.3 Alternative 2 – 10,000 cfs max Diversion

5.2.4.3.1 Direct

Under the 10,000 cfs diversion, no direct impacts to groundwater of the project area would occur.

5.2.4.3.2 Indirect

Under the 10,000 cfs diversion, no indirect impacts to groundwater of the project area would occur.

5.2.4.3.3 Cumulative

Cumulative impacts would be the synergistic effect of the 10,000 cfs diversion on groundwater with the added combination of similar wetland degradation and wetland loss impacts to groundwater, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. No cumulative impacts would be anticipated.

5.2.4.4 Alternative 3 – 15,000 cfs max Diversion

5.2.4.4.1 Direct

Under the 15,000 cfs diversion, no direct impacts to groundwater of the project area would occur.

5.2.4.4.2 Indirect

Under the 15,000 cfs diversion, no indirect impacts to groundwater of the project area would occur.

5.2.4.4.3 Cumulative

Cumulative impacts would be the synergistic effect of the 15,000 cfs diversion on groundwater with the added combination of similar wetland degradation and wetland loss impacts to groundwater, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. No cumulative impacts would be anticipated.

5.2.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.2.4.5.1 Direct

Under the 35,000 cfs diversion, no direct impacts to groundwater of the project area would occur.

5.2.4.5.2 Indirect

Under the 35,000 cfs diversion, no indirect impacts to groundwater of the project area would occur.

5.2.4.5.3 Cumulative

Cumulative impacts would be the synergistic effect of the 35,000 cfs diversion on groundwater with the added combination of similar wetland degradation and wetland loss impacts to groundwater, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity. No cumulative impacts would be anticipated.

5.3 WATER QUALITY AND SALINITY

5.3.1 Water Quality

5.3.1.1 No Action Alternative (Future Without Project Conditions)

5.3.1.1.1 Direct

Under the No Action Alternative, no diversion of river water and no input of river sediments and nutrients would occur in the MDWD project area. None of the potential negative effects of river inflows to this portion of the Breton Sound Basin would result; however, the project area would continue to be isolated from natural riverine processes critical to maintaining functioning and sustainable coastal wetlands and estuaries.

5.3.1.1.2 Indirect

The most notable indirect impact from no action is the ongoing erosion/subsidence and land loss of the coastal areas. This would continue to expose the pipelines of the expansive oil and gas infrastructure along the coast of Louisiana. This would be a precarious situation, especially during storm events and within navigable waterways. Exposed pipelines would be vulnerable to navigation vessels striking them, which could lead to discharges into waters of the project area. In the event of discharges, extensive ecological damage would probably occur. The owner(s) of the infrastructure could incur expensive fines and cleanup costs; and vessel operators could be seriously injured. There would be other forms of infrastructure that could potentially be exposed due to coastal erosion including wastewater collection systems and other commercial industry related systems.

5.3.1.1.3 Cumulative

Without the proposed actions of White Ditch Medium Diversion Project the Breton Sound Basin would still be affected by activities, natural and man-influenced, that would have both beneficial and detrimental effects to water quality conditions. Some of these activities include: other Federal, state, local, and private

restoration efforts such as CWPPRA, USACE ecosystem restoration projects, various NRCS programs (e.g., Coastal Wetlands Restoration Program), and CPRA projects; state and local water quality management programs; national level programs to address hypoxia in the northern Gulf of Mexico; the continued erosion/subsidence of the coast; oil and gas development; industrial, commercial, and residential development; and Federal, state, and municipal navigation and flood-damage reduction projects. There would be a number of present and future activities that would continue to occur without the proposed actions of the LCA Plan and would affect surface water quality conditions within the White Ditch Project Area. The cumulative impact of these activities without the LCA Plan is discussed below. Passage of the Federal Water Pollution Control Act (FWPCA) in 1948 and its amendments including the CWA and the Water Quality Act of 1987 and the establishment of state and Federal environmental protection agencies resulted in water pollution control regulations, including:

- The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution. In 1997 the USEPA granted NPDES delegation to LDEQ, which is known as the Louisiana Pollutant Discharge Elimination System (LPDES).
- LDEQ's Nonpoint Source Pollution Program is continuing to implement watershed initiatives to address nonpoint source pollution sources such as agriculture, home sewage treatment, hydro modification, urban runoff, construction activities, and resource extraction.
- LDNR's Coastal Nonpoint Pollution Program is responsible for identifying Best Management Practices (BMPs) appropriate for all applicable pollutant source categories and carrying out initiatives of public education, technical assistance, and development of enforcement protocols.
- Total Maximum Daily Loads (TMDLs) – Section 303(d) of the CWA requires states to identify, list, and rank for development of TMDLs waters that do not meet applicable water quality standards after implementation of technology-based controls.

The programs discussed above would continue to develop or remain in place with or without MDWD project features to ensure protection of Louisiana's public health and natural resources. Water quality conditions would likely improve with the programs in place. However, some activities that could potentially have negative effects on water quality would also continue to occur with or without the proposed MDWD Plan. Other efforts that would probably improve water quality conditions would be the present and future Federal, state, local, and private ecosystem restoration projects.

Industrial, commercial, and residential development along the coast could contribute to adverse impacts to water quality within the MDWD project area. With this activity comes increased point and nonpoint source pollution from sources such as wastewater treatment facilities and urban runoff from new development. Also, activities associated with maintaining and improving navigation along the coast would continue to occur.

Flood-damage reduction projects would continue to be planned, designed, and constructed especially in areas highly susceptible to flood damages due to hurricanes and tropical storm events. With these activities, more alterations to the hydrology of the coast would potentially occur leading to areas of degraded water quality. Some projects, such as the Southeast Louisiana Urban Flood Control Project, would be providing flood protection for a 10-year rainfall event. However, this is also increasing the flow of urban runoff that is diverted into Lake Pontchartrain and other surrounding water bodies without providing pollutant reduction measures as seen in many stormwater collection systems across the nation. Unfortunately, metro New Orleans' unique geographic setting does not allow for incorporating many pollutant reduction methods; however, the NPDES Storm Water Program and the continued development

of TMDLs could require stormwater professionals to find innovative methods, such as subsurface structural BMP to drain the populated areas effectively while protecting the receiving water bodies as much as practicable. Adverse impacts to water quality by these Federal projects would be mitigated as legally mandated.

5.3.1.2 Alternative 1 – 5,000 cfs max Diversion

5.3.1.2.1 Direct

The direct impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.2.2 Indirect

The indirect impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.2.3 Cumulative

The cumulative impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.3 Alternative 2 – 10,000 cfs max Diversion

5.3.1.3.1 Direct

The Direct impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.3.2 Indirect

The indirect impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.3.3 Cumulative

The cumulative impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.4 Alternative 3 – 15,000 cfs max Diversion

5.3.1.4.1 Direct

The Direct impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.4.2 Indirect

The indirect impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.4.3 Cumulative

The cumulative impacts of this alternative would have the similar effects as the 35,000 cfs diversion, but they would be on a lesser scale due to the amount of water being diverted.

5.3.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.3.1.5.1 Direct

In general, river diversions could cause short- to long-term adverse impacts due to construction of restoration features including: increased total suspended sediments, turbidity, and organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures; and the possible release of oxygen depleting substances (organic or anaerobic sediments) as well as possibly decreasing dissolved oxygen (DO) levels. Note that many of the direct impacts could also be indirect effects (see below). These impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs), the ITM protocols, and other applicable best management practices (BMPs).

Generally, four water quality conditions could change with implementation of the proposed restoration alternative. The four water quality conditions that would change include:

1. Freshwater would be moved throughout the entire MDWD project area;
2. Salinities would decrease throughout the entire project area, especially during and after the months of maximum diversion;
3. Sediments in the project area would increase allowing the maximum amount of marsh creation of all the alternatives, along with accompanying minor increases in trace metals associated with suspended and bed sediments; and
4. Agrochemicals/Nutrients in the project area could increase.

Introduction of river water into the Breton Sound Basin would immediately change the water chemistry of receiving areas. Change could be beneficial or detrimental, depending the water uses. The change from a less fresh to a fresher system could be perceived as beneficial to wetland nourishment, but detrimental to recreational use because of water color changes, and possible changes in fish species assemblages. However, the changes in water chemistry would mimic what occurred naturally prior to the construction of levees.

Data has been collected from the Mississippi River at the Luling Water Plant Collection Site, Site WSS 1, coordinates N 29.56.076, W 90.21.602, for the Davis Pond Diversion project. This data has been reviewed with respect to nutrients and atrazine, and an estimated load was calculated based on the TSP of 35,000 CFS for the months of March and April along with the loads associated with a 1,000 CFS diversion for the rest of the months of the year. This data captures the estimated average Mississippi River water quality for the 10 years that data has been collected for Total Nitrogen and Total Phosphate. The estimated Atrazine loads were calculated on data that was collect from the years 2001 through 2008; however, during 2005 there was no Atrazine data collected and for the years prior to 2001 the observed values were below the detection limit of the laboratory. Table 5.1 shows the estimated average total load per month. The anticipated loads to the project area are estimated values due to the fact that daily values

were not collected, so a monthly value was used for the calculations. During PED, more data will be collected in the project area and analyzed. See Section 3.8.8 for more details.

Table 5.1: Estimated Average Total Load (Tonnes)/Month

Month	Total Nitrogen	Total Phosphate	Total Atrazine
January	169	20	35.4
February	179	15	53.7
March	6927	712	1954.6
April	8131	517	2490.5
May	195	18	78.2
June	225	19	79.1
July	196	22	58.0
August	192	16	66.0
September	137	18	53.1
October	96	16	49.3
November	136	15	48.6
December	159	13	48.7
Total per year	16742	1401	5015.2
Load (mg) = mg/L x (L/ft^3) x (ft^3/sec) x (secs/day) x days			

There could be potential chemical effects due to either an increase or decrease in the methylation of mercury. The potential for increase in mercury methylation would occur during the initial construction of the structure, the outfall canals and the creation of new wetlands due to sediment disturbance. This would be a short term adverse impact. Reintroduction of river water could increase the risk of conditions favorable to the causes of methylation by changing the levels of dissolved organic carbon and changing the pH of the water. This would be a potential long term adverse impact. At the same time the increased sediment load would trap mercury in the soil as new marsh is created by the diversion as well as the accumulation of the mercury in the plants would be a long term positive impact.

The reintroduction of streambed sediments into the MDWD project area could add some contaminants; these could include primarily trace metals and hydrophobic organic compounds from Mississippi River streambed sediments. Trace metals and hydrophobic organic compounds such as pyrenes, hexachlorobenzene, and chlorinated hydrocarbons such as DDT, or its degradates, would adsorb onto sediment particles or the organic coatings of sediment particles (Demas and Demcheck 2003).

5.3.1.5.2 Indirect

Indirect effects of changes to water quality could include: nutrient enrichment possibly leading to increased algae blooms and freshwater tolerant aquatic organisms; increased turbidity leading to disruption of freshwater and marine organisms; decreased water temperatures; increased DO; freshwater areas would increase thereby providing additional habitats for aquatic organisms; salinities would stabilize or decrease; sediments in the coastal zone would increase, with accompanying minor increases in trace metals associated with bed sediments; and agrichemicals in the water could increase.

A model of nitrate-nitrogen retention by wetlands in the Mississippi River Basin was developed combining 24 wetland-years of nitrate-nitrogen data from Ohio and Louisiana with nitrate reduction data from another 26 wetland-years of data from additional wetlands in Ohio, Illinois and Louisiana (Phipps and Crumpton, 1994; Kovacic et al., 2000; Lane et al., 2002; Fink and Mitsch, 2004; Mitsch and Day, in press). The study shows that wetlands in their study area in Louisiana have an average retention of 46 g-N per square meter per year. All of these studies received either Mississippi River diversion water or agricultural runoff. The wetland would be expected to reduce nutrient concentrations by about 45% (William J. Mitsch, et al.). There are approximately 56,000 acres (226,622,200 square meters) of wetlands in the MDWD study area. Table 5.2 shows the estimated residual nitrogen in the water in wetlands in the study area. Hydraulic modeling results show that some of the diversion water would pass through the ridge into the extended influence boundary. From this we can infer that some of the remaining nitrogen would be taken up by the wetlands in that area. The hydraulic model also shows that some of the water would also flow south in to America Bay and Brenton Sound.

Table 5.2: Estimated Residual N After Wetland Uptake

Month	Estimated Avg. Total Load N input water (g-N)	Grams-N/Square Meter wetlands in Study Area	Potential Uptake of Wetlands (g-N/m^2 month)	Residual N in Water (g-N/m^2 month)
January	169,000,000	0.75	3.83	0
February	179,000,000	0.79	3.83	0
March	6,927,000,000	30.57	3.83	26.73
April	8,131,000,000	35.88	3.83	32.05
May	195,000,000	0.86	3.83	0
June	225,000,000	0.99	3.83	0
July	196,000,000	0.86	3.83	0
August	192,000,000	0.85	3.83	0
September	137,000,000	0.60	3.83	0
October	96,000,000	0.42	3.83	0
November	136,000,000	0.60	3.83	0
December	159,000,000	0.70	3.83	0
Total per year	16,742,000,000	73.88	46.00 g-N/m^2 year	27.88 g-N/m^2 year

The uptake of nutrients by wetland plants and sediments would lower the potential for eutrophication of waters in the study area. In addition, long term experience with the operation of the Caernarvon and Davis Pond freshwater diversion structures indicates that the operation of these projects has not been related to eutrophication and fish kills. In 2010 the State of Louisiana operated both of these structures near their maximum capacity for an extended period, contributing greatly to freshening their respective receiving areas with river water. During this time period there were no eutrophication issues or fish kills related to this operation.

At a pulse flow rate of 35,000 cfs at White Ditch, river water would displace the water in the White Ditch receiving area. During these maximum pulse diversions, conditions would not be conducive for algae bloom formation because water movement would keep suspended material in the water column, inhibiting

light penetration. Also, water temperatures would not be at their peak in March and April. After flow is reduced to 1,000 cfs, the potential for algae blooms would increase. However, this would be similar to the conditions that occurred in summer 2010 in the Caernarvon and Davis Pond receiving areas after the flow rates for those structures were reduced to minimum levels.

Monitoring and management of the MDWD project through adaptive management would help to ensure that operation of the project would minimize the potential for algae blooms and eutrophication of the receiving waters. Coordination with LDEQ, USEPA, and other stakeholders would also contribute to minimizing impacts to receiving waters.

This nutrient pulse from the diversion and the associated reduction would have a direct influence on increased plant production within the project area. A concept of nutrient "potential" energy is used to describe the energy or nutrition available to potentially support biomass production per unit area of marsh. The analysis generates an estimate of the maximum biomass production that can be expected in a given marsh type (e.g., fresh, brackish, or salt) from the nutrients available in a volume of water from a given water source (Boustany, Ronald G.). This analysis is part of the ERDC-SAND2 model that was used to identify the potential of the diversion to create marsh. For more information on this model and how it was used, see sections 3.3.4.1, 3.5.4.2, 3.5.4.3, 3.8.2, 3.8.3, and Appendix L.

Estimated atrazine loads were calculated (Table 5.2) based on the Recommended Plan. There are no direct ways to calculate the impacts to water quality associated with the estimated loads into the Breton Sound Basin. However research performed at the University of South Carolina found the following:

The fate and transport of pesticides in aquatic systems are facilitated to a large degree by physical, biological and chemical processes such as oxidation, sorption, volatilization, microbial degradation and photolysis. Atrazine, a preemergent triazine herbicide has the potential to persist in the environment due to its slight water solubility and long half-life. Deethylatrazine (DEA) and deisopropylatrazine (DIA), the two major microbial breakdown products, have been measured extensively in surface and groundwater. The biodegradation of atrazine was monitored in sediments collected from coastal South Carolina by examining the distribution into three chemical fractions over time. Due to sorption to sediment organic matter after 80 days only 50–70% of the total added atrazine was recovered. Of this, between 20 and 30% of the activity measured was associated with the aqueous fraction indicating degradation to more water-soluble metabolites. Another 20–50% of the remaining activity, depending on site, was associated with the basic fraction indicative of sorption of atrazine and/or its metabolites to sediment organic matter. These results suggest that degradation and sorption account for the fate of greater than 80% of the atrazine recovered in these coastal sediments (Kelly L. Smalling and C. Marjorie Aelion).

Similar results are anticipated to occur within the project area based on the estimated atrazine loads calculated to enter the project based on the operations of the Recommended Plan. However the fate would be dependent on the actual load into the project area and the retention time of the diversion within the project area. Furthermore in the article "Atrazine Fate Processes in a Constructed Emergent marsh" 1998 research updates, it is stated that restoration or creation of wetlands adjacent to rivers has been proposed as a means of treating agricultural runoff and protecting downstream surface waters from the effects of non-point pollutants (Detenbeck et al.).

Although the water quality impacts associated with the predicted atrazine loads into Breton Sound cannot be directly calculated, the risk of adverse ecological impacts attributable to the atrazine loading is

anticipated to be low. EPA has developed draft ambient water quality criteria for atrazine for the protection of aquatic life through its authority under section 304(a) of the Clean Water Act (CWA). These water quality criteria are guidance for Sates and Tribes and in themselves have no binding legal effect. The criteria may form the basis for State and Tribal water quality standards and in turn become enforceable through National Pollutant Discharge Elimination System (NPDES) permits or other environmental programs. The EPA has identified 10 to 20 ppb as a level of ecological concern as part of the corn and sorghum monitoring program. Maximum atrazine concentrations in the Mississippi River are less than 3 ppb, lower than not only the ecological level of concern but also the Maximum Contaminant Level for atrazine under the Safe Drinking Water Act (33 U.S.C. section 300f et seq.). Therefore it is not predicted at this time that the project's operation will elevate atrazine concentrations to levels that could cause adverse impacts.

Reduction in salinities could improve water quality by reducing chelating potential of metals since total dissolved solids would be decreased. Also, reduction in salinity would decrease temperature variations in the fresher waters. It should be noted that there has been some discussion in the scientific community of the potential for negative effects due to Mississippi River diversions introducing excessive amounts of nutrients. However, monitoring and management through the adaptive management approach would be necessary to ensure that proper assimilation is occurring in the receiving areas. Coordination with LDEQ, USEPA, and other stakeholders would be necessary to ensure the applicable water bodies would be protected.

5.3.1.5.3 Cumulative

The introduction of agrochemicals into the MDWD project area would be a management issue. Agricultural chemicals, primarily herbicides and fertilizers, would be introduced into the area from the Mississippi River system. These agricultural chemicals would then be further distributed into portions of the basin via the Caernarvon diversion. This input of agrochemicals, known as the spring flush, would be further distributed, to varying degrees, into the Breton Sound Basin area. Adaptive management would be important in addressing this issue. A water quality concern would be the herbicide atrazine, which is known to have endocrine disruption effects. The overall effect of this herbicide on the project area would be unknown. Acute effects, such as marsh plant death would not occur, as evidenced by plants in Breton Sound Basin that are presently exposed to atrazine-laced water from the Mississippi River, with no readily obvious detrimental effects. The fertilizers in the spring flush would have both beneficial and detrimental effects, depending on site-specific areas. In review of nutrient data collected by the USGS from the years 1999 to present it is shown that the highest nutrient loads based on data published in U.S. Geological Survey Open-File Report 2007-1080 at the Mississippi River near St. Francisville, Louisiana (Station ID 07373420) are during the months of March through June. There are slight variations through the years that can be attributed to differences in rainfall and the timing of application of agrochemicals in the upper Mississippi River Basin. Also in reviewing the Caernarvon Freshwater Diversion Structure Hydrologic, Water, and Sediment Quality Monitoring Program 1994 post construction Report, Dated September 1995, it is noted that albeit at a lesser diversion rate there was no significant degradation of water quality or impairment of designated uses in the receiving area such as fish kills or eutrophication.

These nutrients would be strongly implicated in the formation of the hypoxic zone off the mouth of the Mississippi River; however a diversion of this magnitude could aid in reducing the size or duration of the gulf hypoxic zone. But, the reintroductions could have the potential to contribute to eutrophication within the Breton Sound Basin. There would be a monitoring plan developed that would monitor not only

nutrients but also metals, agrochemicals and dissolved oxygen for three years prior to construction and ten years after construction to adequately gauge the water quality impacts in the basin. Monitoring efforts and adaptive management actions would be key to addressing and controlling the effects of the diversion pulses into the MDWD project area.

Implementing the MDWD, the Breton Sound Basin and Subprovince 1 would be affected by other activities and programs that would cumulatively have both beneficial and detrimental effects on water quality conditions. Some of these past, present, and foreseeable future activities include state and local water quality management programs; oil and gas development; industrial, commercial, and residential development; and Federal, state, and local navigation and flood-damage reduction projects.

Management officials should consider these other activities, and ensure that all activities including the other LCA projects complement each other. This is critical to ensure the protection of Louisiana's coastal waters and the health of the public that utilizes these waters.

The LDEQ TMDL program is an example of a present program that would be affected by the implementation of some LCA Plan project elements. Consequently, the incremental impact of both would affect water quality conditions. Section 303(d) of the CWA requires the state to identify, list, and rank for development of TMDLs waters that do not meet applicable water quality standards after implementation of technology based controls. Other programs that could be affected by the MDWD and, simultaneously, cumulatively impact water quality conditions include LDEQ's LPDES program, LDEQ's Nonpoint Source program, LDNR's Coastal Nonpoint Source program and others.

The direct and indirect impacts discussed previously would cumulatively impact water quality conditions along with other coastal activities. The proposed diversion could independently elevate water quality constituents such as nutrients and sediment in receiving areas. Other activities such as development would potentially increase point and nonpoint source pollution in the same water bodies, therefore, causing a cumulative effect. However, continued state and Federal programs tasked with regulating water quality impacts would benefit the same water bodies. It is not possible to quantify the effects to the Breton Sound Basin and Subprovince 1 from all of the coastal activities; however, during the project implementation phase testing and analysis would be conducted to better assess the effects.

In summation the cumulative impacts to water quality would primarily be related to the incremental impact of all past, present, and future actions effecting water quality within the Basin such as:

- Increase in freshwater areas;
- Stabilization or decrease in salinities;
- Increase in sediment introduction to the coastal zone, with accompanying minor increases in trace metals associated with bed sediments;
- Increase in agrichemicals in the water;
- Increased total suspended sediments;
- Increased turbidity;
- Increased organic/nutrient enrichment of the water column;
- Disturbance and release of possible contaminants;

- Decrease in water temperatures along with fewer water temperature fluctuations; and
- Less potential for chelating metals due to reduced total dissolved solids.

However the cumulative impacts to the water quality of the Breton Sound Basin from this alternative would be a synergistic positive result over and above the additive combination of impacts and benefits of the other alternatives.

5.3.2 Salinity

5.3.2.1 No Action Alternative (Future Without Project Conditions)

5.3.2.1.1 Direct

Under the No Action Alternative no direct impacts to salinity levels of the project area would occur.

5.3.2.1.2 Indirect

Indirect impacts of no action would be the persistence of existing conditions and continued degradation of the White Ditch project area with respect to increasing salinities over time. Over the 50-year planning horizon, baseline salinity values of 4.4 ppt in the intermediate marsh zone would be anticipated to increase to approximately 5.0 ppt, the baseline of 6.6 ppt in the brackish marsh zone would be expected to increase to approximately 8.0 ppt, and the saline zone baseline of 13.0 ppt would increase to approximately 15.0.

5.3.2.1.3 Cumulative

Cumulative impacts would be the synergistic effect of the No Action Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal Government. The No Action Alternative would contribute in a negative manner to the cumulative effects on salinity experienced by most marsh areas in Southern Louisiana.

5.3.2.2 Alternative 1 – 5,000 cfs max Diversion

5.3.2.2.1 Direct

Year-long hydrological model simulations were performed to determine salinity changes resulting from diversion operation. Model runs consisted of a March–April open operation (i.e., pulse up to 35,000 cfs) (Figure 5.2) and maintenance flow (i.e., 1,000 cfs) (Figure 5.3) for the May–February period. Flows for the Caernarvon Structure were set to yearly averages. During the March–April open operation period, model results indicated that the fresh-intermediate and brackish zones would become completely fresh and the saline marsh zone would average approximately 1 ppt.

In the fresh marsh areas salinities would remain at 0 ppt during the 2-month pulse and for approximately 2 months afterwards. During the rest of the growing season, salinities would range up to 1.5 ppt. An overall mean salinity during the growing season was calculated to be approximately 0.5 ppt, which is within the optimal range for fresh marsh. Based on the modeling results, a portion of the existing intermediate marsh area would convert to fresh marsh.

The intermediate marsh area is projected to be at 0 ppt during the 2-month pulse and for approximately 1 month afterwards. Salinities begin to increase during the maintenance flow period resulting in a mean salinity during the growing season of 1.6 ppt.

For the brackish area, salinities are projected to be 0 ppt during the 2-month pulse, increase to 2 ppt in the following month, and 4 ppt the next month. Salinities are projected to average approximately 6.6 ppt during the remainder of the year, resulting in a mean annual salinity of 5 ppt.

For the saline area, salinities are projected to average near 1 ppt during the 2-month pulse, then increase to 5 ppt in the following month and 10 ppt in the next month, and average approximately 13 ppt during the remainder of the year. Mean annual salinity would be approximately 10 ppt.

Operation and management measures could work toward establishing target zones for optimum marsh type production throughout the project area. Of the implementation alternatives considered, the 5,000 cfs diversion would have the least amount of flexibility in terms of controlling and manipulating the salinity regime. Consequently, it would present the least amount of options for adaptive management.

5.3.2.2.2 Indirect

Indirect impacts of implementing restoration features into the project area would be the possible permanent transition of marsh types. These changes could have short term consequences, such as displacement of one type of marsh vegetation by another, but have long term benefits by providing a sustainable marsh and delta forming functions. Based on a review of hydrologic modeling output, which provided predicted salinities across the project area, it was determined that a portion of the intermediate marsh area would transition to fresh marsh. The transition line from fresh to intermediate was determined by reviewing the salinity modeling results and reviewing habitat data for the Caernarvon Diversion outfall area to determine the range of fresh marsh in the outfall area. The fresh-intermediate marsh boundary was delineated at the approximate 1.0 ppt isohaline. Based on the modeling results, it was assumed that the intermediate-brackish and brackish-saline marsh boundaries would remain as shown on the 2001 Coastal Marsh Vegetative Type Map.

5.3.2.2.3 Cumulative

Cumulative impacts would be the synergistic effect of the 5,000 cfs Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal Government. The operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin.

5.3.2.3 Alternative 2 – 10,000 cfs max Diversion

5.3.2.3.1 Direct

Salinity levels within the White Ditch project area would be affected. Significant freshening of the project area as well as the entire Breton Sound Basin would occur with maximum operations of the structure. Since all build alternatives completely freshen the Breton Sound, anticipated salinity changes are the same as described in Section 5.3.2.2.1. Operation and management measures could work toward

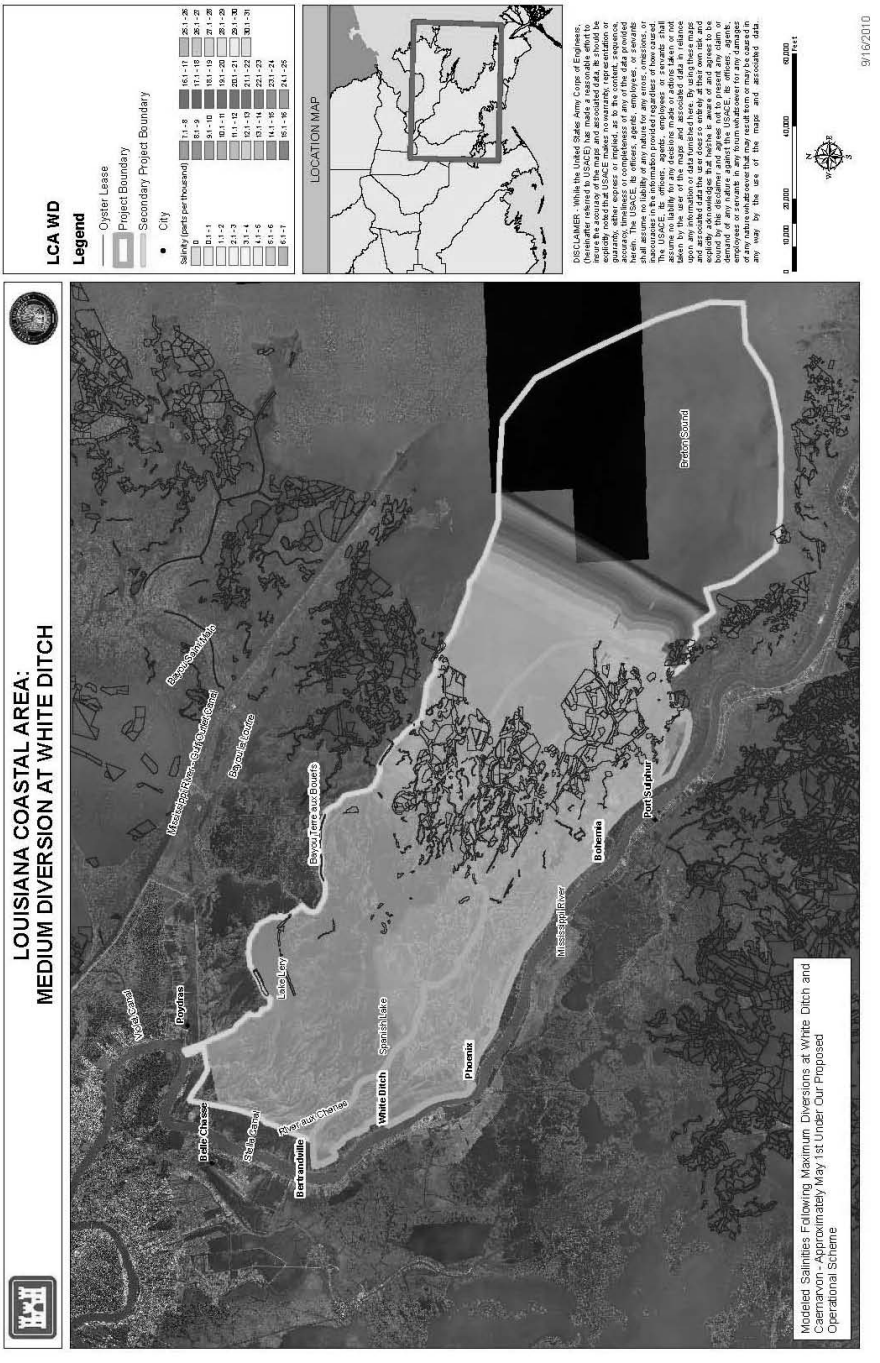


Figure 5.2: Modeled Salinities Following Maximum Diversions at White Ditch and Caernarvon – Approximately May 1st Under Our Proposed Operational Scheme

This page intentionally left blank.

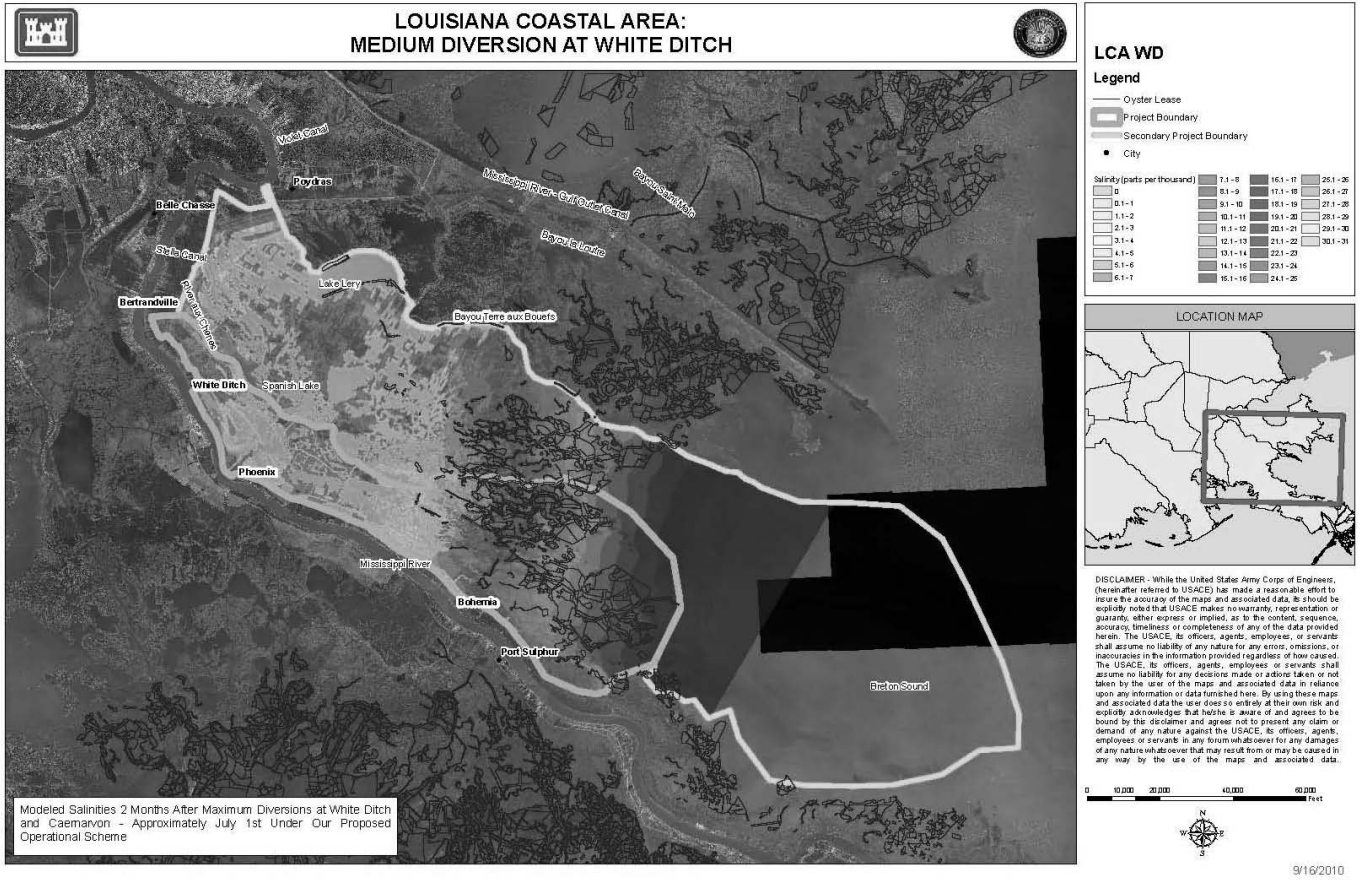


Figure 5.3: Modeled Salinities Two Months After Maximum Diversions at White Ditch and Caernarvon – Approximately July 1st Under Our Proposed Operational Scheme

This page intentionally left blank.

establishing target zones for optimum marsh type production throughout the project area. Of the implementation alternatives considered, the 10,000 cfs diversion would have more flexibility in terms of controlling and manipulating the salinity regime than the 5,000 cfs but less than the 15,000 cfs.

5.3.2.3.2 Indirect

Indirect impacts of implementing restoration features into the project area would be the possible permanent transition of marsh types. These changes could have short-term consequences, such as displacement of one type of marsh vegetation by another, but have long-term benefits by providing a sustainable marsh and delta forming functions. Indirect impacts to marsh zones of the 10,000 cfs alternative would be anticipated to be as described in Section 5.3.2.2.2 under the proposed operating plan; however, the operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin. With these structures running concurrently for an extended period of time, there could be undesired consequences in the Breton Sound.

5.3.2.3.3 Cumulative

Cumulative impacts would be the synergistic effect of the 10,000 cfs Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal Government. The operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin.

5.3.2.4 Alternative 3 – 15,000 cfs max Diversion

5.3.2.4.1 Direct

Under the 15,000 cfs diversion, direct impacts to salinity levels in the Mississippi River would not occur. The proposed operating plan would result in the diversion only operating at maximum flows during spring flood pulses. There would be no salt wedge intrusion from the gulf during this time.

Salinity levels within the White Ditch project area would be affected. Significant freshening of the project area as well as the entire Breton Sound Basin would occur with maximum operations of the structure. Since all build alternatives completely freshen the Breton Sound, anticipated salinity changes are the same as described in Section 5.3.2.2.1. Operation and management measures could work toward establishing target zones for optimum marsh type production throughout the project area. Of the implementation alternatives considered, the 15,000 cfs diversion would have more flexibility in terms of controlling and manipulating the salinity regime than the 10,000 cfs but less than the 35,000 cfs.

5.3.2.4.2 Indirect

Indirect impacts of implementing restoration features into the project area would be the possible permanent transition of marsh types. These changes could have short-term consequences, such as displacement of one type of marsh vegetation by another, but have long-term benefits by providing a sustainable marsh and delta forming functions. Indirect impacts to marsh zones of the 15,000 cfs alternative would be anticipated to be as described in Section 5.3.2.2.2 under the proposed operating plan; however, the operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White

Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin. With these structures running concurrently for an extended period of time, there could be undesired consequences in the Breton Sound.

5.3.2.4.3 Cumulative

Cumulative impacts would be the synergistic effect of the 15,000 cfs Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal Government. The operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin.

5.3.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.3.2.5.1 Direct

Salinity levels within the White Ditch project area would be affected. Significant freshening of the project area as well as the entire Breton Sound Basin would occur with maximum operations of the structure. Since all build alternatives completely freshen the Breton Sound, anticipated salinity changes are the same as described in Section 5.3.2.2.1. Operation and management measures could work toward establishing target zones for optimum marsh type production throughout the project area. Of the implementation alternatives considered, the 35,000 cfs diversion would have the most flexibility in terms of controlling and manipulating the salinity regime. In relation, it would present the most options for adaptive management.

5.3.2.5.2 Indirect

Indirect impacts of implementing restoration features into the project area would be the possible permanent transition of marsh types. These changes could have short-term consequences, such as displacement of one type of marsh vegetation by another, but have long-term benefits by providing a sustainable marsh and delta forming functions. Indirect impacts to marsh zones of the 15,000 cfs alternative would be anticipated to be as described in Section 5.3.2.2.2 under the proposed operating plan; however, the operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin. With these structures running concurrently for an extended period of time, there could be undesired consequences in the Breton Sound.

5.3.2.5.3 Cumulative

Cumulative impacts would be the synergistic effect of the 35,000 cfs Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal Government. The operations of the Caernarvon Diversion, the CWPPRA rehabilitation of the existing White Ditch Siphon, and the proposed White Ditch structure would need a coordinated operations effort to manage salinity levels throughout the Breton Sound Basin.

5.4 AIR QUALITY

5.4.1 No Action Alternative (Future Without Project Conditions)

The No Action Alternative would have no direct impacts on air quality. Indirect impacts of not implementing the diversion and outfall management features would result in the persistence of existing conditions. The project area is a remote and largely uninhabited marsh. Air quality would continue to be subject to institutional recognition and further regulations. However, air quality in the project area would likely decline for the following reasons: continued population growth, further commercialization and industrialization, increased numbers of motor vehicles, and increased emissions from various engines. These impacts would be coupled with the continued loss of Louisiana coastal wetland vegetation that would no longer be available to remove gaseous pollutants. Nevertheless, air quality degradation is not anticipated to be a significant problem in the project area under the No Action Alternative during the 50-year period of analysis. Cumulative impacts would be the synergistic effect of the No Action Alternative on air quality with the additive combination of similar air quality impacts from wetland loss and degradation throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal projects in the vicinity.

5.4.2 Alternative 1 – 5,000 cfs max Diversion

5.4.2.1 Direct

Direct impacts of the 5,000 cfs diversion alternative on air quality would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.2.2 Indirect

Over the 50-year period of analysis, the 5,000 cfs diversion is projected to reduce anticipated future losses of emergent wetlands that help to improve local air quality by reducing particulates and gaseous air pollutants. Impacts of the wetland restoration on air quality would be expected to be similar to, but lesser in magnitude than, those expected to result from implementation of the Recommended Plan.

5.4.2.3 Cumulative

Cumulative impacts of the 5,000 cfs diversion alternative on air quality would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.3 Alternative 2 – 10,000 cfs max Diversion

5.4.3.1 Direct

Direct impacts of the 10,000 cfs diversion alternative on air quality would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.3.2 Indirect

Over the 50-year period of analysis, the 10,000 cfs diversion is projected to reduce anticipated future losses of emergent wetlands that help to improve local air quality by reducing particulates and gaseous air pollutants. Impacts of the wetland restoration on air quality would be expected to be similar to, but lesser in magnitude than, those expected to result from implementation of the Recommended Plan.

5.4.3.3 Cumulative

Cumulative impacts of the 10,000 cfs diversion alternative would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.4 Alternative 3 – 15,000 cfs max Diversion

5.4.4.1 Direct

Direct impacts of the 15,000 cfs diversion alternative on air quality would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.4.2 Indirect

Over the 50-year period of analysis, the 15,000 cfs diversion is projected to reduce anticipated future losses of emergent wetlands that help to improve local air quality by reducing particulates and gaseous air pollutants. Impacts of the wetland restoration on air quality would be expected to be similar to, but lesser in magnitude than, those expected to result from implementation of the Recommended Plan.

5.4.4.3 Cumulative

Cumulative impacts of the 15,000 cfs diversion alternative would be similar to, but lesser in magnitude, than those expected to result from the Recommended Plan.

5.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.4.5.1 Direct

Direct impacts to ambient air quality resulting from construction of the 35,000 cfs diversion and outfall management features would be temporary and localized, resulting primarily from the emissions of construction equipment within the project area. Total emissions generally do not exceed the threshold limit applicable to volatile organic compounds (VOC) for parishes where the most stringent requirement (50 tons per year [49.38 metric tons per year] in serious non-attainment parishes) is in effect. Additionally, these effects to air quality would be temporary, and air quality would return to pre-construction conditions shortly after the completion of construction activities.

5.4.5.2 Indirect

Over the 50-year period of analysis, the 35,000 cfs diversion is projected to restore a substantial portion of emergent wetlands that historically existed in the project area, and protect emergent wetlands that help

to improve local air quality by reducing particulates and gaseous air pollutants, from future losses that would be expected to occur if the project was not constructed. Studies of the effects of common wetland plants on removing or reducing air pollution in the coastal Louisiana area have yet to be done. However, it is reasonable to extrapolate from the findings of researchers such as David J. Nowak (personal communication, Mr. David J. Nowak, Project Leader, USDA Forest Service, Northeastern Research Station, 5 Moon Library, SUNY-CESF, Syracuse, New York) that vegetation in coastal Louisiana would improve air quality. Improvement of air quality would provide positive benefits for humans overall, although this relative difference would be minimal because of the size of the project area and distance from population centers.

5.4.5.3 Cumulative

Implementation of the 35,000 cfs diversion would work synergistically with other ecosystem restoration projects in coastal Louisiana to provide greater longevity for wetlands in the region. Although unlikely to greatly impact air quality alone, the project would provide some air quality improvement from the cumulative effects of creating, nourishing and protecting these wetlands in conjunction with other restoration efforts.

5.5 NOISE

5.5.1 No Action Alternative (Future Without Project Conditions)

There would be no direct, indirect, or cumulative impacts of the No Action Alternative on noise. Not implementing the proposed river diversion and outfall management features would result in the persistence of existing conditions. The project area is a remote and largely uninhabited marsh. The noise from nearby urban areas has little, if any, impact on the project area. This is expected to continue in the future.

5.5.2 Alternative 1 – 5,000 cfs max Diversion

5.5.2.1 Direct

Direct impacts to noise levels resulting from construction of the 5,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.2.2 Indirect

Noise could temporarily cause some local fish and wildlife species to relocate during construction activities. However, any indirect impacts due to noise would be expected to be localized, temporary, and minor in nature.

5.5.2.3 Cumulative

Cumulative impacts to noise levels resulting from construction of the 5,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.3 Alternative 2 – 10,000 cfs max Diversion

5.5.3.1 Direct

Direct impacts to noise levels resulting from construction of the 10,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.3.2 Indirect

Noise could temporarily cause some local fish and wildlife species to relocate during construction activities. However, any indirect impacts due to noise would be expected to be localized, temporary, and minor in nature.

5.5.3.3 Cumulative

Cumulative impacts to noise levels resulting from construction of the 10,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.4 Alternative 3 – 15,000 cfs max Diversion

5.5.4.1 Direct

Direct impacts to noise levels resulting from construction of the 15,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.4.2 Indirect

Noise could temporarily cause some local fish and wildlife species to relocate during construction activities. However, any indirect impacts due to noise would be expected to be localized, temporary, and minor in nature.

5.5.4.3 Cumulative

Cumulative impacts to noise levels resulting from construction of the 15,000 cfs diversion and associated features would be expected to be similar to those anticipated to result from construction of the Recommended Plan.

5.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.5.5.1 Direct

Construction activities associated with implementing the 35,000 cfs diversion and outfall management features would temporarily increase the noise level in the project area. However, the project area is remote and sparsely populated so the noise level would not affect any nearby human communities. Once construction activities would be completed, noise levels would be expected return to preconstruction conditions.

Potential noise impacts concerns could be expected from construction activities, although construction equipment is limited in the level of noise that can be emitted. Institutional recognition of noise, such as provided by the regulations for Occupational Noise Exposure (29 CFR Part 1910.95) under the Occupational Safety and Health Act of 1970, as amended, would continue. This section mandates that noise levels emitted from construction equipment be below 90 dB for exposures of 8 hours per day or more.

Localized and temporary noise impacts would likely result in wildlife and fishery resources temporarily leaving the project area during construction activities. In some instances, noise impacts could directly impact fish and wildlife species. These organisms would generally avoid the construction area. At this point, no sensitive species have been determined to be present in the project area. However, if ever it is determined that a key species of concern is present, then the team would follow feasible administrative and or engineering controls, determine and implement appropriate buffer zones, and implement construction activity windows.

5.5.5.2 Indirect

Noise could temporarily cause some local fish and wildlife species to relocate during construction activities. However, any indirect impacts due to noise would be expected to be localized, temporary, and minor in nature.

5.5.5.3 Cumulative

Cumulative impacts to noise levels resulting from implementation of the 35,000 cfs diversion would principally be related to the potential short-term disruption of fish and wildlife species and similar impacts by other similar Federal, state, local and private restoration activities as well as other human-induced noise disruptions to these organisms. Cumulative impacts would be a synergistic result over and above the additive combination of impacts and benefits of this alternative and other Federal, state, local, and private restoration efforts. Long-term adverse cumulative impacts due to noise levels would not be expected with implementation of the diversion.

5.6 VEGETATIVE RESOURCES

5.6.1 Riparian Vegetation Resources

5.6.1.1 No Action Alternative (Future Without Project Conditions)

5.6.1.1.1 Direct

Under the No Action Alternative, no construction of diversion structure or associated outfall management features would occur, and no BLH would be cleared or filled by construction activities. No opportunities for beneficial use of dredged material for construction features would occur. Existing BLH in the project footprint would continue to degrade and convert to intermediate marsh.

5.6.1.1.2 Indirect

With no action, no input of sediment, freshwater and nutrients to the project area would occur. This would result in the persistence of existing conditions including continued erosion of marsh soils, and continued fragmentation and conversion of BLH to intermediate and brackish marsh habitats. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, and increased water velocities. Over the next 50 years, the remaining BLH species in the study area would experience continued subsidence, sea level rise, and salinity increases. The BLH would eventually diminish and convert to marsh.

5.6.1.1.3 Cumulative

Cumulative impacts would be the same effect of the No Action Alternative with land loss rates of approximately 274.5 acres per year throughout the 50-year project life. In addition, cumulative impacts would include the additive combination of coast wide BLH loss and degradation, as well as the benefits and impacts of other local, state, Federal, and private projects summarized in Section 1.5. The existing freshwater diversion at Caernarvon would freshen the surrounding waters, albeit to an unknown extent. In addition, the LCA Caernarvon Freshwater Diversion Modification (CFDM) project could potentially result in a selected plan having features that create and restore BLH ridges from the secondary use of channel dredging to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

5.6.1.2 Alternative 1 – 5,000 cfs max Diversion

5.6.1.2.1 Direct

Construction of the 5,000 cfs diversion structure would have direct negative impacts to 2.5 acres of BLH between the Mississippi River Levee and the Mississippi River. The proposed 2.5 acres of BLH loss has a value of –1.25 AAHUs. The placement of dredged material would provide direct positive benefit of 16.91 AAHUs by establishing approximately 32 acres of BLH ridge creation.

5.6.1.2.2 Indirect

Operation of the 5,000 cfs diversion alternative would indirectly provide an inflow of freshwater, sediments and nutrients to the project area and redistribute sediments along existing and created BLH ridges during pulses. A net loss of acreage of all habitat types in the project area is expected to continue under this alternative; however, riparian vegetation on the created BLH ridges could persist through much of the 50-year period following project construction.

5.6.1.2.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide BLH loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Modification of the operation of the Caernarvon structure project could potentially result in a selected plan that would have features that create and restore BLH ridges from the secondary use of channels dredged to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

5.6.1.3 Alternative 2 – 10,000 cfs max Diversion

5.6.1.3.1 Direct

Construction of the 10,000 cfs diversion structure would have direct negative impacts to 2.5 acres of BLH between the Mississippi River Levee and the Mississippi River. The proposed 2.5 acres of BLH loss has a value of –1.25 AAHUs. The placement of dredged material would provide direct positive benefit of 16.91 AAHUs by establishing approximately 32 acres of BLH ridge creation.

5.6.1.3.2 Indirect

Operation of the 10,000 cfs diversion alternative would indirectly provide an inflow of freshwater, sediments and nutrients to the project area and redistribute sediments along existing and created BLH ridges during pulses. No net loss of total acreage of vegetation in the project area is expected to occur with this alternative; however, it is possible that existing remnants of BLH in the project area could continue to deteriorate with this alternative.

5.6.1.3.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide BLH loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Modification of the operation of the Caernarvon structure project could potentially result in a selected plan that would have features that create and restore BLH ridges from the secondary use of channels dredged to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

5.6.1.4 Alternative 3- 15,000 cfs max Diversion

5.6.1.4.1 Direct

Construction of the 15,000 cfs diversion structure would have direct negative impacts to 5 acres of BLH between the Mississippi River Levee and the Mississippi River. The proposed 5 acres of BLH loss has a value of –2.50 AAHUs in the study area. The placement of dredged material would provide direct positive benefit of 16.91 AAHUs by establishing approximately 32 acres of BLH ridge creation.

5.6.1.4.2 Indirect

Operation of the 15,000 cfs diversion alternative would indirectly provide an inflow of freshwater, sediments and nutrients to the project area and redistribute sediments along existing and created BLH ridges during pulses. Increases in overall coverage of vegetation would occur in the project area; however, increases in BLH beyond the created ridges is expected to be negligible in the project area.

5.6.1.4.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide BLH loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Modification of the operation of the Caernarvon structure project could potentially result in a selected plan that would have features that create and restore BLH ridges from the secondary use of channels dredged to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

5.6.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.6.1.5.1 Direct

Construction of the 35,000 cfs diversion structure would have direct negative impacts to 5 acres of BLH between the Mississippi River Levee and the Mississippi River. The proposed 5 acres of BLH loss has a value of –2.50 AAHUs in the study area. The placement of dredged material would provide direct positive benefit of 15.99 AAHUs by establishing approximately 31 acres of BLH ridge creation.

5.6.1.5.2 Indirect

Operation of the 35,000 cfs diversion alternative would indirectly provide an inflow of freshwater, sediments and nutrients to the project area and redistribute sediments along existing and created BLH ridges during pulses. No net loss of acreage of all land types in the project area is expected to occur with this alternative. Additionally, the WVA assessment of proposed diversion alternatives projected that the 35,000 cfs diversion would produce overall gains in vegetation coverage in the project area; however, no substantial gains in BLH coverage beyond the created ridges would be expected.

5.6.1.5.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide BLH loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in

Section 1.5. Modification of the operation of the Caernarvon structure project could potentially result in a selected plan that would have features that create and restore BLH ridges from the secondary use of channels dredged to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

5.6.2 Wetland Vegetation Resources

5.6.2.1 No Action Alternative (Future Without Project Conditions)

5.6.2.1.1 Direct

Under the No Action Alternative, no direct impacts to existing wetland vegetation resulting from construction of the proposed diversion and associated features would occur. No opportunities for beneficial reuse of marsh soil and substrate excavated for construction would be realized.

5.6.2.1.2 Indirect

With no action, no increase in input of sediment, freshwater and nutrients to the project area would occur. This would result in the persistence of existing conditions including continued erosion of marsh soils, and continued fragmentation and conversion of existing intermediate, brackish and saline marsh to shallow open-water habitats. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory. Over the next 50 years, substantial acreage of wetland vegetation is projected to be lost.

5.6.2.1.3 Cumulative

Cumulative impacts would be the synergistic effect of implementing the No Action Alternative with the additive combination of coast wide wetland loss and degradation, as well as the benefits and impacts of other state and Federal projects in the vicinity. The existing freshwater diversion at Caernarvon would freshen the surrounding waters, albeit to an unknown extent. Modification of the operation of the Caernarvon structure could result in a conversion of some intermediate marsh to fresh marsh in areas adjacent to the MDWD project area. However, such wetland conversion would probably have little effect on the species composition of the wetlands in the project area other than a slight shift towards less salt-tolerant species. The introduction of nutrients would likely increase the productivity of the nearby marshes, but any potential effects on productivity within the MDWD project area would be unknown at this time.

5.6.2.2 Alternative 1 – 5,000 cfs max Diversion

5.6.2.2.1 Direct

Construction of the 5,000 cfs diversion and associated outfall management features would have an initial negative impact on existing wetland vegetation within the construction footprint, primarily through the excavation of outfall channels and placement of excavated material on existing marsh. However, this placement of excavated material would provide a base for the regeneration of approximately 171 acres of

wetland vegetation, 32 acres of which (ridge creation) is expected to be suitable for the re-establishment of bottomland hardwoods.

5.6.2.2.2 Indirect

Operation of the 5,000 cfs diversion alternative would provide an inflow of freshwater, sediments and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. Loss of acreage of all marsh types in the project area is expected to continue under this alternative. However, the WVA assessment of proposed diversion alternatives projected that the 5,000 cfs diversion would reduce overall wetland vegetation losses in the project area compared to the expected overall loss for the No Action Alternative. It is expected that this alternative would show a gain of approximate 5,197 AAHUs and 35,638 acres. It was anticipated that a small portion (less than 14%; see discussion in Alternative 4) of the project area currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

5.6.2.2.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide wetland vegetation loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Implementing Alternative 1 would result in a small incremental reduction to the rate of loss of wetland vegetation resources in the overall region.

5.6.2.3 Alternative 2 – 10,000 cfs max Diversion

5.6.2.3.1 Direct

Construction of the 10,000 cfs diversion and associated outfall management features would have an initial negative impact on existing wetland vegetation within the construction footprint, primarily through the excavation of outfall channels and placement of excavated material on existing marsh. However, this placement of excavated material would provide a base for the regeneration of approximately 208 acres of wetland vegetation, 32 acres of which (ridge creation) is expected to be suitable for the re-establishment of bottomland hardwoods.

5.6.2.3.2 Indirect

Operation of the 10,000 cfs diversion alternative would provide an inflow of freshwater, sediments and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. It was anticipated that a small portion (less than 14%; see discussion in Alternative 4) of the project area currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. The expectation of this alternative is to create approximately 5,936 AAHUs and 40,419 acres. No net loss of acreage of wetland vegetation in the project area is expected to occur with this alternative over the 50-year period following project construction. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

5.6.2.3.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide wetland vegetation loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Implementing Alternative 2 would result in a reduction to the rate of loss of wetland vegetation resources in the overall region.

5.6.2.4 Alternative 3 – 15,000 cfs max Diversion

5.6.2.4.1 Direct

Construction of the 15,000 cfs diversion and associated outfall management features would have an initial negative impact on existing wetland vegetation within the construction footprint, primarily through the excavation of outfall channels and placement of excavated material on existing marsh. However, this placement of excavated material would provide a base for the regeneration of approximately 267 acres of wetland vegetation, 32 acres of which (ridge creation) is expected to be suitable for the re-establishment of bottomland hardwoods.

5.6.2.4.2 Indirect

Operation of the 15,000 cfs diversion alternative would provide an inflow of freshwater, sediments and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. It was anticipated that a small portion (less than 14%; see discussion in Alternative 4) of the project area currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. The expectation of this alternative is to create approximately 7,742 AAHUs and 45,046 acres. No loss of overall acreage of wetland vegetation in the project area is expected to occur with this alternative, and some net gain in wetland vegetation is anticipated over the 50-year planning horizon. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

5.6.2.4.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide wetland vegetation loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Implementing Alternative 4 would result in an incremental increase in wetland vegetation resources in the overall region.

5.6.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.6.2.5.1 Direct

Construction of the 35,000 cfs diversion and associated outfall management features would have an initial negative impact on existing wetland vegetation within the construction footprint, primarily through the excavation of outfall channels and placement of excavated material on existing marsh. However, this placement of excavated material would provide a base for the regeneration of approximately 416 acres of wetland vegetation, 31 acres of which (ridge creation) is expected to be suitable for the re-establishment of bottomland hardwoods.

5.6.2.5.2 Indirect

Operation of the 35,000 cfs diversion alternative would provide an inflow of freshwater, sediments and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. It was anticipated that approximately 14% of the project area and 4% of the expanded area of influence currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. Substantial net gains compare to no net loss in acreage of wetland vegetation in the project area is expected to occur with this alternative. This gain is approximately 13,355 AAHUs and 59,902 acres. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

5.6.2.5.3 Cumulative

Cumulative impacts would be the synergistic combination of the project with coast wide wetland vegetation loss and degradation, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. Implementing Alternative 3 would result in a small incremental increase in wetland vegetation resources in the overall region.

5.6.3 Upland Vegetation Resources

There would be no upland vegetation resources in the project area.

5.6.4 Submerged Aquatic Vegetation (SAV)

5.6.4.1 No Action Alternative (Future Without Project Conditions)

5.6.4.1.1 Direct

Under the No Action Alternative, no direct impacts to SAV would occur. Baseline SAV coverage was estimated at approximately 15% of open water areas in the vicinity of the proposed construction footprint (25% in the overall project area). Existing SAV in the project footprint would continue to degrade and die off as increased salinities enter the study area and marsh continues to decrease in acreage.

5.6.4.1.2 Indirect

Under the No Action Alternative, no input of sediment, freshwater and nutrients to the project area would occur. This would result in the persistence of existing conditions including continued erosion of marsh soils, and continued fragmentation and conversion of existing intermediate, brackish and saline marsh to shallow open-water habitats. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased turbidity. Over the next 50 years, SAV is projected to be reduced from the estimated baseline of 25% of open water areas to approximately 15% as the area deteriorates.

5.6.4.1.3 Cumulative

Cumulative impacts would be the same effect of the No Action Alternative with the additive combination of coast wide SAV loss, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. The proposed projects have borrow areas, channel dredging, and marsh restoration sites in and adjacent to Lake Lery that would impact SAV from dredging and filling. CFDM could result in a conversion of some intermediate marsh to fresh marsh in areas adjacent to the MDWD project area. The Duffy (1997) study showed that SAV abundance (Eurasian watermilfoil and coontail) has increased in the Breton Sound Basin in response to diversions. The introduction of nutrients would likely increase the productivity of the nearby SAV, but any potential effects on productivity within the MDWD project area would be unknown at this time.

5.6.4.2 Alternative 1 – 5,000 cfs max Diversion

5.6.4.2.1 Direct

Direct impacts to SAV would be expected to result from construction of outfall management features. Baseline SAV coverage is anticipated to decrease to near 0% in the outfall channel footprint. In the marsh creation footprint, little open water would remain, but any remnants would likely experience an increase in the percentage of SAV. This is because SAV would be well adapted to the environmental conditions likely to be present after project implementation.

5.6.4.2.2 Indirect

Operation of the 5,000 cfs diversion is anticipated to result in an increase in SAV coverage in the fresh, intermediate, and brackish zones as a consequence of delivery of nutrients and sediments throughout the project area (no increase in SAV coverage was anticipated to occur in the saline zone). The Habitat Evaluation Team (HET) assumed that maintenance flow conditions (set at 1,000 cfs for all diversion alternatives), rather than maximum pulse, would be the determining factor in effects on SAV. Based on research that Rozas et al. (2005) conducted in the nearby Caernarvon Diversion outfall management area, SAV coverage in the fresh and intermediate zones is expected to increase from the baseline 25% to approximately 70%. In the brackish zone, SAV coverage was expected to increase from the estimated 15% baseline to approximately 30 percent.

5.6.4.2.3 Cumulative

The Alternative 1 outfall management features would impact some SAV during channel dredging and filling open water areas for marsh restoration. Alternative 1 would increase overall SAV abundance in the project area by maintaining a 1,000 cfs maintenance flow. Shallow waterbodies within the proposed converted intermediate to fresh marsh areas would be expected to begin filling in, creating the opportunity for SAV to establish across the project area. Cumulative impacts also include the combination of coast wide SAV loss, as well as the benefits and impacts of other state, Federal, or private projects summarized in Section 1.5. The proposed projects have borrow areas, channel dredging, and marsh restoration sites in and adjacent to Lake Lery that would impact SAV from dredging and filling. The MDWD WVA results show a conversion of some intermediate marsh to fresh marsh in areas adjacent to the MDWD project area. The Duffy (1997) study showed that SAV abundance (Eurasian watermilfoil and coontail) has

increased in the Breton Sound Basin in response to diversions. The introduction of sediments and nutrients would likely increase the productivity of the nearby SAV.

5.6.4.3 Alternative 2 – 10,000 cfs max Diversion

5.6.4.3.1 Direct

Direct impacts of the 10,000 cfs diversion alternative would be essentially the same as for the 5,000 cfs alternative; however, the extent of the affected area would be greater in proportion to the increased construction footprint for this alternative.

5.6.4.3.2 Indirect

Operation of the 10,000 cfs diversion is expected to have the same effect on SAV in the overall project area as the 5,000 cfs alternative. The HET assumed that maintenance flow conditions (set at 1,000 cfs for all diversion alternatives), rather than maximum pulse, would be the determining factor in effects on SAV.

5.6.4.3.3 Cumulative

Cumulative impacts of Alternative 2 would be similar to cumulative impacts described for Alternative 1, except Alternative 2 outfall management features would impact more SAV during construction.

5.6.4.4 Alternative 3 – 15,000 cfs max Diversion

5.6.4.4.1 Direct

Direct impacts of the 15,000 cfs diversion alternative would be essentially the same as for the 5,000 cfs alternative; however, the extent of the affected area would be greater in proportion to the increased construction footprint for this alternative.

5.6.4.4.2 Indirect

Operation of the 15,000 cfs diversion is expected to have the same effect on SAV in the overall project area as the 5,000 cfs alternative. The HET assumed that maintenance flow conditions (set at 1,000 cfs for all diversion alternatives), rather than maximum pulse, would be the determining factor in effects on SAV.

5.6.4.4.3 Cumulative

Cumulative impacts of Alternative 3 would be similar to cumulative impacts described for Alternative 1, except Alternative 3 outfall management features would impact more SAV during construction.

5.6.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.6.4.5.1 Direct

Direct impacts of the 35,000 cfs diversion alternative would be essentially the same as for the 5,000 cfs alternative; however, the extent of the affected area would be greater in proportion to the increased construction footprint for this alternative.

5.6.4.5.2 Indirect

Operation of the 35,000 cfs diversion is expected to have the same effect on SAV in the overall project area as the 5,000 cfs alternative. The HET assumed that maintenance flow conditions (set at 1,000 cfs for all diversion alternatives), rather than maximum pulse, would be the determining factor in effects on SAV.

5.6.4.5.3 Cumulative

Cumulative impacts of Alternative 4 would be similar to cumulative impacts described for Alternative 1, except Alternative 4 outfall management features would impact more SAV during construction.

5.6.5 Invasive Species – Vegetation

5.6.5.1 No Action Alternative (Future Without Project Conditions)

5.6.5.1.1 Direct

Under the No Action Alternative, invasive plant species known to occur in the project area would not be affected.

5.6.5.1.2 Indirect

Indirect impacts to invasive plant species anticipated under the No Action Alternative would be essentially the same as for noninvasive native plant species.

5.6.5.1.3 Cumulative

Cumulative impacts would be the same effect of the No Action Alternative with the additive combination of coast wide invasive species distribution from other state, Federal, or private projects summarized in Section 1.5. The proposed projects have borrow areas, channel dredging, and marsh restoration sites in and adjacent to Lake Lery that would impact and potentially distribute invasive species from dredging and filling. The Duffy (1997) study showed that SAV abundance (Eurasian watermilfoil and coontail) has increased in the Breton Sound Basin in response to diversions. The introduction of nutrients would likely increase the productivity of the nearby invasive species in the surrounding area.

5.6.5.2 Alternative 1 – 5,000 cfs max Diversion

5.6.5.2.1 Direct

Direct impacts to invasive plant species resulting from construction of the 5,000 cfs diversion alternative would be expected to be essentially the same as anticipated for other wetland vegetation and SAV in the construction footprint.

5.6.5.2.2 Indirect

Operation of the 5,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Under the operational plan used for the evaluation of alternatives, during the majority of the growing season the diversion inflow was assumed to be 1,000 cfs for all alternatives. This continuous inflow of freshwater has the potential to promote increased growth of freshwater invasive exotics such as water hyacinth in outfall and distributary channels.

5.6.5.2.3 Cumulative

Cumulative impacts would be the same effect of Alternative 1 with the additive combination of coast wide invasive species distribution from other state, Federal, or private projects summarized in Section 1.5. The proposed projects have borrow areas, channel dredging, and marsh restoration sites in and adjacent to Lake Lery that would impact and potentially distribute invasive species from dredging and filling. The Duffy (1997) study showed that SAV abundance (Eurasian watermilfoil and coontail) has increased in the Breton Sound Basin in response to diversions. The introduction of nutrients would likely increase the productivity of the nearby invasive species in the surrounding area. The MDWD project, even if generally beneficial to native marsh plant communities and animal populations, it could have the unintended consequence of increasing the spatial coverage and density of invasive plant species.

5.6.5.3 Alternative 2 – 10,000 cfs max Diversion

5.6.5.3.1 Direct

Direct impacts to invasive plant species resulting from construction of the 10,000 cfs diversion alternative would be expected to be essentially the same as anticipated for other wetland vegetation and SAV in the construction footprint.

5.6.5.3.2 Indirect

Operation of the 10,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Under the operational plan used for the evaluation of alternatives, during the majority of the growing season the diversion inflow was assumed to be 1,000 cfs for all alternatives. This continuous inflow of freshwater has the potential to promote increased growth of freshwater invasive exotics such as water hyacinth in outfall and distributary channels.

5.6.5.3.3 Cumulative

Cumulative impacts of Alternative 2 would be similar to cumulative impacts described for Alternative 1.

5.6.5.4 Alternative 3 – 15,000 cfs max Diversion

5.6.5.4.1 Direct

Direct impacts to invasive plant species resulting from construction of the 15,000 cfs diversion alternative would be expected to be essentially the same as anticipated for other wetland vegetation and SAV in the construction footprint.

5.6.5.4.2 Indirect

Operation of the 15,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Under the operational plan used for the evaluation of alternatives, during the majority of the growing season the diversion inflow was assumed to be 1,000 cfs for all alternatives. This continuous inflow of freshwater has the potential to promote increased growth of freshwater invasive exotics such as water hyacinth in outfall and distributary channels.

5.6.5.4.3 Cumulative

Cumulative impacts of Alternative 3 would be similar to cumulative impacts described for Alternative 1.

5.6.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.6.5.5.1 Direct

Direct impacts to invasive plant species resulting from construction of the 35,000 cfs diversion alternative would be expected to be essentially the same as anticipated for other wetland vegetation and SAV in the construction footprint.

5.6.5.5.2 Indirect

Operation of the 35,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Under the operational plan used for the evaluation of alternatives, during the majority of the growing season the diversion inflow was assumed to be 1,000 cfs for all alternatives. This continuous inflow of freshwater has the potential to promote increased growth of freshwater invasive exotics such as water hyacinth in outfall and distributary channels.

5.6.5.5.3 Cumulative

Cumulative impacts of Alternative 4 would be similar to cumulative impacts described for Alternative 1.

5.7 WILDLIFE AND HABITAT

5.7.1 No Action Alternative (Future Without Project Conditions)

5.7.1.1 Direct

Under the No Action Alternative, no construction of diversion structure or associated outfall management features would occur.

5.7.1.2 Indirect

Indirect impacts of the No Action Alternative would result in the persistence of existing conditions including the continued degradation of existing wetlands used as foraging, nesting, and over-wintering habitat to open-water habitats; and the decline in habitat quality as wetlands continue to deteriorate and fragment. As interior wetlands convert to open water, there would be an expected loss of species richness.

5.7.1.3 Cumulative

Cumulative impacts would be the synergistic effect of implementing the No Action Alternative with the additive combination of coast wide wildlife habitat losses and degradation, as well as the benefits and impacts of other state and Federal projects in the vicinity.

5.7.2 Alternative 1 – 5,000 cfs max Diversion

5.7.2.1 Direct

Construction of the diversion structure and associated outfall management features of the 5,000 cfs diversion alternative could disrupt or displace wildlife in the immediate vicinity. However, any such impacts would be localized and temporary, and most wildlife species would move to an area with more favorable conditions and return after construction is completed. While some species could be permanently displaced from the construction footprint by channel excavation and placement of excavated material in nearby marsh and shallow water areas, the long-term impact of construction is expected to be beneficial to overall habitat quality. The WVA analysis of outfall management features projected a net benefit of 58.04 AAHUs for the outfall management features associated with this alternative.

5.7.2.2 Indirect

Implementation of the 5,000 cfs diversion alternative would introduce river sediments, freshwater, and nutrients into the project area. Indirect impacts to wildlife resources resulting from the diversion would include the creation, restoration, and protection of wetland habitats utilized by resident and migratory wildlife for nesting, rearing of young, resting, and foraging activities. An increase in wetland acreage would provide increased nesting, brood-rearing, and foraging habitat for resident and migrant avian species. Wetland creation/nourishment and shoreline protection would also help to increase and preserve important stopover habitat for neotropical migrants and wintering habitat for waterfowl. The WVA analysis of the potential effects of the diversion projected a net benefit of 5,399.43 AAHUs for operation

of the diversion, for a total projected net benefit of 5,457.48 AAHUs including benefits projected for the outfall management features.

5.7.2.3 Cumulative

Implementation of the 5,000 cfs diversion alternative would have positive synergistic effects on wildlife resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential wildlife habitats. Migratory birds could increase their use of the project area as critical migratory habitat is protected, created, and nourished. Local populations of game animals, furbearers, reptiles, amphibians, and invasive species such as nutria would benefit from the cumulative effects of protecting, creating and nourishing important and essential transitional wetlands. However, the incremental effect of this alternative is unlikely to benefit populations of these species on a continental scale.

5.7.3 Alternative 2 – 10,000 cfs max Diversion

5.7.3.1 Direct

Construction of the diversion structure and associated outfall management features of the 10,000 cfs diversion alternative could disrupt or displace wildlife in the immediate vicinity. However, any such impacts would be localized and temporary, and most wildlife species would move to an area with more favorable conditions and return after construction is completed. While some species could be permanently displaced from the construction footprint by channel excavation and placement of excavated material in nearby marsh and shallow water areas, the long-term impact of construction is expected to be beneficial to overall habitat quality. The WVA analysis of outfall management features projected a net benefit of 70.79 AAHUs for the outfall management features associated with this alternative.

5.7.3.2 Indirect

Implementation of the 10,000 cfs diversion alternative would introduce river sediments, freshwater, and nutrients into the project area. Indirect impacts to wildlife resources resulting from the diversion would include the creation, restoration, and protection of wetland habitats utilized by resident and migratory wildlife for nesting, rearing of young, resting, and foraging activities. An increase in wetland acreage would provide increased nesting, brood-rearing, and foraging habitat for resident and migrant avian species. Wetland creation/nourishment and shoreline protection would also help to increase and preserve important stopover habitat for neotropical migrants and wintering habitat for waterfowl. The WVA analysis of the potential effects of the diversion projected a net benefit of 6,024.84 AAHUs for operation of the diversion, for a total projected net benefit of 6,095.63 AAHUs including benefits projected for the outfall management features.

5.7.3.3 Cumulative

Implementation of the 10,000 cfs diversion alternative would have positive synergistic effects on wildlife resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential wildlife habitats to a greater degree than Alternative 1. Migratory birds could increase their use of the project area as critical migratory habitat is protected, created and nourished. Local populations of game animals,

furbearers, reptiles, amphibians, and invasive species such as nutria would benefit from the cumulative effects of protecting, creating and nourishing important and essential transitional wetlands. However, the incremental effect of this alternative is unlikely to benefit populations of these species on a continental scale.

5.7.4 Alternative 3 – 15,000 cfs max Diversion

5.7.4.1 Direct

Construction of the diversion structure and associated outfall management features of the 15,000 cfs diversion alternative could disrupt or displace wildlife in the immediate vicinity. However, any such impacts would be localized and temporary, and most wildlife species would move to an area with more favorable conditions and return after construction is completed. While some species could be permanently displaced from the construction footprint by channel excavation and placement of excavated material in nearby marsh and shallow water areas, the long-term impact of construction is expected to be beneficial to overall habitat quality. The WVA analysis of outfall management features projected a net benefit of 88.45 AAHUs for the outfall management features associated with this alternative.

5.7.4.2 Indirect

Implementation of the 15,000 cfs diversion alternative would introduce river sediments, freshwater, and nutrients into the project area. Indirect impacts to wildlife resources resulting from the diversion would include the creation, restoration, and protection of wetland habitats utilized by resident and migratory wildlife for nesting, rearing of young, resting, and foraging activities. An increase in wetland acreage would provide increased nesting, brood-rearing, and foraging habitat for resident and migrant avian species. Wetland creation/nourishment and shoreline protection would also help to increase and preserve important stopover habitat for neotropical migrants and wintering habitat for waterfowl. The WVA analysis of the potential effects of the diversion projected a net benefit of 7,833.06 AAHUs for operation of the diversion, for a total projected net benefit of 7,921.51 AAHUs including benefits projected for the outfall management features.

5.7.4.3 Cumulative

Implementation of the 15,000 cfs diversion alternative would have positive synergistic effects on wildlife resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential wildlife habitats to a greater degree than Alternatives 1 or 2. Migratory birds could increase their use of the project area as critical migratory habitat is protected, created and nourished. Local populations of game animals, furbearers, reptiles, amphibians, and invasive species such as nutria would benefit from the cumulative effects of protecting, creating and nourishing important and essential transitional wetlands. However, the incremental effect of this alternative is unlikely to measurably benefit populations of these species on a continental scale.

5.7.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.7.5.1 Direct

Construction of the diversion structure and associated outfall management features of the 35,000 cfs diversion alternative could disrupt or displace wildlife in the immediate vicinity. However, any such impacts would be localized and temporary, and most wildlife species would move to an area with more favorable conditions and return after construction is completed. While some species could be permanently displaced from the construction footprint by channel excavation and placement of excavated material in nearby marsh and shallow water areas, the long-term impact of construction is expected to be beneficial to overall habitat quality. The WVA analysis of outfall management features projected a net benefit of 152.25 AAHUs for the outfall management features associated with this alternative.

5.7.5.2 Indirect

Implementation of the 35,000 cfs diversion alternative would introduce river sediments, freshwater, and nutrients into the project area. Indirect impacts to wildlife resources resulting from the diversion would include the creation, restoration, and protection of wetland habitats utilized by resident and migratory wildlife for nesting, rearing of young, resting, and foraging activities. An increase in wetland acreage would provide increased nesting, brood-rearing, and foraging habitat for resident and migrant avian species. Wetland creation/nourishment and shoreline protection would also help to increase and preserve important stopover habitat for neotropical migrants and wintering habitat for waterfowl. The WVA analysis of the potential effects of the diversion projected a net benefit of 13,423.01 AAHUs for operation of the diversion, for a total projected net benefit of 13,575.26 AAHUs, including benefits projected for the outfall management features. Nutria currently exist in the project area and would be expected to negatively impact marsh vegetation in the project area under this and all other alternatives, including the No Action Alternative. The existing State bounty program will continue to function as a control measure on the proliferation of nutria, and the long-term restoration of healthy marsh in the project area is expected to enhance existing natural controls (alligator predation) on nutria populations.

5.7.5.3 Cumulative

Implementation of the 35,000 cfs diversion alternative would have positive synergistic effects on wildlife resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential wildlife habitats to the greatest degree of the four alternatives evaluated in detail. Migratory birds could increase their use of the project area as critical migratory habitat is protected, created and nourished. Local populations of game animals, furbearers, reptiles, amphibians, and invasive species such as nutria would benefit from the cumulative effects of protecting, creating and nourishing important and essential transitional wetlands. However, the incremental effect of this alternative is unlikely to measurably benefit populations of these species on a continental scale.

5.8 AQUATIC RESOURCES

5.8.1 Benthic

These resources would be institutionally significant because of the NEPA of 1969; the Coastal Zone Management Act; and the Estuary Protection Act. These resources would be technically significant because benthic animals would be directly or indirectly involved in most physical and chemical processes that occur in estuaries (Day et al. 1989). Benthic resources would be publicly significant because members of the epibenthic community (mussels, etc.) provide commercial and recreational fisheries as well as creating oyster reef habitats used by many marine and estuarine organisms.

5.8.1.1 No Action Alternative (Future Without Project Conditions)

5.8.1.1.1 Direct

Without construction or operation of the project features, or diversion of river water and sediments into the White Ditch Project Area, no direct impacts would occur to the present benthic community.

5.8.1.1.2 Indirect

As stated in the LCA Study – Main Report, under the no action alternative, marine (saltwater) influences would continue to take hold and convert freshwater wetlands into intermediate, brackish, and saline marsh. As freshwater inputs continue to decline and allow marine influences to predominate over riverine influence, salinity levels rise, resulting in the conversion of low-lying vegetated areas to open water and the redistribution of marine sediment. These actions eventually lead to conditions that expedite interior marsh loss. According to Mitsch and Gosselink (1993), the salt marsh is a major producer of detritus for both the salt marsh system and the adjacent estuary. Most plant biomass dies and decays and its energy is processed through the detrital pathway by the benthic community. The bottom estuarine substrate or benthic zone regulates or modifies most physical, chemical, geological, and biological processes throughout the entire estuarine system via what is commonly called a "benthic effect" (Day et al. 1989). As detrital inputs lessen due to the loss of SAV from saltwater intrusion, the benthic community and benthic processes would shift from that of an estuarine community to a more open water marine community.

5.8.1.1.3 Cumulative

Over the long term, without renewed inputs of freshwater, sediment, and nutrients to restore and maintain emergent marsh habitat, the project area is likely to convert from a predominately estuarine habitat to a predominately marine habitat. The benthic community which support the estuarine system processes would be adversely affected by the reduction and eventual loss of this habitat. The species richness (variety of organisms) of the benthic community typically declines as one progresses from ocean waters upstream into lower salinities, and often reaches a minimum between 4 and 6 ppt (Day et al. 1989). Hence, it is expected that increases in marine benthic community species diversity would occur in the project area as marsh loss continues.

5.8.1.2 Alternative 1 – 5,000 cfs max Diversion

5.8.1.2.1 Direct

For the 5,000 cfs diversion alternative, the existing benthic communities in the footprint of the proposed construction and dredging activities would be destroyed. This area would encompass 144 acres of intermediate marsh and 187 acres of shallow open water. Temporary increases in turbidity, temperatures, and biological oxygen demand (BOD), as well as temporary decreases in DO would contribute to further mortality and displacement of the benthic community in the project area. In addition, ridge creation would result in approximately 32 acres becoming unavailable for benthic aquatic fauna. However, following construction, benthic organisms would likely recolonize aquatic habitats in the project area, and the enhancement of freshwater marsh habitat by the diversion should be beneficial to numerous benthic species. Introduction of additional freshwater into estuarine systems could have short-term impacts on benthic populations in receiving waters as well. Introduction of freshwater flows from proposed features would be expected to change benthic abundance, species composition, and species distribution. Changes in benthic species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the benthic community, displacing marine species in favor of fresher and more estuarine, euryhaline species. In addition, some benthic organisms from the Mississippi River would be expected to be entrained in the immediate vicinity of the diversion inflow while it is in operation.

5.8.1.2.2 Indirect

Each of the 5,000, 10,000, 15,000, and 35,000 alternatives would freshen the entire project area, with maximum flows being diverted in March–April, and a base flow of 1,000 cfs the remainder of the year. Diversion of freshwater, sediments, and nutrients for the 5,000 cfs alternative is expected to increase SAV and decrease marsh loss compared to the No Action Alternative. Increased SAV would create more biomass and detrital inputs for the benthic community to process, furthering estuarine processes for the benefit of the salt marsh community. The detritus export by the benthic community and the shelter found along marsh edges make salt marshes important nursery areas for many commercially important fish and shellfish.

The diversion of freshwater is expected to decrease salinities throughout the project area, particularly during full flow in March and April and the weeks immediately following. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. The overall decrease in salinity is expected to displace benthic species less tolerant of freshwater. In addition, the increase in sediment inputs over the project area could disrupt the benthic community and benthic processes where accretion occurs. Nutrient inputs would likely impact the chemical and biological processes of the benthic community, increasing blooms of phytoplankton, and subsequently decomposition.

5.8.1.2.3 Cumulative

The reintroduction of freshwater, sediments, and nutrients from the Mississippi River is expected to restore and maintain emergent marsh habitat over the long term in the project area. The increase in marsh habitat and SAV would increase production of detritus and thereby, increase opportunity for the estuarine benthic community to process energy through the detrital pathway. According to Mitsch and Gosselink

(1993), the salt marsh is a major producer of detritus for both the salt marsh system and the adjacent estuary. They point out that the detritus material exported from the marsh is more important to the estuary than the phytoplankton-based production in the estuary. The cumulative impacts would include the shifting of the benthic abundance, species composition, and species distribution toward those adapted to fresher habitats, and increasing chemical, physical, and biological processes performed by the benthic community. The enhancement of the benthic community through restoration and maintenance of emergent marsh habitat would also benefit fish and other aquatic organisms that depend on estuarine habitat and detritus export to meet all or part of their life cycles.

The cumulative impacts to the benthic resources would have a positive effect, particularly when evaluated in concert with other Federal, state, local, and private conservation and restoration efforts. The positive synergistic effect on the benthic resources in the project area would be greatest for the 35,000 cfs alternative as compared the lower volume alternatives.

5.8.1.3 Alternative 2 – 10,000 cfs max Diversion

5.8.1.3.1 Direct

Direct impacts under the 10,000 cfs diversion alternative include the complete loss of existing benthic communities in the footprint of the proposed construction and dredging activities. This area would include 159 acres of intermediate marsh and 223 acres of shallow open water. Temporary increases in turbidity, temperatures, and BOD, as well as temporary decreases in DO would contribute to further mortality and displacement of the benthic community in the project area. In addition, ridge creation would result in approximately 32 acres becoming unavailable for benthic aquatic fauna. However, following construction, benthic organisms would likely recolonize aquatic habitats in the project area, and the enhancement of freshwater marsh habitat by the diversion should be beneficial to numerous benthic species. Introduction of additional freshwater into estuarine systems could have short-term impacts on benthic populations in receiving waters as well. Introduction of freshwater flows from proposed features would be expected to change benthic abundance, species composition, and species distribution. Changes in benthic species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the benthic community, displacing marine species in favor of fresher and more estuarine, euryhaline species.

In addition, some benthic organisms from the Mississippi River would be expected to be entrained in the immediate vicinity of the diversion inflow while it is in operation.

5.8.1.3.2 Indirect

Each of the 5,000, 10,000, 15,000, and 35,000 alternatives would freshen the entire project area, with maximum flows being diverted in March–April, and a base flow of 1,000 cfs the remainder of the year. Diversion of freshwater, sediments, and nutrients at a maximum of 10,000 cfs is expected to increase SAV and decrease marsh loss to a greater degree than Alternative 1. Increased SAV would create more biomass and detrital inputs for the benthic community to process, furthering estuarine processes for the benefit of the salt marsh community. The detritus export by the benthic community and the shelter found along marsh edges make salt marshes important nursery areas for many commercially important fish and shellfish.

The diversion of freshwater is expected to decrease salinities throughout the project area, particularly during full flow in March–April and the weeks immediately following. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. The overall decrease in salinity is expected to displace benthic species less tolerant of freshwater. In addition, the increase in sediment inputs over the project area could disrupt the benthic community and benthic processes where accretion occurs. Nutrient inputs would likely impact the chemical and biological processes of the benthic community, increasing blooms of phytoplankton, and subsequently decomposition.

5.8.1.3.3 Cumulative

The reintroduction of freshwater, sediments, and nutrients from the Mississippi River is expected to restore and maintain emergent marsh habitat over the long term in the project area. The increase in marsh habitat and SAV would increase production of detritus and thereby, increase opportunity for the estuarine benthic community to process energy through the detrital pathway. According to Mitsch and Gosselink (1993), the salt marsh is a major producer of detritus for both the salt marsh system and the adjacent estuary. They point out that the detritus material exported from the marsh is more important to the estuary than the phytoplankton-based production in the estuary. The cumulative impacts would include the shifting of the benthic abundance, species composition, and species distribution toward those adapted to fresher habitats, and increasing chemical, physical, and biological processes performed by the benthic community. The enhancement of the benthic community through restoration and maintenance of emergent marsh habitat would also benefit fish and other aquatic organisms that depend on estuarine habitat and detritus export to meet all or part of their life cycles.

The cumulative impacts to the benthic resources would have a positive effect, particularly when evaluated in concert with other Federal, state, local, and private conservation and restoration efforts. The positive synergistic effect on the benthic resources in the project area would be greater for the 35,000 cfs alternative than for the lower volume alternatives.

5.8.1.4 Alternative 3 – 15,000 cfs max Diversion

5.8.1.4.1 Direct

Direct impacts under the 15,000 cfs diversion alternative include the complete loss of existing benthic communities in the footprint of the proposed construction and dredging activities (203 acres of intermediate marsh and 253 acres of shallow open water). Temporary increases in turbidity, temperatures, and BOD, as well as temporary decreases in DO would contribute to further mortality and displacement of the benthic community in the project area. In addition, ridge creation would result in approximately 32 acres becoming unavailable for benthic aquatic fauna. However, following construction, benthic organisms would likely recolonize aquatic habitats in the project area, and the enhancement of freshwater marsh habitat by the diversion should be beneficial to numerous benthic species. Introduction of additional freshwater into estuarine systems could have short-term impacts on benthic populations in receiving waters as well. Introduction of freshwater flows from proposed features would be expected to change benthic abundance, species composition, and species distribution. Changes in benthic species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the benthic community, displacing marine species in favor of fresher and more estuarine, euryhaline species.

In addition, some benthic organisms from the Mississippi River would be expected to be entrained in the immediate vicinity of the diversion inflow while it is in operation.

5.8.1.4.2 Indirect

Each of the 5,000, 10,000, 15,000, and 35,000 alternatives would freshen the entire project area, with maximum flows being diverted in March–April, and a base flow of 1,000 cfs the remainder of the year. Diversion of freshwater, sediments, and nutrients at a maximum of 10,000 cfs is expected to increase SAV and decrease marsh loss to a greater degree than Alternatives 1 or 2. Increased SAV would create more biomass and detrital inputs for the benthic community to process, furthering estuarine processes for the benefit of the salt marsh community. The detritus export by the benthic community and the shelter found along marsh edges make salt marshes important nursery areas for many commercially important fish and shellfish.

The diversion of freshwater is expected to decrease salinities throughout the project area, particularly during full flow in March–April and the weeks immediately following. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. The overall decrease in salinity is expected to displace benthic species less tolerant of freshwater. In addition, the increase in sediment inputs over the project area could disrupt the benthic community and benthic processes where accretion occurs. Nutrient inputs would likely impact the chemical and biological processes of the benthic community, increasing blooms of phytoplankton, and subsequently decomposition.

5.8.1.4.3 Cumulative

The reintroduction of freshwater, sediments, and nutrients from the Mississippi River is expected to restore and maintain emergent marsh habitat over the long term in the project area. The increase in marsh habitat and SAV would increase production of detritus and thereby, increase opportunity for the estuarine benthic community to process energy through the detrital pathway. According to Mitsch and Gosselink (1993), the salt marsh is a major producer of detritus for both the salt marsh system and the adjacent estuary. They point out that the detritus material exported from the marsh is more important to the estuary than the phytoplankton-based production in the estuary. The cumulative impacts would include the shifting of the benthic abundance, species composition, and species distribution toward those adapted to fresher habitats, and increasing chemical, physical, and biological processes performed by the benthic community. The enhancement of the benthic community through restoration and maintenance of emergent marsh habitat would also benefit fish and other aquatic organisms that depend on estuarine habitat and detritus export to meet all or part of their life cycles.

The cumulative impacts to the benthic resources would have a positive effect, particularly when evaluated in concert with other Federal, state, local, and private conservation and restoration efforts. The positive synergistic effect on the benthic resources in the project area would be greatest for the 35,000 cfs alternative when compared to the lower volume alternatives.

5.8.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.8.1.5.1 Direct

Under the 35,000 cfs diversion alternative, the existing benthic communities in the footprint of the proposed construction and dredging activities would be lost. This area would encompass 283 acres of intermediate marsh and 363 acres of shallow open water. Temporary increases in turbidity, temperatures, and BOD, as well as temporary decreases in DO would contribute to further mortality and displacement of the benthic community in the project area. In addition, ridge creation would result in approximately 31 acres becoming unavailable for benthic aquatic fauna. However, following construction, benthic organisms would likely recolonize aquatic habitats in the project area, and the enhancement of freshwater marsh habitat by the diversion should be beneficial to numerous benthic species. Introduction of additional freshwater into estuarine systems could have short-term impacts on benthic populations in receiving waters as well. Introduction of freshwater flows from proposed features would be expected to change benthic abundance, species composition, and species distribution. Changes in benthic species assemblages would likely be similar to what is observed along present day estuarine salinity gradients except that increased freshwater flows would shift the benthic community, displacing marine species in favor of fresher and more estuarine, euryhaline species.

In addition, some benthic organisms from the Mississippi River would be expected to be entrained in the immediate vicinity of the diversion inflow while it is in operation.

5.8.1.5.2 Indirect

Each of the 5,000, 10,000, 15,000, and 35,000 alternatives would freshen the entire project area, with maximum flows being diverted in March–April, and a base flow of 1,000 cfs the remainder of the year. Diversion of freshwater, sediments, and nutrients at a maximum of 35,000 cfs is expected to increase SAV and decrease marsh loss to the greatest degree of all the alternatives evaluated in detail. Increased SAV would create more biomass and detrital inputs for the benthic community to process, furthering estuarine processes for the benefit of the salt marsh community. The detritus export by the benthic community and the shelter found along marsh edges make salt marshes important nursery areas for many commercially important fish and shellfish.

The diversion of freshwater is expected to decrease salinities throughout the project area, particularly during full flow in March–April and the weeks immediately following. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. The overall decrease in salinity is expected to displace benthic species less tolerant of freshwater. In addition, the increase in sediment inputs over the project area could disrupt the benthic community and benthic processes where accretion occurs. Nutrient inputs would likely impact the chemical and biological processes of the benthic community, increasing blooms of phytoplankton, and subsequently decomposition.

5.8.1.5.3 Cumulative

The reintroduction of freshwater, sediments, and nutrients from the Mississippi River is expected to restore and maintain emergent marsh habitat over the long term in the project area. The increase in marsh habitat and SAV would increase production of detritus and thereby, increase opportunity for the estuarine

benthic community to process energy through the detrital pathway. According to Mitsch and Gosselink (1993), the salt marsh is a major producer of detritus for both the salt marsh system and the adjacent estuary. They point out that the detritus material exported from the marsh is more important to the estuary than the phytoplankton-based production in the estuary. The cumulative impacts would include the shifting of the benthic abundance, species composition, and species distribution toward those adapted to fresher habitats, and increasing chemical, physical, and biological processes performed by the benthic community. The enhancement of the benthic community through restoration and maintenance of emergent marsh habitat would also benefit fish and other aquatic organisms that depend on estuarine habitat and detritus export to meet all or part of their life cycles.

The cumulative impacts to the benthic resources would have a positive effect, particularly when evaluated in concert with other Federal, state, local, and private conservation and restoration efforts. The positive synergistic effect on the benthic resources in the project area would be greatest for this alternative when compared to the lower volume alternatives.

5.8.2 Plankton

This resource is institutionally significant because of the NEPA of 1969, the Coastal Zone Management Act, and the Estuary Protection Act. This resource is technically significant because plankton provide a major, direct food source for animals in the water column and in the sediments; plankton would be responsible for at least 40 percent of the photosynthesis occurring on the earth; plankton would be important for their role in nutrient cycling; plankton productivity is a major source of primary food-energy for most estuarine systems throughout the world; and phytoplankton production is the major source of autochthonous organic matter in most estuarine ecosystems (Day et al., 1989). This resource is publicly significant because plankton form part of the lowest trophic food level for many larger organisms important to commercial and recreational fishing. Historically, salinity appears to be the chief controlling factor in the number of species present, while temperature, competition, and predation control the number of individuals present (Perret et al. 1971). Further, the abundance of certain zooplankton could be indicative of good fishing areas.

5.8.2.1 No Action Alternative (Future Without Project Conditions)

The No Action Alternative would result in the persistence of existing conditions including the continued degradation and eventual loss of salt marsh and concomitant loss of long-term estuarine sustainability. None of the potential negative effects of freshwater inflows to the project area would result.

5.8.2.1.1 Direct

Current rates of salt marsh loss would be expected to continue or increase with no additional input of sediment, freshwater and nutrients from river water to the project area. No direct impacts to existing salt marsh vegetation resulting from construction of the proposed diversion and associated features would occur. No opportunities for beneficial reuse of marsh soil and substrate excavated for construction would be realized.

5.8.2.1.2 Indirect

Under the No Action Alternative, both man-made and natural processes would contribute to continued loss of habitat/vegetation as the salt marshes convert to more open water conditions. This in turn would lead to additional reductions in salt marsh plankton production and thus a loss in primary and secondary food sources for salt marsh fish and wildlife. Plankton assemblages that currently inhabit the project area would experience reductions in population as salinities increased. Further, under the No Action Alternative it would be anticipated that the continued loss of salt marsh would eventually result in a decrease of available nutrients and detritus, ultimately affecting plankton population dynamics. No indirect benefits or impacts would occur as a result of construction and freshwater diversion into the salt marsh.

In addition, there is a public health concern associated with the No Action Alternative. For example, phytoplankton in more saline environments can cause blooms of *Karenia breve* (formerly known as *Gymnodinium breve*), a dinoflagellate that has been associated with red tides. Red tides would be so named because the prolific growth stains the water red. Toxins associated with red tides would be capable of killing fish and shellfish. Red tide populations well below the fish kill level pose a serious problem for public health through shellfish contamination. Bivalve shellfish, especially oysters, clams, and coquinas, can accumulate so many toxins that they become toxic to humans. Public health concerns also emerge from studies that show that the presence of airborne toxins have an impact on the human respiratory system. Freshwater diversion has been utilized in some instances to attempt to reduce the spread of red tides into coastal waters.

5.8.2.1.3 Cumulative

Cumulative impacts to plankton resources would primarily be related to the incremental impact of all past, present, and future actions affecting plankton resources. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, increased water velocities, and increased herbivory. It is predicted that within the foreseeable future the lack of any reintroduction of nutrients and sediments to the estuarine system would continue to produce conditions for significant losses of all marsh types throughout the project area. As a result open-water habitats would continue to grow allowing for further intrusion of saltwater into the marsh. This loss of emergent salt marsh habitat would have significant changes on plankton communities and the organisms that depend on them for their life history requirements. Plankton populations would continue to convert from primarily estuarine-dependent plankton species assemblages and biomass to more marine and open water plankton species.

5.8.2.2 Alternative 1 – 5,000 cfs max Diversion

5.8.2.2.1 Direct

Direct impacts, primarily during the construction phase, of Alternative 1 would be similar to Alternative 4; however, the extent of the affected area would be greater in proportion to the increased construction footprint. Operation of the 5,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Impacts would result from the placement of three 15-ft x 15-ft box culverts. Additionally, there would be direct impacts to plankton associated with the 32 acres of ridge and terrace creation and 139 acres of

marsh creation — all developed utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

5.8.2.2.2 Indirect

Indirect impacts would also be similar to Alternative 4. Primary differences would be associated with the period and depth of freshwater inundation. Increases in submersed aquatic vegetation (SAV) would likely contribute to and be correlated with changes in plankton production and composition, especially in the fresh, intermediate, and brackish zones (see submersed aquatic vegetation section 1.1.1). Changes in plankton as a result of freshwater inundation would be expected to positively influence EFH within and beyond the immediate outfall area of the diversion. Sediment delivery to the system would likely fall short of the project goal.

5.8.2.2.3 Cumulative

Cumulative impacts to plankton resources would primarily be related to the synergistic effect of all past, present, and future actions affecting plankton resources. Alternative 1 would have positive synergistic effects on estuarine plankton resources when combined with other Federal, state, local, and private restoration efforts. Notably, any future management actions would likely have cumulative impacts relative to plankton species abundances, composition, and distribution.

5.8.2.3 Alternative 2 – 10,000 cfs max Diversion

5.8.2.3.1 Direct

Direct impacts, primarily during the construction phase, of Alternative 1 would be similar to Alternative 4; however, the extent of the affected area would be greater in proportion to the increased construction footprint. Operation of the 10,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Impacts would result from the placement of three 15-ft x 15-ft box culverts. Additionally, there would be impacts to plankton associated with the 32 acres of ridge and terrace creation and 176 acres of marsh creation – all developed utilizing dredged material from an adjacent 167 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

5.8.2.3.2 Indirect

Indirect impacts would also be similar to Alternative 4. Primary differences would be associated with the period and depth of freshwater inundation. Increases in submersed aquatic vegetation (SAV) would likely contribute to and be correlated with changes in plankton production and composition, especially in the fresh, intermediate, and brackish zones (see submersed aquatic vegetation section 1.1.1). Changes in plankton as a result of freshwater inundation would be expected to positively influence EFH within and beyond the immediate outfall area of the diversion. Sediment delivery to the system would likely fall short of the project goal.

5.8.2.3.3 Cumulative

Cumulative impacts to plankton resources would primarily be related to the synergistic effect of all past, present, and future actions affecting plankton resources. Alternative 4 would have positive synergistic

effects on estuarine plankton resources when combined with other Federal, state, local, and private restoration efforts. Notably, any future management actions would likely have cumulative impacts relative to plankton species abundances, composition, and distribution.

5.8.2.4 Alternative 3 – 15,000 cfs max Diversion

5.8.2.4.1 Direct

Direct impacts, primarily during the construction phase, of Alternative 1 would be similar to Alternative 4; however, the extent of the affected area would be greater in proportion to the increased construction footprint. Operation of the 15,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. Impacts would result from the placement of ten 15-ft x 15-ft box culverts. Additionally, there would be impacts to plankton associated with the 32 acres of ridge and terrace creation and 235 acres of marsh creation — all developed utilizing dredged material from an adjacent 182 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

5.8.2.4.2 Indirect

Indirect impacts would also be similar to Alternative 4. Primary differences would be associated with the period and depth of freshwater inundation. Increases in submersed aquatic vegetation (SAV) would likely contribute to and be correlated with changes in plankton production and composition, especially in the fresh, intermediate, and brackish zones (see submersed aquatic vegetation section 1.1.1). Changes in plankton as a result of freshwater inundation would be expected to positively influence EFH within and beyond the immediate outfall area of the diversion. Sediment delivery to the system would likely fall short of the project goal.

5.8.2.4.3 Cumulative

Cumulative impacts to plankton resources would primarily be related to the synergistic effect of all past, present, and future actions affecting plankton resources. Alternative 4 would have positive synergistic effects on estuarine plankton resources when combined with other Federal, state, local, and private restoration efforts. Notably, any future management actions would likely have cumulative impacts relative to plankton species abundances, composition, and distribution.

5.8.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.8.2.5.1 Direct

Operation of the 35,000 cfs diversion alternative would introduce fresh river water, sediment and nutrients into the constructed outfall channels and existing distributary channels within the project area. During actual construction activities of project features there would be short-term direct impacts to plankton populations due to increases in turbidity, low DO, and introduction of dredged sediments into shallow open water areas. Impacts would result from the placement of ten 15-ft x 15-ft box culverts. Additionally, there would be impacts to plankton associated with the 31 acres of ridge and terrace creation and 385 acres of marsh creation — all developed utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments. There would be long-term

loss of shallow water habitats in some areas due to dredge disposal activities. However, overall, there is an abundance of shallow open-water habitat in the project area available for use by plankton.

5.8.2.5.2 Indirect

Increases in freshwater flows and associated sediments and nutrients, along with changes in the salinity gradient from proposed features would be expected to change plankton species assemblage, composition, and distribution within a relatively short time frame. Plankton population dynamics would respond to associated changes in nutrient cycling, enrichment, and fluxes, especially under different annual flow regimes. Changes in plankton species assemblages would likely resemble what is observed along present day estuarine salinity gradients as increased freshwater flows displace marine species in favor of fresher and more estuarine, euryhaline species. Additionally, hypoxic conditions would be expected to occur less often with the introduction of freshwater to the system which would contribute to increased abundances of plankton, especially zooplankton. For example, while some zooplankton would be euryhaline, others have distinct salinity preferences. Therefore, introduction of river water into estuarine systems can have dramatic short-term impacts on plankton populations in adjacent coastal waters (Hawes and Perry, 1978). Under this alternative, it is anticipated that the longer inundation period and more sediment would lead to more plankton production – correlated with growth and establishment of more aquatic vegetation. In addition, changes in plankton as a result of freshwater inundation would be expected to positively influence EFH within and beyond the immediate outfall area of the diversion.

Increases in submersed aquatic vegetation (SAV) would contribute to changes in plankton production and composition especially in the fresh, intermediate, and brackish zones (see submersed aquatic vegetation section 1.1.1). Increased plant growth would result in greater production of organic detritus and production of phytoplankton and zooplankton would increase particularly in areas where turbidity is not limiting. These increases in plankton production would benefit larval and juvenile fishes and other aquatic animals and, as a result, the harvest of sport and commercial finfish and shellfish that depend on these microorganisms would increase.

Indirect impacts to plankton resources would primarily be related to increases in the export of dissolved organic compounds and detritus from enhanced marsh habitats that would benefit local plankton populations by increasing the planktonic food web. It is unknown whether proposed diversion flows and associated nutrients would result in noxious blooms of blue-green algae, but there is likely some upper limit to the assimilation of nutrients into estuarine waters, beyond which blooms would occur. Potentially, freshwater diversion would increase sediments in the project area with accompanying minor increases in trace metals and also increase agrochemicals. This nutrient enrichment could potentially lead to increased algal blooms.

5.8.2.5.3 Cumulative

Cumulative impacts to plankton resources would primarily be related to the synergistic effect of all past, present, and future actions affecting plankton resources. Alternative 4 would have positive synergistic effects on estuarine plankton resources when combined with other Federal, state, local, and private restoration efforts. It is anticipated that intertidal restoration efforts would result in greater resources for phytoplankton and zooplankton due to export of dissolved organic compounds and detritus. Notably, any future management actions would likely have cumulative impacts relative to plankton species abundances, composition, and distribution.

Additionally, public concerns have been raised regarding potential excessive changes in the salinity gradient that would convert the existing estuarine habitats into purely freshwater and intermediate types. Although there would be many proponents of freshwater and sediment diversions, some members of the public would be concerned about possible unintended consequences of implementing this type of restoration feature. Commercial and recreational fishermen would be concerned that the change in the salinity regime often associated with a freshwater diversion, would cause loss or displacement of current recreational and commercially valuable fishery species. As mentioned, in addition to altering salinity, diversions could increase the amount of nutrients supplied to lakes and bays. Increased nutrients create the possibility of algal blooms, which would be potentially detrimental to many aquatic organisms including fish, shellfish, and invertebrates, and could contribute to the formation of hypoxic zones.

5.8.3 Other Aquatic Resources

No other aquatic communities would be anticipated to be significantly impacted by implementation of any one of the alternatives in the MDWD project area.

5.9 FISHERIES

Although freshwater fisheries and long-term estuarine sustainability would be expected to benefit from freshwater diversions, the potential for short-term losses to estuarine fisheries (e.g., oysters) must also be considered in the evaluation of project alternatives.

5.9.1 No Action Alternative (Future Without Project Conditions)

5.9.1.1 Direct

Under the No Action Alternative no direct impacts to freshwater, estuarine or marine fisheries would occur. Current rates of marsh loss would be expected to continue with no additional input of sediment, freshwater and nutrients from river water to the project area. Louisiana coastal marshes including the MDWD project area would be recognized as an important and productive fisheries nursery habitat, and conversion to open water reduces availability of this habitat. Moreover, juvenile fish and invertebrates would be important food sources for migratory birds, such as wading birds and waterfowl, and the conversion of marsh to open water can only reduce food abundance for these species.

5.9.1.2 Indirect

Continued conversion of emergent marsh to open water is expected to have long-term adverse impacts to many fish species that depend on estuarine wetlands in the project area to meet life stage requirements. Freshwater fish species that currently inhabit the project area would experience reductions in population as salinities increase. Over time, indirect impacts of the No Action Alternative would result in a substantial decrease in the quality of EFH in the project area, including nursery habitat and marsh edge in the project area, and reduce the area's ability to support federally managed species. The abundances of aquatic organisms would decrease, indirectly impacting species that would be linked in the food web to directly affected species. The reduction in emergent wetlands would also result in shifts in predator/prey relationships, a decline in fishery productivity, and reduced recreational fishing opportunities.

5.9.1.3 Cumulative

Over the long term, without reintroduction of Mississippi River flows of sediment and nutrients to restore and maintain emergent marsh habitat, the project area is likely to convert from a predominately estuarine habitat to a predominately marine habitat, and populations of fish and other aquatic organisms that depend on estuarine habitat in the project area to meet all or part of their life cycles would be adversely affected by the reduction and eventual loss of this habitat.

5.9.2 Alternative 1 – 5,000 cfs diversion

5.9.2.1 Direct

Construction of the 5,000 cfs alternative is expected to have substantial but localized impacts to fisheries resources in the immediate vicinity of the outfall management features. Sessile or slow moving individuals or species in the construction footprint would likely suffer complete, albeit temporary, losses during excavation of outfall channels and placement of excavated material into marsh creation areas. No direct impacts to oyster would be anticipated to result from construction of Alternative 1, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters. Construction activities would temporarily increase turbidity and BOD, and decrease DO. These temporary conditions would likely displace more mobile fisheries species from the construction areas. Following construction, displaced fish would likely return to the project area and some sessile or slow-moving species would recolonize enlarged channels. The notched weirs included as an outfall management feature could have some modifying impact on fisheries access to the area causing species to use other routes. As reflected in the WVA assessment (included with Appendix B), aquatic organism access under with project conditions is expected to be approximately 60 percent of optimum (without project access is assumed to be at optimum level, or 100 percent). Negative impacts to fisheries resulting from construction of this alternative would be less than for the 10,000, 15,000, and 35,000 cfs alternatives (except for restrictions on fish access due to notched weirs, which would be the same for all alternatives), but positive impacts from marsh creation using excavated material would also be less than those expected for the larger diversion alternatives.

5.9.2.2 Indirect

Implementation of the 5,000 cfs alternative following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area while the diversion is at full flow and for several weeks after the return to maintenance flow operation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. Entrainment of eggs, larvae or fry of Mississippi River fish species in the immediate vicinity of the diversion inflow could occur during operation of the structure. To mitigate for these impacts, one or more of the box culverts could be modified to accommodate fish passage.

The notched weirs are expected to slow channel flow velocities and retain sediment and some nutrients within the project area. While these structures will reduce channel cross-sections where they are located, they are not anticipated to completely block fisheries access between the project area and River aux Chenes. Additional details on the expected effects of notched weirs is provided in the WVA analysis at the end of Appendix B. The impact to natural oyster settlement and growth will be less than the 35,000

cfs alternative due to the quicker recovery from the lower pulse. See Section 5.15.15.2 for a discussion on impacts to oyster leases.

Freshwater fishery species, such as crawfish, catfish, largemouth bass, and other sunfish should benefit from implementation of the diversion.

Freshwater inflow is an important component of circulation and flushing processes in estuaries that assist in the transportation of planktonic organisms, nutrients, and detritus to the Gulf of Mexico. Over the long term, operation of the diversion is expected to help support the aquatic food web of marine fishery species. An aquatic model will be conducted during PED to help evaluate potential impacts (see Section 3.8.9).

5.9.2.3 Cumulative

Implementation of the 5,000 cfs diversion alternative would have positive synergistic effects on fishery resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential estuarine wetland habitats used by fishery populations for spawning, cover, nursery, and other life stage requirements. Localized increases in important fishery habitats could contribute to increased productivity on a local (basin) scale. However, the incremental effect of this alternative is unlikely to benefit populations of these species on a continental scale.

5.9.3 Alternative 2 – 10,000 cfs max Diversion

5.9.3.1 Direct

Construction of the 10,000 cfs alternative is expected to have substantial but localized impacts to fisheries resources in the immediate vicinity of the outfall management features. Sessile or slow moving individuals or species in the construction footprint would likely experience complete, albeit temporary, losses during excavation of outfall channels and placement of excavated material into marsh creation areas. No direct impacts to oysters would be anticipated to result from construction of Alternative 2, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters. Construction activities would temporarily increase turbidity, temperatures and BOD; and decrease DO. These temporary conditions would likely displace more mobile fisheries species from the construction area. Following construction, displaced fish would likely return to the project area and some sessile or slow-moving species would recolonize enlarged channels. The notched weirs included as an outfall management feature could have some negative impact on fisheries access to the area. As reflected in the WVA assessment (included with Appendix B), aquatic organism access under with project conditions is expected to be approximately 60 percent of optimum (without-project access is assumed to be at optimum level, or 100 percent). Negative impacts to fisheries resulting from construction of this alternative would be less than for the 15,000 and 35,000 cfs alternatives (except for restrictions on fish access due to notched weirs, which would be the same for all alternatives), but positive impacts from marsh creation using excavated material would also be less than those expected for the larger diversion alternatives.

5.9.3.2 Indirect

Implementation of the 10,000 cfs alternative following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area and beyond River aux Chenes to a portion of the Caernarvon sub basin while the diversion is at full flow and for several weeks after the return to maintenance flow operation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. Entrainment of eggs, larvae or fry of Mississippi River fish species in the immediate vicinity of the diversion inflow could occur during operation of the structure. To mitigate for these impacts, one or more of the box culverts could be modified into a fish passage.

The notched weirs are expected to slow channel flow velocities and retain sediment and some nutrients within the project area. While these structures will reduce channel cross-sections where they are located, they are not anticipated to completely block fisheries access between the project area and River aux Chenes. Additional details on the expected effects of notched weirs is provided in the WVA analysis at the end of Appendix B. The impact to natural oyster settlement and growth will be less than the 35,000 cfs alternative due to the quicker recovery from the lower pulse. See Section 5.15.15.2 for a discussion on impacts to oyster leases.

Freshwater fishery species, such as crawfish, catfish, largemouth bass, and other sunfish should benefit from implementation of the diversion. However, decreases in salinity resulting from operation of the diversion could disrupt nursery functions of some marine species by affecting food and habitat availability. Some fishery species would be impacted by anticipated decreases in salinity and water temperature, and increased turbidity during maximum flow periods. Less freshwater tolerant species, such as brown shrimp and spotted seatrout, could be displaced from the northwestern portion of the project area. An aquatic model will be conducted during PED to help evaluate potential impacts (see Section 3.8.9).

5.9.3.3 Cumulative

Implementation of the 10,000 cfs diversion alternative would have positive synergistic effects on fishery resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential estuarine wetland habitats used by fishery populations for spawning, cover, nursery, and other life stage requirements. Localized increases in important fishery habitats could contribute to increased productivity on a local (basin) scale. However, the incremental effect of this alternative is unlikely to benefit populations of these species on a continental scale.

5.9.4 Alternative 3 – 15,000 cfs max Diversion

5.9.4.1 Direct

Construction of the 15,000 cfs alternative is expected to have substantial but localized impacts to fisheries resources in the immediate vicinity of the outfall management features. Sessile or slow moving individuals or species in the construction footprint would likely experience complete, albeit temporary, losses during excavation of outfall channels and placement of excavated material into marsh creation areas. No direct impacts to oysters would be anticipated to result from construction of Alternative 3,

primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters. Construction activities would temporarily increase turbidity, temperatures and BOD; and decrease DO. These temporary conditions would likely displace more mobile fisheries species from the construction area. Following construction, displaced fish would likely return to the project area and some sessile or slow-moving species would recolonize enlarged channels. The notched weirs included as an outfall management feature could have some negative impact on fisheries access to the area. As reflected in the WVA assessment (included with Appendix B), aquatic organism access under with project conditions is expected to be approximately 60 percent of optimum (without project access is assumed to be at optimum level, or 100 percent). Negative impacts to fisheries resulting from construction of this alternative would be less than for the 35,000 cfs alternative (except for restrictions on fish access due to notched weirs, which would be the same for all alternatives), but positive impacts from marsh creation using excavated material would also be less than those expected for the larger diversion alternatives.

5.9.4.2 Indirect

Implementation of the 15,000 cfs alternative following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area and beyond River aux Chenes to a portion of the Caernarvon sub basin while the diversion is at full flow and for several weeks after the return to maintenance flow operation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. Entrainment of eggs, larvae or fry of Mississippi River fish species in the immediate vicinity of the diversion inflow could occur during operation of the structure. To mitigate for these impacts, one or more of the box culverts could be modified to accommodate fish passage.

The notched weirs are expected to slow channel flow velocities and retain sediment and some nutrients within the project area. While these structures will reduce channel cross-sections where they are located, they are not anticipated to completely block fisheries access between the project area and River aux Chenes. Additional details on the expected effects of notched weirs is provided in the WVA analysis at the end of Appendix B. The impact to natural oyster settlement and growth will be less than the 35,000 cfs alternative due to the quicker recovery from the lower pulse. See Section 5.15.15.2 for a discussion on impacts to oyster leases.

Freshwater fishery species, such as crawfish, catfish, largemouth bass, and other sunfish should benefit from implementation of the diversion. However, decreases in salinity resulting from operation of the diversion could disrupt nursery functions of some marine species by affecting food and habitat availability. Some fishery species would be impacted by anticipated decreases in salinity and water temperature, and increased turbidity during maximum flow periods. Less freshwater tolerant species, such as brown shrimp and spotted seatrout, could be displaced from the northwestern portion of the project area.

Freshwater inflow is an important component of circulation and flushing processes in estuaries that assist in the transportation of planktonic organisms, nutrients, and detritus to the Gulf of Mexico. Over the long term, operation of the diversion is expected to help support the aquatic food web of marine fishery species. An aquatic model will be conducted during PED to help evaluate potential impacts (see Section 3.8.9).

5.9.4.3 Cumulative

Implementation of the 15,000 cfs diversion alternative would have positive synergistic effects on fishery resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential estuarine wetland habitats used by fishery populations for spawning, cover, nursery, and other life stage requirements. Localized increases in important fishery habitats could contribute to increased productivity on a local (basin) scale. However, the incremental effect of this alternative is unlikely to measurably benefit populations of these species on a continental scale.

5.9.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.9.5.1 Direct

Construction of the 35,000 cfs alternative is expected to have substantial but localized impacts to fisheries resources in the immediate vicinity of the outfall management features. Sessile or slow moving individuals or species in the construction footprint would likely experience complete, albeit temporary, losses during excavation of outfall channels and placement of excavated material into marsh creation areas. No direct impacts to oysters would be anticipated to result from construction of Alternative 4, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters. Construction activities would temporarily increase turbidity, temperatures and BOD; and decrease DO. These temporary conditions would likely displace more mobile fisheries species from the construction area. Following construction, displaced fish would likely return to the project area and some sessile or slow-moving species would recolonize enlarged channels. The notched weirs included as an outfall management feature could have some negative impact on fisheries access to the area. As reflected in the WVA assessment (included with Appendix B), aquatic organism access under with project conditions is expected to be approximately 60 percent of optimum (without project access is assumed to be at optimum level, or 100 percent). Negative impacts to fisheries resulting from construction of this alternative would be greater than for the 5,000, 10,000, and 15,000 cfs alternatives (except for restrictions on fish access due to notched weirs, which would be the same for all alternatives), but positive impacts from marsh creation using excavated material would also be greater than those expected for the smaller diversion alternatives.

5.9.5.2 Indirect

Implementation of the 35,000 cfs alternative following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area and beyond River aux Chenes to a substantial portion of the Caernarvon sub basin while the diversion is at full flow and for several weeks after the return to maintenance flow operation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. Entrainment of eggs, larvae or fry of Mississippi River fish species in the immediate vicinity of the diversion inflow could occur during operation of the structure. To mitigate for these impacts, one or more of the box culverts could be modified to accommodate fish passage.

The notched weirs are expected to slow channel flow velocities and retain sediment and some nutrients within the project area. While these structures will reduce channel cross-sections where they are located,

they are not anticipated to completely block fisheries access between the project area and River aux Chenes. Additional details on the expected effects of notched weirs is provided in the WVA analysis at the end of Appendix B.

Freshwater fishery species, such as crawfish, catfish, largemouth bass, and other sunfish should benefit from implementation of the diversion. However, decreases in salinity resulting from operation of the diversion could disrupt nursery functions of some marine species by affecting food and habitat availability. Some fishery species would be impacted by anticipated decreases in salinity and water temperature, and increased turbidity during maximum flow periods. Less freshwater tolerant species, such as brown shrimp and spotted seatrout, could be displaced from the northwestern portion of the project area. Comparison of Figures 4.6 and 5.3 demonstrates that there is very little potential to impact natural oyster settlement or growth. See Section 5.15.15.2 for a discussion on impacts to oyster leases. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

Freshwater inflow is an important component of circulation and flushing processes in estuaries that assist in the transportation of planktonic organisms, nutrients, and detritus to the Gulf of Mexico. Over the long term, operation of the diversion is expected to help support the aquatic food web of marine fishery species. An aquatic model will be conducted during PED to help evaluate potential impacts (see Section 3.8.9).

5.9.5.3 Cumulative

Implementation of the 35,000 cfs diversion alternative would have positive synergistic effects on fishery resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion. This alternative would protect, create and nourish important and essential estuarine wetland habitats used by fishery populations for spawning, cover, nursery, and other life stage requirements. Localized increases in important fishery habitats could contribute to increased productivity on a local (basin) scale. However, the incremental effect of this alternative is less likely to measurably benefit populations of these species on a continental scale.

5.10 ESSENTIAL FISH HABITAT (EFH)

5.10.1 No Action Alternative (Future Without Project Conditions)

5.10.1.1 Direct

The No Action Alternative (no construction of river diversion structure or associated outfall management features) would have no direct impact on EFH.

5.10.1.2 Indirect

Indirect impacts of not implementing wetland creation/nourishment and shoreline protection features would result in the persistence of existing conditions resulting in the conversion of categories of EFH, such as estuarine marsh and SAV, to marine water column and mud, sand, or shell substrates is expected to continue. Over time, the No Action Alternative would result in the conversion of emergent marsh to

open water. Substantial decreases in the quality of EFH in the project area would reduce the area's ability to support federally managed species.

5.10.1.3 Cumulative

Cumulative impacts would be the synergistic effect of the No Action Alternative on EFH with the additive combination of similar EFH degradation and losses throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal projects in the vicinity. Continued conversion of existing marsh to shallow open-water habitats anticipated with the No Action Alternative would contribute to declining quality of EFH, particularly nursery habitat for larval and juvenile fish and shrimp species.

5.10.2 Alternative 1 – 5,000 cfs max Diversion

5.10.2.1 Direct

Direct impacts associated with construction of the 5,000 cfs diversion and associated outfall management features include the disturbance and displacement of managed species in the construction footprint (144 acres of intermediate marsh and 187 acres of shallow open water). Adult and juvenile fish would be expected to move out of the area during construction. Ridge creation would result in approximately 32 acres becoming unavailable for fishery species, and notched weirs at River aux Chenes and at the end of the outfall channel could reduce fisheries access into the project area. However, this loss of EFH would be offset by expected increases in the quality of EFH in the marsh creation sites.

5.10.2.2 Indirect

Implementation of the 5,000 cfs diversion following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area while the diversion is at full flow and for several weeks after the return to maintenance flow operation. The accretion of sediment and input of nutrients is expected to benefit estuarine EFH within and beyond the immediate outfall area of the diversion. This alternative is projected to increase SAV in the project area and decrease emergent marsh loss across all marsh zones (intermediate, brackish, and saline) over the 50-year planning horizon. These changes in the project area would not only increase the areal extent of EFH, but would also improve the quality of EFH for several managed species.

Diversion of freshwater, sediments and nutrients into the project area under the evaluated operational plan is expected to decrease salinities throughout the project area, particularly within the existing intermediate marsh zone. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. High nutrient levels could result in blooms of algae and phytoplankton, and subsequent decomposition of these organisms could decrease DO levels of water bodies within the project area. These changes could result in localized adverse impacts to marine fishery productivity, particularly when the diversion is at full flow. The operational plan used to evaluate all diversion alternatives was developed to avoid or minimize these adverse impacts to marine fisheries and EFH while maximizing sediment and nutrient input to the extent practicable to meet project objectives. While this alternative has similar potential for negative impacts to marine fisheries and EFH as the 10,000, 15,000, and 35,000 diversions, its capacity for positive impacts to these resources would be less than for the larger alternatives.

5.10.2.3 Cumulative

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts. Implementation of this alternative would be expected to have a positive synergistic effect on EFH in the project area, but to a lesser extent than the effect anticipated for the larger diversion alternatives.

5.10.3 Alternative 2 – 10,000 cfs max Diversion

5.10.3.1 Direct

Direct impacts associated with construction of the 10,000 cfs diversion and associated outfall management features include the disturbance and displacement of managed species in the construction footprint (159 acres of intermediate marsh and 223 acres of shallow open water). Adult and juvenile fish would be expected to move out of the area during construction. Ridge creation would result in approximately 32 acres becoming unavailable for fishery species, and notched weirs at River aux Chenes and at the end of the outfall channel could reduce fisheries access into the project area. However, this loss of EFH would be offset by expected increases in the quality of EFH in the marsh creation sites.

5.10.3.2 Indirect

Implementation of the 10,000 cfs diversion following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area while the diversion is at full flow and for several weeks after the return to maintenance flow operation. The accretion of sediment and input of nutrients is expected to benefit estuarine EFH within and beyond the immediate outfall area of the diversion. This alternative is projected to increase SAV in the project area and decrease emergent marsh loss across all marsh zones (intermediate, brackish, and saline) over the 50-year planning horizon. These changes in the project area would not only increase the aerial extent of EFH, but would also improve the quality of EFH for several managed species.

Diversion of freshwater, sediments and nutrients into the project area under the evaluated operational plan is expected to decrease salinities throughout the project area, particularly within the existing intermediate marsh zone. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. High nutrient levels could result in blooms of algae and phytoplankton, and subsequent decomposition of these organisms could decrease DO levels of water bodies within the project area. These changes could result in localized adverse impacts to marine fishery productivity, particularly when the diversion is at full flow. The operational plan used to evaluate all diversion alternatives was developed to avoid or minimize these adverse impacts to marine fisheries and EFH while maximizing sediment and nutrient input to the extent practicable to meet project objectives. While this alternative has similar potential for negative impacts to marine fisheries and EFH as the 15,000 and 35,000 diversions, its capacity for positive impacts to these resources is less than for the larger alternatives.

5.10.3.3 Cumulative

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts. Implementation of this alternative would be expected to have a positive synergistic effect on EFH in the project area, but to a lesser extent than the effect anticipated for the larger diversion alternatives.

5.10.4 Alternative 3 – 15,000 cfs max Diversion

5.10.4.1 Direct

Direct impacts associated with construction of the 15,000 cfs diversion and associated outfall management features include the disturbance and displacement of managed species in the construction footprint (203 acres of intermediate marsh and 253 acres of shallow open water). Adult and juvenile fish would be expected to move out of the area during construction. Ridge creation would result in approximately 32 acres becoming unavailable for fishery species, and notched weirs at River aux Chenes and at the end of the outfall channel could reduce fisheries access into the project area. However, this loss of EFH would be offset by expected increases in the quality of EFH in the marsh creation sites.

5.10.4.2 Indirect

Implementation of the 15,000 cfs diversion following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area while the diversion is at full flow and for several weeks after the return to maintenance flow operation. The accretion of sediment and input of nutrients is expected to benefit estuarine EFH within and beyond the immediate outfall area of the diversion. This alternative is projected to increase SAV in the project area and decrease emergent marsh loss across all marsh zones (intermediate, brackish, and saline) over the 50-year planning horizon. These changes in the project area would not only increase the aerial extent of EFH, but would also improve the quality of EFH for several managed species.

Diversion of freshwater, sediments and nutrients into the project area under the evaluated operational plan is expected to decrease salinities throughout the project area, particularly within the existing intermediate marsh zone. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. High nutrient levels could result in blooms of algae and phytoplankton, and subsequent decomposition of these organisms could decrease DO levels of water bodies within the project area. These changes could result in localized adverse impacts to marine fishery productivity, particularly when the diversion is at full flow. The operational plan used to evaluate all diversion alternatives was developed to avoid or minimize these adverse impacts to marine fisheries and EFH while maximizing sediment and nutrient input to the extent practicable to meet project objectives. While this alternative has similar potential for negative impacts to marine fisheries and EFH as the 35,000 diversion, its capacity for positive impacts to these resources is less than for the larger alternative.

5.10.4.3 Cumulative

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration

efforts. Implementation of this alternative would be expected to have a positive synergistic effect on EFH in the project area, but to a lesser extent than the effect anticipated for the largest diversion alternative.

5.10.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.10.5.1 Direct

Direct impacts associated with construction of the 35,000 cfs diversion and associated outfall management features include the disturbance and displacement of managed species in the construction footprint (283 acres of intermediate marsh and 363 acres of shallow open water). Adult and juvenile fish would be expected to move out of the area during construction. Ridge creation would result in approximately 31 acres becoming unavailable for fishery species, and notched weirs at River aux Chenes and at the end of the outfall channel could reduce fisheries access into the project area. However, this loss of EFH would be offset by expected increases in the quality of EFH in the marsh creation sites.

5.10.5.2 Indirect

Implementation of the 35,000 cfs diversion following the operational plan evaluated in the hydraulic modeling and WVA analysis (full flow in March–April; 1,000 cfs rest of year) is expected to freshen the entire project area while the diversion is at full flow and for several weeks after the return to maintenance flow operation. The accretion of sediment and input of nutrients is expected to benefit estuarine EFH within and beyond the immediate outfall area of the diversion. This alternative is projected to increase SAV in the project area and decrease emergent marsh loss across all marsh zones (intermediate, brackish, and saline) over the 50-year planning horizon. These changes in the project area would not only increase the aerial extent of EFH, but would also improve the quality of EFH for several managed species.

Diversion of freshwater, sediments and nutrients into the project area under the evaluated operational plan is expected to decrease salinities throughout the project area, particularly within the existing intermediate marsh zone. A substantial portion of this zone is expected to convert to fresh marsh within the first several years after project implementation. Water levels, velocities, and turbidity in outfall areas would be all expected to increase during full flow conditions. High nutrient levels could result in blooms of algae and phytoplankton, and subsequent decomposition of these organisms could decrease DO levels of water bodies within the project area. These changes could result in localized adverse impacts to marine fishery productivity, particularly when the diversion is at full flow. The operational plan used to evaluate all diversion alternatives was developed to avoid or minimize these adverse impacts to marine fisheries and EFH while maximizing sediment and nutrient input to the extent practicable to meet project objectives. While this alternative has similar potential for negative impacts to marine fisheries and EFH as the 5,000, 10,000, or 15,000 diversions, its capacity for positive impacts to these resources is greater than for the smaller alternatives.

5.10.5.3 Cumulative

Cumulative impacts would be the synergistic effect with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local, and private restoration efforts. Implementation of this alternative would be expected to have a higher positive synergistic effect on EFH in the project area than the effect anticipated for the smaller diversion alternatives.

5.11 THREATENED AND ENDANGERED SPECIES

5.11.1 No Action Alternative (Future Without Project Conditions)

5.11.1.1 Direct

No federally listed threatened or endangered species would be known to occur within the project area boundary (USFWS, 2010). The No Action Alternative (no construction of a river diversion structure and associated outfall management features in the project area) would have no direct impacts on listed species or their critical habitat in the project area.

5.11.1.2 Indirect

The primary consequence of not implementing a river diversion in the project area would be the continued degradation and loss of estuarine wetland habitats used by many different fish and wildlife species for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements. The loss and deterioration of transitional wetland habitats over time could continue to indirectly affect, to an undetermined degree, all listed species that could potentially utilize the Breton Sound basin including: Gulf sturgeon, green sea turtle, hawksbill sea turtle, Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle, brown pelican, piping plover, and the West Indian manatee.

5.11.1.3 Cumulative

Adverse cumulative impacts associated with the No Action Alternative would be the additive effect of the continued deterioration of habitat quality and quantity in the project area with continued coastal land losses and deterioration of critical habitats in other parts of southeastern Louisiana and the Gulf Coast. Cumulative effects on listed species would be offset, to some degree, by the positive impacts of implementing other state and Federal projects.

5.11.2 Alternative 1 – 5,000 cfs max Diversion

5.11.2.1 Direct

Direct impacts associated with construction of the 5,000 cfs diversion and associated outfall management features could potentially include disturbance and displacement of individuals of some threatened or endangered species that could potentially occur within the project area boundary. The construction footprint for this alternative is limited in size relative to the project area (<1.0 percent) and does not encroach on critical habitat for any listed species. For these reasons, construction of the proposed diversion and associated outfall management features would not jeopardize the continued existence of any listed species or destroy or adversely modify critical habitat.

5.11.2.2 Indirect

Implementation of the 5,000 cfs diversion alternative would divert water, sediments and nutrients from the Mississippi River into the project area. Water diversions are used for flood control, water supply, and habitat restoration in the lower Mississippi River (LMR) but their impacts on imperiled sturgeon

populations are unknown. Corps-sponsored sampling efforts have shown catch data that suggests that pallid sturgeon populations decline as you progress further downstream (RM 0 to RM 320). Pallid and shovelnose sturgeon, as well as evidence of recruitment, are noticeably present with RM 80–160 of the LMR. The proposed diversion at Violet will be located at RM 85. This falls within a reach of the MRGO that ERDC has shown has a population of pallid sturgeon that are showing signs of recruitment. This increased presence of adult, sub-adult, post-larval, and larval pallid sturgeon within the LMR suggests that there is an increased potential of entrainment of small sized sturgeon in diversions. The extent of impacts to this sturgeon population from entrainment in water diversion structures is currently not quantifiable. Further population analysis is needed to be able to project the size of the LMR pallid population and what impact pallid sturgeon entrainment has on this population. Given this current information CEMVN concludes that there is a risk of entrainment of pallid sturgeon by this diversion structure and that therefore the proposed MDWD project "May Affect" the species. Appendix A presents a Biological Assessment that describes those factors used in determining the potential impacts of the proposed action on pallid sturgeon. No critical habitat for pallid sturgeon has been identified in the vicinity of the White Ditch project area.

5.11.2.3 Cumulative

Cumulative impacts to listed species would be related to the incremental impacts of the anticipated restoration features being constructed within the vicinity of the proposed action. The combination of this effort with the numerous other restoration projects occurring in southeastern Louisiana will be the slowing of the rate of shoreline retreat and restoring some of the delicate wetland habitats within the area. These coastal habitats are requisites for some portion of the life cycle of all of the listed species that occur within the project area. The improvement of this habitat will reduce at least one stressor that is hindering the recovery of these T&E species. Cumulative impacts to the pallid sturgeon resulting from entrainment by freshwater diversion structures cannot be determined at this time. Further population analysis is needed to be able to determine what the additive effect entrainment from all the existing and proposed freshwater and sediment diversion structures being constructed in the lower Mississippi River would have on the species.

5.11.3 Alternative 2 – 10,000 cfs max Diversion

5.11.3.1 Direct

Impacts would be similar to Alternative 1 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 1. Direct impacts associated with construction of the 10,000 cfs diversion and associated outfall management features could potentially include disturbance and displacement of individuals of some threatened or endangered species that could potentially occur within the project area boundary. The construction footprint for this alternative is limited in size relative to the project area (<1.0 percent) and does not encroach on critical habitat for any listed species. For these reasons, construction of the proposed diversion and associated outfall management features would not jeopardize the continued existence of any listed species or destroy or adversely modify critical habitat.

5.11.3.2 Indirect

Impacts would be similar to Alternative 1 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 1. Implementation of the 10,000 cfs diversion alternative would divert water, sediments and nutrients from the Mississippi River into the project area. This could potentially result in the entrainment of larval and YOY, and adult fish into the marsh and open water of the project area, particularly when the diversion is flowing at full capacity. Entrainment of larval YOY, and adult fish could potentially include individual specimens of federally listed species such as the pallid sturgeon, if these would be present in the immediate vicinity of the diversion intake. Appendix A presents a Biological Assessment that describes those factors used in determining the potential impacts of the proposed action on pallid sturgeon. No critical habitat for pallid sturgeon has been identified in the vicinity of the White Ditch project area. While there is a potential for individuals of the species to be adversely affected by entrainment during operation of the diversion, the proposed project is not considered likely to jeopardize the continued existence of pallid sturgeon in the lower Mississippi River.

5.11.3.3 Cumulative

Impacts would be similar to Alternative 1 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 1. Implementation of the diversion project is anticipated to have positive synergistic effects on listed species when combined with other Federal, state, local, and private restoration efforts. Cumulative impacts to listed species would be related to the incremental impacts of the anticipated restoration of wetland habitat, compared to all past, present, and future restoration activities that have or would increase and enhance all coastal wetland habitats.

5.11.4 Alternative 3 – 15,000 cfs max Diversion

5.11.4.1 Direct

Impacts would be similar to Alternative 2 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 2. Direct impacts associated with construction of the 15,000 cfs diversion and associated outfall management features could potentially include disturbance and displacement of individuals of some threatened or endangered species that could potentially occur within the project area boundary. With the increased diversion size there is a corresponding increase in the likelihood of entraining a larval, YOY or adult pallid sturgeon that may be in the project area.

5.11.4.2 Indirect

Impacts would be similar to Alternative 2 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 2.

5.11.4.3 Cumulative

Impacts would be similar to Alternative 2 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 2.

5.11.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.11.5.1 Direct

Impacts would be similar to Alternative 2 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 2. On May 14, 2010, CEMVN sent a letter to the USFWS requesting the initiation of consultation regarding potential impacts from the Recommended Plan to the pallid sturgeon. A response letter from the USFWS was received on July 1, 2010, requesting that CEMVN provide additional data regarding the proposed action and the pallid sturgeon species, and that CEMVN initiation formal consultation with the USFWS. In a July 15, 2010, dated letter, CEMVN provided all supplemental data, as requested by the USFWS, and requested that formal consultation for the MDWD project be initiated. On July 16, 2010, the USFWS responded via letter acknowledging the receipt of the supplemental data provided and initiated the formal consultation process. Consultation was completed on September 23, 2010, for the MDWD project. The USFWS Biological Opinion can be found in Appendix A. The document concludes:

> *"After reviewing the current status of the pallid sturgeon, the effects of the current freshwater diversions and the proposed Medium Diversion at White Ditch, and the cumulative effects, it is the Service's biological opinion that construction and subsequent operation of a new freshwater diversion at White Ditch between RM 64 and 59 is not likely to jeopardize the continued existence of the species. No critical habitat has been designated for the pallid sturgeon; therefore, none will be affected."*
>
> ***REASONABLE AND PRUDENT MEASURES***
>
> *The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of pallid sturgeon by entrainment through the medium diversion at White Ditch.*
>
> 1. *Gate operations should minimize velocity through the structure by maximizing the open cross-section, especially at Mississippi River stages of 6 feet mean sea level or less (equates to velocities at the culvert face of 7.2 fps or less).*
>
> 2. *Any gate operation that would significantly increase or decrease the velocity (change greater than 500 cfs) should be implemented over several hours to allow fish sufficient time to migrate back to the river or swim away from the structure.*
>
> 3. *Once the end of the annual discharge period is reached minimal gate openings should be maintained for several days to allow passage of any sturgeon that may have emigrated downstream.*
>
> 4. *The downstream edge of the culverts should have a slope to act as a ramp and/or sufficient erosion protection that would prevent scour from forming a vertical ledge greater than 6 inches at the downstream end of the culvert.*

5. *In channel refuge consisting of several submerged wing dikes (or similar structures) on both banks should be constructed no further downstream than 75 feet from the structure. Minimal spacing between the structures should be 10 feet but can be moved to account for scour. The maximum suggested height is 24 inches, but the length extending into the channel is not yet determined.*

6. *The downstream side walls should be angled towards the culverts so they will guide fish back into the culverts at lower velocities.*

7. *The two outer most culverts should have fish passage baffles constructed on the floor of the culverts.*

8. *Monitoring to determine take and to reduce potential take by returning pallid sturgeon to the river should be undertaken*

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall execute the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. *Manuals (or other similar documents) written to guide the daily operations and maintenance activities of the diversion should be written in cooperation with the Service. Any proposed changes to such document would require re-initiation of consultation under Section 7 of the ESA*

2. *Detailed design of wing dikes and the scour protection to prevent development of a vertical ledge should be coordinated with the Service. After construction annual inspection (i.e., measurements) should be taken at the downstream edge of the culvert to determine need to for maintenance. If maintenance is required funding should be immediately requested.*

3. *Design of downstream side walls and detailed design of the fish passage baffles should be coordinated with the Service.*

4. *Three days of sampling effort will be made each quarter. Sampling will consist of at minimum utilizing otter trawls, gillnets (i.e., 27.4 meter by 1.8 meter, six mesh panel ranging from 23 to 76 centimeters), and trotlines (61 meters long with 60 dropper lines at 0.9 meter intervals using 2/0 hooks baited with worms). Up to eight trotlines will be fished on the bottom overnight and two gillnets will also be fish overnight. All procedures and protocols for handling sturgeon should be followed and are available at:*
   www.fws.gov/mountainpraire/endspp/protocoisIPallidSturgeonHandiingProtocol2008B.pdf

All pallid sturgeon captures should be measured and tagged according to the protocol; if permitted and when feasible, ageing and endoscopy to determine sex and reproductive

stage should also be conducted. All pallid sturgeon captured should be returned to the Mississippi River as soon as practicable. The number and size of each pallid sturgeon caught by date and gear type should be provided to the Service. Unsuccessful sampling efforts should also be reported by date and gear type.

Upon locating a dead or injured pallid sturgeon that may have been harmed or destroyed as a direct or indirect result of the proposed project, the Corps and/or contractor shall be responsible for notifying the Service's Lafayette, Louisiana, Field Office (337/291-3100) and the LDWF's Natural Heritage Program (225/765-2821). Care shall be taken in handling an injured sturgeon to ensure effective treatment or disposition and in handling dead specimens to preserve biological materials in the best possible state for later analysis. Disposition of dead sturgeon is also addressed in the protocols."

5.11.5.2 Indirect

Impacts would be similar to Alternative 3 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 3.

5.11.5.3 Cumulative

Impacts would be similar to Alternative 3 except this alternative includes additional restoration measures and a larger diversion structure not identified in Alternative 3.

5.12 CULTURAL AND HISTORIC RESOURCES

A cultural resources survey of the Oak River landscape features was completed by contractors employed by the USACE New Orleans District. Three archaeological sites and one standing structure (Site 16PL193) were identified during the survey. In consultation with the Louisiana State Historic Preservation Officer (SHPO), two of the archaeological sites and the standing structure were determined to be not eligible for inclusion in the National Register of Historic Places. The remaining archaeological site was determined to be National Register eligible. In consultation with the Chitimacha Tribe of Louisiana and the SHPO, it was decided that the White Ditch diversion would probably have no adverse effect on this historic property as it is located just outside the project area. However, it was also agreed that the site would be monitored to determine what effect the project has on the site and if the effect was adverse then a treatment plan would be devised by the New Orleans District through consultation with the Chitimacha Tribe of Louisiana and the SHPO. One other site, Fort De La Boulaye, is located outside the project area and will not be affected by the White Ditch Diversion.

Two additional areas within the overall project area remain to be surveyed. These would be the Bayou Garelle and the batture of the Mississippi River. Field conditions during the investigative period for this study effort have prevented these two areas from being surveyed for cultural resources.

5.12.1 No Action Alternative (Future Without Project Conditions)

5.12.1.1 Direct

Under the No Action Alternative, no archeological sites would be impacted by construction activities.

5.12.1.2 Indirect

All archaeological sites within the project area would continue to be affected by erosion and subsidence.

5.12.1.3 Cumulative

Archaeological sites in southeast Louisiana would be all subjected to the same natural forces, subsidence and erosion from natural wave action, storm surge and wakes created by motor boats. Eventually most sites, unless protected would disappear from the archaeological record.

5.12.2 Alternative 1 – 5,000 cfs max Diversion

5.12.2.1 Direct

Construction of the 5,000 cfs diversion alternative and associated outfall management features would not be expected to adversely affect archaeological sites.

5.12.2.2 Indirect

Indirect impacts of implementing the 5,000 cfs diversion alternative on archaeological sites would be expected to be the same as for the No Action Alternative.

5.12.2.3 Cumulative

Cumulative impacts of the 5,000 cfs diversion alternative would be expected to be the same as for the No Action Alternative.

5.12.3 Alternative 2 – 10,000 cfs max Diversion

5.12.3.1 Direct

Construction of the 10,000 cfs diversion alternative and associated outfall management features would not be expected to adversely affect archaeological sites.

5.12.3.2 Indirect

Indirect impacts of implementing the 10,000 cfs diversion alternative on archaeological sites would be expected to be the same as for the No Action Alternative.

5.12.3.3 Cumulative

Cumulative impacts of the 10,000 cfs diversion alternative would be expected to be the same as for the No Action Alternative.

5.12.4 Alternative 3 – 15,000 cfs max Diversion

5.12.4.1 Direct

Construction of the 15,000 cfs diversion alternative and associated outfall management features would not be expected to adversely affect archaeological sites.

5.12.4.2 Indirect

Indirect impacts of implementing the 15,000 cfs diversion alternative on archaeological sites would be expected to be the same as for the No Action Alternative.

5.12.4.3 Cumulative

Cumulative impacts of the 15,000 cfs diversion alternative would be expected to be the same as for the No Action Alternative.

5.12.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.12.5.1 Direct

Construction of the 35,000 cfs diversion alternative and associated outfall management features would not be expected to adversely affect archaeological sites.

5.12.5.2 Indirect

Indirect impacts of implementing the 35,000 cfs diversion alternative on archaeological sites would be expected to be the same as for the No Action Alternative.

5.12.5.3 Cumulative

Cumulative impacts of the 35,000 cfs diversion alternative would be expected to be the same as for the No Action Alternative.

5.13 AESTHETICS

5.13.1 No Action Alternative (Future Without Project Conditions)

5.13.1.1 Direct

The visual complexity surrounding the project area is related to its geomorphic structures including ridge, swamp and marsh. All of these elements would be critical systems inclusive to the White Ditch Study Area. Together, all of these elements provide a pleasing aesthetic view shed to the public, especially from atop the existing levee system. Direct impacts would evolve from the natural conditions of the area and the associated changes to these geomorphic structures.

5.13.1.2 Indirect

Indirect impacts can also be derived from the conversion of wetland and marshlands into open water. These landscape types would be excellent habitat for a variety of wildlife and fisheries. Excellent examples of habitat and their associated wildlife typically provide the viewer with focal points and accents (typically made up of both the landscape and the wildlife) that make a view shed dynamic, scenic and memorable. If loss of these habitats persists, then this is just one more element of the viewscape that is lost along with it.

5.13.1.3 Cumulative

Cumulative impacts of the No Action Alternative in this instance include the incremental impacts to aesthetic resources (not only in the project area, but to the hydrologic basin, Louisiana, and the U.S.) resulting from the past, present and reasonably foreseeable future impacts associated with conversion and loss of marsh, wetland and/or swamps. Without implementation of wetland creation and other protection measures, continued conversion of existing fragmented wetlands to open-water habitats would persist. Degradation of the land would convert existing view sheds of marsh and wetland to more open water views. Open waters would be somewhat less desirable because they lack those vertical and horizontal features which provide a viewer with the necessary elements of form, line, texture and color that make a view scenic and memorable.

5.13.2 Alternative 1 – 5,000 cfs max Diversion

5.13.2.1 Direct

Direct Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion. However, in terms of direct impacts to aesthetics, these elements translate into how quickly the study area can rebuild itself with the inflow of sediments and are not as relevant as the actual location of the diversion itself.

5.13.2.2 Indirect

Indirect Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.2.3 Cumulative

Cumulative Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.3 Alternative 2 – 10,000 cfs max Diversion

5.13.3.1 Direct

Direct Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion. However, in terms of direct impacts to aesthetics, these elements translate into how quickly the study area can rebuild itself with the inflow of sediments and are not as relevant as the actual location of the diversion itself.

5.13.3.2 Indirect

Indirect Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.3.3 Cumulative

Cumulative Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.4 Alternative 3 – 15,000 cfs max Diversion

5.13.4.1 Direct

Direct Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion. However, in terms of direct impacts to aesthetics, these elements translate into how quickly the study area can rebuild itself with the inflow of sediments and are not as relevant as the actual location of the diversion itself.

5.13.4.2 Indirect

Indirect Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.4.3 Cumulative

Cumulative Impacts to Aesthetic Resources would be similar to those presented under the Recommended Plan. Differences between the plans include velocities and flow rates of the diversion.

5.13.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.13.5.1 Direct

The visual resources of the project corridor would be temporarily impacted by construction activities related to implementing the proposed action and by transport activities needed to move equipment and materials to and from the site. Boating and other water traffic would most likely not be affected.

The creation of artificial, manmade features could decrease the natural, scenic quality in any area. In the case of the proposed action, the diversion is an un-natural element and could work to decrease the scenic quality. However, the potential benefits of reclaimed land mass and marsh area, and the need to protect this marsh area outweigh the visual impacts of developing the diversion.

5.13.5.2 Indirect

With the implementation of the proposed action, the creation, or re-creation, of marsh and wetland would indirectly impact the study area by increasing habitat for desirable land based wildlife. On the flip side, as another indirect impact, open-water habitat would be decreased over time.

5.13.5.3 Cumulative

Long term negative impacts to the aesthetic (visual) resources would be negligible. Landscapes converted or reorganized into natural or, in some cases, seminatural visual conditions similar to the proposed project could be considered as visually superior. As a cumulative impact, the proposed scenario is desirable throughout the hydrologic basin, Louisiana, and the U.S. for reclaiming lost land mass.

5.14 RECREATION

The following discussion addresses the potential recreational resource impacts of each MDWD Alternative. There would be five alternatives for the project including No Action.

5.14.1 No Action Alternative (Future Without Project Conditions)

5.14.1.1 Direct

Recreational resources in the region that would most likely be affected under the No Action Alternative would be those related to loss of wetlands and habitat diversity.

Continued wetland fragmentation and the eventual conversion to shallow open-water habitat would likely have negative consequences on a variety of recreational resources in the project area. Wildlife abundance is directly related to the amount of wetlands present. As wetland deterioration and high rates of land loss continues throughout the area, wildlife abundance would continue to decrease. Continued loss of essential fish and wildlife habitat, especially marsh-edge habitat and transitional habitat between estuarine and marine environments, would most likely result in a reduction in productivity. Lower quality fishery

spawning, nursery, and foraging habitat would likely translate to a decline in recreational fishing, shrimping, and crabbing catch rates in the future.

The local abundance of resident, transitional wetland-dependent wildlife, would likely decrease as these species relocate to find more suitable transitional wetland habitats. Migratory birds would be required to find other, more suitable stopover habitats on their trans-Gulf migrations. With the continued conversion of transitional estuarine wetlands to open water, estuarine fishery abundance and diversity would be expected to decline over time. With continued habitat deterioration, recreational waterfowl hunting would likely decline with reduced bag limits much of it due to higher salinity levels and the loss of SAV.

Likewise, as usage of the study area by migratory birds declines, so would the opportunities for viewing. Ridge habitat would also decline resulting in fewer opportunities for deer and small game hunting.

5.14.1.2 Indirect

Long term potential indirect impacts could include loss of associated recreational support facilities such as marinas and bait shops that would be the basis for most recreational use. This would result in a reduction in economic activity associated with recreation uses.

5.14.1.3 Cumulative

Cumulative impacts would be the impacts on the environment which result from the incremental impact of the no action plan when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Existing and planned projects in the project vicinity include the twenty year old Caernarvon Diversion and a proposed Caernarvon modification. Cumulative effects of these projects on recreational resources in the White Ditch project area would be expected to be minimal. Turbidity created by the Caernarvon Diversion could infiltrate the southern part of the White Ditch project area during the high water pulse periods, which could be seen during certain tidal flows. The effects on recreational resources would be expected to be minimal and temporary.

Effects from the No Action Alternative would result in substantial changes in recreation opportunities and potential loss of much of the recreational resource base in the project area, as described in the direct and indirect impact sections.

5.14.2 Alternative 1 – 5,000 cfs max Diversion

5.14.2.1 Direct

Recreational uses in the study area such as fishing and hunting could be affected due to the implementation and operations of the freshwater diversion.

During high flow pulse periods, large influxes of freshwater into the existing habitat in the project area would increase turbidity and flow and reduce salinity levels in the project area. During these high pulse periods and afterward, recreational activities would likely be curtailed.

Due to lower salinity levels and turbidity, saltwater fish species would likely migrate to more desirable locations. In turn, catch rates would potentially decrease in the project area during these high flow periods.

While some habitat transition based on decreased salinity levels is anticipated, overall benefits associated with marsh creation, and improved aquatic habitat for fisheries and waterfowl should result in improved recreational experiences during normal flow conditions. Decreases in salinity within the intermediate marsh zone could potentially enhance conditions for freshwater fish species within this portion of the project area.

Waterfowl hunting within the study area would likely improve due to reduced salinity levels and increased SAV. In addition, deer and other small game hunting could improve over time due to stabilization and improved ridge habitat.

Channel dredging and placement of dredged material for marsh creation and ridge restoration would displace resident fish and wildlife and could temporarily disrupt fishing and hunting activity in the construction zone. Following construction, the created marsh, restored ridges, and enlarged outfall channels could increase or enhance recreational resources within and adjacent to the construction footprint. Marsh creation could benefit recreation by providing additional land for birding and hunting. The marsh could also attract ducks and serve as a duck hunting area. The increase in habitat value would likely result in increased species of fish and mammal wildlife usage of the area. This would enhance the productivity of the marsh and sustain its longevity. Marsh creation could also be beneficial for protecting interior areas, including any recreational structures, from the negative effects of storm surges.

In terms of recreational user days, no substantial change through year 5 is anticipated. After the two month high flow pulse, water quality changes should, over time return to normal. There could be an increase in user day values due to decreased salinity levels, and increased marsh acres and habitat units. The net AAHUs would be expected to increase by 5,457. The increase in marsh acres is projected to increase compared to future without project conditions. The increase is anticipated to be incremental until project year 20; however, no increases would be anticipated after project year 20.

5.14.2.2 Indirect

Potential indirect impacts from the proposed action would primarily consist of effects on recreational fishing from increased turbidity to the water bodies outside of the study area. These impacts could include fish species temporarily migrating away from these disturbed conditions.

5.14.2.3 Cumulative

Implementation of the 5,000 cfs alternative would be expected to have positive synergistic effects on recreation resources when combined with other Federal, state, local, and private restoration efforts, including the Caernarvon diversion and its proposed modification. The incremental effects of this alternative have the potential to support and sustain wetland-dependent recreation opportunities, provide for a more stable localized recreation economy, and could result in a slight increase in local recreation-related employment and income.

The cumulative impacts would create and maintain critical marsh habitat within the project area necessary for the viable protection of market fisheries and aquatics resources. The impacts should stabilize or potentially improve recreational opportunities in the area.

This alternative would support and sustain a greater number of freshwater-based recreational opportunities such as duck hunting and bass fishing, while maintaining saltwater fishing opportunities.

5.14.3 Alternative 2 – 10,000 cfs max Diversion

5.14.3.1 Direct

Alternative 2 incorporates a 10,000 cfs maximum flow diversion which is twice the flow of Alternative 1. Impacts would be similar to Alternative 1 but could affect a larger area. The increase in flow rate would be directly related to the increase in freshwater distributed through the project area. Therefore, the direct effects to the surrounding marsh and aquatic habitats would likely cover a larger area and potentially result in a prolonged recovery time once the 2-month pulse is complete.

Several fish species would be deterred from the turbid water, and as a result, would travel elsewhere. Turbidity from the high pulse flows would also deter the waterfowl and other wildlife during the high water levels. There would be a benefit to introducing freshwater into these areas, as long as the increased currents do not contribute to marsh fragmentation in other areas. Bankline stabilization and notched weirs would need to be monitored carefully to protect adjacent marsh habitats.

A slight reduction in recreational user days is possible through year 10 due to increased turbidity and flow during the pulse period and longer recovery time. However beyond year 10, a slight increase above without project conditions in recreation user days is anticipated due to improved quality and quantity of habitat.

The increase in marsh acres is projected to be greater than the increase projected for Alternative 1. The net AAHUs would be expected to rise to 6,096. The increase is incremental until project year 20; however, there would be no increases after project year 20.

5.14.3.2 Indirect

This alternative would have similar indirect impacts to those described under Alternative 1. The main difference is that indirect impacts associated with increased turbidity to water bodies outside of study area would potentially be experienced in a larger area due to the increased water flows under the pulse condition.

5.14.3.3 Cumulative

This alternative would have similar cumulative impacts to those described under Alternative 1.

5.14.4 Alternative 3 – 15,000 cfs max Diversion

5.14.4.1 Direct

Alternative 3 incorporates a 15,000 cfs maximum flow diversion which is three times the flow of Alternative 1. Impacts would be similar to Alternative 1 but could affect a larger area. The increase in flow rate would be directly related to the increase in freshwater distributed through the project area. Therefore, the direct effects to the surrounding marsh and aquatic habitats would cover a large area and result in a prolonged recovery time once the 2-month pulse is achieved.

Several fish species would be deterred from the turbid water, and as a result, would migrate to a more desirable location. Turbidity from the high pulse flows would also deter the waterfowl and other wildlife during the high water levels. There would be a benefit to introducing freshwater into these areas, as long as the increased velocities do not contribute to marsh fragmentation in other areas. Bankline stabilization and notched weirs would need to be monitored carefully to protect the adjacent marsh habitats.

While freshwater-based recreational opportunities such as waterfowl hunting and bass fishing could improve, brackish and saltwater-based recreation activities such as fishing and shrimping could migrate further south and east in the project area possibly increasing the access distance to such opportunities.

A slight reduction in recreational user days is possible through year 10 due to increased turbidity and flow during the pulse period and longer recovery time. However beyond year 10, a slight increase above without project conditions in recreation user days is anticipated due to improved quality and quantity of habitat.

The increase in marsh acres is projected to be greater than increases anticipated for Alternatives 1 or 2. The net AAHUs would be expected to rise to 7,922. The increase is incremental until project year 20; however, there would be no increases after project year 20.

5.14.4.2 Indirect

This alternative would have similar indirect impacts to those described under Alternative 2.

5.14.4.3 Cumulative

This alternative would have similar cumulative impacts to those described under Alternative 1 with the exception that saltwater-based recreational opportunities could shift further south and east in the project area potentially increasing the access distance to such opportunities.

5.14.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.14.5.1 Direct

The maximum flow of Alternative 4 is seven times greater than that of Alternative 1.

Impacts would be similar to Alternative 1 but could affect a larger area. The increased flows from the diversion could cause high surge and back flow. The channels should be monitored carefully as to ensure

they do not flood and cause direct impacts to recreational facilities and surrounding structures. The turbidity impacts would likely be substantial and potentially be temporarily detrimental to fish and waterfowl use in much of the project area specifically during and after the pulse.

While freshwater-based recreational opportunities could increase in the project area, brackish and saltwater-based recreational opportunities could decline. In turn, a substantial reduction in recreational user days would be anticipated over the initial 20 years of the project.

The increase in marsh acres is projected to be greater than increases expected for Alternatives 1, 2, or 3. The increase is incremental until project year 20; however, there would be no increases after project year 20.

5.14.5.2 Indirect

This alternative would have similar indirect impacts to those described under Alternative 2.

5.14.5.3 Cumulative

This alternative would have similar cumulative impacts to those described under Alternative 1 with the exception that saltwater-based recreational opportunities could shift further south and east in the project area potentially increasing the access distance to such opportunities.

5.15 SOCIOECONOMICS AND HUMAN RESOURCES

5.15.1 Displacement of Population and Housing

5.15.1.1 No Action Alternative (Future Without Project Conditions)

5.15.1.1.1 Direct

There would be no direct impacts to population and housing around this diversion site if the proposed diversion was not constructed.

5.15.1.1.2 Indirect

There would be no indirect impacts to population and housing around this diversion site if the proposed action was not implemented.

5.15.1.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to population and housing consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the Federal Greater New Orleans Hurricane and Storm Damage Risk Reduction System (GNOHSDRRS), and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. As noted in the FPEIS for the LCA study, regional trends show population increases in urban and suburban areas, and retreat from rural and coastal areas such as the White Ditch project area.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

The exception to the foregoing would be the cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could enhance the desirability of living within the protected areas. As a result, a shift in the dispersion of population within the New Orleans Metropolitan Statistical Area, or beyond, could occur. Also, to the extent that the completion of the GNOHSDRRS encourages regional economic growth, any additional jobs thus created could manifest itself in either in-migration to the area or an increase in commuting activity.

5.15.1.2 Alternative 1 – 5,000 cfs Diversion

5.15.1.2.1 Direct

There would be no direct impacts to population and housing around this diversion site if Alternative 1 is constructed.

5.15.1.2.2 Indirect

Indirect impacts to population and housing in the study area if Alternative 1 is implemented, if any, would be anticipated to be negligible and indistinguishable from other local and regional influences on population growth and decline.

5.15.1.2.3 Cumulative

Cumulative impacts that include Alternative 1 would be expected to be similar to the No Action Alternative.

5.15.1.3 Alternative 2 – 10,000 cfs max Diversion

5.15.1.3.1 Direct

There would be no direct impacts to population and housing around this diversion site if Alternative 2 is constructed.

5.15.1.3.2 Indirect

Indirect impacts to population and housing in the study area associated with implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.1.3.3 Cumulative

Cumulative impacts that include Alternative 2 would be expected to be similar to the No Action Alternative.

5.15.1.4 Alternative 3 – 15,000 cfs max Diversion

5.15.1.4.1 Direct

There would be no direct impacts to population and housing around this diversion site if Alternative 3 is constructed.

5.15.1.4.2 Indirect

Indirect impacts to population and housing in the study area associated with implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.1.4.3 Cumulative

Cumulative impacts that include Alternative 3 would be expected to be similar to the No Action Alternative.

5.15.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.1.5.1 Direct

There would be no direct impacts to population and housing around this diversion site if Alternative 4 is implemented.

5.15.1.5.2 Indirect

Indirect impacts to population and housing in the study area associated with implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.1.5.3 Cumulative

Cumulative impacts that include Alternative 4 would be expected to be similar to the No Action Alternative.

5.15.2 Employment, Business, and Industrial Activity

5.15.2.1 No Action Alternative (Future Without Project Conditions)

5.15.2.1.1 Direct

There would be no direct impacts to employment, business, and industry in the Phoenix vicinity if the proposed diversion is not constructed.

5.15.2.1.2 Indirect

There would be no indirect impacts to employment, business, and industry in the vicinity of the White Ditch study area if the proposed action is not implemented.

5.15.2.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to employment, business and industry consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs. Cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety could occur. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could have the effect of spurring additional economic growth in the region than would otherwise occur. As a result, an increase in the number of firms and the output of business and industry would likely manifest itself in such growth.

5.15.2.2 Alternative 1 – 5,000 cfs Diversion

5.15.2.2.1 Direct

There could be minor temporary increases in local employment and related business activity during the construction period if Alternative 1 is implemented.

5.15.2.2.2 Indirect

Over the 50-year period of analysis Alternative 1 is expected to protect, create and nourish emergent wetlands that would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, and ecotourism; as well as provide benefits for supporting economic activities such as marinas, bait and tackle shops, and others.

5.15.2.2.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts for employment, business and industry consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. Cumulative impacts that include the proposed action would be no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

Alternative 1 would incrementally add to these other activities and programs help support coast wide wetland-dependent employment. However, this incremental effect would be insignificant compared to cumulative impacts to employment and income described under the No Action Alternative.

5.15.2.3 Alternative 2 – 10,000 cfs max Diversion

5.15.2.3.1 Direct

There could be minor temporary increases in local employment and related business activity during the construction period if Alternative 2 is implemented.

5.15.2.3.2 Indirect

Over the 50-year period of analysis Alternative 2 is expected to protect, create and nourish emergent wetlands that would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, and ecotourism; as well as provide benefits for supporting economic activities such as marinas, bait and tackle shops, and others.

5.15.2.3.3 Cumulative

Cumulative impacts of Alternative 2 would be expected to be incrementally greater than Alternative 1, but similarly insignificant compared to cumulative impacts to employment and income described under the No Action Alternative.

5.15.2.4 Alternative 3 – 15,000 cfs max Diversion

5.15.2.4.1 Direct

There could be minor temporary increases in local employment and related business activity during the construction period if Alternative 3 is implemented.

5.15.2.4.2 Indirect

Over the 50-year period of analysis Alternative 3 is expected to protect, create and nourish emergent wetlands that would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, and ecotourism; as well as provide benefits for supporting economic activities such as marinas, bait and tackle shops, and others.

5.15.2.4.3 Cumulative

Cumulative impacts of Alternative 3 would be expected to be incrementally greater than Alternative 3, but would be not anticipated to be significant compared to cumulative impacts to employment and income described under the No Action Alternative.

5.15.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.2.5.1 Direct

There could be minor temporary increases in local employment and related business activity during the construction period if Alternative 4 is implemented.

5.15.2.5.2 Indirect

Over the 50-year period of analysis Alternative 4 is expected to protect, create and nourish emergent wetlands that would benefit, to some undetermined level, local employment in wetland-dependent jobs such as commercial and recreational fisheries, and ecotourism; as well as provide benefits for supporting economic activities such as marinas, bait and tackle shops, and others.

5.15.2.5.3 Cumulative

Cumulative impacts of Alternative 4 would be expected to be incrementally greater than Alternative 3, but would be not anticipated to be significant compared to cumulative impacts to employment and income described under the No Action Alternative.

5.15.3 Community Cohesion

5.15.3.1 No Action Alternative (Future Without Project Conditions)

5.15.3.1.1 Direct

Without implementation of the proposed action there would be no direct impacts to community cohesion in the vicinity of the proposed diversion site.

5.15.3.1.2 Indirect

Without implementation of the proposed action there would be no indirect impacts to community cohesion in the vicinity of the proposed diversion site.

5.15.3.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to community cohesion consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs. Cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety could occur. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could have the effect of enhancing community cohesion. The reason for this is that the lower incidence of flooding reduces the likelihood that patterns of social interaction and communication within the community would be interrupted or permanently altered.

5.15.3.2 Alternative 1 – 5,000 cfs Diversion

5.15.3.2.1 Direct

There would be no direct impacts to community cohesion around this diversion site if Alternative 1 is implemented.

5.15.3.2.2 Indirect

There would be no indirect impacts to community cohesion around this diversion site if Alternative 1 is implemented.

5.15.3.2.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts for community cohesion consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Cumulative impacts that include the proposed action would be no greater than the sum of those impacts indicated individually for each project component.

5.15.3.3 Alternative 2 – 10,000 cfs max Diversion

5.15.3.3.1 Direct

There would be no direct impacts to community cohesion around this diversion site if Alternative 2 is implemented.

5.15.3.3.2 Indirect

There would be no indirect impacts to community cohesion around this diversion site if Alternative 2 is implemented.

5.15.3.3.3 Cumulative

Cumulative impacts for Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.3.4 Alternative 3 – 15,000 cfs max Diversion

5.15.3.4.1 Direct

There would be no direct impacts to community cohesion around this diversion site if Alternative 3 is implemented.

5.15.3.4.2 Indirect

There would be no indirect impacts to community cohesion around this diversion site if Alternative 3 is implemented.

5.15.3.4.3 Cumulative

Cumulative impacts for Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.3.5.1 Direct

There would be no direct impacts to community cohesion around this diversion site if Alternative 4 is implemented.

5.15.3.5.2 Indirect

There would be no indirect impacts to community cohesion around this diversion site if Alternative 4 is implemented.

5.15.3.5.3 Cumulative

Cumulative impacts for Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.4 Environmental Justice

5.15.4.1 No Action Alternative (Future Without Project Conditions)

5.15.4.1.1 Direct

Minority and/or low-income communities have not been identified in the study area of Plaquemines Parish. In a future without project scenario, no anticipated disproportionately high or adverse human health or environmental effects on minority or low-income populations would occur, as no property would be acquired for construction of the proposed project within the study area.

5.15.4.1.2 Indirect

No disproportionately high or adverse human health or environmental indirect impacts on minority or low-income populations would occur.

5.15.4.1.3 Cumulative

There would be no cumulative impacts on minority and/or low-income communities within the study area per 2000 U.S. Census information and requirements of E.O. 12898. The No Action Alternative would not contribute to any additional EJ issues when combined with other Federal, state, local, and private restoration efforts.

5.15.4.2 Alternative 1 – 5,000 cfs Diversion

5.15.4.2.1 Direct

No minority populations have been identified within the study area of Plaquemines Parish. Per 2000 U.S. Census information and requirements of E.O. 12898, this area is not an Environmental Justice community. Direct impacts from construction activities such air quality, noise, traffic, safety, etc., would occur in the study area; but as there would be no permanent residences along the proposed project area, no direct impacts on human health or environmental effects would be expected for this Alternative.

5.15.4.2.2 Indirect

Under Alternative 1 no indirect impacts on human health or environmental effects within the study area would occur.

5.15.4.2.3 Cumulative

No minority and/or low-income communities have been identified within the proposed study area per 2000 U.S. Census information and requirements of E.O. 12898. Cumulative impacts would be the synergistic effect of implementing Alternative 1 with the additive combination of impacts and benefits for overall net acres created, nourished, and protected by other Federal, state, local and private activities and restoration efforts as summarized in Section 1 of this report The cumulative impacts of Alternative 1 would be similar to those described for the No Action Alternative.

5.15.4.3 Alternative 2 – 10,000 cfs max Diversion

5.15.4.3.1 Direct

Direct impacts of Alternative 2 would be similar to Alternative 1.

5.15.4.3.2 Indirect

Indirect impacts of Alternative 2 would be similar to Alternative 1.

5.15.4.3.3 Cumulative

Cumulative impacts of Alternative 2 would be similar to Alternative 1

5.15.4.4 Alternative 3 – 15,000 cfs max Diversion

5.15.4.4.1 Direct

Direct impacts of Alternative 3 would be similar to Alternative 1.

5.15.4.4.2 Indirect

Indirect impacts of Alternative 3 would be similar to Alternative 1.

5.15.4.4.3 Cumulative

Cumulative impacts of Alternative 3 would be similar to Alternative 1

5.15.4.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.4.5.1 Direct

Direct impacts of Alternative 4 would be similar to Alternative 1.

5.15.4.5.2 Indirect

Indirect impacts of Alternative 4 would be similar to Alternative 1.

5.15.4.5.3 Cumulative

Cumulative impacts of Alternative 4 would be similar to Alternative 1.

5.15.5 Infrastructure

5.15.5.1 No Action Alternative (Future Without Project Conditions)

5.15.5.1.1 Direct

There would be no direct impacts to infrastructure if the proposed diversion was not constructed.

5.15.5.1.2 Indirect

Under the No Action Alternative, continuing loss of marsh soils and vegetation in the project area over the 50-year planning horizon could potentially result in increased vulnerability of existing infrastructure to the erosive force of wind and wave action from the Gulf of Mexico. Beyond this, no indirect impacts to infrastructure would be anticipated if the proposed action was not implemented.

5.15.5.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to infrastructure consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the Federal Greater New Orleans Hurricane and Storm Damage Risk Reduction System (GNOHSDRRS), and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.5.2 Alternative 1 – 5,000 cfs Diversion

5.15.5.2.1 Direct

There would be short-term impacts to flood control infrastructure during construction of a box culvert diversion structure either through or under the existing levee if Alternative 1 is implemented. Temporary impacts to transportation infrastructure could occur if the existing highway system is partially closed during construction. Construction practices would be implemented to avoid and minimize any potential construction-related adverse impacts to existing infrastructure (e.g., pipelines, etc.), and to ensure that the integrity of the Federal levee is not compromised at any time during or after construction.

5.15.5.2.2 Indirect

No long-term indirect negative or positive impacts to existing infrastructure in the project area would be anticipated to occur if Alternative 1 is implemented.

5.15.5.2.3 Cumulative

Cumulative impacts of Alternative 1 on existing infrastructure in the project area would be similar to those anticipated for the No Action Alternative.

5.15.5.3 Alternative 2 – 10,000 cfs max Diversion

5.15.5.3.1 Direct

Direct impacts to infrastructure resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.3.2 Indirect

Indirect impacts to infrastructure resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.3.3 Cumulative

Cumulative impacts of Alternative 2 on existing infrastructure in the project area would be similar to those anticipated for the No Action Alternative.

5.15.5.4 Alternative 3 – 15,000 cfs max Diversion

5.15.5.4.1 Direct

Direct impacts to infrastructure resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.4.2 Indirect

Indirect impacts to infrastructure resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.4.3 Cumulative

Cumulative impacts of Alternative 3 on existing infrastructure in the project area would be similar to those anticipated for the No Action Alternative.

5.15.5.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.5.5.1 Direct

Direct impacts to infrastructure resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.5.2 Indirect

Indirect impacts to infrastructure resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.5.5.3 Cumulative

Cumulative impacts of Alternative 3 on existing infrastructure in the project area would be similar to those anticipated for the No Action Alternative.

5.15.6 Business and Industry

5.15.6.1 No Action Alternative (Future Without Project Conditions)

5.15.6.1.1 Direct

Without construction of the proposed action there would be no direct impacts to business and industry in the vicinity of the project area.

5.15.6.1.2 Indirect

Without implementation of the proposed action there would be no indirect impacts to business and industry in the vicinity of the project area.

5.15.6.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to business and industry consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

Cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety could occur. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could have the effect of spurring greater economic growth in the region than would otherwise occur. It follows that increases in business and industry would ensue given additional economic growth. In addition, the lower incidence of flooding that the GNOHSDRRS is designed to achieve would have the effect of preserving, if not enhancing, property values within the protected areas.

5.15.6.2 Alternative 1 – 5,000 cfs Diversion

5.15.6.2.1 Direct

During construction of the diversion structure there could be a short-term disruption to fuel and storage facilities located along the Mississippi River. However, such disruption would be minimal. There could

be some disruption to pipelines located along the diversion site during construction, but no long-term impact is expected to affect pipeline operations.

5.15.6.2.2 Indirect

There would be no indirect impacts to business and industry around this diversion site if Alternative 1 is implemented.

5.15.6.2.3 Cumulative

Cumulative impacts of Alternative 1 on business and industry in the project area would be similar to those anticipated for the No Action Alternative.

5.15.6.3 Alternative 2 – 10,000 cfs max Diversion

5.15.6.3.1 Direct

Direct impacts to business and industry resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.3.2 Indirect

Indirect impacts to business and industry resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.3.3 Cumulative

Cumulative impacts of Alternative 2 on business and industry in the project area would be similar to those anticipated for the No Action Alternative.

5.15.6.4 Alternative 3 – 15,000 cfs max Diversion

5.15.6.4.1 Direct

Direct impacts to business and industry resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.4.2 Indirect

Indirect impacts to business and industry resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.4.3 Cumulative

Cumulative impacts of Alternative 3 on business and industry in the project area would be similar to those anticipated for the No Action Alternative.

5.15.6.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.6.5.1 Direct

Direct impacts to business and industry resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.5.2 Indirect

Indirect impacts to business and industry resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.6.5.3 Cumulative

Cumulative impacts of Alternative 4 on business and industry in the project area would be similar to those anticipated for the No Action Alternative.

5.15.7 Traffic and Transportation

5.15.7.1 No Action Alternative (Future Without Project Conditions)

5.15.7.1.1 Direct

Without implementation of the proposed action there would be no direct impacts to transportation resources in the vicinity of the proposed Phoenix diversion site.

5.15.7.1.2 Indirect

Without implementation of the proposed action there would be no indirect impacts to transportation resources in the vicinity of the proposed Phoenix diversion site.

5.15.7.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to transportation resources consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

The potential exists for cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could have the effect of spurring additional economic growth in the region than would otherwise occur. An increase in the demand for transportation resources usually follows gains in economic activity and would thus be expected given any additional economic growth in the region.

5.15.7.2 Alternative 1 – 5,000 cfs Diversion

5.15.7.2.1 Direct

Activities associated with construction of the diversion structure and outfall management features of Alternative 1 could result in increased activity by trucks along LA HWY 39. However, the relatively remote location of the diversion site tends to render the potential for such traffic congestion effects to a relatively low magnitude. Wear and tear on roadways used to transport materials to construction sites would be expected to remain proportionate to the quantity of traffic emanating from all local and regional activities.

5.15.7.2.2 Indirect

There would be no indirect impacts to transportation in the project area and vicinity if Alternative 1 is implemented.

5.15.7.2.3 Cumulative

Cumulative impacts to traffic and transportation resulting from implementation of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.7.3 Alternative 2 – 10,000 cfs max Diversion

5.15.7.3.1 Direct

Direct impacts to traffic and transportation resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.3.2 Indirect

Indirect impacts to traffic and transportation resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.3.3 Cumulative

Cumulative impacts to traffic and transportation resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.4 Alternative 3 – 15,000 cfs max Diversion

5.15.7.4.1 Direct

Direct impacts to traffic and transportation resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.4.2 Indirect

Indirect impacts to traffic and transportation resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.4.3 Cumulative

Cumulative impacts to traffic and transportation resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.7.5.1 Direct

Direct impacts to traffic and transportation resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.5.2 Indirect

Indirect impacts to traffic and transportation resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.7.5.3 Cumulative

Cumulative impacts to traffic and transportation resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.8 Public Facilities and Services

5.15.8.1 No Action Alternative (Future Without Project Conditions)

5.15.8.1.1 Direct

There would be no direct impacts to the availability of public facilities and services if the proposed action is not implemented.

5.15.8.1.2 Indirect

There would be no indirect impacts to the availability of public facilities and services if the proposed action is not implemented.

5.15.8.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to the availability of public facilities and services consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.8.2 Alternative 1 – 5,000 cfs Diversion

5.15.8.2.1 Direct

There would be no long-term direct impacts to public utilities and services around this diversion site if Alternative 1 is constructed.

5.15.8.2.2 Indirect

There would be no indirect impacts to public utilities and services in the project area and vicinity if Alternative 1 is implemented.

5.15.8.2.3 Cumulative

Cumulative impacts of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.8.3 Alternative 2 – 10,000 cfs max Diversion

5.15.8.3.1 Direct

Direct impacts associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.3.2 Indirect

Indirect impacts of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.3.3 Cumulative

Cumulative impacts of Alternative 2 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.8.4 Alternative 3 – 15,000 cfs max Diversion

5.15.8.4.1 Direct

Direct impacts associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.4.2 Indirect

Indirect impacts of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.4.3 Cumulative

Cumulative impacts of Alternative 3 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.8.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.8.5.1 Direct

Direct impacts associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.5.2 Indirect

Indirect impacts of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.8.5.3 Cumulative

Cumulative impacts of Alternative 4 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.9 Tax Revenues and Property Values

5.15.9.1 No Action Alternative (Future Without Project Conditions)

5.15.9.1.1 Direct

Without construction of the proposed action there would be no direct impacts to tax revenues and property values in the vicinity of the proposed diversion site.

5.15.9.1.2 Indirect

Without implementation of the proposed action there would be no indirect impacts to tax revenues and property values in the project area and vicinity.

5.15.9.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to tax revenues and property values consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects. Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

Under the no action scenario, cumulative indirect impacts associated with the completion of the GNOHSDRRS in its entirety could occur. The lower flood risk that accrues to the much of the New Orleans metropolitan area upon completion of the GNOHSDRRS could have the effect of spurring additional economic growth in the region than would otherwise occur. It follows that increases in tax revenues would ensue given additional economic growth. In addition, the lower incidence of flooding that the GNOHSDRRS is designed to achieve would have the effect of preserving, if not enhancing, property values within the protected areas.

5.15.9.2 Alternative 1 – 5,000 cfs Diversion

5.15.9.2.1 Direct

There would be no direct impacts to tax revenue and property around this diversion site if Alternative 1 is constructed.

5.15.9.2.2 Indirect

There would be no indirect impacts to tax revenue and property in the project area and vicinity if Alternative 1 is implemented.

5.15.9.2.3 Cumulative

Cumulative impacts of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.9.3 Alternative 2 – 10,000 cfs max Diversion

5.15.9.3.1 Direct

Direct impacts associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.3.2 Indirect

Indirect impacts of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.3.3 Cumulative

Cumulative impacts of Alternative 2 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.9.4 Alternative 3 – 15,000 cfs max Diversion

5.15.9.4.1 Direct

Direct impacts associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.4.2 Indirect

Indirect impacts of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.4.3 Cumulative

Cumulative impacts of Alternative 3 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.9.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.9.5.1 Direct

Direct impacts associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.5.2 Indirect

Indirect impacts of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.9.5.3 Cumulative

Cumulative impacts of Alternative 4 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.10 Disruption of Desirable Community and Regional Growth

5.15.10.1 No Action Alternative (Future Without Project Conditions)

5.15.10.1.1 Direct

Without construction of the proposed action there would be no direct impacts to community and regional growth in the vicinity of the proposed diversion site.

5.15.10.1.2 Indirect

Without implementation of the proposed action there would be no indirect impacts to community and regional growth in the project area and vicinity.

5.15.10.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts to community and regional growth consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.10.2 Alternative 1 – 5,000 cfs Diversion

5.15.10.2.1 Direct

There would be no direct impacts to community and regional growth around this diversion site if Alternative 1 is constructed.

5.15.10.2.2 Indirect

There would be no indirect impacts to community and regional growth in the project area and vicinity if Alternative 1 is implemented.

5.15.10.2.3 Cumulative

Cumulative impacts resulting from implementation of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.10.3 Alternative 2 – 10,000 cfs max Diversion

5.15.10.3.1 Direct

Direct impacts associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.3.2 Indirect

Indirect impacts of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.3.3 Cumulative

Cumulative impacts of Alternative 2 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.10.4 Alternative 3 – 15,000 cfs max Diversion

5.15.10.4.1 Direct

Direct impacts associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.4.2 Indirect

Indirect impacts of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.4.3 Cumulative

Cumulative impacts of Alternative 3 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.10.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.10.5.1 Direct

Direct impacts associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.5.2 Indirect

Indirect impacts of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.10.5.3 Cumulative

Cumulative impacts of Alternative 4 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11 Land Use Socioeconomics

5.15.11.1 Agriculture

5.15.11.1.1 No Action Alternative (Future Without Project Conditions)

5.15.11.1.1.1 Direct

There would be no direct impacts on commercial agriculture in the vicinity of the freshwater diversion site if the proposed diversion is not constructed.

5.15.11.1.1.2 Indirect

There would be no indirect impacts on commercial agriculture in the project area and vicinity if the proposed action is not implemented.

5.15.11.1.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on commercial agriculture consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct and indirect cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.11.1.2 Alternative 1 – 5,000 cfs Diversion

5.15.11.1.2.1 Direct

There would be no substantial direct impacts on commercial agriculture in the vicinity of the diversion site if Alternative 1 is constructed.

Any alligator nesting sites located within the construction footprint could be temporarily disrupted during construction activities if these activities occur during nest-building and incubation periods. Excavation of outfall channels could permanently disrupt nesting activity within the footprint of this feature. However, creation of marsh and ridges using material dredged during construction and maintenance of outfall channels also could directly provide additional nesting habitat.

5.15.11.1.2.2 Indirect

There would be no substantial indirect impacts on commercial agriculture in the project area and vicinity if Alternative 1 is implemented.

Maximum flows from this alternative would be planned to occur in the March–April timeframe and would return to maintenance flows (1,000 cfs) by the beginning of May. This would be just prior to the season for alligator mating and nesting in this region. Water levels would not be substantially elevated during maximum flow operation and would not measurably differ from without-project levels during maintenance flow operations. For these reasons, no impacts to alligator reproductive cycles or egg production would be anticipated to result from implementation of this alternative.

5.15.11.1.2.3 Cumulative

Cumulative impacts of Alternative 1 on commercial agriculture would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.1.3 Alternative 2 – 10,000 cfs max Diversion

5.15.11.1.3.1 Direct

Direct impacts associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.1.3.2 Indirect

Indirect impacts resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.1.3.3 Cumulative

Cumulative impacts of Alternative 2 on commercial agriculture would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.1.4 Alternative 3 – 10,000 cfs max Diversion

5.15.11.1.4.1 Direct

Direct impacts associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.1.4.2 Indirect

Indirect impacts resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.1.4.3 Cumulative

Cumulative impacts of Alternative 3 on commercial agriculture would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.11.1.5.1 Direct

Direct impacts associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.1.5.2 Indirect

Indirect impacts resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

During maximum flow, large areas of the marsh extending from approximately 1 mile south and west of Bayou Garelle and the main outfall channel, extending to the northern extent of the project boundary, and being contained by the River aux Chenes and Mississippi River ridges would be inundated on the order of 0.3 to 0.6 foot during maximum diversion operations. Maximum flows from this alternative would be planned to occur in the March–April timeframe and would return to maintenance flows (1,000 cfs) by the beginning of May at the latest, just prior to the season for alligator mating and nesting in this region. These areas would quickly drain out to their naturally inundated area on the order of 5 to 7 days (going from maximum diversions to the proposed 1,000 cfs maintenance flow).

There would not be a measurable difference in water levels during the 1,000 cfs maintenance flows. Tidal conditions would be the driver of stages within the project area during this time and would not measurably differ from without-project levels during maintenance flow operations. For these reasons, no impacts to alligator reproductive cycles or egg production would be anticipated to result from implementation of this alternative.

5.15.11.1.5.3 Cumulative

Cumulative impacts of Alternative 4 on commercial agriculture would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.2 Forestry

5.15.11.2.1 No Action Alternative (Future Without Project Conditions)

5.15.11.2.1.1 Direct

There would be no direct impacts on commercial forestry production in the project area and vicinity if the proposed diversion is not constructed.

5.15.11.2.1.2 Indirect

There would be no indirect impacts on commercial forestry production in the project area and vicinity if the proposed action is not implemented.

5.15.11.2.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on commercial forestry production consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.11.2.2 Alternative 1 – 5,000 cfs Diversion

5.15.11.2.2.1 Direct

There would be no substantial direct impacts on commercial forestry production around the diversion site if Alternative 1 is constructed.

5.15.11.2.2.2 Indirect

There would be no substantial indirect impacts on commercial forestry production in the project area and vicinity if Alternative 1 is implemented.

5.15.11.2.2.3 Cumulative

Cumulative impacts of Alternative 1 on commercial forestry production would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.2.3 Alternative 2 – 10,000 cfs max Diversion

5.15.11.2.3.1 Direct

Direct impacts on commercial forestry production associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.3.2 Indirect

Indirect impacts on commercial forestry production resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.3.3 Cumulative

Cumulative impacts of Alternative 2 on commercial forestry production would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.2.4 Alternative 3 – 15,000 cfs max Diversion

5.15.11.2.4.1 Direct

Direct impacts on commercial forestry production associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.4.2 Indirect

Indirect impacts on commercial forestry production resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.4.3 Cumulative

Cumulative impacts of Alternative 3 on commercial forestry production would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.11.2.5.1 Direct

Direct impacts on commercial forestry production associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.5.2 Indirect

Indirect impacts on commercial forestry production resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.2.5.3 Cumulative

Cumulative impacts of Alternative 4 on commercial forestry production would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.3 Public Lands

5.15.11.3.1 No Action Alternative (Future Without Project Conditions)

5.15.11.3.1.1 Direct

There would be no direct impacts on public lands in the project area and vicinity if the proposed diversion is not constructed.

5.15.11.3.1.2 Indirect

There would be no indirect impacts on public lands in the project area and vicinity if the proposed action is not implemented.

5.15.11.3.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on public lands consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.11.3.2 Alternative 1 – 5,000 cfs Diversion

5.15.11.3.2.1 Direct

There would be no substantial direct impacts on public lands around the diversion site if Alternative 1 is constructed.

5.15.11.3.2.2 Indirect

There would be no substantial indirect impacts on public lands in the project area and vicinity if Alternative 1 is implemented.

5.15.11.3.2.3 Cumulative

Cumulative impacts of Alternative 1 on public lands would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.3.3 Alternative 2 – 10,000 cfs max Diversion

5.15.11.3.3.1 Direct

Direct impacts on public lands associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.3.2 Indirect

Indirect impacts on public lands resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.3.3 Cumulative

Cumulative impacts of Alternative 2 on public lands would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.3.4 Alternative 3 – 15,000 cfs max Diversion

5.15.11.3.4.1 Direct

Direct impacts on public lands associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.4.2 Indirect

Indirect impacts on public lands resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.4.3 Cumulative

Cumulative impacts of Alternative 3 on public lands would be expected to be similar to those anticipated for the No Action Alternative.

5.15.11.3.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.11.3.5.1 Direct

Direct impacts on public lands associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.5.2 Indirect

Indirect impacts on public lands resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.11.3.5.3 Cumulative

Cumulative impacts of Alternative 4 on public lands would be expected to be similar to those anticipated for the No Action Alternative.

5.15.12 Water Use and Supply

5.15.12.1 No Action Alternative (Future Without Project Conditions)

5.15.12.1.1 Direct

There would be no direct impacts on water use and supply in the project area and vicinity if the proposed diversion is not constructed.

5.15.12.1.2 Indirect

There would be no indirect impacts on water use and supply in the project area and vicinity if the proposed action is not implemented.

5.15.12.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on water use and supply consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct and indirect cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.12.2 Alternative 1 – 5,000 cfs Diversion

5.15.12.2.1 Direct

Construction of Alternative 1 could require replacement of a water supply pipeline at the diversion site to continue providing water services to the Pointe à la Hache and Phoenix communities. Short-term impacts to water delivery could potentially occur during replacement; however, no long-term interruptions to delivery of water supply would be anticipated.

5.15.12.2.2 Indirect

Implementation of Alternative 1 is not anticipated to have any indirect impacts to water supply and use in the project area and vicinity.

5.15.12.2.3 Cumulative

Cumulative impacts on water supply and use resulting from implementation of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.12.3 Alternative 2 – 10,000 cfs max Diversion

5.15.12.3.1 Direct

Direct impacts of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.3.2 Indirect

Indirect impacts of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.3.3 Cumulative

Cumulative impacts on water supply and use resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.12.4 Alternative 3 – 15,000 cfs max Diversion

5.15.12.4.1 Direct

Direct impacts of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.4.2 Indirect

Indirect impacts of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.4.3 Cumulative

Cumulative impacts on water supply and use resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.12.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.12.5.1 Direct

Direct impacts of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.5.2 Indirect

Indirect impacts of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.12.5.3 Cumulative

Cumulative impacts on water supply and use resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.13 Navigation

5.15.13.1 No Action Alternative (Future Without Project Conditions)

5.15.13.1.1 Direct

There would be no direct impacts on navigation in the project area and vicinity if the proposed diversion is not constructed.

5.15.13.1.2 Indirect

There would be no indirect impacts on navigation in the project area and vicinity if the proposed action is not implemented.

5.15.13.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on navigation consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct and indirect cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.13.2 Alternative 1 – 5,000 cfs Diversion

5.15.13.2.1 Direct

Construction of Alternative 1 could disturb current flow patterns in the Mississippi River adjacent to the diversion site, requiring merchant vessels to compensate for the diverted current. The potential for disruption in current patterns during construction is not anticipated to be substantial enough to require alteration of the navigation channel or disruption in traffic on the waterway.

5.15.13.2.2 Indirect

Under the operation plan evaluated in this feasibility study and SEIS, implementation of Alternative 1 would involve diversion of Mississippi River flows into the project area at a rate of 5,000 cfs for up to 60 days in the spring (March–April) and at a rate of up to 1,000 cfs the remaining days of the year. Diversion of river sediment and water with this operating plan is unlikely to increase the potential for sedimentation and shoaling in the Mississippi River downstream of the diversion, or to require additional or increased dredging. Based on the small size of the diversion relative to the average Mississippi River flows and the limited number of days when the diversion would be operated at maximum capacity, no indirect adverse

impacts would be expected to result from this alternative. Additional discussion of the potential effects of the White Ditch diversion project would be provided in Appendix N of this report.

Channels and canals within the project area could be affected by project implementation. The alternative would introduce sediment into the project area for the purpose of creating marsh. Most of this sediment would accumulate in open water areas where there is little to no flow. However, some could accumulate in channels and canals. It could potentially become necessary to perform maintenance dredging on some channels and canals.

5.15.13.2.3 Cumulative

Cumulative impacts of Alternative 1 on navigation consists simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

The unconstructed Myrtle Grove diversion would be directly across the river from the proposed White Ditch structure. The combination effect of these two structures working in such close proximity to each other on opposite sides of the river could create changes in the Mississippi River.

Other existing and proposed diversions on the Mississippi River could collectively have impacts on flows and sediments. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole could have effects on flows and stages from the Mississippi River. System-wide coordination of diversion operations would likely be necessary.

5.15.13.3 Alternative 2 – 10,000 cfs max Diversion

5.15.13.3.1 Direct

Direct impacts to navigation resulting from construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.13.3.2 Indirect

Under the operation plan evaluated in this feasibility study and SEIS, implementation of Alternative 2 would involve diversion of Mississippi River flows into the project area at a rate of 10,000 cfs for up to 60 days in the spring (March–April) and at a rate of up to 1,000 cfs the remaining days of the year. Diversion of river sediment and water with this operating plan is unlikely to increase the potential for sedimentation and shoaling in the Mississippi River downstream of the diversion, or to require additional or increased dredging.

While the potential for indirect impacts of Alternative 2 is greater than for Alternative 1 based on the difference in maximum flow capacity, because of the comparatively small size of the diversion relative to the average Mississippi River flows and the limited number of days when the diversion would be operated at maximum capacity, no indirect adverse impacts would be expected to result from this alternative. Additional discussion of the potential effects of the White Ditch diversion project would be provided in Appendix N of this report.

Channels and canals within the project area could be affected by project implementation. The alternative would introduce sediment into the project area for the purpose of creating marsh. Most of this sediment would accumulate in open water areas where there is little to no flow. However, some could accumulate in channels and canals. It could potentially become necessary to perform maintenance dredging on some channels and canals.

5.15.13.3.3 Cumulative

Cumulative impacts of Alternative 1 on navigation consists simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

The unconstructed Myrtle Grove diversion would be directly across the river from the proposed White Ditch structure. The combination effect of these two structures working in such close proximity to each other on opposite sides of the river could create changes in the Mississippi River.

Other existing and proposed diversions on the Mississippi River could collectively have impacts on flows and sediments. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole could have effects on flows and stages from the Mississippi River. System-wide coordination of diversion operations would likely be necessary.

5.15.13.4 Alternative 3 – 15,000 cfs max Diversion

5.15.13.4.1 Direct

Direct impacts to navigation resulting from construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.13.4.2 Indirect

Under the operation plan evaluated in this feasibility study and SEIS, implementation of Alternative 3 would involve diversion of Mississippi River flows into the project area at a rate of 15,000 cfs for up to 60 days in the spring (March–April) and at a rate of up to 1,000 cfs the remaining days of the year. Diversion of river sediment and water with this operating plan is unlikely to increase the potential for sedimentation and shoaling in the Mississippi River downstream of the diversion, or to require additional or increased dredging.

While the potential for indirect impacts of Alternative 3 is greater than for Alternatives 1 or 2 based on the difference in maximum flow capacity, because of the comparatively small size of the diversion relative to the average Mississippi River flows and the limited number of days when the diversion would be operated at maximum capacity, no substantial indirect adverse impacts would be expected to result from this alternative. Additional discussion of the potential effects of the White Ditch diversion project would be provided in Appendix N of this report.

Channels and canals within the project area could be affected by project implementation. The alternative would introduce sediment into the project area for the purpose of creating marsh. Most of this sediment would accumulate in open water areas where there is little to no flow. However, some could accumulate

in channels and canals. It could potentially become necessary to perform maintenance dredging on some channels and canals.

5.15.13.4.3 Cumulative

Cumulative impacts of Alternative 1 on navigation consists simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

The unconstructed Myrtle Grove diversion would be directly across the river from the proposed White Ditch structure. The combination effect of these two structures working in such close proximity to each other on opposite sides of the river could create changes in the Mississippi River.

Other existing and proposed diversions on the Mississippi River could collectively have impacts on flows and sediments. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole could have effects on flows and stages from the Mississippi River. System-wide coordination of diversion operations would likely be necessary.

5.15.13.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.13.5.1 Direct

Direct impacts to navigation resulting from construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.13.5.2 Indirect

Under the operation plan evaluated in this feasibility study and SEIS, implementation of Alternative 4 would involve diversion of Mississippi River flows into the project area at a rate up to 35,000 cfs for up to 60 days in the spring (March–April) and at a rate of up to 1,000 cfs the remaining days of the year. Diversion of river sediment and water with this operating plan is unlikely to substantially increase the potential for sedimentation and shoaling in the Mississippi River downstream of the diversion, or to require additional or increased dredging over the 50-year planning horizon.

While the potential for indirect impacts of Alternative 4 is greater than for Alternatives 1, 2, or 3 based on the difference in maximum flow capacity, because of the small size of the diversion relative to the average Mississippi River flows during the maximum capacity operation period, and the limited number of days when the diversion would be operated at maximum capacity, no substantial indirect adverse impacts would be expected to result from this alternative. Additional discussion of the potential effects of the White Ditch diversion project would be provided in Appendix N of this report.

Channels and canals within the project area could be affected by project implementation. The alternative would introduce sediment into the project area for the purpose of creating marsh. Most of this sediment would accumulate in open water areas where there is little to no flow. However, some could accumulate in channels and canals. It could potentially become necessary to perform maintenance dredging on some channels and canals.

5.15.13.5.3 Cumulative

Cumulative impacts of Alternative 1 on navigation consists simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

The unconstructed Myrtle Grove diversion would be directly across the river from the proposed White Ditch structure. The combination effect of these two structures working in such close proximity to each other on opposite sides of the river could create changes in the Mississippi River.

Other existing and proposed diversions on the Mississippi River could collectively have impacts on flows and sediments. While many of the projects along the Mississippi River would be considered small diversions (100–5,000 cfs), the collective impacts of the whole could have effects on flows and stages from the Mississippi River. System-wide coordination of diversion operations would likely be necessary.

5.15.14 Man-Made Resources

5.15.14.1 Oil, Gas, Utilities

5.15.14.1.1 No Action Alternative (Future Without Project Conditions)

5.15.14.1.1.1 Direct

There would be no direct impacts on oil, gas, and utilities in the project area and vicinity if the proposed diversion is not constructed.

5.15.14.1.1.2 Indirect

There would be no indirect impacts on oil, gas, and utilities in the project area and vicinity if the proposed action is not implemented.

5.15.14.1.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oil, gas, and utilities consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion projects.

Under the no action scenario, direct cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.14.1.2 Alternative 1 – 5,000 cfs Diversion

5.15.14.1.2.1 Direct

Construction of Alternative 1 could require avoidance or relocation or of several wells located near the construction footprint of the diversion. There would be no pipelines located within or near the

construction footprint. Construction activities would not be expected to result in direct impact to utilities or oil services within the diversion area.

5.15.14.1.2.2 Indirect

No indirect impacts on oil or gas utilities would be expected to occur in the project area and vicinity if Alternative 1 is not implemented.

5.15.14.1.2.3 Cumulative

Cumulative impacts on oil or gas utilities resulting from implementation of Alternative 1 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.14.1.3 Alternative 2 – 10,000 cfs max Diversion

5.15.14.1.3.1 Direct

Direct impacts on oil or gas utilities associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.3.2 Indirect

Indirect impacts to oil or gas utilities resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.3.3 Cumulative

Cumulative impacts on oil or gas utilities resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.14.1.4 Alternative 3 – 15,000 cfs max Diversion

5.15.14.1.4.1 Direct

Direct impacts on oil or gas utilities associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.4.2 Indirect

Indirect impacts to oil or gas utilities resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.4.3 Cumulative

Cumulative impacts on oil or gas utilities resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.14.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.14.1.5.1 Direct

Direct impacts on oil or gas utilities associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.5.2 Indirect

Indirect impacts to oil or gas utilities resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.1.5.3 Cumulative

Cumulative impacts on oil or gas utilities resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for the No Action Alternative.

5.15.14.2 Flood Control and Hurricane Protection

5.15.14.2.1 No Action Alternative (Future Without Project Conditions)

5.15.14.2.1.1 Direct

There would be no direct impacts on flood control and hurricane protection in the project area and vicinity if the proposed diversion is not constructed.

5.15.14.2.1.2 Indirect

There would be no indirect impacts on flood control and hurricane protection in the project area and vicinity if the proposed action is not implemented.

5.15.14.2.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on flood control and hurricane protection consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Under the no action scenario, cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

5.15.14.2.2 Alternative 1 – 5,000 cfs Diversion

5.15.14.2.2.1 Direct

Construction of Alternative 1 would involve construction of a diversion structure through/under the Federal Mississippi River levee, and excavation of outfall management channels leading away from the diversion structure on the east side of the Federal levee. Construction activity would not directly affect any non-Federal levees located to the north or south of the construction site. Construction specifications would include measures to ensure that the integrity of the levee is not compromised and the level of

protection during high river stages or storm surges is not lessened at any time during or after construction. For these reasons, no adverse impacts to flood control and hurricane protection would be expected to result from construction of this alternative.

5.15.14.2.2.2 Indirect

Indirect effects within the project area resulting from operation of Alternative 1 would include an increase in water levels within interior distributaries such as River aux Chenes and Bayou Garelle, and minor increased inundation of low-lying lands, particularly when the diversion is operated at maximum capacity. These hydrologic alterations would be expected to distribute and deposit river sediments throughout the project area. No significant adverse effects on existing Federal or non-Federal levees would be expected to result from implementation of this alternative.

5.15.14.2.2.3 Cumulative

Cumulative impacts would be the synergistic effect of Alternative 1 on flow and water levels with the added combination of similar wetland degradation and wetland loss impacts to flow and water levels throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

Cumulative indirect impacts of this alternative combined with other state and Federal coastal restoration projects could potentially benefit existing and proposed flood control and hurricane protection projects by decreasing the vulnerability of protective works to wind and wave erosion from hurricane and tropical storm surges.

Operations of the White Ditch structure would need to be done in consideration with the existing Caernarvon diversion, as well as the proposed CWPPRA project for the rehabilitation and expansion of the existing siphon at White Ditch. Coordinated operations of all three structures would be necessary to optimize potential benefits within the Breton Sound Basin. Uncoordinated efforts could lead to prolonged inundation, or excessively elevated water levels on Federal and non-Federal levees in the project area and vicinity.

5.15.14.2.3 Alternative 2 – 10,000 cfs max Diversion

5.15.14.2.3.1 Direct

Direct impacts to flood control and hurricane protection in the project area and vicinity associated with construction of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.3.2 Indirect

While the maximum inflow capacity of this alternative is incrementally greater than that of Alternative 1, indirect impacts on flood control and hurricane protection resulting from implementation of Alternative 2 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.3.3 Cumulative

Cumulative impacts to flood control and hurricane protection resulting from implementation of Alternative 2 would be expected to be similar to, though incrementally greater than, those anticipated for Alternative 1.

5.15.14.2.4 Alternative 3 – 15,000 cfs max Diversion

5.15.14.2.4.1 Direct

Direct impacts to flood control and hurricane protection in the project area and vicinity associated with construction of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.4.2 Indirect

While the maximum inflow capacity of this alternative is incrementally greater than that of Alternative 1, indirect impacts on flood control and hurricane protection resulting from implementation of Alternative 3 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.4.3 Cumulative

Cumulative impacts to flood control and hurricane protection resulting from implementation of Alternative 3 would be expected to be similar to, though incrementally greater than, those anticipated for Alternative 1.

5.15.14.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.14.2.5.1 Direct

Direct impacts to flood control and hurricane protection in the project area and vicinity associated with construction of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.5.2 Indirect

While the maximum inflow capacity of this alternative is incrementally greater than that of Alternative 1, indirect impacts on flood control and hurricane protection resulting from implementation of Alternative 4 would be expected to be similar to those anticipated for Alternative 1.

5.15.14.2.5.3 Cumulative

Cumulative impacts to flood control and hurricane protection resulting from implementation of Alternative 4 would be expected to be similar to, though incrementally greater than, those anticipated for Alternative 1.

5.15.15 Natural Resources

5.15.15.1 Commercial Fisheries

5.15.15.1.1 No Action Alternative (Future Without Project Conditions)

5.15.15.1.1.1 Direct

There would be no direct impacts on natural resources and commercial fisheries within the project area and vicinity if the proposed diversion is not constructed.

5.15.15.1.1.2 Indirect

Without implementation of the proposed diversion, indirect impacts on natural resources and commercial fisheries would occur as a result of continuing loss of emergent wetland and increase in shallow open water. Increased saltwater intrusion into some of the upper portions of the project area would be anticipated as marshes continued to degrade. In time, this would result in a shift in the populations of fishes and invertebrates, with more saline-dominated species replacing freshwater species in previously intermediate-to-fresh areas. Over the 50-year planning horizon, essential fish habitat for many commercial fishery species would likewise decline, leading to a net loss in fisheries population size and diversity.

5.15.15.1.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on commercial fisheries consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Under the no action scenario, cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

Without the contribution of the proposed White Ditch diversion, continued wetland habitat losses would incrementally decrease the productivity of Louisiana's coastal fisheries. The commercial fishing and seafood industry could potentially suffer losses in employment as estuaries that would be necessary to produce shrimp, oysters, and other valuable species, erode. Job losses could occur in the areas reliant on fishing, harvesting, processing, and shipping of the seafood catch. Thus, changes in existing fisheries habitat caused by wetland loss, saltwater intrusion, and reduced salinity gradients would likely increase the risk of a decline in the supply of nationally distributed seafood products from Louisiana's coast.

5.15.15.1.2 Alternative 1 – 5,000 cfs Diversion

5.15.15.1.2.1 Direct

Construction of the outfall management features required for Alternative 1 could have a direct impact on natural resources and commercial fishing in the immediate vicinity of the construction site as a result of excavation of material for channel construction, placement of excavated material to create marsh and ridge habitat, and construction notched flow restrictors at selected canal connections to River aux Chenes.

During and after construction, direct impacts to commercial fisheries of Alternative 1 would primarily be related to reduced or impeded access to fishing areas.

5.15.15.1.2.2 Indirect

Implementation of Alternative 1 would have indirect impacts on commercial fisheries by affecting the location of target species. Changes in salinity levels in the project area as a result of project operation (see Section 5.3, Water Quality) would change the distribution of fish and shellfish species based on their salinity tolerance. Changes in fisheries distribution would in turn impact commercial fishing patterns and locations. There is also a potential for some indirect impact on commercial seafood processing facilities located on the West Bank of Plaquemines Parish if Alternative 1 is implemented.

Over the 50-year planning horizon, implementation of Alternative 1 is expected to benefit commercial fisheries by decreasing the rate of loss of marsh and associated critical nursery habitat in the project area compared to the No Action Alternative. Alternative 1 is projected to provide a net benefit of approximately 5,197 AAHUs over the period of analysis, thereby benefitting the nationally important commercial fishing industry in the area.

5.15.15.1.2.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on commercial fisheries consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of freshwater diversion sites.

Cumulative impacts on commercial fisheries resulting from implementation of Alternative 1 would incrementally increase the availability of marsh and estuarine habitat essential to support several commercially targeted species of fish and shellfish at critical life stages. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, would continue and/or increase, as coastal residents protect themselves and their property from hurricane damage and flooding. Implementation of Alternative 1 would contribute to an overall benefit to commercial fisheries compared to the future with no action.

5.15.15.1.3 Alternative 2 – 10,000 cfs max Diversion

5.15.15.1.3.1 Direct

Construction of the outfall management features required for Alternative 2 could have a direct impact on natural resources and commercial fishing in the immediate vicinity of the construction site as a result of excavation of material for channel construction, placement of excavated material to create marsh and ridge habitat, and construction of notched restrictors at selected canal connections to River aux Chenes. During and after construction, direct impacts to commercial fisheries of Alternative 2 would primarily be related to reduced or impeded access to fishing areas.

5.15.15.1.3.2 Indirect

Implementation of Alternative 2 would have indirect impacts on commercial fisheries by affecting the location of target species. Changes in salinity levels in the project area as a result of project operation (see Section 5.3, Water Quality) would change the distribution of fish and shellfish species based on their salinity tolerance. Changes in fisheries distribution would in turn impact commercial fishing patterns and locations. There is also a potential for some indirect impact on commercial seafood processing facilities located on the West Bank of Plaquemines Parish if Alternative 2 is implemented.

Over the 50-year planning horizon, implementation of Alternative 2 is expected to benefit commercial fisheries by decreasing the rate of loss of marsh and critical nursery habitat in the project area compared to the No Action Alternative. Alternative 2 is projected to provide a net benefit of approximately 5,936 AAHUs over the period of analysis, thereby benefitting the nationally important commercial fishing industry in the area.

5.15.15.1.3.3 Cumulative

Cumulative impacts on commercial fisheries resulting from implementation of Alternative 2 would incrementally increase the availability of marsh and estuarine habitat essential to support several commercially targeted species of fish and shellfish at critical life stages. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, would continue and/or increase, as coastal residents protect themselves and their property from hurricane damage and flooding. Implementation of Alternative 2 would contribute to an overall benefit to commercial fisheries compared to the future with no action.

5.15.15.1.4 Alternative 3 – 15,000 cfs max Diversion

5.15.15.1.4.1 Direct

Construction of the outfall management features required for Alternative 3 could have a direct impact on natural resources and commercial fishing in the immediate vicinity of the construction site as a result of excavation of material for channel construction, placement of excavated material to create marsh and ridge habitat, and construction notched restrictors at selected canal connections to River aux Chenes. During and after construction, direct impacts to commercial fisheries of Alternative 3 would primarily be related to reduced or impeded access to fishing areas.

5.15.15.1.4.2 Indirect

Implementation of Alternative 3 would have indirect impacts on commercial fisheries by affecting the location of target species. Changes in salinity levels in the project area as a result of project operation (see Section 5.3, Water Quality) would change the distribution of fish and shellfish species based on their salinity tolerance. Changes in fisheries distribution would in turn impact commercial fishing patterns and locations. There is also a potential for some indirect impact on commercial seafood processing facilities located on the West Bank of Plaquemines Parish if Alternative 2 is implemented.

Over the 50-year planning horizon, implementation of Alternative 3 is expected to benefit commercial fisheries by restoring marsh and critical nursery habitat in the project area compared to the No Action Alternative. Alternative 3 is projected to provide a net benefit of approximately 7,742 AAHUs over the period of analysis, thereby benefitting the nationally important commercial fishing industry in the area.

5.15.15.1.4.3 Cumulative

Cumulative impacts on commercial fisheries resulting from implementation of Alternative 3 would incrementally increase the availability of marsh and estuarine habitat essential to support several commercially targeted species of fish and shellfish at critical life stages. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, would continue and/or increase, as coastal residents protect themselves and their property from hurricane damage and flooding. Implementation of Alternative 3 would contribute to an overall benefit to commercial fisheries compared to the future with no action.

5.15.15.1.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.15.1.5.1 Direct

Construction of the outfall management features required for Alternative 4 could have a direct impact on natural resources and commercial fishing in the immediate vicinity of the construction site as a result of excavation of material for channel construction, placement of excavated material to create marsh and ridge habitat, and construction notched restrictors at selected canal connections to River aux Chenes. During and after construction, direct impacts to commercial fisheries of Alternative 4 would primarily be related to reduced or impeded access to fishing areas.

5.15.15.1.5.2 Indirect

Implementation of Alternative 4 would have indirect impacts on commercial fisheries by affecting the location of target species. Changes in salinity levels in the project area as a result of project operation (see Section 5.3, Water Quality) would change the distribution of fish and shellfish species based on their salinity tolerance. Changes in fisheries distribution would in turn impact commercial fishing patterns and locations. There is also a potential for some indirect impact on commercial seafood processing facilities located on the West Bank of Plaquemines Parish if Alternative 2 is implemented.

Over the 50-year planning horizon, implementation of Alternative 4 is expected to benefit commercial fisheries by restoring marsh and critical nursery habitat in the project area compared to the No Action Alternative. Alternative 4 is projected to provide a net benefit of approximately 13,355 AAHUs over the period of analysis, thereby benefitting the nationally important commercial fishing industry in the area.

5.15.15.1.5.3 Cumulative

Cumulative impacts on commercial fisheries resulting from implementation of Alternative 4 would incrementally increase the availability of marsh and estuarine habitat essential to support several

commercially targeted species of fish and shellfish at critical life stages. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. It is likely that the construction of levees, water control structures and hurricane protection features, which can result in direct loss of habitat, alter water flow, and have the potential to block fisheries access to habitat, would continue and/or increase, as coastal residents protect themselves and their property from hurricane damage and flooding. Implementation of Alternative 4 would contribute to an overall benefit to commercial fisheries compared to the future with no action.

5.15.15.2 Oyster Leases

5.15.15.2.1 No Action Alternative (Future Without Project Conditions)

5.15.15.2.1.1 Direct

There would be no direct impacts to oyster leases in the project area and vicinity if the proposed diversion is not constructed.

5.15.15.2.1.2 Indirect

Without implementation of the proposed diversion, indirect impacts on natural resources and oyster leases would occur as a result of continuing loss of emergent wetland and increase in shallow open water. Increased saltwater intrusion into some of the upper portions of the project area would be anticipated as marshes continued to degrade. In time, this would result in a shift in oyster population toward the middle and upper reaches of the estuary. At the same time, currently productive oyster leases in the lower portions of the project area could degrade in time if salinity shifts above the optimal range. Over the 50-year planning horizon, optimal habitat for oyster production would likewise decline, leading to a net loss in oyster lease productivity and harvest.

5.15.15.2.1.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oyster leases consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Under the no action scenario, cumulative impacts remain no greater than the sum of those impacts indicated individually for each project component of the aforementioned programs.

Without the contribution of the proposed White Ditch diversion, continued wetland habitat losses would incrementally decrease the productivity of Louisiana's coastal fisheries, including oyster beds. The commercial fishing and seafood industry could potentially suffer losses in employment as estuaries that would be necessary to produce shrimp, oysters, and other valuable species, erode. Job losses could occur in the areas reliant on fishing, harvesting, processing, and shipping of the seafood catch. Thus, changes in existing fisheries habitat caused by wetland loss, saltwater intrusion, and reduced salinity gradients would likely increase the risk of a decline in the supply of nationally distributed seafood products from Louisiana's coast.

5.15.15.2.2 Alternative 1 – 5,000 cfs Diversion

5.15.15.2.2.1 Direct

No measurable direct impacts to oyster leases would be anticipated to result from construction of Alternative 1, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters and where no leases currently exist, as determined from examination of state databases.

5.15.15.2.2.2 Indirect

Indirect impacts to oyster leases around this diversion site if Alternative 1 is implemented could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site, during the period when the diversion is at full operational capacity and for up to 2 months after the return to maintenance flow conditions. This could result in a loss of revenue for commercial oyster harvesters.

The operational plan proposed and evaluated in this feasibility study and SEIS limits the period of full flow to no more than 2 months (60 days) in the spring timeframe (March–April was used in the analysis). It was formulated in part to avoid or minimize the potential for incidental adverse effects (e.g. mortality, interference with reproduction) to oysters and other invertebrate or fishery species that require brackish or saline environments. Hydraulic modeling of the project area indicated that the return to maintenance flows for the remainder of the year (10 months) should maintain brackish and saline zones in the project area, though at somewhat reduced average salinities. The number of leases impacted should be less than for the 35,000 cfs alternative because the recovery time should be quicker. For these reasons, indirect adverse impacts to oyster leases would not be anticipated to be significant.

Over the 50-year planning horizon, potential beneficial effects to oyster populations could result if reduced salinities resulting from diversion operation were to increase the spatial extent of habitats experiencing salinities in the optimal range for oyster production. Continued water quality and biological monitoring of the project area before and after project construction should assist in refining the operation plan as needed to meet project objectives for restoring marsh while maintaining a functioning salinity regime in the estuary.

5.15.15.2.2.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oyster leases consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Cumulative impacts on oyster leases resulting from implementation of Alternative 1 would incrementally increase the ability of marsh and estuarine habitat essential to maintain salinity gradients and protect against excessive salinities that could be detrimental to the long-term viability of oyster populations in coastal Louisiana. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. Implementation

of Alternative 1 would contribute to an overall long-term benefit to commercial fisheries, including oyster harvesting, compared to the future with no action.

5.15.15.2.3 Alternative 2 – 10,000 cfs max Diversion

5.15.15.2.3.1 Direct

No measurable direct impacts to oyster leases would be anticipated to result from construction of Alternative 2, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters and where no leases currently exist, as determined from examination of state databases.

5.15.15.2.3.2 Indirect

Indirect impacts to oyster leases around this diversion site if Alternative 2 is implemented could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site, during the period when the diversion is at full operational capacity and for up to 2 months after the return to maintenance flow conditions. This could result in a loss of revenue for commercial oyster harvesters.

The operational plan proposed and evaluated in this feasibility study and SEIS limits the period of full flow to no more than 2 months (60 days) in the spring timeframe (March–April was used in the analysis). It was formulated in part to avoid or minimize the potential for incidental adverse effects (e.g. mortality, interference with reproduction) to oysters and other invertebrate or fishery species that require brackish or saline environments. Hydraulic modeling of the project area indicated that the return to maintenance flows for the remainder of the year (10 months) should maintain brackish and saline zones in the project area, though at somewhat reduced average salinities. For these reasons, indirect adverse impacts to oyster leases would not be anticipated to be significant. The number of leases impacted should be less than for the 35,000 cfs alternative because the recovery time should be quicker.

Over the 50-year planning horizon, potential beneficial effects to oyster populations could result if reduced salinities resulting from diversion operation were to increase the spatial extent of habitats experiencing salinities in the optimal range for oyster production. Continued water quality and biological monitoring of the project area before and after project construction should assist in refining the operation plan as needed to meet project objectives for restoring marsh while maintaining a functioning salinity regime in the estuary.

5.15.15.2.3.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oyster leases consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Cumulative impacts on oyster leases resulting from implementation of Alternative 2 would incrementally increase the ability of marsh and estuarine habitat essential to maintain salinity gradients and protect against excessive salinities that could be detrimental to the long-term viability of oyster populations in coastal Louisiana. This incremental effect combined with existing and planned restoration efforts in the

state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. Implementation of Alternative 2 would contribute to an overall long-term benefit to commercial fisheries, including oyster harvesting, compared to the future with no action.

5.15.15.2.4 Alternative 3 – 15,000 cfs max Diversion

5.15.15.2.4.1 Direct

No measurable direct impacts to oyster leases would be anticipated to result from construction of Alternative 3, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters and where no leases currently exist, as determined from examination of state databases.

5.15.15.2.4.2 Indirect

Indirect impacts to oyster leases around this diversion site if Alternative 3 is implemented could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site, during the period when the diversion is at full operational capacity and for up to 2 months after the return to maintenance flow conditions. This could result in a loss of revenue for commercial oyster harvesters.

The operational plan proposed and evaluated in this feasibility study and SEIS limits the period of full flow to no more than 2 months (60 days) in the spring timeframe (March–April was used in the analysis). It was formulated in part to avoid or minimize the potential for incidental adverse effects (e.g. mortality, interference with reproduction) to oysters and other invertebrate or fishery species that require brackish or saline environments. Hydraulic modeling of the project area indicated that the return to maintenance flows for the remainder of the year (10 months) should maintain brackish and saline zones in the project area, though at somewhat reduced average salinities. For these reasons, indirect adverse impacts to oyster leases would not be anticipated to be significant. The number of leases impacted should be less than for the 35,000 cfs alternative because the recovery time should be quicker.

Over the 50-year planning horizon, potential beneficial effects to oyster populations could result if reduced salinities resulting from diversion operation were to increase the spatial extent of habitats experiencing salinities in the optimal range for oyster production. Continued water quality and biological monitoring of the project area before and after project construction should assist in refining the operation plan as needed to meet project objectives for restoring marsh while maintaining a functioning salinity regime in the estuary.

5.15.15.2.4.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oyster leases consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities, including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Cumulative impacts on oyster leases resulting from implementation of Alternative 3 would incrementally increase the ability of marsh and estuarine habitat essential to maintain salinity gradients and protect

against excessive salinities that could be detrimental to the long-term viability of oyster populations in coastal Louisiana. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. Implementation of Alternative 3 would contribute to an overall long-term benefit to commercial fisheries, including oyster harvesting, compared to the future with no action.

5.15.15.2.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.15.15.2.5.1 Direct

No measurable direct impacts to oyster leases would be anticipated to result from construction of Alternative 4, primarily because the construction footprint is located in the upper portion of the project area, where existing salinity conditions would be not favorable for oysters and where no leases currently exist, as determined from examination of state databases.

5.15.15.2.5.2 Indirect

Indirect impacts to oyster leases around this diversion site if Alternative 4 is implemented could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site, during the period when the diversion is at full operational capacity (Figure 5.2) and for up to 2 months after the return to maintenance flow conditions. This could result in a loss of revenue for commercial oyster harvesters.

The operational plan proposed and evaluated in this feasibility study and SEIS limits the period of full flow to no more than 2 months (60 days) in the spring timeframe (March–April was used in the analysis). It was formulated in part to avoid or minimize the potential for incidental adverse effects (e.g. mortality, interference with reproduction) to oysters and other invertebrate or fishery species that require brackish or saline environments. Hydraulic modeling (Figure 5.3) of the project area indicated that the return to maintenance flows for the remainder of the year (10 months) should maintain brackish and saline zones in the project area, though at somewhat reduced average salinities. There will be approximately three oyster leases in the study area and another five in the extended boundary that could be impacted by the project. For these reasons, indirect adverse impacts to oyster leases would not be anticipated to be significant. If this diversion were operated fully open outside the 2-month window that is described in the document, then there could be significantly different impacts with some potentially being very negative.

Over the 50-year planning horizon, potential beneficial effects to oyster populations could result if reduced salinities resulting from diversion operation were to increase the spatial extent of habitats experiencing salinities in the optimal range for oyster production. Continued water quality and biological monitoring of the project area before and after project construction should assist in refining the operation plan as needed to meet project objectives for restoring marsh while maintaining a functioning salinity regime in the estuary.

5.15.15.2.5.3 Cumulative

Unless otherwise indicated, cumulative socioeconomic impacts on oyster leases consist simply of the sum of the direct and indirect impacts for this alternative added to all other local and regional activities,

including construction of the GNOHSDRRS, and existing and in-progress elements of the LCA Ecosystem Restoration program, including development of Freshwater Diversion sites.

Cumulative impacts on oyster leases resulting from implementation of Alternative 4 would incrementally increase the ability of marsh and estuarine habitat essential to maintain salinity gradients and protect against excessive salinities that could be detrimental to the long-term viability of oyster populations in coastal Louisiana. This incremental effect combined with existing and planned restoration efforts in the state (e.g., CWPPRA, the Community-based Restoration Program sponsored by the NMFS Restoration Center, various state and local efforts, and others) would continue to aid fisheries habitat. Implementation of Alternative 4 would contribute to an overall long-term benefit to commercial fisheries, including oyster harvesting, compared to the future with no action.

5.16 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTES

5.16.1 No Action Alternative (Future Without Project Conditions)

The condition with the No Action Alternative regarding the potential for HTRW is dependent on site-specific HTRW discovery. Based on the Phase I in the project action area, there is reason to believe that the potential to encounter HTRW problems would be low.

5.16.2 Alternative 1 – 5,000 cfs max Diversion

5.16.2.1 Direct

Direct impacts would be slightly lower than Alternative 2.

5.16.2.2 Indirect

Indirect impacts would be slightly lower Alternative 2.

5.16.2.3 Cumulative

Cumulative impacts would be slightly lower Alternative 2.

5.16.3 Alternative 2 – 10,000 cfs max Diversion

5.16.3.1 Direct

Direct impacts would be slightly lower than Alternative 3.

5.16.3.2 Indirect

Indirect impacts would be slightly lower Alternative 3.

5.16.3.3 Cumulative

Cumulative impacts would be slightly lower Alternative 3.

5.16.4 Alternative 3 – 15,000 cfs max Diversion

5.16.4.1 Direct

Direct impacts would be lower than Alternative 4.

5.16.4.2 Indirect

Indirect impacts would be lower than Alternative 4.

5.16.4.3 Cumulative

Cumulative impacts would be lower than Alternative 4.

5.16.5 Alternative 4 – 35,000 cfs max Diversion (Recommended Plan)

5.16.5.1 Direct

Consistent with ER 1165-2-132, an HTRW investigation of the project area was conducted. Based upon findings from this investigation, the potential for direct impacts to the project area from implementation of Alternative 4 would be low and would likely continue to be low into the future.

5.16.5.2 Indirect

Consistent with ER 1165-2-132, an HTRW investigation of the project area was conducted. Based upon findings from this investigation, the potential for direct impacts to the project area from implementation of Alternative 4 would be low and would likely continue to be low into the future.

5.16.5.3 Cumulative

Consistent with ER 1165-2-132, an HTRW investigation of the project area was conducted. Based upon findings from this investigation, the potential for direct impacts to the project area from implementation of Alternative 4 would be low and would likely continue to be low into the future.

5.17 UNAVOIDABLE ADVERSE EFFECTS

Wetland impacts were avoided and minimized to the extent possible in the preliminary design of the Recommended Plan. With avoidance and minimization of wetland impacts the Recommended Plan would impact approximately 277 acres of intermediate marsh, 363 acres of shallow open water and 5 acres of bottomland hardwoods for construction of the diversion and approximately 223 acres of intermediate marsh and shallow open water would be impacted from excavation of the channel. The diversion channel is the best way to divert water from the Mississippi River to American Bay, California Bay and Breton Sound near Bay Gardens to the south. The creation of approximately 385 acres of intermediate marsh habitat and creation of 32 acres of ridge habitat would mitigate for wetland impacts resulting from construction activities. There would be no other unavoidable adverse impacts as a result of the implementation of reasonable alternatives for this project.

5.18 RELATIONSHIP OF SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

NEPA Section 102(2)(c)(iv) and 40 CFR 1502.16 requires that an EIS include a discussion of the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity. This section describes how the Proposed Action would affect the short-term use and the long-term productivity of the environment.

In reference to the Proposed Action, "short-term" refers to the temporary phase of construction of the proposed project, while "long-term" refers to the operational life of the proposed project and beyond. Section 5 of this document evaluates the direct, indirect and cumulative effects that could result from the Proposed Action.

Construction of the Proposed Action would result in short-term construction-related impacts within parts of the project area and would include to some extent interference with local traffic, minor limited air emissions, and increases in ambient noise levels, disturbance of fisheries and wildlife, increased storm runoff, and disturbance of recreational and other public facilities. These impacts would be temporary and would occur only during construction, and would not be expected to alter the long-term productivity of the natural environment.

The Proposed Action would assist in the long-term productivity of the Breton Sound ecological community by improving the water quantity, water quality, nutrients, and sediments. This in turn would facilitate the growth and productivity of emergent intermediate marsh. The Proposed Action would also result in enhancing the long-term productivity of the natural communities throughout the region. These long-term beneficial effects of the Proposed Action would outweigh the impacts to the environment resulting primarily from project construction.

5.19 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

NEPA requires that environmental analysis include identification of "any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." The proposed action would require the expenditure of human and fiscal resources and the potential modification of natural resources. Construction would require the expenditure of materials that are generally not retrievable. Considerable amounts of fossil fuels, labor, and construction materials such as cement, aggregate, iron, and rock would be expended. Large amounts of labor and natural resources would be necessary in the fabrication and preparation of construction materials. However, although these materials are generally not retrievable, they are not in short supply and their use would not have an adverse effect upon their continued availability. Other impacts that could have a longer effect can be reduced through appropriate measures and best management practices (e.g., silt fencing to control erosion). In addition, construction would require a large, one-time investment of Federal funds that are not retrievable. The commitment of these resources is based on the concept that residents both within the project area, as well as the region and nation, would benefit by improvements in the quality of the marsh system. No irreversible or irretrievable commitment has occurred which would have the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative. No commitment of resources has occurred that would prejudice the selection of any alternative before making a final decision on this project.

5.20 MITIGATION

Project plans and alternatives were developed in accordance with Corps planning guidance at ER 1105-2-100, which directs that ecosystem restoration projects be designed to avoid the need for compensatory fish and wildlife mitigation. Formulation of project alternatives, including diversion site location, design of structures, and operating plans, was conducted in compliance with this guidance. Also in accordance with Corps planning guidance, net ecosystem benefits expected to accrue if the proposed project is implemented could not be used as wetland banks or mitigation credit by the non-Federal sponsor. The possible addition of fish passages during the PED may be used to offset impacts to fishery resource and to an endangered species.

5.21 ENVIRONMENTAL CONSEQUENCES SUMMARY

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
1) Soils and Water Bottoms	Continued advanced degradation of soils within the SA and increase in acreage of water bottoms.	Direct impact to 153 acres of marsh and water bottom for construction of diversion, canal and ridge habitat. Beneficially creating 139 acres marsh, nourish.	Direct impacts to 167 acres of marsh and water bottom Creation of 176 acres of marsh, 32 acres of ridge/terrace.	Direct impacts to 182 acres of marsh and water bottom Create 235 acres marsh; 32 acres ridge/terrace.	Direct impact to 477 acres of marsh and water bottom for construction of diversion, canal and ridge habitat. Beneficially creating 385 acres marsh, nourish 35,000 acres and create 31 acres of ridge/terrace habitat.
2) Hydrology: Flows and Water Levels	Persistence of existing conditions including lack of hydrologic connectivity to the Mississippi River. Salinity intrusion would persist and marsh habitat would continue to decline and convert to open water.	No effect on Mississippi River flows anticipated. Increased hydrologic connectivity that provide freshwater, nutrients and sediment to marsh, improving productivity, accretion and improve conditions conducive to SAV development.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
3) Hydrology: Sedimentation and Erosion	Continued lack of sediment inputs into SA.	Diversion of 5,000 cfs would deliver 74,000 tons of sediment/yr. Increase sediment introduction could fill-in shallow water bodies adjacent to Bayou Garelle. Increased delivery of freshwater to the marsh would deliver nutrients and sediments that would enhance productivity and increase SAV growth. Cumulative effects of multiple diversion could alter sedimentation patterns of Mississippi River.	Diversion of 10,000 cfs would deliver 108,000 tons of sediment/yr. Increase sediment introduction could fill-in shallow water bodies adjacent to Bayou Garelle. Increased delivery of freshwater to the marsh would deliver nutrients and sediments that would enhance productivity and increase SAV growth. Cumulative effects of multiple diversion could alter sedimentation patterns of Mississippi River.	Diversion of 15,000 cfs would deliver 143,000 tons of sediment/yr. Increase sediment introduction could fill-in shallow water bodies adjacent to Bayou Garelle. Increased delivery of freshwater to the marsh would deliver nutrients and sediments that would enhance productivity and increase SAV growth. Cumulative effects of multiple diversion could alter sedimentation patterns of Mississippi River.	Diversion of 35,000 cfs would deliver 279,000 tons of sediment/yr. Increase sediment introduction could fill-in shallow water bodies adjacent to Bayou Garelle. Increased delivery of freshwater to the marsh would deliver nutrients and sediments that would enhance productivity and increase SAV growth. Cumulative effects of multiple diversion could alter sedimentation patterns of Mississippi River.
4) Hydrology: Groundwater	Nearby human populations and industry continue to increase resulting in increased groundwater demands and decrease in groundwater resources. Continued decreasing marsh habitat no longer functions as effectively as natural water quality filtration system to aquifers.	Minor variations in groundwater seepage due to head gradients created by the diversion. Restoration of marsh acts as natural water quality filtration system to the aquifers.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
5) Water Quality	Conversion of intermediate vegetation to open water reduces natural water quality filtration. Water bodies in study area meet designated uses.	Temporary negative impacts (e.g., increased turbidity, decreased dissolved oxygen) during construction. Restoration of the marsh contributes to improvements in water quality.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
6) Water Quality: Salinity	Taking no action would result in continued salinity intrusion and loss of wetland productivity and conversion to open water.	Implementing this alternative would result in direct benefits to the estuary in combating salinity intrusion and wetland loss.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
7) Air Quality	Plaquemines Parish is in attainment.	Temporary impacts to air quality associated with construction.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
8) Noise	Limited increases in noise due to limited transportation, development, and navigation in the study area.	Temporary increases in noise levels during construction activities.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
9) Vegetation Resources	Continued loss of wetland habitat, SAVs and bottomland hardwood resources due to increased saltwater intrusion, flood duration, impoundment, and herbivory. Invasive species would continue to thrive.	Direct impacts to 477 acres marsh and water bottom from construction. Benefits include restoring 32 acres of ridge habitat and 139 acres of marsh and nourishment of 10,603 cumulative acres of existing vegetation. Diversion of freshwater would provide sediment and nutrients for improved marsh productivity, accretion) increase in SAV. Net average annualized habitat unit is 55.51.	Direct impacts to 477 acres marsh and water bottom from construction. Benefits include restoring 32 acres of ridge habitat and 139 acres of marsh and nourishment of existing vegetation throughout project area. Diversion of freshwater would provide sediment and nutrients for improved marsh productivity, accretion) increase in SAV. Net average annualized habitat unit is 70.35.	Direct impacts to 631acres marsh and water bottom and 5 acres bottomland hardwoods from construction. Benefits include restoring 32 acres of ridge habitat and 235 acres of marsh and nourishment of existing vegetation throughout project area. Diversion of freshwater would provide sediment and nutrients for improved marsh productivity, accretion increase in SAV. Net average annualized habitat unit is 87.21.	Direct impacts to 863 acres of marsh and water bottom and 5 acres of bottomland hardwoods for construction. Create 385 acres of marsh, 32 acres ridge/terrace habitat and nourish existing marsh throughout project area. Diversion of freshwater would provide sediment and nutrients for improved marsh productivity, accretion, increased SAV. Net average annualized habitat unit is 139.94.
10) Wildlife	Continued decline in quality of wildlife habitat adversely impacts wetland dependent wildlife populations.	Temporary impacts to wildlife due to construction activities. Improvement and creation of habitat for wetland dependent wildlife. Increases in populations of wildlife dependent on ridge habitat.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
11) Fisheries	Persistence of existing conditions including low oxygen that could lead to fish kills and low species diversity in the study area. Loss of wetland habitats used by fish species for shelter, feeding, and life cycle requirements.	Localized and temporary impacts to fisheries during construction. Overall increases in productivity and fisheries populations in the study area. Displacement of some fish species due to changes in salinity.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Environmental Resources	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
12) Aquatic Resources	A shift in plankton and benthic populations to species assemblages that prefer open water, marine habitats as marsh converts to open water and salinity intrusion continues.	Localized and temporary impacts to aquatic resources during construction. Increases in populations due to increases in productivity in the marsh.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
13) Essential Fish Habitat (EFH)	Loss of more valuable productive EFH due to continued subsidence, erosion and salinity intrusion as marsh converts to open water. Potential decrease in habitat for juvenile stages of red drum and white shrimp.	Improved marsh productivity providing a higher quality EFH. Increase in habitat for juvenile stages of red drum and white shrimp.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
14) Threatened and Endangered Species	Continued degradation, conversion, and eventual loss of important wetland habitats used by threatened and endangered species.	Potential entrainment of pallid sturgeon in the intake structures. Potential creation of structures beneficial to pallid sturgeon. Potential to improve environment for gulf sturgeon. Ridge habitat would be beneficial to bald eagles and other raptors.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
15) Cultural Resources	No impacts to cultural resources should occur within the study area as a result of the No Action Alternative.	No impacts to cultural resources should occur within the study area as a result of this alternative. Potential protection of cultural resources due to deposition of sediment and restoration of wetlands.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
16) Aesthetics	Continued wetland loss and conversion of existing wetlands to open-water habitats resulting in decreased structural complexity and habitat diversity.	Improvement of the visual aesthetics of the study area through restoration marsh and ridge habitat.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
17) Recreation	Continued degradation of existing wetlands would diminish the wildlife habitat of the area, which in turn would adversely impact the recreational opportunities of the study area. Decreasing annual dollar revenues.	Localized and temporary impacts to recreation during construction. Overall, this alternative would serve to maintain and improve natural habitat, thereby maintaining and increasing recreational opportunities within the study area and leading to a substantial increase in recreational economic value. $57,284 annual dollar revenues based on unit day values.	Impacts similar to Alternative 1 however recreational economic value would be $60,704 annual dollar revenues based on unit day values.	Impacts similar to Alternative 1 however recreational economic value would be $67,496 annual dollar revenues based on unit day values.	Impacts similar to Alternative 1 however recreational economic value would be $40,517 annual dollar revenues based on unit day values.
19) Socioeconomics: Population and Housing	There would be no impacts to populations or housing under the No Action Alternative.	There would be no impacts to populations or housing under Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
20) Socioeconomics: Employment, Business, and Industrial Activity	Continued natural habitat degradation would have localized impacts on fishery- and wildlife-related employment and industries.	No direct, indirect or cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
21) Socioeconomics: Availability of Public Facilities and Services	No impacts to the availability of public facilities and services should occur within the study area as a result of the No Action Alternative.	No impacts to the availability of public facilities and services should occur within the study area as a result of the proposed action.	Impacts similar to Alternative 2.	Impacts similar to Alternative 2.	Impacts similar to Alternative 2.
22) Socioeconomics: Transportation	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	Impacts on transportation resources would include temporary increase in demand of the transportation network during construction. Overall, the proposed action would slow or reverse the trend of wetland degradation, thereby facilitating travel within the study area.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
23) Socioeconomics: Disruption of Desirable Community and Regional Growth (including Community Cohesion)	Continued natural habitat degradation would have localized impacts on fishery- and wildlife-related employment and industries, which could impede community and regional growth.	There would be no direct, indirect or cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
24) Socioeconomics: Tax Revenues and Property Values	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	There would be no direct, indirect or cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
25) Socioeconomics: Infrastructure	Continued wetland degradation, including coastal land loss, would impact infrastructure along and leading to the coastline, affecting both relocations and maintenance.	Potential impacts to water management infrastructure from construction of Diversion.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
26) Socioeconomics: Environmental Justice	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	There would be no direct, indirect of cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
27) Socioeconomics: Navigation	There would be no impacts to navigation as a result of the No Action Alternative.	Implementation of this alternative could cause direct impacts to flow from Mississippi River, indirect impacts resulting from potential to increase shoaling.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
28) Socioeconomics: Agriculture	There would be no impacts to agriculture as a result of the No Action Alternative.	There would be no direct, indirect of cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
29) Socioeconomics: Forestry	There would be no impacts to forestry from taking no action.	Implementing this alternative would directly impact 2.5 acres of Bottomland hardwoods. Benefits include the restoration of 32 acres of ridge habitat that would be conducive to bottomland hardwood regeneration.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
30) Socioeconomics: Public Lands	Continued loss of public land and access resulting from marsh degradation and conversion of marsh to open water.	There would be no direct, indirect of cumulative impacts anticipated from implementation of this alternative.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
31) Socioeconomics: Water Use and Supply	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	Implementation of this alternative could have direct and indirect impacts to water supply pipeline.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
32) Socioeconomics: Oil, Gas, and Utilities	The effects of land loss and degradation could lead to increased costs for maintaining and repairing existing oil, gas, and utilities in the study area.	Implementation of this alternative could have direct and indirect impacts to water supply pipeline.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
33) Socioeconomics: Flood Control and Hurricane Protection	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	Implementing this alternative could have direct and indirect impact on existing levees in the area.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
34) Socioeconomics: Commercial Fisheries	Persistence of existing conditions including the continued conversion of existing wetlands to open-water habitats, restricted water circulation, and decreased water quality could result in declines in commercial fisheries.	Overall increases in fisheries productivity due to increased nutrient inputs and wetland building processes. The potential short term displacement of some commercial fisheries and indirect impacts to local commercial seafood processing facilities.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.

Environmental Resources	Alternative Description				
	No Action	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
	No Action/Without Project Condition.	Location 3 – 5,000 cfs diversion. Consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater.	Location 3 – 10,000 cfs diversion consisting of three 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 176 acres of marsh creation using dredged material from adjacent 167 acres of canal reconfiguration to convey freshwater.	Location 3 – 15,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal reconfiguration to convey freshwater.	Location 3 – 35,000 cfs diversion consisting of ten 15-ft x 15-ft box culverts, 32 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal reconfiguration to convey freshwater.
35) Socioeconomics: Oyster Leases	There would be no direct, indirect or cumulative impacts anticipated from taking no action.	Implementing this alternative could result in direct and indirect adverse impacts to oyster leases and significant loss of revenue for parties holding those leases.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.	Impacts similar to Alternative 1.
36) HTRW	An HTRW Phase I in the study area was performed on the study area, and identified a low probability of encountering contaminants of concern.	Potential for impacts to the SA from implementation of Alternative 1 is low and would likely continue to be low into the future.	Potential for impacts to the SA from implementation of Alternative 1 is low and would likely continue to be low into the future.	Potential for impacts to the SA from implementation of Alternative 1 is low and would likely continue to be low into the future.	Potential for impacts to the SA from implementation of Alternative 1 is low and would likely continue to be low into the future.

This page intentionally left blank.

6.0 PUBLIC INVOLVEMENT

6.1 NEPA SCOPING

Scoping is a critical component of the overall public involvement program to solicit input from affected Federal, State, and local agencies, Indian Tribes, and interested stakeholders. The NEPA scoping process is designed to provide an early and open means of determining the scope of issues (problems, needs, and opportunities) to be identified and addressed in the Draft Environmental Impact Statement (DEIS). Scoping is the process used to: a) identify the affected public and agency concerns; b) facilitate an efficient DEIS preparation process; c) define the issues and alternatives that will be examined in detail in the DEIS; and d) save time in the overall process by helping to ensure that relevant issues are adequately addressed. Scoping is a process, not an event or a meeting; it continues throughout the EIS (draft and final) process and may involve meetings, telephone conversations, and/or written comments.

A notice of intent (NOI) to prepare a draft EIS for the LCA MDWD Restoration Feasibility Study (MDWD Study) was published in the *Federal Register* (volume 73, number 246) on December 22, 2008

A project kick-off meeting was held on December 12, 2008, and a public scoping meeting was organized and hosted in accordance with NEPA on February 5, 2009. A scoping meeting announcement requesting comments on the scope of the MDWD Study was mailed to Federal, State, and local agencies; and interested groups and individuals on January 7, 2009. The media advisory announcing the scoping meeting was provided to 350 media outlets. An advertisement for the public scoping meeting appeared in the following publications:

- *Baton Rouge Advocate*, January 30, 2009
- *St. Bernard Voice*, January 30, 2009
- *Times-Picayune*, January 31, 2009
- *Plaquemines Gazette*, February 3, 2009

The public scoping meeting was held on:

Thursday, February 5, 2009
Phoenix High School
13073 Highway 15
Phoenix, LA 70040

The schedule for the scoping meeting was:

6:00 – 7:00 p.m. Open House
7:00 – 7:30 p.m. Presentations
7:30 – 8:00 p.m. Question and Answer Session
8:00 – 8:50 p.m. Open Forum for Comments
8:50 – 9:00 p.m. Wrap-up

The open house session provided attendees with an opportunity to visit a series of poster stations staffed by project team members and subject matter experts regarding the following topics: the LCA plan, the NEPA process and milestones, an overview of the study and its goals and objectives, as well as maps of the study area.

Following the open house, there was a brief presentation on the MDWD planned for the area and a description of the NEPA process. During this segment, the LCA Environmental Manager and both the USACE and CPRA Project Managers presented introductory remarks, including the agenda, purpose of the meeting, public involvement under NEPA, a brief history leading to the study, the scope of the analysis, and the intent to prepare a draft EIS for the MDWD study.

The question and answer portion focused on the study process and any other general questions presented by attendees. Following this portion, the floor was opened for scoping comments. Individuals were invited to present their verbal scoping comments to be recorded without interruption. The floor remained open until no further scoping comments were given. During the wrap-up, attendees were reminded to pick up self mailing comment cards, should they wish to submit additional comments at a later date, and to drop off the meeting evaluation forms at the registration table.

A transcript of comments recorded at the scoping meeting was prepared by a court reporter. The scoping comments were documented in a Scoping Report and describe the public's concerns about the restoration effort and strategies for restoration efforts. See Appendix A for the Scoping Report. The Scoping Report presents and summarizes the scoping comments expressed at the public scoping meeting, as well as all other scoping comments received during the comment period beginning December 22, 2008, and ending February 18, 2009. The Scoping Report indicates where in the draft EIS individual comments should be addressed. This Scoping Report was provided to all scoping participants who provided their address, and is published on the www.lca.gov Web site.

Approximately 26 people attended the MDWD scoping meeting. Names of those who signed in are listed in the Scoping Report. A total of 16 multi-part comments were received during the comment period, of which one was received via E-mail and two were copies of letters. Fourteen individuals expressed comments at the scoping meeting. A total of three written comments (letter, email, Web site) were received during the comment period.

A scoping comment may contain several specific statements directed at multiple areas of concern. Hence, a single comment could potentially be generally addressed in multiple sections of the draft EIS. A total of 95 specific comments were expressed.

The comments were categorized according to their applicability to the EIS. EIS categories include: Purpose and Need; Alternatives; Affected Environment; Environmental Consequences; and Consultation, Coordination, and Compliance with Regulations. Although, an individual scoping comment may be categorized under more than one EIS subject matter heading, no comment was assigned more than three categories.

Purpose and Need

A majority of comments received in this category stressed the need for introducing more sediment into the study area. In addition, several comments indicated that the storm surge was the root cause of the

problems in this area: *"The problem is the surge. If you can contain the sediment, you can protect the surge from destroying what you built."* One respondent stressed a significant problem to be hyacinths in the area*: "A significant problem within the marshes is hyacinths. Hyacinths come into the open water, which also has dugg grass. They cover the dugg grass and kill it. When the storm comes in, it kills the hyacinths and then you are ultimately left with nothing but mud at the bottom."*

Alternatives

A number of respondent comments fell into this category. Converting the project to a sediment diversion as opposed to a freshwater diversion was the most common suggestion. *"It is extremely important that this effort become a sediment diversion and the Corps reviews how sediments deposited initially by nature create a marsh."* One commenter suggested adding new sections to the EIS to describe potential impacts to the resources that could be impacted by the proposed project: *"NOAA's National Marine Fisheries Service (NMFS) recommends the supplemental environmental impact statement (SEIS) include separate sections titled, "Essential Fish Habitat"* and *"Marine Fishery Resources" that identify the EFH and fisheries resources of the study area. These sections should describe the potential impacts, both positive and negative, to those resources that could be caused by the proposed river diversion."* Other comments included constructing a controlled diversion as an "enhanced artificial crevasse" for large discharge and sediment pulses and designing a structure with a large operational range for river stages.

Affected Environment

Most comments relating to the natural resources in the project area focused on EFH and the water bodies that provide nursery and foraging habitats*: "Aquatic and tidally influenced wetland habitats in portions of the study area are designated as essential fish habit for various federally managed species, including white shrimp, brown shrimp, red drum, lane snapper, dog snapper, and gulf stone crab."*

Environmental Consequences

Several comments indicated the USACE consider the erosion effects from the water: "Should consider choking down areas to slow the water flow in and out so that the sediment can go up the bankline instead of being washed out." Respondents also indicated the importance of sediment on the environment and this project and stressed a need to keep it intact: "Sediment is extremely important at the opening of the diversion as is the distribution of that sediment so that it does not fall out 100 to 1,000 years from now at the opening." In addition, concerns about impacts to oyster beds and other marine fisheries dominated the comments received: "NMFS believes adverse impacts to marine fishery productivity could be caused by structure operations, especially during high flow periods. These impacts include: 1) displacement of less freshwater tolerant, or cold water tolerant, marine fishery species from large areas of wetlands and water bodies that serve as nursery and foraging areas; 2) destruction of productive oyster reefs that serve as habitat and a food sources for some fishery species; 3) increased turbidity and associated decreases in coverage of submerged aquatic vegetation in some areas; and 4) potential low dissolved oxygen levels in areas water bodies caused by decomposition of large quantities of algae and/or phytoplankton resulting from high nutrient levels in diverted river water."

Consultation, Coordination, and Compliance with Regulations

The majority of comments received in this area concerned this project and the history of other projects: "Request the Corps analyze what was done on the Caernarvon diversion project as it destroyed the land in 20 years, but it should have naturally eroded in 100 years." Additional comments included the need for the USACE to implement an evaluation program and to include additional sections within the report regarding Essential Fish Habitat, Marine Fishery Resources, and Essential Fish Habitat sub-categories.

Table 6.1 displays the categorization of specific comments by EIS subject matter. The majority of the comments addressed Alternatives followed by Affected Environment and Consultation, Coordination, and Compliance with Regulations (tie); Purpose and Need; and Affected Environment.

Table 6.1: Categorization of Scoping Comments by Draft EIS Subject Matter

PN = Purpose and Need, ALT = Alternatives, AE = Affected Environment, EC = Environmental Consequences, and CC = Consultation, Coordination, and Compliance with Regulations

Source of Scoping Comment	PN	ALT	AE	EC	CC	Totals
Scoping Meeting	10	13	7	13	11	54
Scoping Comment Letters	3	16	5	3	8	35
Scoping Comments E-mails	2	0	2	2	0	6
Totals	15	29	14	18	19	95

NOTE: A single scoping comment may be categorized under multiple DPEIS subject matter headings.

6.2 OTHER PUBLIC COMMENTS

6.2.1 Federal and State Agencies

A project kick-off meeting was held on January 13, 2009, to present the study authority, purpose, goals and objectives. Federal, State and local agencies from Louisiana participated in the discussions. Representatives of Federal and State agencies were invited to be members of the Project Delivery Team (PDT) and the Habitat Evaluation Team (HET). The PDT facilitates the interagency collaboration and coordination necessary for study execution. Agency team members provide guidance and recommendations throughout the planning process to assure the successful delivery of a quality product.

The HET is part of the PDT and is composed of resource agency representatives. The HET performs planning and technical assessments consistent with their agency responsibilities and expertise. The HET has been involved at all stages of the planning process, and has assisted with the development, evaluation, and analysis of project alternatives. The HET has participated in the public information/involvement program, exchanged study information, provided recommendations, and assisted in the resolution of any interagency issues that may have surfaced in the study process. The HET was an integral part of the Wetland Values Assessment process to determine the habitat value of the alternatives.

Federal and State agencies are also involved through the NEPA process, with some agencies serving as official cooperating agencies and other agencies with official coordination and consultation roles.

6.2.2 Land Owner, Non-Governmental Organization (NGO), Parish and Other Involvement

The following meetings were held to provide opportunities for landowners, NGOs, the Parish and other interested parties to see progress on the project and to solicit feedback from the attendees. Federal and state agencies frequently attended as well.

April 28, 2009

On April 28, 2009, a presentation about the proposed project was given to the Maritime Navigation Safety Association (MNSA) board members. Approximately 20 people attended the MNSA meeting. Attendees included board members, Coastal Protection and Restoration Authority (CPRA) managers for the Myrtle Grove Diversion project and representatives from the Environmental Defense Fund. The MDWD presentation focused on the development and schedule of the project as well as the initial array of measures. Since the project was still relatively early in the feasibility process at the time of the presentation, few specifics were known. The project manager did specifically seek feedback from the Board and committed to keeping them engaged with progress on the project. Numerous suggestions were received regarding the importance of introducing sediments into the project area along with recommendations for coordinating the MDWD with the Myrtle Grove Diversion project.

May 29, 2009

On May 29, 2009, site visits with eight local landowners, one land manager, and a representative from the Plaqueminnes Parish Coastal Zone Management Department were conducted. The USACE was represented by the project manager and two other members of the PDT. The proposed project was discussed and land owner comments and concerns were solicited. Comments and concerns included the need to maintain access for oil and gas lessees, control of invasive species and potential destruction of private property by the project. Several landowners also recommended potential features including using many smaller structures instead of one large structure and levee removal.

July 16, 2009

On July 16, 2009, a presentation was given about the proposed project to the LCA Science and Technology board members. The meeting was assembled to present updates on numerous coastal restoration efforts to the board and to solicit their input for review of the projects.

Approximately 50 people attended the LCA meeting. Attendees included board members, CPRA managers for this and other LCA projects as well as representatives from numerous stakeholder, consulting, and other interest groups. The MDWD presentation focused on the development of an initial array of alternatives and the numerous measures being considered. Feedback was specifically sought from the Board and a commitment to keeping them engaged with progress on the project was stressed. The Board asked several questions about the project including how habitat benefits are realized and what efforts are being considered to control invasive species. There was also discussion about the limits of the WRDA authorization and how benefits from the project could easily reach beyond the current project boundary.

July 22, 2009

On July 22, 2009, the project manager gave a presentation about the proposed project to the Plaquemines Parish Coastal Zone Advisory Committee. The monthly meeting was assembled to discuss several coastal issues within the Parish and a specific request was made for an update on the MDWD project. Approximately 15 people attended the meeting. Attendees included board members, the MDWD CPRA manager, the H&H lead, the CZM director as well as other interested stakeholders and landowners. The presentation focused on the development of an initial array of alternatives and the numerous measures being considered. The project manager did specifically seek feedback from the Committee and pledged to keep them engaged with progress on the project. The Committee asked several questions about the project including what efforts are being considered to control invasive species and how the salinity isohalines will be determined. A land manager spoke at length about the ill effects of the project and insisted that some of the mistakes made on other diversion projects were not repeated. There was also discussion about what the Committee could do to help advance the project and support it.

July 29, 2009

On July 29, 2009, the PM attended a modeling meeting hosted by the CPRA in conjunction with their contractors in an effort to coordinate development of the MDWD with the proposed Myrtle Grove Water Diversion (MG). Both MDWD and MG are looking at and evaluating large-scale freshwater diversions (up to 100,000 cfs) at several locations on the Mississippi River, some of which could be directly across from each other, east bank and west bank. Twenty five people were present at this meeting.

August 27, 2009

On August 27, 2009, an update was given about the proposed project features to the Delacroix Corporation chairman and land manager. This update was a secondary discussion after meeting with Delacroix and other land owners to acquire right-of-entry (ROE) for the MRGO Ecosystem Restoration project.

Seven people attended the ROE meeting. Attendees included the Delacroix president, attorney and land manager, two additional landowner reps, a COE real estate rep and an MRGO Eco rep. The MDWD discussion focused on the development of a final array of alternatives that included the potential elimination of three diversion sites as well as the different types and capacities for diversion structures. The Delacroix president indicated his support for a large scale diversion structure that focused on introducing as much sediment as possible into the project area and that he would be happy to see such a project implemented as quickly as possible. He also indicated that other landowners in the area would also likely be interested in maximizing sediment introduction. Graphics of potential diversion locations with outfall management features were handed out for review. Discussion also ensued about the potential for a nearby landowner to be especially interested in utilizing their property for placement of the diversion.

September 14, 2009

On September 14, 2009, the project manager and the URS modeling contractor met with representatives from the Delacroix Corporation and the Plaquemines Parish Government to discuss issues related to the topography, hydrology, bathymetry, and general condition of the White Ditch project area. The purpose

was to help inform the contractor of the unique project area characteristics in developing and refining the hydraulic model to be used to estimate and simulate the effects of a diversion structure on the marsh.

Six people attended the meeting. Attendees included two Delacroix land managers and field staff, the Plaquemines Parish Local Coastal Program Manager, Dr. Reed and Mr. MacInnes. The MDWD discussion focused on the numerous elements that will affect the final calibration of the hydraulic model including general marsh elevation, water depths across the project area including canals, bayous, converted open water, ponds and lakes, general salinities, the flow of water across the marsh, areas that have become water from marsh, etc. Considerable time was spent discussing the effects on water hyacinth a diversion might have and the numerous problems the invasive species causes.

The land managers also discussed some of the potential options for a diversion structure with outfall management features that could be constructed. Significant discussion focused on the operations of a structure and how that is more important than what is built. They reiterated some of the problems associated with the Caernarvon diversion and its flows, suggesting that a diversion should be run minimally if even at all throughout the fall and winter. They supported the idea of a sediment diversion but also suggested that the large amounts of water that would be diverted could have a severe negative effect on the existing marsh if the structure is operated at high capacities for too long.

An outfall proposal was suggested that could help deliver beneficial sediments, nutrients, and freshwater through an area experiencing high marsh-loss rates. The land managers felt this modification could have a beneficial impact on the surrounding marshes.

November 13, 2009

On November 13, 2009, a focus group of 16 participants was interviewed about potential effects of a freshwater diversion on recreation resources. Information discussed included the general effects of the diversion, effects of culverts on fish access, effects of dredging, effects of marsh creation, and effects of ridge restoration. A more-detailed discussion of these effects can be found in section 5.14.

March 26, 2010

A brief update on the current status of the project was presented to the Delacroix Corporation. Details of the project were discussed, including the size, location, and potential operating scheme of the diversion. Draft graphics were handed out and an update on the project schedule was provided.

March 31, 2010

A presentation was given to the Plaquemines Parish Coastal Zone Advisory Committee meeting held at 6:00 p.m. in Belle Chasse, Louisiana. Eleven members of the Committee and representatives from the Parish Government and public were in attendance. The presentation focused on all project details including the plan formulation, hydraulic modeling results, proposed operating scheme, size, location, and potential effects. There was active participation at the meeting and numerous questions were asked about project details.

6.2.3 Public Comments on the Draft SEIS

Copies of this draft SEIS will be made available to all interested parties through mailings, advertisements, media advisories, public meetings, and websites. All comments received during the 45-day public comment period on the draft SEIS are documented and responded to in Appendix G. All commenters will be sent a Notice of Availability of this Integrated Feasibility Study and SEIS after its completion.

7.0 COORDINATION AND COMPLIANCE

This chapter documents the coordination and compliance efforts for this project regarding statutory authorities including: environmental laws, regulations, executive orders, policies, rules, and guidance. Consistency of the Recommended Plan and other Louisiana coastal restoration efforts is also addressed.

7.1 USACE PRINCIPLES AND GUIDELINES (P&G)

The guidance for conducting Civil Works planning studies (ER 1105-2-100) is based on the P&G adopted by the Water Resources Council. The P&G are composed of two parts: The Economic and Environmental Principles and Guidelines for Water and Related Land Implementation Studies and the Economic and Environmental Guidelines for Water and Related Land Resources Implementation Studies. The P&G require the systematic formulation of alternative plans to ensure all reasonable alternatives are evaluated. The P&G also include guidance on the development and structure of the studies and reports for projects requiring specific authorization.

Under the study guidance for projects requiring specific authorization, the feasibility study requirements include documentation of the planning process and environmental compliance. The feasibility report is required to document the planning process and all assumptions made during plan formulation along with the rationale for decision making. The report should culminate in a recommended plan along with documentation of how the plan relates to the NED, NER, or a combined NED/NER plan. If the project deviates from those plans, the degree and reasons for the deviation must be documented. The feasibility study is also required to document compliance with applicable environmental laws and regulations which can be included as an EA or EIS included with the feasibility study or an integrated feasibility study document with NEPA information.

Planning for this feasibility study has been conducted in accordance with the ER 1105-2-100 guidance. This report is an integrated feasibility study and EIS. Policy reviews have been conducted to ensure compliance with applicable USACE policies.

7.2 ENVIRONMENTAL COORDINATION AND COMPLIANCE

Following completion of the final integrated report, the Assistant Secretary of the Army for Civil Works will issue a written Record of Decision (ROD) concerning the proposed action. The ROD will be issued within a framework of laws, regulations, executive orders, policies, rules, and other guidance. These authorities establish regulatory compliance standards for environmental resources pertaining directly to USACE management of water resources development projects, or provide planning guidance for the management of environmental resources. Relevant Federal statutory authorities and executive orders are listed in Table 7.1. Relevant State of Louisiana statutory authorities are listed in Table 7.2. Full compliance with statutory authorities will be accomplished upon review of the final integrated feasibility report and Supplemental Environmental Impact Statement by appropriate agencies and the public and the signing of a ROD, in compliance with the Fish and Wildlife Coordination Act (1958).

Table 7.1: Relevant Federal Statutory Authorities and Executive Orders
(Note: This list is not complete or exhaustive)

Abandoned Shipwreck Act of 1987	Marine Mammal Protection Act of 1972
American Indian Religious Freedom Act of 1978	Marine Protected Areas (EO 13158) of 2000
Anadromous Fish Conservation Act of 1965	Marine Protection, Research, and Sanctuaries Act of 1972
Archaeological Resources Protection Act of 1979	Migratory Bird Conservation Act of 1929
Archaeological and Historical Preservation Act of 1974	Migratory Bird Treaty Act of 1918
Bald Eagle Protection Act of 1940	Migratory Bird Habitat Protection (EO 13186) of 2001
Clean Air Act of 1970	National Environmental Policy Act of 1969
Clean Water Act of 1977	National Historic Preservation Act of 1966
Coastal Barrier Improvement Act of 1990	National Invasive Species Act of 1996
Coastal Barrier Resources Act of 1982	Native American Graves Protection and Repatriation Act of 1990
Coastal Wetlands Planning, Protection, and Restoration Act of 1990	Neotropical Migratory Bird Conservation Act of 2000
Coastal Zone Management Act of 1972	Noise Control Act of 1972
Coastal Zone Protection Act of 1996	Nonindigenous Aquatic Nuisance Prevention and Control Act of 1996
Comprehensive Environmental Response, Compensation, and Liability Act of 1980	North American Wetlands Conservation Act of 1989
Consultation and Coordination with Indian Tribal Governments (EO 13175) of 2000	Oil Pollution Act of 1990
Deepwater Port Act of 1974	Outer Continental Shelf Lands Act of 1953
Emergency Planning and Community Right-to-Know Act of 1986	Pollution Prevention Act of 1990
Emergency Wetlands Restoration Act of 1986	Prime or Unique Farmlands, 1980 CEQ Memorandum
Endangered Species Act of 1973	Protection and Enhancement of the Cultural Environment (EO 11593) of 1971
Environmental Quality Improvement Act of 1970	Protection and Enhancement of Environmental Quality (EO 11991) of 1977
Estuaries and Clean Waters Act of 2000	Protection of Children from Environmental Health Risks and Safety Issues (EO 13045) of 1997
Estuary Protection Act of 1968	Protection of Cultural Property (EO 12555) of 1986
Estuary Restoration Act of 2000	Protection of Wetlands (EO 11990) of 1977
Exotic Organisms (EO 11987) of 1977	Reclamation Projects Authorization and Adjustments Act of 1992
Farmland Protection Policy Act of 1981	Recreational Fisheries (EO 12962) of 1995
Federal Actions to Address Environmental Justice in Minority Populations & Low-Income Populations (EO 12898, 12948) of 1994, as amended	Resource Conservation and Recovery Act of 1976
Federal Compliance with Pollution Control Standards (EO 12088) of 1978	Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186) of 2001
Federal Emergency Management (EO 12148) of 1979	Rivers and Harbors Acts of 1899, 1956
Federal Water Pollution Control Act of 1972	River and Harbor and Flood Control Act of 1970
Federal Water Project Recreation Act of 1965	Safe Drinking Water Act of 1974
Fish and Wildlife Conservation Act of 1980	Submerged Land Act of 1953
Fish and Wildlife Coordination Act of 1958	Sustainable Fisheries Act of 1996
Flood Control Act of 1944	Toxic Substances Control Act of 1976
Floodplain Management (EO 11988) of 1977	Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646)
Food Security Act of 1985	Water Resources Development Acts of 1976, 1986, 1990, 1992, and 2007
Greening of the Government Through Leadership in Environmental Management (EO 13148) of 2000	Water Resources Planning Act of 1965
Historic Sites Act of 1935	Watershed Protection & Flood Prevention Act of 1954
Historical and Archaeological Data-Preservation Act of 1974	Water Pollution Control Act Amendments of 1961
Indian Sacred Sites (EO 13007) of 1996	Wild and Scenic River Act of 1968
Invasive Species (EO 13112) of 1999	Wilderness Act of 1964
Land & Water Conservation Fund Act of 1965	
Magnuson-Stevens Fishery Conservation and Management Act of 1976, as amended	

Table 7.2: Relevant State Statutory Authorities
(Note: This list is not complete or exhaustive)

Air Control Act Archeological Treasury Act of 1974 Louisiana Coastal Resources Program Louisiana Natural and Scenic Rivers System Act	Louisiana Threatened and Endangered Species and Rare & Unique Habitats Protection of Cypress Trees Water Control Act

7.2.1 U.S. Fish and Wildlife Coordination Act

The USACE has coordinated with the U.S. Fish and Wildlife Service, NMFS, and LDWF per the Fish and Wildlife Coordination Act (16 U.S.C. 661-667e; the Act of March 10, 1934; Ch. 55; 48 Stat. 401), as amended by the Act of June 24, 1936). A Final Coordination Act Report has been received and the comments incorporated into the project plan. The Fish and Wildlife Coordination Act authorizes the Secretaries of Agriculture and Commerce to provide assistance to and cooperate with Federal and State agencies to protect, rear, stock, and increase the supply of game and fur-bearing animals, as well as to study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife.

The amendments enacted in 1946 require consultation with the Fish and Wildlife Service and the fish and wildlife agencies of states where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified" by any agency under a Federal permit or license. Consultation is to be undertaken for the purpose of "preventing loss of and damage to wildlife resources."

Service Position and Recommendations

The Recommended Plan will benefit the fish and wildlife resources of the MDWD area by providing fresh water, nutrients, and sediments to the study area thus facilitating sediment deposition, increasing organic production, increasing biological productivity, and reducing marsh loss. Approximately 13,353 AAHUS and 35,146 net acres of fresh/intermediate, brackish, and saline marsh and ridge habitats would benefit by the proposed project at the end of the project life. The Service supports implementation of a 35,000 cfs diversion at White Ditch provided the following fish and wildlife recommendations are implemented concurrently with project implementation:

1. Future hydrological modeling should be conducted with longer-duration simulations (i.e., 13-month simulations) to allow more complete projections of salinity change within the study area. In addition, modeling of different operational plans should be conducted. We recommend the following operational plans be evaluated; 1) March–April open operation with a 1,000 cfs maintenance flow the remainder of the year, 2) March open operation with a 1,000 cfs maintenance flow the remainder of the year, and 3) March 1 to March 14 open operation with a 1,000 cfs maintenance flow the remainder of the year.

USACE Response to Recommendation #1: Concur. Modeling of alternative operational plans will be conducted during PED phase.

2. To determine potential impacts to marine fishery resources in the study area, models which simulate changes in nekton community composition based on changes in salinity should be utilized. For example, the Ecopath/Ecosim (www.ecopath.org) models have been utilized to simulate changes in the nekton community in the Caernarvon Diversion outfall area. Hydrological modeling output could be used as input for the Ecopath/Ecosim models or other similar models. The Corps will investigate the use of other aquatic models and will not limit themselves to use of Ecopath/Ecosim.

USACE Response to Recommendation #2: Concur. Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the Corps for the PED Phase. At this time a SOW is being developed as part of the Donaldsonville to the Gulf project to look a various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project.

3. The best available data and modeling tools should be utilized to select a more precise location near Phoenix, Louisiana for the diversion structure to maximize the capture of suspended sediment. The State of Louisiana Office of Coastal Protection and Restoration (OCPR) is funding the development of a 3-dimensional river model which could greatly assist in determining the optimal location for the diversion structure.

USACE Response to Recommendation #3: Concur. The precise location of the diversion structure will be determined during the PED phase.

4. The Service has concerns regarding the Monitoring and Adaptive Management Plan and its ability to ensure the goals and objectives are measured and achieved. The Corps should work with the Service, NOAA's NMFS, and the LDWF during future planning efforts to address our concerns.

USACE Response to Recommendation #4: Concur. The Corps appreciates the assistance of the Service in continued development of the Monitoring and Adaptive Management Plan.

5. If a proposed project feature is changed significantly or is not implemented within one year of the Endangered Species Act consultation letter, we recommend that the Corps reinitiate coordination with each office to ensure that the proposed project would not adversely affect any Federally listed threatened or endangered species or their habitat.

USACE Response to Recommendation #5: Concur. The Corps will reinitiate coordination with the Service and NMFS if project features change significantly or if the project is not implemented within a year after issuance of the Biological Opinion for this project.

6. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of project features and timing of construction. A qualified biologist should inspect the proposed work site for the presence of undocumented wading bird nesting colonies and bald eagles during the nesting season (i.e., February 16 through October 31 for wading bird nesting colonies, and October through mid-May for bald eagles).

USACE Response to Recommendation #6: Concur. The proposed inspection will be scheduled during the PED phase.

7. To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present). In addition, we recommend that on-site contract personnel be informed of the need to identify colonial nesting birds and their nests, and should avoid affecting them during the breeding season.

USACE Response to Recommendation #7: Concur. These restrictions will be included in project plans and specifications.

8. If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

USACE Response to Recommendation #8: Concur. Should a bald eagle nest be discovered in the vicinity of construction activities, the Corps will conduct an on-line evaluation as directed and utilize the results to determine whether additional consultation with the Service is necessary, and will forward the results of the evaluation to the Lafayette Field Office.

9. Land clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable.

USACE Response to Recommendation #9: Concur. Seasonal restrictions on land clearing will be stipulated in project plans and specifications when practicable.

10. Further detailed planning of project features (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service and other State and Federal natural resource agencies, and shall be provided an opportunity to review and submit recommendations on the all work addressed in those reports.

USACE Response to Recommendation #10: Concur. Close coordination will be maintained with the Service and NMFS during the PED phase.

11. A report documenting the status of implementation, maintenance and adaptive management measures should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, U.S. Environmental Protection Agency (EPA), Louisiana Department of Natural Resources (LDNR), OCPR, and LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

USACE Response to Recommendation #11: Concur. The Corps will coordinate with the listed agencies to ensure preparation of the recommended report.

12. The Service recommends a comprehensive examination of the river and all existing and proposed diversions to coordinate their operation and ensure that their operation will maximize their restoration capabilities. The ongoing Mississippi River Hydrodynamic and Delta Management Study should be utilized to address this issue. The Service and other natural resource agencies should be involved in this study.

USACE Response to Recommendation #12: Concur. The Corps will continue to coordinate with the Service and other natural resource agencies to facilitate their involvement in the ongoing Mississippi River Hydrodynamic and Delta Management Study.

13. The Service recommends establishment of a committee similar to the Caernarvon Interagency Advisory Committee to review the operation and its results of the MDWD and when necessary, provide recommendations regarding any future operational and maintenance changes. The Service and other natural resource agencies should be on this committee.

USACE Response to Recommendation #13: Concur. The Corps will work with OCPR, the Service and other natural resource agencies to establish an advisory committee for the White Ditch project.

7.2.2 Clean Water Act – Section 404(b)(1)

The USACE is responsible for administering regulations under Section 404(b)(1) of the CWA. Potential project-related impacts subject to these regulations, such as the discharge of dredged material into wetlands to create marsh and ridge habitat, have been evaluated in compliance with Section 404(b)(1) of the CWA (Appendix D).

The evaluation of potential impacts to water quality indicated that, on the basis of the guidelines, the proposed disposal sites for the discharge of dredged material comply with the requirement of these guidelines, with the inclusion of appropriate and practicable methods to minimize adverse effects to the aquatic ecosystem. The 404(b)(1) will be signed after the receipt of the 401 Water Quality Certificate from the State of Louisiana.

7.2.3 Section 122 of the Rivers and Harbors Act

Section 122 of the Rivers and Harbors Act of 1970 (Public Law 91-611, 84 STAT. 1823) requires that consideration be given to possible adverse economic, social and environmental effects. It also requires that final decisions on the project be made in the best overall public interest, taking into consideration the need for flood control, navigation and associated purposes; and the associated costs of eliminating or minimizing the following adverse affects:

- Air, water and noise pollution;
- Destruction or disruption of man-made and natural resources, aesthetic values, community cohesion, and availability of public facilities and services;
- Adverse employment effects;
- Tax and property value losses;
- Injurious displacement of people, businesses and farms;

- Disruption of desirable community and regional growth.

Alternative 4 (Recommended Plan) would have no significant impacts on Section 122 identified economic, social or environmental resources.

7.2.4 Coastal Zone Management Act of 1972

Section 307 of the Coastal Zone Management Act (CZM) of 1972 (16 U.S.C. 1456(c)(1)(A)) directs Federal agencies proposing activities or development projects (including civil work activities), whether within or outside the coastal zone, must assure that those activities or projects are consistent, to the maximum extent practicable, with the approved state coastal zone management program. A Consistency Determination is included with this report (Appendix E) and has been submitted to Louisiana Department of Natural Department of Natural Resources (LDNR) for consistency review. Implementation of the Recommended Plan is considered consistent, to the maximum extent practicable, with the approved Louisiana state coastal management program. Concurance with our determination was received from LDNR on July 29, 2010.

7.2.5 Endangered Species Act of 1973

Threatened and endangered species protected under the ESA, as amended, are present in the project area. No critical habitats for those species would be directly affected, and no indirect adverse impacts are expected to such habitats. As provided by the implementing regulations of the ESA, biological assessments have been prepared and provided to the USFWS and NMFS to address the potential for the proposed action to affect listed species. The biological assessments conclude that only one species, the pallid sturgeon, may be adversely affected by the proposed action. The USACE will continue to consult with the USFWS concerning the potential impacts to pallid sturgeon as necessary to comply with the ESA. Formal consultation with USFWS began on July 16, 2010, and the Biological Opinion (BO) ending it was signed on September 23, 2010. The BO can be found in Appendix A. All Reasonable and Prudent Measures as well as Terms and Conditions provided in the USFWS biological opinion will be implemented if feasible.

7.2.6 Magnuson-Stevens Fishery Conservation and Management Act of 1996; and the Magnuson-Stevens Act Reauthorization of 2006 (Essential Fish Habitat)

As directed by the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104-297), the USACE has coordinated with NMFS and that agency's experts on various marine organisms as well as EFH. The NMFS provided a letter dated February 10, 2009, to help guide the development of the FS/SEIS for the proposed action (Appendix C). The NMFS identified white shrimp, brown shrimp, red drum, lane snapper, dog snapper, and Gulf stone crab as species managed by the Gulf of Mexico Fishery Management Council that have EFH in the proposed action area. They also listed estuarine emergent wetlands, mud, sand and shell substrates, and estuarine and marine water column as primary categories of EFH in the proposed action area. In accordance with NMFS recommendation by letter dated January 26, 2010, the USACE (MVN) commits to undertake and obtain output from ecological simulation modeling and analysis of State fisheries data to assess the effects of this project individually as well as cumulatively

with other projects involving the Breton estuary, as part of project Planning, Engineering, and Design efforts, for use in developing an operation plan prior to implementation that will be applied under an adaptive management plan. The analysis of potential impacts of the Recommended Plan on EFH is described in Section 4.7 Essential Fish Habitat in the project vicinity.

7.2.7 Clean Air Act – Air Quality Determination

Compliance with the Clean Air Act (42 U.S.C.A. §§7401) has been fully coordinated with the Air Quality Section of the LDEQ (see also Section 4.2.4 Air Quality). As required by Louisiana Administrative Code, Title 33 (LAC 33:III.1405 B), an air quality applicability determination was made for the Recommended Plan. This included consideration of the proposed action for the category of general conformity, in accordance with the Louisiana General Conformity, State Implementation Plan (LDEQ, 1994). An air quality determination has been calculated, based upon direct and indirect air emissions (Section 5.4). Generally, since no other indirect Federal action, such as licensing or subsequent actions would likely be required or related to the restoration construction actions, it is likely that indirect emissions, if they would occur, would be negligible.

7.2.8 National Historic Preservation Act of 1966

In compliance with Section 106 of the NHPA, as amended, and 36 CFR 800, Federal agencies are required to identify and consider potential effects that their undertakings might have on significant historic properties, district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. Additionally, a Federal agency shall consult with any tribe that attaches religious and cultural significance to such properties. Agencies shall afford the State Historic Preservation Office (SHPO) and tribes a reasonable opportunity to comment before decisions are made. Accordingly, coordination of the proposed action with the SHPO and tribes has been initiated.

7.2.9 Farmland Protection Policy Act (Prime and Unique Farmlands)

The purpose of the Farmland Protection Policy Act (7 U.S.C. 658) is to minimize the extent to which Federal programs contribute to the unnecessary and irreversible conversion of farmland to non-agricultural uses. There are no farmlands within the study area. Hence, there would be no unnecessary or irreversible conversion of farmland to non-agricultural uses.

7.2.10 Executive Order 13186 – Migratory Bird Habitat Protection

Executive Order 13186 proclaims the intent to support the conservation of previous migratory bird conventions by integrating bird conservation principles, measures, and practices into agency activities and by avoiding or minimizing, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions. This Executive Order requires environmental analyses of Federal actions required by NEPA or other established environmental review processes to evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern. In addition, each Federal agency shall restore and enhance the habitat of migratory birds, as practicable. Implementation of the Recommended Plan would result in a net increase in migratory bird habitat.

7.2.11 Executive Order 12898 – Environmental Justice

Concern with EJ issues can be traced to Title VI, Section 601 of the Civil Rights Act of 1964 (Public Law 88-352):

> *No person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.*

On February 11, 1994, President Clinton issued Executive Order 12898 regarding Federal actions to address EJ issues in minority populations and low-income populations:

> *To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.*

Executive Order 12898 is designed to focus Federal attention on the environmental and human health conditions in minority communities and low-income communities. The order is also intended to promote non-discrimination in Federal programs substantially affecting human health and the environment, and to provide minority communities and low income communities access to public information on, and an opportunity for public participation in, matters relating to human health or environmental planning, regulations, and enforcement. Potential EJ issues have been considered throughout the entire study process, and will continue to be considered through project implementation. As part of the NEPA process, a scoping input request was provided to the public and interested parties. The scoping comments did not identify any potential EJ issues. The USACE is committed to ensuring that any potential EJ issues are addressed as the study proceeds. The proposed ecosystem restoration measures would equally impact all potential users in the area. There would be no potential EJ issues from implementing the Recommended Plan.

7.2.12 Executive Order 13112 – Invasive Species

On February 3, 1999, President Clinton issued Executive Order 13112 to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause by establishing the National Invasive Species Council. The Recommended Plan is consistent with Executive Order 13112 to the extent practicable and permitted by law and subject to the availability of appropriations, and within Administration budgetary limits. The Recommended Plan will use relevant programs and authorities to prevent the introduction of invasive species and not authorize, fund, or carry out actions likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere, unless the USACE has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species, and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.

7.2.13 Executive Order 11990 – Floodplain Management

Executive Order 11988 – Floodplain Management directs all Federal agencies to avoid, if possible, development and other activities in the 100-year base floodplain. Where the base floodplain cannot be avoided, special considerations and studies for new facilities and structures are needed.

Design and siting are to be based on scientific, engineering, and architectural studies; consideration of human life, natural processes, and cultural resources; and the planned lifespan of the project. Federal agencies are required to:

- Reduce the risk of flood loss
- Minimize the impact of floods on human safety, health, and welfare
- Restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibility

The proposed action area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana; in Zone A (no base flood elevation determined) of the Special Flood Hazard Areas inundated by 100-year flood (source: National Flood Insurance Program, Firm Flood Insurance Rate Map, Plaquemines Parish, Louisiana, Unincorporated Areas, Community-Panel Number 220139 0165B and 220139 0170B, effective date September 30, 1993, Federal Emergency Management Agency). Consistent with Executive Order 11988, implementing the Recommended Plan would have no significant impacts on the risk of flood loss. Implementing the Recommended Plan would have no significant flooding impacts on human safety, health and welfare. Implementing the Recommended Plan, ecosystem restoration of over 98,000 acres of intermediate to brackish intertidal wetland habitats within portions of the Breton Sound estuarine area, would contribute to restoring and preserving the natural and beneficial values served by floodplains.

7.2.14 Executive Order 11988 – Protection of Wetlands

President Jimmy Carter issued Executive Order 11990: Protection of Wetlands on May 24, 1977 (42 FR 26961, 3 CFR, 1977 Comp., p. 121) in order to avoid, to the extent possible, the long and short term adverse impacts associated with the destruction or modification of wetlands. Executive Order 11990 directs that each Federal agency shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Consistent with Executive Order 11990, the following factors have been considered as part of the alternative plan formulation process in developing the Recommended Plan for ecosystem restoration and avoiding potential effects on the survival and quality of wetlands:

a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion;

b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses.

7.2.15 Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646)

All real estate interests acquired for construction of the Recommended Plan will be in accordance with the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Uniform Act), as amended in 42 USC 4601-4655, and the Uniform Regulations contained in 49 C.F.R. Part 24. The Uniform Act sets forth procedures for the acquisition of private property for public use and specifically requires that the acquiring agency appraise the real property interests it wishes to acquire and provide the owner a written summary of the basis for the amount established as just compensation.

7.2.16 Louisiana State Rare, Threatened, and Endangered Species, and Natural Communities Coordination

The USACE reviewed the database maintained by the Louisiana National Heritage Program (LNHP) that provides the most recent listing and locations for rare, threatened and endangered species of plants and animals and natural communities within the State of Louisiana. The proposed action would not adversely impact any rare, threatened or endangered species, or unique natural communities. The proposed action would increase the extent of fresh marsh within portions of the study area, which is identified as a rare and imperiled natural community for certain regions of the state (see also Section 5.6 Vegetation Resources).

7.2.17 Clean Water Act – Section 401 Water Quality

Under provisions of the CWA (33 U.S.C. § 1251), any project that involved placing dredged or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands would require a water quality certification from the LDEQ, Office of Environmental Services. A final Supplemental Environmental Impact Statement addressing impacts of all activities associated with the proposed White Ditch Diversion Project has been prepared. The document includes an assessment of impacts of excavation, dredging, and disposal operations. Application for certification has been submitted by the U.S. Army Engineer District, New Orleans, to the LDEQ, Office of Environmental Services, in accordance with statutory authority contained in LRS: 30:2074 A(3) and provisions of Section 401 of the CWA (P.L. 92-500, as amended).

Under provisions of the CWA (33 U.S.C. § 1251), any project that involves placing dredged or fill material in waters of the United States or wetlands, or mechanized clearing of wetlands would require a water quality certification from the LDEQ, Office of Environmental Services. A public notice for the proposed action has been issued. Along with a copy of this final FS/EIS, an application for water quality certification has been provided to the LDEQ, stating that the proposed placement of fill material into waters of the state will not violate established water quality standards. Issuance of an LDEQ state Water Quality Certification is anticipated on October 4, 2010, prior to the start of the 30-day review period. The 401 Water Quality Certificate will be available for review and placed on www.LCA.Gov when it is issued.

This page intentionally left blank.

8.0 CONCLUSIONS AND DETERMINATIONS

8.1 AREAS OF CONTROVERSY AND UNRESOLVED ISSUES

During the scoping meeting and throughout the alternative identification and evaluation a number of issues have been raised regarding diversions in general and those under consideration in the study area. Every effort has been made to address these concerns and clearly identify the impacts, both beneficial and detrimental of the alternatives considered. Through public review of the document most of these issues clarified and resolved. However, it is also likely that if construction and operation of the Recommended Plan were to occur, these issues would continue to be raised. They are summarized as follows:

- Joint operation of the proposed White Ditch Diversion with the existing Caernarvon Diversion would be key to maintaining the condition of the overall Breton Sound ecosystem. These two projects should not be operated independently of one another. Modeling results and monitoring data suggests that Caernarvon has the ability to substantially freshen the Breton Sound even without freshwater inputs from another source. In order for Breton Sound salinities to rebound after the March–April pulse from the White Ditch Diversion, flow from Caernarvon would have to be closely controlled. This will mean a change to the current operational plan. It will be crucial that future modeling during PED for White Ditch and during Feasibility for the LCA Modification to Caernarvon investigate joint operation. The LCA 4 Modification to Caernarvon will consider and account for the proposed Medium Diversion at White Ditch project during its analysis. Additionally the existing and proposed operational plans for both White Ditch and Caernarvon are subject to refinement based on any newly acquired data. If significant changes are required, these would be properly disclosed to the public through the NEPA process.
- Potential negative impacts to oysters from over-freshening of the basin. An evaluation of the impacts to the salinity regimes in the study area was conducted and the areas most important to commercial oyster harvesting could experience significant changes as a result of the project, especially if an unfavorable operational regime is implemented. During the PED phase, detailed and extensive aquatic modeling using the fisheries modeling software will be used to thoroughly evaluate the potential impacts to fisheries resources, including commercially important species such as oysters. These results could assist in further refinement of the proposed operational regime.
- Converting the estuary to fresh/intermediate marsh. Fresh and intermediate marsh types are an important habitat type in coastal areas and specifically the study area. The loss of these areas has diminished the ecological integrity of the study area. The restoration of fresh and intermediate marsh types will not exceed historic trends and is not expected to displace significant areas of brackish or saline marsh. Additionally the Recommended Plan has the potential to create new areas of brackish and saline marsh through restoration of the functional processes that create and sustain them.
- Creating 'flotant' marsh that is not anchored and provides no surge protection. The short duration of the pulse (March–April) operating regime has the potential to saturate existing marsh. However, due to the relatively short pulsing season, significant habitat switching is not expected to occur.

- Direct sediment delivery with dredging from the river. The cost of this approach would be excessive. While building marsh directly would have an immediate benefit, it would not restore the processes needed to sustain marsh within the study area.
- Impacts to pallid sturgeon. At this time, surveys are being conducted to determine whether pallid sturgeon are present and whether the Recommended Plan will impact the species. Preliminary indications are that the species is not present; however, the USFWS has not yet made a formal determination. That information will be available before a public review draft of the report is completed.
- Creating access and/or land use problems for private landowners. The Recommended Plan will have immediate impacts in the area being considered for the location of the structure. Access during construction may be limited but this would be temporary.
- Did we pick the best spot on the river to capture sediment? Based on the available information the supply of sediment at the Phoenix Location would be adequate to meet the goals and objectives of the project and operational requirements of the structure. The information used to predict project benefits in the ERDC-Sand2 Model came from data obtained from the Belle Chasse station, which represented the longest continuous dataset from a nearby location. When comparing the ERDC-Sand2 Model inputs to data that have been collected within the project area itself, it is seen that the programs estimates are conservative. Data collected by the USGS in the outfall canal of the existing White Ditch Siphon suggests that more sediment is available to enter into the project area than represented by the Belle Chasse Data. Using the Belle Chasse Data, it is expected that the Recommended Plan will deliver approximately 16,600 tons of sediment per day into the project area during the March–April Pulse. Using the USGS sediment loads and the same pulse operation, approximately 17,900 tons of sediment per day could enter the project area. This results in a potential 8% increase in sediment loads from what are currently being projected.

  Current research being done by the University of Texas in conjunction with the State of Louisiana also suggests that there will be further increased sediment concentrations specifically at the Phoenix site. The Phoenix location of the Recommended Plan was selected because there is a "back-current" in flows on the Mississippi River. This will enhance the amount of sediment available in the area of the diversion as the back-current will continually pull sediments into the diversion.

  Additional analysis will be conducted during PED to determine the best orientation and placement of the structure within close proximity of its presently proposed location. The project would not move from the Phoenix Location.
- Relative Sea-Level Rise (RSLR). Extensive consideration of RSLR occurred during formulation. Further, the impacts of the moderate and high sea-level rise scenarios on the Recommended Plan were evaluated but it should be noted that no evaluated alternative is able to entirely offset the high rate of sea-level rise.
- Induced shoaling effects and other effects to the navigation/shipping industry. No impacts are expected to the day-to-day activities of the navigation/shipping industry. A qualitative analysis of induced shoaling effects is included in Appendix N. Further analysis is recommended during design to accurately assess and minimize, through the diversion structure design, potential impacts.

- The Recommended Plan for this project exceeds the cost authorization presented in the 2004 LCA Report. The District Commander recommends seeking additional authorization in order to construct the Recommended/NER plan; however, the need to request additional authorization has the potential to impact the project construction schedule.
- Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the USACE for the PED Phase. At this time, a SOW is being developed as part of the Donaldsonville to the Gulf project to look at various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project.

- The impacts of the Deepwater Horizon oil spill on coastal Louisiana are uncertain at this time (August 2010). The impacts of the oil spill as well as the various emergency actions taken to address oil spill impacts (e.g., use of oil dispersants, creation of sand berms, use of Hesco baskets, rip-rap, sheet piling and other actions) could potentially impact USACE water resources projects and studies within the Louisiana coastal area, including the MDWD project. Potential impacts could include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. The USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors in determining how to best address any potential problems associated with the oil spill that may adversely impact project implementation. Supplemental planning and environmental documentation may be required as information becomes available. If at any time petroleum or crude oil is discovered on project lands, all efforts will be taken to seek clean up by the responsible parties, pursuant to the Oil Pollution Act of 1990 (33 U.S.C. 2701 et seq.).

  Ongoing documentation of the impacts associated with the Deepwater Horizon Oil spill can be found in several governmental sources. The USFWS Situation Report for August 2, 2010 (http://www.fws.gov/home/dhoilspill/pdfs/MondayAugust22010.pdf) indicates the following environmental-related Deepwater Horizon oil spill information: 563 personnel are actively engaged in the response, working to protect wildlife and their habitats, including 36 national wildlife refuges. They are also assessing the damage from the oil spill in preparation for the work that will be needed to restore the Gulf of Mexico. Some 1,643 visibly oiled birds have been collected alive by the U.S. Fish and Wildlife Service, the states and our partners in response to the Deepwater Horizon oil spill. Of those, 594 birds have been rehabilitated and released. Another 1,451 visibly oiled birds have been collected dead. Aerial operations over Louisiana observed an oil sheen covering 300 acres in the northeastern portion of Barataria Bay. A heavily oiled coastline covering about one-half mile was found at Bayou Chalond and heavy oil and tar balls were observed on landfall east of Point-Au-Fer and along Timbalier Island. Beached bird surveys were conducted in Texas, Louisiana, Mississippi, Alabama and Florida. Aerial missions are scheduled for Southwest Pass, Chandeleur Islands, Biloxi Marsh, Barataria Bay, Terrebonne, Marsh Islands, Atchafalaya Delta, Point-Au-Fer and Timbalier Bay.

  – Overall number of personnel responding: approximately 30,100
  – Total vessels responding: more than 4,500
  – Total boom deployed: more than 2,155 miles
  – Boom available: more than 856 miles

- Oily water recovered: more than 34.7 million gallons
- Estimated 11.14 million gallons of oil burned
- Estimated total of more than 1.84 million gallons of dispersant used including:
  - Estimated more than 1.07 million gallons surface dispersant used
  - Estimated more than 771,000 gallons of sub-sea dispersant used
- Estimated approximately 632 miles of Gulf Coast shoreline is currently oiled-approximately 365 miles in Louisiana, 111 miles in Mississippi, 68 miles in Alabama, and 88 miles in Florida.

The USACE, New Orleans District Regulatory Branch has considered and responded to approximately 55 emergency permits related to the Deepwater Horizon oil spill. In addition, the State of Louisiana is permitted to dredge and fill to construct a six sand berm reaches along the shoreline of the Chandeleur Islands/Breton National Wildlife Refuge westward to Baptiste Collette Bayou and along the seaward shoreline of Timbalier Island eastward to Sandy Pont. Material to construct the berms would be dredged from Ship Shoal, South Pelto, the Mississippi River Offshore Disposal Site, Pass a Loutre, St. Bernard Shoal and Hewes Point. Emergency permits have the following clause that provides for removing, relocating or altering permitted structures if necessary and upon due notice from the Corps. The clause would pertain to future actions by the United States, such as proposed Louisiana Coastal Area restoration projects:

> *The permittee understands and agrees that, if future operations by the United States require the removal, relocation, or other alteration, of the structure or work herein authorized, or if, in the opinion of the Secretary of the Army or his authorized representative, said structure or work shall cause unreasonable obstruction to the free navigation of the navigable waters, the permittee shall be required upon due notice from the Corps of Engineers, to remove, relocate, or alter the structural work or obstructions caused thereby, without expense to the United States. No claim shall be made against the United States on account of any such removal or alteration.*

As is evident from the numerous ongoing actions, the dynamic nature of the impacts associated with the Deepwater Horizon oil spill will likely require additional consideration in the near future for USACE Civil Works projects.

8.2 CONCLUSIONS

The Recommended Plan would create and nourish approximately 20,315 acres of fresh, intermediate, brackish and saline wetlands. This alternative involves construction of a structure capable of diverting up to 35,000 cfs consisting of ten 15-ft x 15-ft box culverts. Additionally, the project will have 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Restoration of freshwater, nutrient and sediment inputs to the project area will result in the creation and nourishment of a variety of marsh types within the study area. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The project will be operated in a pulsed manner diverting up to 35,000 cfs during March and April and up to 1,000 cfs the rest of the year.

The Recommended Plan is the plan that best meets the Louisiana Coastal Area goals and objectives as well as those identified for the study area in partnership with the State of Louisiana. The Recommended Plan is also the plan that best meets the P&G's four criteria of completeness, effectiveness, efficiency, and acceptability, as well as the Environmental Operating Principles of environmental sustainability, interdependence, balance and synergy, accountability, knowledge, respect, and assessing and mitigating cumulative impacts.

8.3 RECOMMENDATIONS

The District Commander has considered all the significant aspects of this study including the environmental, social, and economic effects, the engineering feasibility, and the comments received from other resource agencies, the Non-Federal Sponsors, and the public and has determined that the Recommended Plan presented in this report is in the overall public interest and a justified expenditure of Federal funds. As a comprehensive approach to restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges, the District Commander recommends the construction of a diversion structure capable of diverting up to 35,000 cfs consisting of ten 15-x-15-ft box culverts. Additionally, 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments. Notched weirs would be installed in outflow canals to restrict flow into the River aux Chenes and retain diverted water in the project area. The project will be operated in a pulsed manner diverting up to 35,000 cfs during March and April and up to 1,000 cfs the rest of the year.

The fully funded cost for the project is $387,620,000, inclusive of associated investigation, environmental, engineering and design, construction, supervision and administration, and contingency costs. The operations and maintenance of this project may be assumed by the State of Louisiana as the non-Federal sponsor. The project is funded 65% by the Federal Government and 35% by the non-Federal sponsor, and subject to the implementation requirements and responsibilities specified in Section 3.9 of this report.

The recommendation contained herein reflects the information available at this time, March 2010 price levels, and current Departmental policies governing the 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 levels of review within the Executive Branch. Consequently, the recommendation may be modified before they are transmitted to the Congress as proposals for authorization and/or implementation funding.

This page intentionally left blank.

9.0 DISTRIBUTION LIST AND OTHER

9.1 DISTRIBUTION LIST

The DEIS was distributed to Federal, state, parish, and local agencies; Tribes; businesses; libraries; museums; universities; environmental organizations, groups and individuals; and scoping participants. The complete distribution list is available upon request from the U.S. Army Corps of Engineers at the following address:

U.S. Army Corps of Engineers
New Orleans District
P.O. Box 60267
New Orleans, Louisiana 70160-0267

This Integrated Feasibility Report and SEIS will be distributed to Federal, state, parish, and local agencies; tribes; businesses; libraries; museums; universities; environmental organizations, groups and individuals; and scoping participants. The complete distribution list will be available upon request from the USACE at the following address.

U.S. Army Corps of Engineers
New Orleans District
P.O. Box 60267
New Orleans, Louisiana 70160-0267

9.2 LIST OF PREPARERS

Many individuals were involved with the completion of this document. The following table lists those people who assisted in writing this Integrated Feasibility Study and EIS.

Table 9.1: List of Preparers

Name	Job Description/Experience/ Education/Registration	Subject Matter
Baker, Ariele	Coastal Resource Scientist (CPRA)/1 year/M.S. Environmental Science, LSU	CPRA Study Manager
Boyce, Mayely	Assistant District Counsel (MVN)/ 3 years/J.D./M.E.M., Duke University	Legal Review
Brown, Michael	Biologist/7 years/B.A. Biology Southeastern Louisiana University	Vegetation Resources
Carmack, Charlene	Community Planner (MVR)/25 years/ M.A. Geography, University of Iowa	Functional Team Leader for EIS Preparation
Clouse, Paul	GIS Coordinator (MVS)/18 years/B.A Computer Science, Huntingdon College/ Certified GIS Professional	Data Acquisition & Support
Cook, Kenneth	Fishery Biologist (MVS)/7 years/M.S. Zoology, SIU-Carbondale	Plankton

Name	Job Description/Experience/ Education/Registration	Subject Matter
Dayan, Nathan	Fisheries Biologist (MVN)/14 years/M.S Marine Biology, University of Charleston	Environmental Oversight
Demarcay, Gary	Archaeologist/23 years/M.A. Anthropology, Texas A&M University	Cultural Resources
Eagan, Timothy	Civil Engineer Technician (MVS)/ 3 years/B.A. Information Technology, Lindenwood University	Geospatial Eng. Rept. and Mapping
Farmer, Jason	Project Manager (MVS)/2 years/M.S. Wetland Ecology, /Professional Wetland Scientist	Project Manager – General Project Oversight
Fiorentino, John	Biologist/1year/ M.S. Marine Biology Northeastern University	Coastal Zone Consistency Determination
Fitzgerald, Tye	Engineer Intern (CPRA)/1 year/ B.S., Civil Engineering, LSU/E.I.T.	Project Engineer with Louisiana
Henry, Donovan	Ecologist (MVS)/1 year/M.S. Zoology, Southern Illinois-Carbondale	Benthic Ecology
Hoerner, Melissa	Realty Specialist (MVS)/13 years/M.B.A Business, SIU-Edwardsville	Real Estate
William Klein	Environmental Manager (MVN)/16 Years/ M.S. Wildlife Management, West Virginia University	Environmental
Mach, Rodney	Supervisory Civil Engineer (MVN)/30 Years/ B.S. Civil Engineering, Southeastern Massachusetts University	MVN H&H Rep. on Oversight Team
MacInnes, Andrew	Project Planner (MVN)/10 years Coastal Zone Management/B.S. Geography, Utah State	Project Manager
Mann, Joseph	Regional Economist (MVN)/14 years/ D.B.A., Nova Southeastern-Ft. Lauderdale	Economics
McCaffrey, Kelly	Landscape Architect (MVN)/8 years/ B.L.A. Landscape Architecture –Mississippi State University	Aesthetics/Visual Resources
Parker, Thomas	Environmental Resource Specialist/1 year/B.S. Biology, University of Colorado-Denver	Biological Assessment
Perez, Andrew	Outdoor Recreation Planner (MVN)/ 5 Years/M.U.R.P.-UNC-Chapel Hill	Recreation/Incidental Recreation Benefits
Plumley, Marshall	Community Planner (MVR)/9 years/ B.S. History/Political Science, Illinois State University	Plan Formulation Team Leader
Richardson, Jerica	Archaeologist (MVN)/12 years/ B.A. Anthropology, Mississippi State University	Environmental Justice Coordinator
Roy, Kevin	Senior Field Biologist (USFWS)/15 years/ B.S. Louisiana Tech University	Habitat Evaluation Team Leader
Slattery, Kevin	Environmental Specialist (MVS)/ 10 years/B.A. Environmental Studies, Westminster College/ Certified Professional in Stormwater Quality	HTRW and Water Quality

Name	Job Description/Experience/ Education/Registration	Subject Matter
Stohl, Melbourne	Mechanical Engineer (MVS)/35 years/ B.S. Civil Engineering, Washington University (St. Louis)	Mechanical Engineer
Terry, William	Hydraulic Engineer (MVS)/1 year/ B.S. Civil Engineering, University of Missouri – Rolla/E.I.T.	Functional Team Leader Engineering; Hydraulic Engineering
Tokraks, Nancy	Civil Engineer (MVS)/18 years/B.S. Civil Engineering, University of Missouri-Rolla	Civil Design
Villarrubia, Chuck	Coastal Resources Senior Scientist (CPRA)/ 29 years/M.S. Wildlife and Fisheries Science, University of Tennessee	CPRA Operations
Vosburg, Brian	Geologist, III (CPRA)/5 years/B.S. Geology, LSU	CPRA Geology Review
Wood, Cynthia		Document Administration

MVN = New Orleans District; MVS = St. Louis District; MVE = Rock Island District; USFWS = U.S. Fish and Wildlife Service; CPRA = Louisiana Coastal Protection and Restoration Authority

9.3 LITERATURE CITED

Autin, W. J., S.F. Burns, B.J. Miller, R.T. Saucier, and J.I. Snead. 1991. Quaternary geology of the Lower Mississippi valley. Pages 547–582 in R. B. Morrison, editor. Geology of North America. Volume K-2. Quaternary nonglacial geology: conterminous U.S. Geological Society of America, Boulder, CO.

Barras, J.A., 2006, Land area change in coastal Louisiana after the 2005 hurricanes--a series of three maps: U.S. Geological Survey Open-File Report 06-1247

Barras, J.A., S. Britsch, D. Hartley, S. Hawes, J., Johnson, P. Kemp, Q. Kinler, A. Martucci, J. Porthouse, D. Reed, K. Roy, S. Sapkota, and J. Suhayda. 2003. Historical and projected coastal Louisiana land changes: 1978–2050. USGS Open File Report 03-334, 39 p. (Revised January 2004)

Barras, J.A. 2002. GIS analysis and classification by USGS NWRC for LCA Study planning and desktop analysis. Unpublished.

Barras, J.A., P.E. Bourgeois, L. R. Handley. 1994. Land loss in coastal Louisiana 1956–90: National Biological Survey, National Wetlands Research Center Open-File Report 94-01. 4 p.

Boustany, Ronald G. Estimating the Benefits of Freshwater Introduction into Coastal Wetland Ecosystems in Louisiana: Nutrient and Sediment Analyses.

Caffey, R.H., and M. Schexnayder. 2002. Fisheries implications of freshwater reintroductions. *Interpretive Topic Series on Coastal Wetland Restoration in Louisiana.* Coastal Wetland Planning, Protection, and Restoration Act (eds.). National Sea Grant Library No. LSU-G-02-003. 8 p.

Carr, S.H., F. Tatman, and F.A. Chapman. 1996. Observations on the natural history of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus de sotoi*, Vladykov 1955) in the Suwannee River, southeastern United States. Ecology of Freshwater Fish 5:169–174.

Coleman, E. 2003. The Gulf Oyster Industry: Seizing a Better Future. Louisiana Sea Grant College Program, Louisiana State University, Baton Rouge. 17 pp.

Center for Environmental Excellence (CEE). 2009. http://www.environment.transportation.org/environmental_issues/environmental_justice/

Commission for Environmental Equality. 2009. Waiting for Reference from Author.

Conner, W. H., and J. W. Day. 1987. The ecology of Barataria Basin, Louisiana: An estuarine profile. Biological Report 85(7.13). U.S. Fish and Wildlife Service, Washington, D.C.

Davis, W. E., Jr. 1993. Black-crowned Night-Heron (*Nycticorax nycticorax*). In The Birds of North America, No. 74 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.

Day, J. W., Jr., C. A. S. Hall, W. M. Kemp, A. Yanez-Arancibia. 1989. *Estuarine Ecology*. John Wiley and Sons, New York. 558 pp.

Day, J.W. and P.H. Templet, 1989. Consequences of Sea Level Rise: Implications from the Mississippi Delta. Coastal Management. Vol. 17:241–257.

Delaune, R.D., and W. H. Patrick Jr. 2002. Development of Methods and Guidelines for Use in Maximizing Marsh Creation at a Mississippi River Freshwater Diversion Site. DNR Contract No. 2512-98-7.

Demas and Demcheck. 2003. Waiting for Reference from Author.

Detenbeck, N.E., R. Hermanutz, K. Allen, and M.C. Swift. 1996. Fate and effects of the herbicide atrazine in flow-through wetland mesocosms. Environmental Toxicology and Chemistry.

Duffy, K. 1997. Macrofaunal Community Structure in the Introduced and Native Submerged Macrophyte Beds of the Lake Pontchartrain Estuary. Doctoral Dissertation, Louisiana State University. Baton Rouge.

Dundee, H. A., and D. A. Rossman. 1989. *The Amphibians and Reptiles of Louisiana.* Louisiana State University Press, Baton Rouge.

Eastern Oyster Biological Review Team (EOBRT). 2007. Status review of the eastern oyster (*Crassostrea virginica*). Report to the National Marine Fisheries Service, Northeast Regional Office. February 16, 2007. 105 pp.

Environmental Systems Research Institute, Inc. (ESRI). 2008. Business Analyst Program: Census 2000 Summary Profile, Census 2000 Detailed Race Profile, 2008/2013 Demographic and Income Profile.

Fisk, H. N. 1944. Geological investigation of the alluvial valley of the lower Mississippi River. U.S. Army Corps of Engineers. Mississippi River Commission, Vicksburg, MS. 78 pp.

Floyd, R. J. 1981. Cultural Resources Survey of Proposed 24" Pipeline Route from Loop's Clovelly Facilities, Lafourche Parish, Louisiana to Gulf's Oil Alliance Refinery, Plaquemines Parish, Louisiana to Murphy Oil's Meraux Refinery, St. Bernard Parish, Louisiana. Gulf Refining Company, New Orleans Louisiana.

Frazier, D. E. 1967. Recent deposits of the Mississippi River, their development and chronology. Transactions of the Gulf Coast Association of Geological Societies 17: 287–311.

Gosselink, J.G. 1984. The ecology of delta marshes of coastal Louisiana: A community profile. FWS/OBS-84/09. U.S. Fish and Wildlife Service, Washington D.C. 134 pp.

Haig, S. M., and J. H. Plissner. 1992. The 1991 international piping plover census. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 200 pp.

Hawes, S. R., and H. M. Perry. 1978. Effects of 1973 floodwaters on plankton populations in Louisiana and Mississippi. Gulf Research Reports 6:109–124.

Hildebrand, H. H. 1983. Random Notes on Sea Turtles in the Western Gulf of Mexico. Pages 34–41, *in* Western Gulf of Mexico Sea Turtle Workshop Proceedings, January 13–14, 1983.

Hirth, H. F. 1971. Synopsis of biological data on the green turtle *Chelonia mydas* (Linnaeus) 1758. FAO Fisheries Synopsis. 85:1–77.

Kesel, R. H. 1988. The decline of the suspended load of the lower Mississippi River and its influence on adjacent wetlands. Environmental Geological Water Sciences 11:271–281.

Kesel, R.H. 1989. The role of the Mississippi River in wetland loss in southeastern Louisiana, U.S.A. Environmental Geology and Water Sciences 13:183–193.

Kesel, R. H., E. Yodis, and D. McCraw. 1992. An approximation of the sediment budget of the lower Mississippi River prior to major human modification. Earth Surf. Process. Landf. 17:711–722.

Kryter, K. D. 1994. *The Handbook of Hearing and the Effects of Noise: Physiology, and Public Health*. McGraw Hill, New York.

LACPR, 2008. USACE Louisiana Coastal Protection and Restoration (LACPR): Draft Technical Report.

LCA, 2004. USACE Louisiana Coastal Area (LCA) Ecosystem Restoration Study.

Lane, R.R., J. W. Day, Jr., and J. N. Day. 2006. Wetland surface elevation, vertical accretion, and subsidence at three Louisiana estuaries receiving diverted Mississippi River Water. Wetlands 26:1130-1142.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 2002. Coastal wetlands planning, protection, and restoration act, wetland value assessment methodology: coastal chenier/ridge community model.

Louisiana Coastal Wetlands Conservation and Restoration Task Force. 2009. Coastal wetlands planning, protection, and restoration act, wetland value assessment methodology: coastal marsh community models.

Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority. 1999. Coast 2050: Toward a Sustainable Coastal Louisiana, Louisiana Department of Natural Resources. Baton Rouge, La.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. 2nd Edition. Van Nostrand Reinhold, New York, USA. 722 pp.

Mitsch, William and James Gosselink, 2000, Wetlands, John Wiley & Sons 3rd edition, New York, New York 14 Boesch, D. F. M. N. Josselyn, A. J. Mehata, J.T. Morris. W.K. Nuttle, C. A. Simensted, and D.J.P. Swift, 1994, Scientific Assessment of Coastal Wetland Loss, Restoration and Management in South Louisiana, Journal of Coastal Research, Special Issue No. 20. 103 p.

Mitsch,W.J., J.W. Day Jr., J.W. Gilliam, P.M. Groffman, D.L. Hey, G.W. Randall, and N. Wang. 2001. Reducing nitrogen loading to the Gulf of Mexico from the Mississippi River Basin: strategies to counter a persistent ecological problem.

Morgan, J. P., and Larimore, P. B., 1957, Changes in the Louisiana shoreline: Transactions of the Gulf Coast Association of Geological Societies, v. 7, p. 303–10.

Morton, R., J. Bernier, J. Barras, and N. Fernia. 2005. Rapid subsidence and historical wetland loss in the Mississippi Delta Plain, likely causes and future implications: U.S. Geological Survey Open-File Report 2005-1216, 124 pp. http://pubs.usgs.gov/of/2005/1216/, accessed August 9, 2006.

Louisiana Department of Wildlife and Fisheries (LDWF). Leatherback Sea Turtle (*Dermochelys coriacea*). 2005. Accessed 26 February 2008. http://www.wlf.louisiana.gov/pdfs/experience/natural heritage/rareanimal/kempridleyseaturtle.pdf

Mashriqui, H. S., G. P. Kemp, J. W. Day, R. R. Lane, and R. Cunningham. 2002. Mississippi River diversion into the Maurepas Swamp—Hydrologic and Ecological Modeling. Coastal Water Resources AWRA Spring Specialty Conference.

Mitsch, W. J. and J. G. Gosselink. 1993. *Wetlands*. 2nd Edition. Van Nostrand Reinhold, New York, USA. 722 pp.

National Oceanic and Atmospheric Administration (NOAA). 2009. Letter dated 10 February 2009, to Ms. Elizabeth Wiggins from Mr. Miles M. Croom (Assistant Regional Administrator, Habitat Conservation Division

Penland, S., and R. Boyd. 1985. Mississippi delta shoreline development. Pages 53–122 in S. Penland and R. Boyd, editors. Transgressive depositional environments of the Mississippi River delta plain: a

guide to barrier islands, beaches, and shoals in Louisiana. Louisiana Geological Survey, Baton Rouge.

Perret, W.S., B.B. Barrett, W.R. Latapie, J.F. Pollard, W.R. Mock, G.B. Adkins, W.J. Gaidry, and C.J. White. 1971. Cooperative Gulf of Mexico estuarine inventory and study, Louisiana. Phase I. Area description by Perret, W.S. Phase II. Biology, pp. 31–69. La. Wildl. Fish. Comm. 171 pp.

NOAA Fisheries, Office of Protected Resources (NOAA-1). 2008. Green Turtle (*Chelonia mydas*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 25 February 2008. <http://www.nmfs.noaa.gov/pr/species/turtles/green.htm>

Penland, Shea, and Boyd, Ron, 1981, Shoreline changes on the Louisiana barrier coast: Oceans, v. 81, p. 209–219.

Phipps, R.G., and W.G. Crumpton. 1994. Factors affecting nitrogen loss in experimental wetlands with different hydrologic loads.

Rozas, L. P., T. J. Minello, I. Munuera-Fernandez, B. Fry, and B. Wissel. 2005. Macrofaunal distributions and habitat change following winter-spring releases of freshwater into the Breton Sound estuary, Louisiana (USA). Estuarine, Coastal and Shelf Sciences 65:319–336.

Saucier, R. T. 1994. Geomorphology and quaternary geologic history of the Lower Mississippi Valley. Volume 1 (Text). U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Shaffer, Gary P. Thais E. Perkins, Susanne Hoeppner, Susan Howell, Heath Bernard and Carol Parsons, 2003, Ecosystem Health of the Maurepas Swamp: Feasibility and Projected Benefits of a Freshwater Diversion, Prepared for EPA Region 6.

Smalling, K.L., and C.M. Aelion. Kelly L. Smalling, University of South Carolina, Department of Environmental Health Sciences, C. Marjorie Aelion, University of South Carolina, Department of Environmental Health Sciences, Microbial Degradation of Atrazine in Coastal Sediments: Distribution of Metabolites into Aqueous and Basic Fractions.

Snedden, G.A., Cable, J.E. Swarzenski, C., Swenson, E., 2006. Sediment discharge into a subsiding Louisiana deltaic estuary through a Mississippi River diversion. Estuarine, Coastal and Shelf Science. 71:181–193.

Teal, J.M. (1986) The Ecology of Regularly Flooded Salt Marshes of New England: A Community Profile. US Fish and Wildlife Serv., Div. Biol. Serv., Washington DC. FWS/OBS-82-07

Titus, J. and C. Richman, 2001. Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations along the U.S. Atlantic and Gulf Coasts. Climate Research, CR 18:205–228.

The Coypu Foundation. http://is.cbr.tulane.edu. Center for Bioenvironmental Research, Invasive Species Initiative at Tulane and Xavier University.

United Church of Christ (UCC). 1987. Toxic Waste and Race in the United States. Commission for Racial Justice Report. Accessed at: www.ucc.org/about-us/archives/pdfs/toxwrace87.pdf.

U.S. Army Corps of Engineers (USACE). 1984. Louisiana Coastal Area, Louisiana: Feasibility Report on Freshwater Diversion to Barataria and Breton Sound Basin. U.S. Army Corps of Engineers, New Orleans District.

U.S. Census Bureau (USCB). 2000 U.S. Census, Summary File 1 (SF1), Summary File 3 (SF3) and Summary File 4 (SF4). Accessed at http://factfinder.census.gov on 28 October 2009.

U.S. Census Bureau (USCB). 2009. Waiting for Reference from Author.

U.S. Department of Agriculture, Soil Conservation Service. 1992. Project No. BS-4. Feasibility Report, White's Ditch Diversion Siphon Outfall Management Plan, completed for Louisiana Department of Natural Resources – Coastal Restoration Division.

U.S. Department of Agriculture, Soil Conservation Service. Project No. BS-4. Feasibility Report, White's Ditch Diversion Siphon Outfall Management Plan, completed for Louisiana Department of Natural Resources – Coastal Restoration Division. December 31, 1992.

U.S. Department of Health and Human Services poverty guidelines. 2009. Accessed at http://aspe.hhs.gov/poverty/09poverty.shtml on 28 October 2009.

U.S. Environmental Protection Agency (USEPA). 1995a; 1995b; 1995c; 1995d. Waiting for References from Author.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat evaluation procedures (HEP). Div. Ecol. Serv. ESM 102, U. S. Fish and Wildl. Serv., Washington, DC. 141 pp.

U.S. Fish and Wildlife Service (USFWS). 2001. Florida manatee recovery plan. Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. 144 pp. + Appendices.

U.S. Fish and Wildlife Service (USFWS). 2004. Final Fish and Wildlife Coordination Act Report, Near-Term Ecosystem Restoration Plan for the Louisiana Coastal Area. Ecological Services Office, Lafayette, Louisiana.

U.S. Fish and Wildlife Service (USFWS). 2007. Red wolf recovery plan. Southeast Region. U.S. Fish and Wildlife Service, Manteo, North Carolina. http://www.fws.gov/redwolf/

U.S. Fish and Wildlife Service (USFWS). 2008. Black Bear Critical Habitat Fact Sheet USFWS. Southeast Region. U.S. Fish and Wildlife Service, Lafayette, Louisiana.

U.S. Fish and Wildlife Service (USFWS). 2009a. Bald Eagle Fact Sheet USFWS. Southeast Region. U.S. Fish and Wildlife Service, Endangered Species Program, Arlington, Virginia.

U.S. Fish and Wildlife Service (USFWS). 2009b. Biological Opinion. 2008 Operation of the Bonnet Carré Spillway. U.S. Fish and Wildlife Service, Lafayette, Louisiana.

U.S. Geological Survey. 2006. USGS Reports Latest Land-Water Changes for Southeastern Louisiana.

U.S. Fish and Wildlife Service, Ecological Services, Lafayette, Louisiana. Final Fish and Wildlife Coordination Act Report, Near-Term Ecosystem Restoration Plan for the Louisiana Coastal Area. October 2004.

Wicker, K.M., 1980. The Mississippi Deltaic Plain habitat mapping study: U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS 79/07, 464 maps.

9.4 GLOSSARY

Acceptability – Adequate to satisfy a need, requirement, or standard. One of the U.S. Army Corps of Engineers requirements for a project.

Adaptive management – An interdisciplinary approach acknowledging our insufficient information base for decision-making; that uncertainty and change in managed resources are inevitable; and that new uncertainties will emerge. An iterative approach that includes monitoring and involves scientists, engineers and others who provide information and recommendations that are incorporated into management actions; results are then followed with further research, recommendations and management actions, and so on.

Aggradational Process of Plant Growth – Plant root material building elevation, usually in fresh marsh.

Air Quality Determination – The Louisiana Department of Environmental Quality ensures that projects do not adversely affect air quality through this determination as a requirement of the Clean Air Act.

Alternative Plan – A set of one of more management measures within a subprovince functioning together to address one or more objectives.

Amplitude – The maximum absolute value of a periodically varying quantity.

Anadromous – Ascending rivers from the sea for breeding.

Anoxia – Absence of oxygen.

Anthropogenic – Caused by human activity.

Average Annual Habitat Unit (AAHU) – Represent a numerical combination of habitat quality and quantity (acres) existing at any given point in time. The habitat units resulting from the future without- and future with-project scenarios are annualized, and averaged over the project life, to determine Average Annual Habitat Units (AAHUs).

Aquaculture – The science and business of farming marine or freshwater food fish or shellfish, such as oysters, crawfish, shrimp and trout, under controlled conditions.

Astronomical Tides – Daily tides controlled by the moon, as opposed to wind-generated tides.

Barbary Soils – Soils in swamps (with logs and stumps) that are level, very poorly drained, with a thin mucky surface layer and clayey underlying material.

Benefits – Valuation of positive performance measures.

Benthic – Living on or in sea, lake, or stream bottoms.

Biomass – The total mass of living matter (plant and animal) within a given unit of environmental area.

Bottomland Hardwood Forest – Low-lying forested wetlands found along streams and rivers.

Brackish Marsh (BRM) – Intertidal plant community typically found in the area of the estuary where salinity ranges between 4–15 ppt.

Chenier Plain – Western part of coastal Louisiana with little influence from Mississippi and Atchafalaya rivers.

Clean Water Act Section 404 (b) (1) – There are several sections of this Act that pertain to regulating discharges into wetlands. The discharge of dredged or fill material into waters of the United States is subject to permitting specified under Title IV (Permits and Licenses) of this Act and specifically under Section 404 (Discharges of Dredge or Fill Material) of the Act.

Coastal Zone Consistency Determination – The U.S. Environmental Protection Agency reviews plans for activities in the coastal zone to ensure they are consistent with federally approved State Coastal Management Programs under Section 307(c)(3)(B) of the Coastal Zone Management Act.

Coast-wide Plan – Combination of alternative plans assembled to address an objective of set of objectives across the entire Louisiana Coast.

Collocated Team – A collection of scientists and professionals from the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, NOAA Fisheries, Natural Resources Conservation Service, U.S. Geological Survey, U.S. Environmental Protection Agency, Louisiana Department of Natural Resources, and Louisiana Department of Wildlife and Fisheries that are located at the USACE, New Orleans District, office and work together on the LCA Plan.

Compaction of Holocene Deposits – Deltaic mud that packs down under its own weight.

Completeness – The ability of a plan to address all of the objectives. One of the USACE four requirements for a project.

Comprehensive Plan – Same as Coast-wide Plan.

Conditional Authorization – Authorization for implementation of a project subject to approval of the project feasibility-level decision document by the Assistant Secretary of the Army for Civil Works.

Congressional Authorization – Authorization for investigation to prepare necessary feasibility-level report to be recommended for authorization of potential future project construction by Congress.

Connectivity – Property of ecosystems that allows for exchange of resources and organisms throughout the broader ecosystem.

Continental Shelf – The edge of the continent under gulf waters; the shallow Gulf of Mexico fringing the coast.

Control Structure – A gate, lock, or weir that controls the flow of water.

Crevasse – A breach or gap in the levee or embankment of a river (natural or manmade), through which floodwaters flow.

Cumulative Impacts – The combined effect of all direct and indirect impacts to a resource over time.

Datum – A point, line, or surface used as a reference, as in surveying, mapping, or geology.

Deciduous Forest – Forest composed mostly of trees that lose their leaves in the winter.

Decomposition – Breakdown or decay of organic materials.

Degradation Phase – The phase of the deltaic cycle when sediments are no longer delivered to a delta, and it experiences erosion, dieback, or breakup of marshes.

Deltaic Cycle – Capture of the Mississippi River by a distributary that offered a shorter route to the Gulf of Mexico. After abandonment of an older delta lobe, which would cut off the primary supply of freshwater and sediment, an area would undergo compaction, subsidence, and erosion. The old delta lobe would begin to retreat as the gulf advanced, forming lakes, bays, and sounds. Concurrently, a new delta lobe would begin its advance gulfward.

Deltaic Deposits – Mud and sand deposited at the mouth of a river.

Deltaic Plain – The land formed and reworked as the Mississippi River switched channels in the eastern part of the Louisiana coastal area.

Demersal – Dwelling at or near the bottom of a body of water (e.g., a demersal fish).

Detritus – The remains of plant material that has been destroyed or broken up.

Dewatering – The process of dredged sediments compacting while losing water after being deposited.

Discharge – The volume of fluid passing a point per unit of time, commonly expressed in cubic feet per second, millions of gallons per day, or gallons per minute.

Dissolved Oxygen – Oxygen dissolved in water, available for respiration by aquatic organisms. One of the most important indicators of the condition of a water body.

Direct Impacts – Those effects that result from the initial construction of a measure (e.g., marsh destroyed during the dredging of a canal). Contrast with “Indirect Effects.”

Diurnal – Relating to or occurring in a 24-hour period; daily.

Diversion – A turning aside or alteration of the natural course or flow of water. In coastal restoration this usually consists of such actions as channeling water through a canal, pipe, or conduit to introduce water and water-borne resources into a receiving area.

Dredged material embankments (Spoil Banks, Side-cast Banks, Excavated Material Banks) – Dredged material removed from canals and piled in a linear mound along the edge of canals.

Dynamic – Characterized by continuous change and activity.

Ecological – Refers to the relationship between living things and their environment.

Economic – Of or relating to the production, development, and management of material wealth, as of a country, household, or business enterprise.

Ecosystem – An organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation and animal life.

Ecosystem Restoration – activities that seek to return a organic community of plants and animals and their habitat to a previously existing or improved natural condition or function.

Effectiveness – Having an intended or expected effect. One of the USACE four requirements for a project.

Efficiency – The quality of exhibiting a high ratio of output to input. One of the USACE four requirements for a project.

Egress – A path or opening for going out; an exit.

Electrical Conductivity – The ability of a medium to conduct electricity. Salt water has a higher electrical conductivity than freshwater, and this property allows the measurement of salinity through a simple meter.

Embankment – A linear mound of earth or stone existing or built to hold back water or to support a roadway.

Encroachment –Entering gradually into an area not previously occupied, such as a plant species distribution changing in response to environmental factors such as salinity.

Endangered Species – Animals and plants that are threatened with extinction.

Endpoints – see Objectives

***Engineering News Record* (*ENR*)** – A magazine that provides news needed by anyone in or from the construction industry.

Enhance – To augment or increase/heighten the existing state of an area.

Entrenchment – Being firmly embedded.

Environmental Impact Statement (EIS) – A document that describes the positive and negative environmental effects of a proposed action and the possible alternatives to that action. The EIS is used by the Federal Government and addresses social issues as well as environmental ones.

Estuary – A semi-enclosed body of water with freshwater input and a connection to the sea where freshwater and saltwater mix.

Estuarine – Related to an estuary.

Evaporation – The process by which any substance is converted from a liquid state into, and carried off in, vapor; as, the evaporation of water.

Exotic Species – Animal and plant species not native to the area; usually undesirable (e.g., hyacinth, nutria, tallow tree, giant salvinia).

Faulting – A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are displaced relative to one another and parallel to the plane of fracture.

Feasibility Report – A description of a proposed action, previously outlined in a general fashion in a Reconnaissance Report, that will satisfy the Federal interest and address the problems and needs identified for an area. It must include an assessment of impacts to the environment (either in an Environmental Assessment, or the more robust Environmental Impact Statement), an analysis of alternative methods of completion, and the selection of a Recommended Plan through the use of a cost-effectiveness analysis.

Feature – A constructible increment of an alternative plan.

Federal Principals Group (FPG) –A collaboration among Federal agencies at the Washington level to facilitate the flow of information, to provide guidance and recommendations to the USACE and LDNR throughout the study process, and to facilitate resolution of any interagency issues that may be identified in the conduct of the study.

Final Array – The final grouping of the most effective coast-wide plans from which a final recommendation can be made.

Foreshore Dikes – An embankment of earth and rock built to prevent floods or erosion that is built in the area of a shore that lies between the average high tide mark and the average low tide mark.

Framework Development Team (FDT) – A group of professionals from various Federal and state agencies, academia and the public formed to provide a forum for individual members to discuss LCA Comprehensive Study activities and technical issues and to provide comments to the Senior Management Committee.

Fresh Marsh (FAM) – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 0–3 ppt.

Furbearer – An animal whose skin is covered with fur, especially fur that is commercially valuable, such as muskrat, nutria, and mink.

Geomorphic – Related to the geological surface configuration.

Geosynclinal Down-warping – The downward bend or subsidence of the earth's crust, which allows of the gradual accumulation of sediment

Geotropically – Downward growth in response to gravity, as in plant roots.

Glycophytes – A plant that cannot live in high salinity environments, most plants.

Goals – Statements on what to accomplish and/or what is needed to address a problem without specific detail.

Gradient – A slope; a series of progressively increasing or decreasing differences in a system or organism.

Habitat – The place where an organism lives; part of physical environment in which a plant or animal lives.

Habitat Loss – The disappearance of places where target groups of organisms live. In coastal restoration, usually refers to the conversion of marsh or swamp to open water.

Habitat Units (HUs) – Represent a numerical combination of quality (HIS) and quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with project scenarios are annualized, and averaged over the project life, to determine Average Annual Habitat Units (ASHUs). The "benefit" of a project can be quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference is AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality.

Hazardous, Toxic, and Radioactive Wastes (HTRW) – Projects features must be examined to ensure that their implementation will not result in excessive exposure to pollutants possibly located in the study area.

Headland – A point of land projecting into the sea or other expanse of water, still connected with the mainland.

Herbaceous – A plant with no persistent woody stem above ground.

Hydrodynamic – The continuous change or movement of water

Hydrology – The pattern of water movement on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hypoxia – The condition of low dissolved oxygen concentrations.

Indemnification – Insurance against or compensation for loss or damage.

Indirect Impacts – Those effects that are not as a direct result of project construction, but occur as secondary impacts due to changes in the environment brought about by the construction. Contrast with "Direct Impacts."

Infrastructure – The basic facilities, services, and installations needed for the functioning of a community or society, such as transportation and communications systems, water and power lines, and public institutions including schools, post offices, and prisons.

Ingress – An entrance or the act of entering.

Inorganic – Not derived from living organisms; mineral; matter other than plant or animal.

Interdistributary Deposits – Sand and mud deposited between the river channels or between bayous.

Intermediate Marsh (INM) – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 2–5 ppt.

Intertidal – Alternately flooded and exposed by tides.

Invertebrates – Animals without backbones, including shrimp, crabs, oysters, and worms.

Keystone Strategy – A strategy that other strategies rely upon for successful implementation.

Land-water Ratio – The relative proportion or wetlands and uplands to water in an area.

Larvae – The stage in some animal's life cycles between egg and adult (most invertebrates).

Leeward – Sheltered from the wind; away from the wind.

Levee – A linear mound of earth or stone built to prevent a river from overflowing; a long, broad, low ridge built by a stream on its flood plain along one or both banks of its channel in time of flood.

Loamy – Soil composed of a mixture of sand, clay, silt, and organic matter.

Maintain – To keep in existing state.

Measure – A programmatic restoration feature that can be assembled with other measures to produce alternative plans. See also "Project."

Methodology – A set of practices, procedures, and rules.

Mineral Substrate – Soil composed predominately of mineral rather than organic materials; less than 20 percent organic material.

Mudflats – Flat, unvegetated wetlands subject to periodic flooding and minor wave action.

Myatt Series – Gray terrace soil, with whitish, pebbly subsoil.

National Ecosystem Restoration (NER) – USACE standard for cost-effectiveness based on ecosystem, not economic, benefits.

Near-shore Currents – Movement of water parallel to the shoreline. Usually generated by waves breaking on the shore at an angle other than perpendicular.

National Environmental Policy Act (NEPA) – Ensures that Federal agencies consider the environmental impacts of their actions and decisions. NEPA requires all Federal agencies to consider the values of environmental preservation for all significant actions and prescribes procedural measures to ensure that those values are fully respected.

Net Gain – The amount of cumulative land gain less land loss, when gain is greater than loss.

Net Loss – The amount of cumulative land gain less land loss, when gain is less than loss.

No Action Alternative – The alternative in the LCA Plan which describes the ecosystem of the coastal area if no restoration efforts/projects were done.

Nursery – A place for larval or juvenile animals to live, eat, and grow.

Objectives – More specific statements than "Goals," describing how to achieve the desired targets.

Oceanic-dumping – The discharge of wastes or pollutants into offshore waters.

Organic – Composed of or derived from living things.

Oscillations – Fluctuations back and forth, or up and down.

Oxidation of Organic Matter – The decomposition (rotting, breaking down) of plant material through exposure to oxygen.

Oxygen-depleted – Situation of low oxygen concentrations where living organisms are stressed.

Petrochemical – Any compound derived from petroleum or natural gas.

Planning Scale – Planning term that reflects the degree to which environmental processes would be restored or reestablished, and the resulting ecosystem and landscape changes that would be expected over the next 50 years. This uppermost scale is referred to as "Increase." No net loss of ecosystem function is "Maintain." Reducing the project rate of loss of function is "Reduce." The lowest possible scale was no further action above and beyond existing projects and programs.

Point-Bar Deposit – The shallow depositional area on the inside bank of a river bend.

Post-larval – Stage in an animal's lifecycle after metamorphosis from the larval stage, but not yet fully grown.

Potable Water – Water that is fit to drink.

ppt – parts per thousand. The salinity of ocean water is approximately 35 ppt.

Primary Consolidation/Secondary Compression – Two processes acting on a substrate that has a load applied to it to cause the sediment to increase in density, and decrease in volume.

Prime Farmland – Land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, oilseed, and other agricultural crops with minimum inputs of fuel, fertilizer, pesticides, and labor, and without intolerable soil erosion. One of the categories of concern in the EIS.

Principles – Framing statements that can be used to evaluate alternatives while considering issues that affect them. Used along with targets and assessments of ecosystem needs to provide guidance in formulation of alternative plans.

Productivity – Growth of plants and animals.

Progradation – The phase during the deltaic cycle where land is being actively accreted through deposition of river sediments near the mouth.

Programmatic Environmental Impact Statement (PEIS) – and Environmental Impact Statement that supports a broad authorization for action, contingent on more specific detailing of impacts from specific measures.

Project – A constructible increment of an alternative plan.

Project Implementation Report (PIR) – A project-specific follow-up report that expands on the information contained in a Programmatic Feasibility Report to ensure NEPA compliance, such as conducting public meetings, preparing the appropriate environmental documentation, and preparing the engineering designs as specifications necessary to build the project.

Province – A major division of the coastal zone of Louisiana. (e.g., Deltaic Plain and Chenier Plain).

Pulsing – Letting a diversion flow periodically at a high rate for a short time, rather than continuously.

Quantitative – Able to assign a specific number; susceptible to measurement.

Radiocarbon Age Determination –The use of the ratio of carbon isotopes to determine age.

Rebuild – To some extent build back a structure/landform that had once existed.

Reconnaissance Report – A document prepared as part of a major authorization that examines a problem or need and determines if sufficient methods and Federal interest exists to address the problem/need. If so, then a "Feasibility Report" is prepared, which details the solution and its impacts further.

Reduce – To diminish the rate or speed of a process.

Regional Working Group (RWG) – An interagency team formed to support the Washington-level Federal Principal's Group and to facilitate regional level collaboration and coordination on the LCA study.

Rehabilitate – To focus on historical or pre-existing ecosystems as models or references while emphasizing the reparation of ecosystem processes, productivity and service.

Relative Sea Level Rise – The sum of the sinking of the land (subsidence) and eustatic sea level change; the change in average water level with respect to the surface.

Restore – Return a wetland to a close approximation of its condition or function prior to disturbance by modifying conditions responsible for the loss or change; re-establish the function and structure of that ecosystem.

Sangamonian Interglacial Period – the last interglacial period before the Holocene period (the current geological period).

Saline Marsh (SAW) – Intertidal herbaceous plant community typically found in that area of the estuary with salinity ranging from 12–32 ppt.

Salinity – The concentration of dissolved salts in a body of water, commonly expressed as parts per thousand.

Salt Marshes – See "Saline Marsh."

Scoping – Soliciting and receiving public input to determine issues, resources, impacts, and alternatives to be addressed in the draft EIS.

Sea-Level – Long-term average position of the sea surface.

Sediment Plume – Caused by sediment rich rainwater runoff entering the ocean. The runoff creates a visible pattern of brown water that is rich in nutrients and suspended sediments that forms a kind of cloud in the water spreading out from the coastline. Commonly forms at river and stream mouths, near sloughs, and along coasts where a large amount of rain runoff flows directly into the ocean.

Sheet Flow – Flow of water, sediment, and nutrients across a flooded wetland surface, as opposed to through channels.

Shoaling – The shallowing of an open-water area through deposition of sediments.

Slikensides – The smooth or partially polished surface of rock caused by one rock mass sliding over another in a fault plane.

Social – Relating to human society and its modes of organization.

Socioeconomic – Involving both social and economic factors.

Spoil Banks – Dredged material removed from canals and piled in a linear mound along the edge of canals.

Stabilize – To fix the level or fluctuation of; to make stable.

State Historic Preservation Office (SHPO) – The part of the Louisiana Department of Culture, Recreation, and Tourism that deals with Indian sites and other archaeological remains.

Stillstand – A period of time when sea level did not change.

Storm Overwash – The process by which sand is transposed landward over the dunes during a storm event by waves.

Storm Surge – An abnormal and sudden rise of the sea along a shore as a result of the winds of a storm.

Stough soils – Yellowish brown coarse-loamy soil.

Strategy – Ecosystem restoration concept from the Coast 2050 Plan.

Stream Gaging Data – Records of water levels in streams and rivers.

Submergence – Going under water.

Subprovince – The divisions of the two Provinces (see "Province") into smaller groupings: 1) east of the Mississippi River; 2) west of the Mississippi River to Bayou Lafourche; 3) Bayou Lafourche to Freshwater Bayou; 4) Freshwater Bayou to Sabine River.

Subsidence – The gradual downward settling or sinking of the Earth's surface with little or no horizontal motion.

Sustain – To support and provide with nourishment to keep in existence; maintain.

Tarbert Flow – Stream gage data recorded at Tarbert's Landing on the Mississippi River.

Target – A desired ecosystem state that meets and objective or set of objectives.

Terrestrial Habitat – The land area or environment where an organism lives; as distinct from water or air habitats.

Third Delta – A proposed project that would divert up to 120,000 cubic feet of water per second from the Mississippi River near Donaldsonville, Louisiana down a conveyance channel to the marshes in southern Barataria and Terrebonne Basins.

Toxicity – The measure of how poisonous something is.

Transpiration – The process by which water passes through living plants into the atmosphere.

Turbidity – The level of suspended sediments in water; opposite of clarity or clearness.

Unique Farmland – Land other than Prime Farmland (see "Prime Farmland") that is used for the production of specific high-value food and fiber crops, such as citrus, tree nuts, olives, cranberries, fruits, and vegetables.

Upconing – The tendency of underground saltwater to move closer to the surface in the vicinity of a well by drawing fresh ground water out.

Upland (UPL) – A general term for non-wetland elevated land above low areas along streams or between hills.

Water Resource Units (WRU) – Stage-damage data developed as part of the Flood Damage Estimation System (FDES) in 1980 for the Mississippi River and Tributaries (MR&T) project were used to estimate the flood damages that are expected to occur in subprovinces 1, 2, and 3. The data collected for the FDES were delineated into geographic areas with homogenous physical and hydraulic characteristics. These geographic areas were numerically coded and designated as Water Resource Units (WRUs). Within each WRU, land-use elements (structures, cropland, roads, bridges, railroads, etc.) were categorized by location, value, and corresponding depth-damage relationship. The structural damage categories included residential, commercial, industrial, public, and farm buildings.

Water Resources Development Act (WRDA) – A bill passed by Congress that provides authorization and/or appropriation for projects related to the conservation and development of water and related resources.

Weir – A dam placed across a canal or river to raise, divert, regulate or measure the flow of water.

9.5 ACRONYMS AND ABBREVIATIONS

ASA(CW)	Assistant Secretary of the Army for Civil Works
ATR	Agency Technical Review
CAA	Clean Air Act
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CIAP	Coastal Impact Assistance Program
CPRA	Coastal Protection and Restoration Authority (State of Louisiana)
CRCL	Coalition to Restore Coastal Louisiana
CWPPRA	Coastal Wetlands Planning, Protection, and Restoration Act
CZM	Coastal Zone Management
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ER	Engineering Regulation
ESA	Endangered Species Act
FHWA	Federal Highway Administration
FMP	Fisheries Management Plan
GIS	Geographic Information System
GIWW	Gulf Intracoastal Waterway

GMFMC	Gulf of Mexico Fishery Management Council
HET	Habitat Evaluation Team
HSDRRS	Hurricane and Storm Damage Risk Reduction System
HTRW	Hazardous, Toxic, and Radioactive Waste
IPET	Interagency Performance Evaluation Task force
IPDT	Interagency Project Delivery Team
IWR	Institute of Water Resources
LACPR	Louisiana Coastal Protection and Restoration
LCA	Louisiana Coastal Area (*Ecosystem Restoration Study*, 2004)
LCWRP	Louisiana Coastal Wetlands Restoration Plan
LDNR	Louisiana Department of Natural Resources
LDWF	Louisiana Department of Wildlife and Fisheries
LERRD	Land, Easements, Rights-Of-Way, Relocation, and Disposal Areas
LEQA	Louisiana Environmental Quality Act
LNHP	Louisiana Natural Heritage Program
LOSCO	Louisiana Oil Spill Coordinator's Office
LPBF	Lake Pontchartrain Basin Foundation
MDWD	Medium Diversion at White Ditch
MR&T	Mississippi River and Tributaries
MSA	Metropolitan Statistical Area
MVD	USACE Mississippi Valley Division
MVN	USACE New Orleans District
MVR	USACE Rock Island District
MVS	USACE St. Louis District
NAAQS	National Ambient Air Quality Standards
NAC	Noise Abatement Criteria
NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NGO	Non-Governmental Organization
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWRC	National Wildlife Research Center
CPRA	Coastal Protection and Restoration Authority
O&M	Operation and Maintenance
OMRR&R	Operation and Maintenance, Repair, Replacement and Rehabilitation
PEIS	Programmatic Environmental Impact Statement
PDT	Project Delivery Team
PPL	Project Priority List
S&T	Science and Technology

SEIS	Supplemental Environmental Impact Statement
USACE	U.S. Army Corps of Engineers
USDA-SCS	United States Department of Agriculture, Soil Conservation Service
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCRF	Wetlands Conservation and Restoration Fund
WVA	Wetland Value Assessment
WRDA	Water Resources Development Act

Integrated Feasibility Study and

Supplemental Environmental Impact Statement

for the

LCA Medium Diversion at White Ditch
Plaquemines Parish, Louisiana

(APPENDICES A – N)

The responsible lead Federal agency for this study is the U. S. Army Corps of Engineer District, *New Orleans*. The Non-Federal Sponsor for the study is *the Louisiana Coastal Protection and Restoration Authority*. The responsible cooperating Federal agency is the *U.S. Fish and Wildlife Service*. This report is a combined feasibility report and supplemental environmental impact statement complying with requirements of the U.S. Army Corps of Engineers (USACE) and the Council of Environmental Quality (CEQ), and is intended to reduce duplication and paperwork. An asterisk (*) in the table of contents notes paragraphs that are required for National Environmental Policy Act (NEPA) compliance.

October 2010

U.S Army Corps of Engineers
New Orleans District

Coastal Protection and Restoration Authority

Appendix A-1

Biological Assessment
U.S. Fish and Wildlife Service

U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT



September 2010

BIOLOGICAL ASSESSMENT for LCA - Medium Diversion at White Ditch

Prepared by: **U.S. Army Corps of Engineers**
New Orleans District

Lead Contact: **Thomas Parker**
U.S. Army Corps of Engineers, PD-RP

Physical Address:
7400 Leake Ave. Room 363
New Orleans, LA 70118

Mailing Address:
P.O. Box 60267
New Orleans, LA 70160-0267

Email: thomas.w.parker@usace.army.mil
Phone: (504) 862-2526
Fax: (504) 862-2088

Table of Contents

Introduction....1
Threatened, Endangered, and Proposed Threatened or Endangered Species....1
Sensitive Species and Species of Concern....1
Critical Habitat....2
Previous Consultation....2
Purpose....2
Location of the Proposed Action....3
Proposed Action....5
Species Description....8
Pallid Sturgeon....8
Status....8
Species and Habitat Description....8
Management and Protection....10
West Indian Manatee....12
Status....12
Species and Habitat Description....12
Management and Protection....13
Piping Plover....14
Status....14
Species and Habitat Description....14
Management and Protection....16
Bald Eagle....16
Status....16
Brown Pelican....17
Status....17
Colonial Nesting Birds....17
Status....17
Effects of the Proposed Action....17
Pallid Sturgeon....17
West Indian Manatee....18
Piping Plover....19
Conclusion....19
Literature Cited....20

Tables

Table 1: Summary of effort and number of sturgeon collected from the Mississippi River during the period 2001-2009 12

Figures

Figure 1: Study Area Map 4
Figure 2: Proposed Medium Diversion at White Ditch 6
Figure 3: Map of Proposed Medium Diversion at White Ditch 7
Figure 4: Piping Plover Range 14

[Cover Photo: Existing siphon at White Ditch]

Introduction

This Biological Assessment (BA) is submitted to the U.S. Fish and Wildlife Service (USFWS) by the U.S. Army Corps of Engineers, New Orleans District (CEMVN) in order to initiate formal consultation with USFWS regarding potential impacts to threatened and endangered species from construction and operation of the LCA Medium Diversion at White Ditch (MDWD) project. The following BA is promulgated in accordance with Section 7 (Interagency Consultation) of the Endangered Species Act of 1973, as amended (PL 93-205; 16 U.S.C. 1531 et. seq.). A separate BA has been prepared and will be submitted to the National Marine Fisheries Service for species under their purview, including Gulf sturgeon (*Acipenser oxyrhynchus desotoi*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricate*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochylys coriacea*), and the loggerhead sea turtle (*Caretta caretta*).

The purpose of this biological assessment is to evaluate the possible effects of the proposed construction and operation of the MDWD project on threatened, endangered and proposed threatened and endangered species and their habitats. Threatened, endangered and proposed threatened and endangered species are managed under the authority of the Federal Endangered Species Act (ESA) (PL 93-205, as amended). Under provisions of the ESA, Federal agencies shall use their authorities to carry out programs for the conservation of listed species, and shall insure any action authorized, funded, or implemented by the agency is not likely to: (1) adversely affect listed species or designated critical habitat; (2) jeopardize the continued existence of proposed species; or (3) adversely modify proposed critical habitat (16 USC 1536).

The species of concern that are known to inhabit the area are:

Threatened, Endangered, and Proposed Threatened or Endangered Species

Pallid Sturgeon (*Scaphirynchus albus*), was listed as endangered throughout its range on October 9, 1990 (55 FR 36641-36647)

West Indian Manatee (*Trichechus manatus*), was listed as endangered on June 2, 1970 (35 FR 8491, Appendix A)

Piping Plover (*Charadrius melodus*), was listed as threatened and endangered on December 11, 1985 (50 FR, 50720-50734)

Sensitive Species and Species of Concern

Bald Eagle (*Haliaeetus leucocephalus*), was de-listed on August 9, 2007 (72 FR 37345 37372)

Brown Pelican (*Pelecanus occidentalis*), was de-listed on November 17, 2009 (74 FR 59443 59472)

Colonial Nesting Birds

Critical Habitat

No critical habitat is currently designated for any of the threatened, endangered, or sensitive species within the project area.

Previous Consultation

Informal coordination with the USFWS Lafayette, LA office, for the effects to pallid sturgeon from entrainment through diversion structures, has been ongoing since the 2008 operation of the Bonnet Carre Spillway. There has been no coordination conducted for the proposed action described in this document.

Purpose

This LCA Medium Diversion at White Ditch (MDWD) project is to help restore areas where an altered supply and distribution of freshwater, lack of deltaic forming sediments, marsh subsistence and human development in the White Ditch area have resulted in degraded and unbalanced distribution of freshwater, brackish, and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, altered hydrology and changed salinity regimes.

Installation of the White Ditch diversion siphon was completed in 1963 with the objective of enhancing muskrat and oyster habitat. In the absence of an outfall management plan, the surrounding marsh received limited benefits from the diverted river water. Two 50-inch steel pipes divert water from the Mississippi River through the White Ditch, into the Belair Canal and then into the River aux Chenes, where it continues south and out of the project area. Usage of the siphons was abandoned for many years and they degraded into a non-usable condition. The siphons were recently refurbished and water was diverted into White Ditch as part of research efforts.

Wetlands in the project area are deteriorating for several reasons: 1) subsidence, 2) lack of sediment and nutrient deposition, 3) erosion via tidal exchange, 4) channelization, 5) saltwater intrusion and 6) lack of freshwater. Recent hurricanes and tropical storms have also caused significant damage to the project area. These activities have resulted in the loss of several thousand acres of previously solid, vegetated marsh. Deterioration will continue unless preventative measures are taken.

In the absence of supplemental freshwater and sediment from the Mississippi River, subsidence, sea-level rise, wave erosion, and saltwater intrusion will continue to be problems. Protection and enhancement of this area are dependent on providing a hydrologic and sediment regime that minimizes the physiological stress to wetland vegetation from saltwater intrusion and tidal energy and is conducive to the retention of locally provided freshwater and sediments

The historic geology of the project area indicates that the current course of the Mississippi River has remained the same for the last 700 years and has directly influenced the

development of the entire area. The project area is located on the east side of the Mississippi River and was formed between two natural levee ridge systems, River aux Chenes on the east and the Mississippi River on the west. There are also two unnamed bayou ridges found within the project area. These ridges formed along the old natural bayous which were distributary channels for the Mississippi River. These natural bayous once carried sediments and nutrients into the project area during high river stages when the natural ridges were seasonally overtopped.

In the historical setting, floodwater from the river would recede and sediments and nutrients would be deposited in the inter-distributary basins located between ridges. During normal or low river stages the ridges along the distributary channels served like levees and buffered the basin areas from the daily tidal influence. This buffering effect created a low energy freshwater environment in the inter-distributary basins, forming deep organic soils. Drainage to the area was provided by a high water event breaching the River aux Chenes ridge in the southern part of the project area. This event caused the development of the Bayou Garelle tributary channel.

The present day hydrology of the project area has been altered and no longer functions in a historically natural pattern. Historically, water moved very slowly through the system. Freshwater slowly exited the system through meandering pathways in the marsh and saltwater was slow to intrude. Presently, changes in the marsh allow water to rapidly pass through the system and saltwater is able to quickly intrude. The hydrologic balance within the marsh has been disturbed due to the following man-made changes:

1. The Mississippi River can no longer overflow its banks into the project area due to the Mississippi River protection levee. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns.
2. Channels have been dredged through natural ridges which has increased drainage and tidal exchange and exposed the soil to erosive forces.

This project was identified as a Near-term Critical Restoration Feature Recommended for Study and Future Congressional Authorization in the LCA Main Report dated January 21, 2005. In November 2007, the Water Resources Development Act of 2007 passed, authorizing this and other projects from the LCA Main Report. The MDWD feasibility study is anticipated to result in a Chief's Report containing a recommended plan to construct a Mississippi River diversion in the vicinity of White Ditch for the purposes of introducing freshwater, sediments, and nutrients into the study area.

Location of the Proposed Action

The MDWD project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana (see Figure 1). The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats that has been heavily influenced by both man-made and natural processes. Channel construction, subsidence, erosion, saltwater intrusion, and storm-related damages have all significantly altered the natural environment, causing extensive losses of wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal

back levee and the forty-arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound basin.

There are two discreet project locations that will be considered for the purposes of the feasibility study: The area along the Mississippi River where a freshwater diversion structure might be located; and the project area that could be influenced and benefited by the diverted freshwater. The area of interest where a diversion structure could be located occurs on the left descending bank of the Mississippi River, between White Ditch to the north (river mile 64.5) and the community of Phoenix to the south (river mile 59.8). This 4.7 mile stretch is unique in that there is no hurricane protection levee (back levee) on the marsh side that protects existing homes and infrastructure from elevated water levels (tidal or storm surge). The Mississippi River levee is the only flood protection structure that keeps river water from entering the project study area. This situation minimizes the amount of infrastructure that could be affected by construction of a diversion structure and allows for a broader array of measures to be considered in addressing problems in the project area.

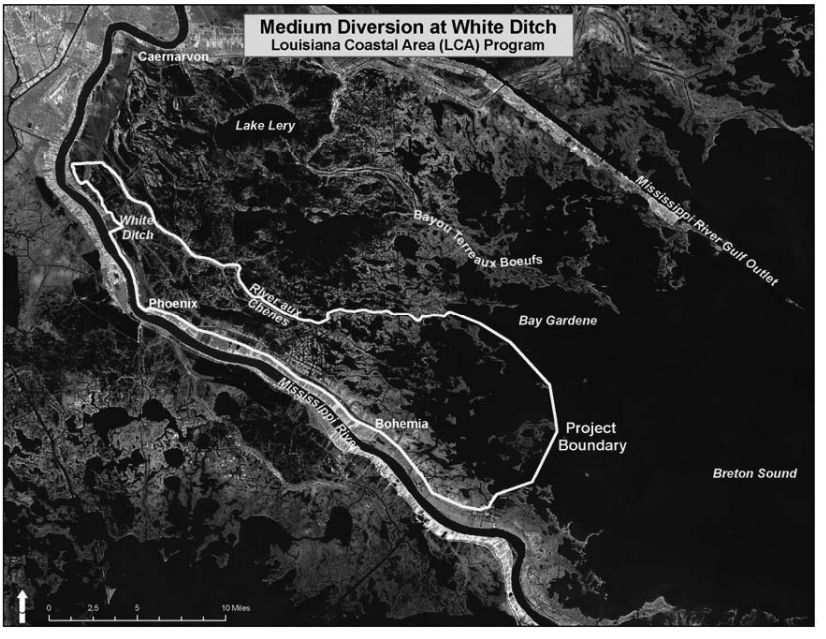


Figure 1: Study Area Map

Proposed Action

The tentatively selected plan proposes the construction of a medium sized diversion structure capable of diverting up to 35,000 cfs consisting of 10 15-ft. x 15-ft. box culverts with hydraulic operated sluice gates, and constructing an outfall channel to carry fresh water and sediment to the desired locations in the marsh. Additionally, there will be 32 acres of ridge and terrace creation and 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

The current operating plan for the tentatively selected plan at the White Ditch Diversion is limited to a diversion pulse of 35,000 cfs in March-April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year. This flow rate may not be experienced over the full 60-day period. The proposed 35,000 cfs diversion will be the largest man-made diverted flow for wetland building on the Lower Mississippi River, but the one to two month duration will be a modifying factor. The diversion should approximate five percent or less of the main channel flow for most years.

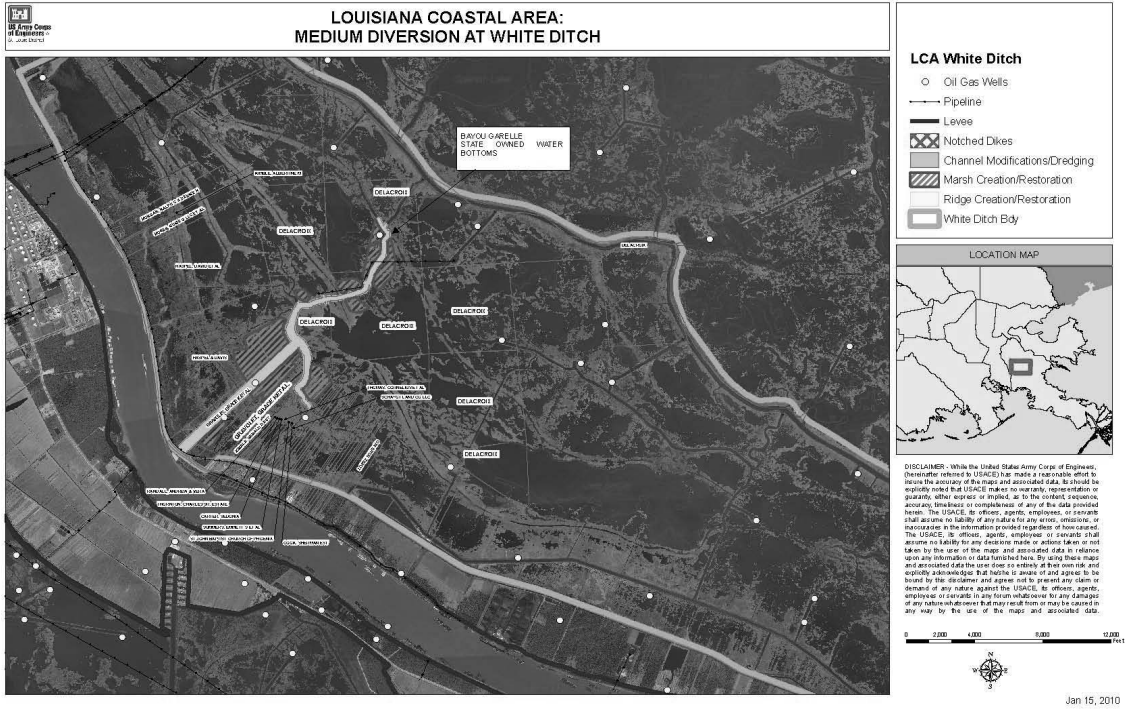


Figure 2: Proposed Medium Diversion at White Ditch

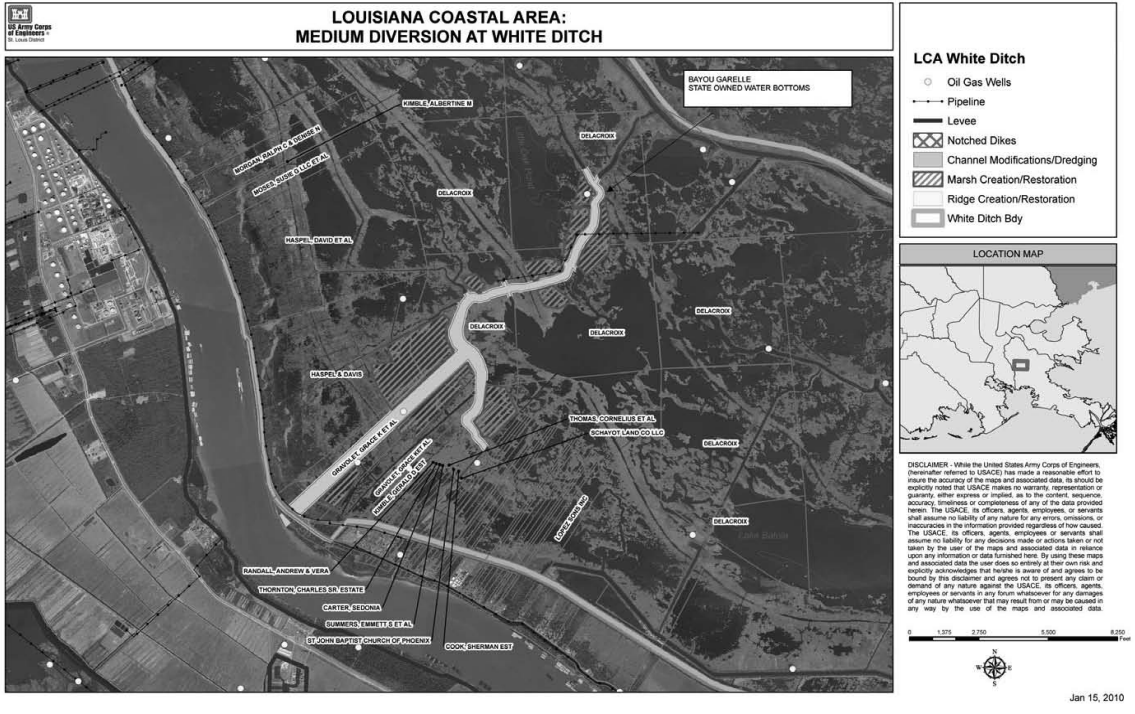


Figure 3: Map of Proposed Medium Diversion at White Ditch

Species Descriptions

Pallid Sturgeon (*Scaphirynchus albus*)

Status

The pallid sturgeon was listed as endangered throughout its range on October 9, 1990 (55 FR 36641-36647). The reasons for listing were habitat modification, apparent lack of natural reproduction, commercial harvest, and hybridization in parts of its range. To date no critical habitat has not been proposed or designated for this species.

Species and Habitat Description

The pallid sturgeon is a bottom oriented, large river obligate inhabiting the Missouri and Mississippi Rivers from Montana to Louisiana and the Atchafalaya River. The pallid sturgeon is adapted to the predevelopment habitat conditions that historically existed in these large rivers. Those conditions can generally be described as large, free-flowing, warm water, turbid habitats with a diverse assemblage of physical attributes that were in a constant state of change. Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters formed the large-river ecosystem that provided macrohabitat requirements for all life stages of pallid sturgeon and other large river fish. Within this range, pallid sturgeon tend to select main channel habitats in the Mississippi River and main channel areas with islands or sand bars in the upper Missouri River (USFWS 2009).

Pallid sturgeon are Federally listed as endangered and have been described as one of the rarest fish in North America. The pallid sturgeon was listed due to the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of decline in reproduction, growth, and survival of the pallid sturgeon. The curtailment of range and habitat destruction/modification were primarily attributed to the construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stem Missouri River and Mississippi Rivers. Dams substantially fragmented pallid sturgeon range in the upper Missouri River. However, free-flowing riverine conditions currently exist throughout the lower 2,000 mi (3218 km) (60%) of the pallid sturgeon's historical range (USFWS 2009). Until this past decade, they were considered a rare occurrence in the Lower Mississippi. New information from recent collection efforts indicates that the Mississippi River currently supports substantial numbers of wild fish. Since 1997, more than 200 pallid have been collected at more than 60 locations in the Mississippi River between the confluence of the Missouri River and New Orleans, LA (Bettoli, 2006). When listed, there were only 28 recognized records of pallid sturgeon from the Mississippi River, with no recognized records from the Atchafalaya River (USFWS 2009).

Pallid sturgeon feed on a range of animals from aquatic insects to fish depending upon life stage. Individuals of the species can be long lived with females reaching sexual maturity later than males. Spawning is thought to take place in side channels and backwaters and appears to occur between June and August. Larval fish produced from the spawning event drift

downstream from the hatching site and begin to settle from the lower portion of the water column 11 to 17 days post hatch. Although morphologically distinct pallid sturgeon as small as 450 mm FL are occasionally captured, some young-of-year and sub-adult pallid sturgeon may be misidentified as shovelnose or hybrids (USFWS 2007). Although pallid sturgeon captures in the middle and lower reaches of the Mississippi River continue to increase with fishing effort, habitat use, population levels and trends, and movement patterns within this portion of the species range remain unknown. Extensive sampling in the lower Mississippi River is currently being undertaken by U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) so that a better understanding of population size, population density, habitat preference, extent of range in lower Mississippi River, and impacts from entrainment on the population can be quantified.

Forbes and Richardson (1905), Schmulbach et al. (1975), Kallemeyn (1983), and Gilbraith et al. (1988) describe pallid sturgeon as being a fish well-adapted to life on the bottom in swift water of large, turbid, free-flowing rivers. Mayden and Kuhajda (1997) describe the natural habitats to which pallid sturgeon are adapted as: braided channels, irregular flow patterns, flooding of terrestrial habitats, extensive microhabitat diversity and turbid waters. The historic floodplain habitat of the Missouri and Mississippi Rivers provided important functions for the native large-river fish. Floodplains were the major sources of organic matter, sediments, and woody debris for the main stem rivers when flood flows crested their banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels. The chutes or sloughs between the islands and shore were shallower and hand less current than the main channel. These areas provided valuable diversity to the fish habitat, and probably served as nursery and feeding areas for many aquatic species (Funk and Rovinson 1974). The still waters in this transition zone allow organic matter accumulations; important to macroinvertebrate production. Both shovelnose and pallid sturgeon have a high incidence of aquatic invertebrates in their diet (Carlson et al. 1985; Gardner and Stewart 1987). Flood flows connected those important habitats and allowed fish from the main channel to utilize those habitat areas and to exploit available food sources (USFWS 2009).

Captures of pallid sturgeon in the Mississippi River have been associated with islands, sand bars, gravel bars, and dikes, in both the main channel and in secondary channels (USFWS 2007). On April 4, 2008, one week prior to the 2008 opening of the Bonnet Carre Spillway, personnel of the LDWF captured at least one pallid sturgeon in willow trees along the flooded bank of the river adjacent the Spillway structure. Although no diagnostic measurements were taken of the sturgeon, experts who have reviewed the photographic evidence have all concluded that the fish was a pallid sturgeon. This capture represents a very rare capture of a pallid sturgeon from the flooded riverbank of the river. Prior to this capture, pallid sturgeon were generally believed to inhabit only the main river channel and side slopes, not overbank areas during high-water events. It is not known if pallid sturgeon might also be found in grassy or revetted areas. Dr. Jack Killgore, who is in charge of the ERDC's sampling efforts, believes that pallid sturgeon could be found over nearly any flooded habitat, if enough sampling effort was expended, but they are more likely to be found in open water than in flooded willows. Currently as part of the sampling effort being performed by ERDC habitat data is being collected to better understand what habitat features are attracting the pallid sturgeon to swim up in the water

column and to the flooded river banks which makes them more prone to entrainment by diversion structures.

Genetic and morphological data have been used to differentiate pallid sturgeon into three groupings, an upper Missouri River group and two less differentiated groups in the lower Missouri/middle Mississippi and Atchafalaya River (USFWS 2007). This data suggest that the genetic structuring within the pallid sturgeon's range represents two distinct groups at the extremes of the species range with a middle intermediate group representing the lower Missouri and middle Mississippi Rivers. This pattern is suggestive of a pattern of isolation by distance, with gene flow more likely to occur between adjacent groups than among geographically distant groups, and thus, genetic differences increase with geographical distance.

Management and Protection

Aquatic habitats in the Mississippi River have been modified though the construction of flood control levees and channel modification through time, and some changes resulting from those modifications have likely been detrimental to pallid sturgeon (USFWS 2007). Although the river flows unobstructed for about 2,000 river miles (RM) from Gavins Point Dam in the middle Missouri River to the Gulf of Mexico, tributary impoundments, bendway cutoffs, and dike and levee construction have each changed localized patterns of channel erosion and deposition in the Mississippi River; collectively they resulted in a degradation trend throughout the system. Effects of these changes on pallid sturgeon are unknown, because there are no historical data for comparison. In 1981, the USACE established the Lower Mississippi River Environmental Program, with a goal of protecting fisheries and other natural resources in the lower Mississippi River (USFWS 2007). Input from the Lower Mississippi River Environmental Program resulted in experimentations with dike placement and notches as measures to protect secondary channels and maintain shallow water and fisheries habitats.

The Pallid Sturgeon Lower Basin Recovery Workgroup has identified information gaps essential to the consultation and recovery processes in the Lower Mississippi River Basin. These include: relative abundance of pallid sturgeon, demographics, feeding habits, habitat use, hybridization ratios, presence of fish diseases in the wild, population anomalies, and reliable separation and identification of pallid sturgeon, shovelnose sturgeon, and hybrids. While recent publications have contributed to filling some of these data gaps (e.g., Killgore et al., 2007) incomplete knowledge of those areas remains. Therefore, the sturgeons' response and the effect to encountering the diversion flows (e.g., avoidance, actively sought) is unknown, which can affect the number of sturgeon believed to be "taken" by a structure's operation. It is not know if the number of sturgeon that risk entrainment within a diversion structure are; only those located near the structure during its opening (no increase in sturgeon entrained because of active avoidance); are sturgeon that actively swam into the structure seeking velocity refuge from main-channel flows and/or seeking food sources on the batture and/or in a perceived secondary channel (i.e., spillway); or are entrained during down-river migration passively (i.e., no avoidance) or actively (i.e., failed to resist entrainment) or a combination of any of the above. There are no known topographic or hydrographic features that would appear to attract the sturgeon to the vicinity of the MDWD (USFWS 2009).

Water diversions are used for flood control, water supply, and habitat restoration in the lower Mississippi River (LMR) but their impacts on imperiled sturgeon populations are unknown. Comprehensive risk assessments for entrainment of sturgeon by water diversions require substantial inputs including field data on local sturgeon populations, life history information, output from population modeling simulations, and results of experimental studies. These risk assessments, however, can provide probability of entrainment for specific environmental scenarios (e.g., time of year, river stage, and flow fields generated by a structure). After the entrainment of 14 pallid sturgeon by a diversion structure was documented during the 2008 operation of the Bonnet Carre Spillway the USFWS tasked CEMVN with researching what effect diversion structures might have on the pallid sturgeon. CEMVN tasked ERDC with analyzing the effects and a scope of work (SOW) was prepared. The SOW provided details on materials and methods of sampling, duration, etc. and was provided to the USFWS Lafayette, LA office for review. The USFWS provided its comments on the SOW. Since this time ERDC has contracted USFWS Fisheries Biologist's from the Baton Rouge, LA office as well as Dr. Dave Shultz from Nicholls State University to assist in sampling river sites within the vicinity of existing and proposed diversion structures.

ERDC has documented numerous shovelnose and pallid sturgeon within two of the three reaches of the Mississippi River with proposed or existing diversions, and trotline data provide estimates of relative abundance among adjacent reaches (Table 1). No sturgeon have been collected from RM 0-70, the reach including White's Ditch and the proposed Myrtle Grove diversion. Only four adult sturgeon have been collected from RM 70-100, the reach containing Violet siphon and Caernarvon. Catch-per-unit-effort (CPUE) values for shovelnose sturgeon (0.14/trotline) and pallid sturgeon (0.05/trotline) are low, compared to those previously documented (1.88-5.41/trotline and 0.12-0.31/trotline, respectively) suggesting that densities are substantially lower than elsewhere in the free-flowing Mississippi River (Killgore et al., 2007). Over 150 sturgeon have been collected from RM 100-200, the reach including Davis Pond and Bonnet Carre, and the proposed Convent/Blind River and Hope Canal projects. CPUE is relatively low in this reach for shovelnose sturgeon (0.79/trotline) but high for pallid sturgeon (0.32/trotline). More than 200 sturgeon have been collected from RM 200-300 where no diversions are under consideration. CPUE is relatively high in this reach for shovelnose sturgeon (6.0/trotline) and pallid sturgeon (0.25/trotline). Trawling data are less robust than trotline data but support a longitudinal trend of greater sturgeon abundance upriver.

The data indicates entrainment risk by diversions to pallid sturgeon. Although catch rates are comparatively low in the affected reaches, ratios of pallid sturgeon to shovelnose sturgeon are high: 1:3 in RM 70-100, 1: 2.4 in RM 100-200. These ratios are substantially greater than the 1:6 ratio documented previously for RM 154-502 and 1:16 to 1:36 ratios observed elsewhere (Killgore et al., 2007). Young-of-year sturgeon, with weaker swimming abilities than adults (Adams et al., 1997; Adams et al., 1999) also occur and will be at greater risk of entrainment. To date, entrainment of pallid sturgeon has been documented for the Davis Pond diversion and Bonnet Carre spillway.

Table 1: Summary of effort and number of sturgeon collected from the Mississippi River during the period 2001-2009.					
River Mile	Gear	Times Deployed	Number of Shovelnose sturgeon	Number of Pallid sturgeon	Number of Sturgeon yoy
0-70	Trotline	21	0	0	0
	Trawl	21	0	0	0
70-100	Trotline	21	3	1	0
	Trawl	10	0	0	2
100-200	Trotline	150	118	49	
	Trawl	46	1	0	5
200-300	Trotline	31	186	8	0
	Trawl	16	11	1	5

Commercial take of any species of sturgeon was prohibited by Mississippi and Louisiana during the early 1990s to avoid incidental take of pallid sturgeon. Although some poaching of the species probably still occurs this value is not quantifiable. Other factors which threaten the species include: predation, disease, contaminants, tug boat propeller entrainment, and hybridization.

West Indian Manatee (*Trichechus manatus*)

Status

The West Indian manatee was listed as endangered throughout its range for both the Florida and Antillean subspecies on June 2, 1970 and received Federal protection with the passage of the ESA in 1973. Critical habitat was designated in 1976, 1994, 1998, 2002, and 2003 for the Florida subspecies.

Species and Habitat Description

The West Indian manatee is a large gray or brown aquatic mammal. Adults average approximately 10 feet in length and weigh up to 2,200 pounds. They have no hind limbs, and their forelimbs are modified as flippers. Manatee tails are flattened horizontally and rounded. Their body is covered with sparse hairs and their muzzles with stiff whiskers (USFWS 2001). The nostrils, located on the upper snout, open and close by means of muscular valves as the animal surfaces and dives (Husar 1977, Hartman 1979). Manatees will consume any aquatic vegetation (i.e., submerged, floating, and emergent) available to them and sometimes even shoreline vegetation. Although primarily herbivorous, they will occasionally feed on fish. Manatees may spend about 5 hours a day feeding, and may consume 4 to 9 percent of their body weight per day.

Observations of mating herds indicate that females mate with a number of males during their 2- to 4-week estrus period, and then they go through a pregnancy estimated to last 12 to 14 months (O'Shea *et al.* 1992). Births occur during all months of the year with a slight drop during winter months. Manatee cows usually bear a single calf, but 1.5 percent of births are twins. Calves reach sexual maturity at 3 to 6 years of age. Mature females may give birth every 2 to 5 years (USFWS 2001).

Manatees inhabit both salt and freshwater of sufficient depth (5 feet to usually less than 20 feet) throughout their range. Shallow grassbeds with ready access to deep channels are preferred feeding areas in coastal and riverine habitats (USFWS 2001). They may also be encountered in canals, rivers, estuarine habitats, saltwater bays, and have been observed as much as 3.7 miles off the Florida Gulf Coast. Between October and April, Florida manatees concentrate in areas of warmer water. Severe cold fronts have been known to kill manatees when the animals did not have access to warm water refuges. During warmer months they appear to choose areas based on an adequate food supply, water depth, and proximity to fresh water. Manatees may not need fresh water, but they are frequently observed drinking water from hoses, sewage outfalls, and culverts.

During winter months, the United States' 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. Power plant and paper mill outfalls created most of the artificial warm water refuges utilized by manatees. During summer months, they migrate as far north as coastal Virginia on the east coast and the Louisiana coast in the Gulf of Mexico.

During summer months, manatees disperse from winter aggregation areas, and are commonly found almost anywhere in Florida where water depths and access channels are greater than 3.3 to 6.6 feet (O'Shea 1988). In the warmer months, manatees usually occur alone or in pairs, although interacting groups of 5 to 10 animals are not unusual (USFWS 2001). A few individuals have been known to stray as far north as the northern Georgia coast and as far west as the coastal waters of Louisiana.

In the early 1980s, scientists tried to develop procedures for estimating the overall manatee population in the southeastern United States (USFWS 2001). The best estimate throughout the State of Florida was 1,200 manatees (Reynolds and Wilcox 1987). In the early 1990s, the State of Florida initiated a statewide aerial survey in potential winter habitats during periods of severe cold weather (Ackerman 1995), and the highest count of 3,276 manatees was recorded in January 2001. Manatees were reported in Lake Pontchartrain prior to the landfall of Hurricane Katrina, however, there were no reports of manatee mortality following the hurricane.

Management and Protection

The most significant problem faced by manatees in Florida is death or injury from boat strikes (USFWS 2001). Minimum flows and levels for warm water refuges need to be established to ensure their long-term availability for manatees. Their survival will depend on maintaining the ecosystems and habitat sufficient to support a viable manatee population

(USFWS 2001). The focus of recovery is on implementing, monitoring, and addressing the effectiveness of conservation measures to reduce or remove threats that will lead to a healthy and self-sustaining population (USFWS 2001).

The West Indian manatee is also protected under the Marine Mammal Protection Act (MMPA) of 1972. The MMPA establishes a national policy for the maintenance of health and stability of marine ecosystems and for obtaining and maintaining optimum sustainable populations of marine mammals. It includes a moratorium on the taking of marine mammals. The recovery planning under the ESA includes conservation planning under the MMPA (USFWS 2001).

Piping Plover (*Charadrius melodus*)

Status

The USFWS determined the piping plover to be endangered and threatened on December 11, 1985. Endangered status was determined for the plover in the watershed of the Great Lakes (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario). It was determined to be threatened in the remainder of its range: northern Great Plains (Iowa, northwestern Minnesota, Montana, Nebraska, North Dakota, South Dakota, Alberta, Manitoba, and Saskatchewan); Atlantic coast (Quebec, Newfoundland, Maritime Provinces, and states from Maine to Florida); Gulf coast (Florida to Mexico); Bahamas; and West Indies.

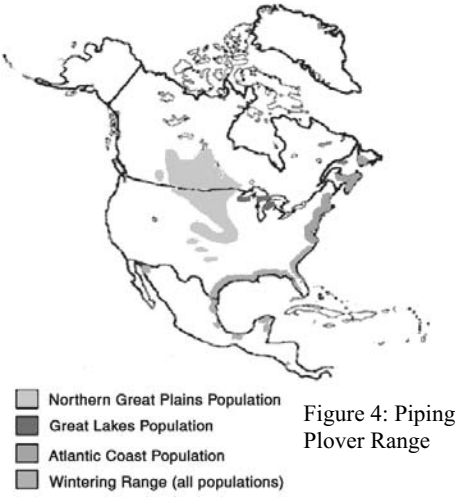


Figure 4: Piping Plover Range

Species and Habitat Description

The piping plover is a shorebird that inhabits open beaches, alkali flats, and sandflats of North America. It breeds primarily along the Atlantic coast from North Carolina to southern Canada, along rivers and wetlands of the northern Great Plains from Nebraska to the southern prairie provinces, and along portions of the western Great Lakes. In winter, most individuals are found on coastal beaches and sand flats from the Carolinas to Yucatan; some scatter through the Bahamas and West Indies. (Haig, 1992)

This plover is divided into two subspecies based on geographic distribution and presence or absence of complete neck bands, although there is little support for this designation (Haig and Oring 1988a). Numerous breeding studies have been conducted across the species range, yet habitat requirements and limiting factors remain poorly known. Conservation efforts are well

organized in breeding areas across North America, whereas little has been attempted in winter areas.

Ideal wintering habitat for the piping plover on the Gulf of Mexico coast would contain large sand flats or sand-mud flats adjacent to a tidal pass or tidal inlet (Haig 1985, Nicholls 1989). A thin layer of mud covering the sand seems to attract plovers, due to possible food or refuge association (Nicholls 1989). Nicholls observed that barrier beaches with over wash areas or sections of old marshes also attract plovers. A gulf-facing beach having a very low gradient, thus an increased intertidal zone, offers an almost equally attractive area (Haig 1985). Also piping plovers will inhabit spoil islands on the Gulf Intracoastal Waterway on both Atlantic and Gulf Coasts. Birds are frequently associated with bays, lagoons and inlets. Winter 2001 census observations were in the following habitat type: mudflats (36.3%), sandy beaches (33.2%), sand/salt flats (23.1%) algal mats (2.8%), oyster reefs (1.0%) and gravel shores (0.1%; Haig 2004).

Foraging habitat in winter is fairly consistent among numerous Gulf and Atlantic coast sites. On Dauphin Island, AL: protected mudflats or sandflats exposed at low tide; at Texas sites: primarily bayshore sand and algal flats. Comparison among 36 Atlantic winter sites (222 birds observed once each) and 75 Gulf sites (1,508 birds observed once each) indicates foraging activity most often associated with mudflats (25.6% of observations), sandflats (25.1%), and sandy mudflats (31.8%; Haige, 2004).

The historical breeding range in North America of the piping plover included the Atlantic coastal beaches from Newfoundland to South Carolina; beaches of the Great Lakes; and the northern Great Plains region from Alberta to Ontario and south to Nebraska (USFWS, 1988). These populations were reported to winter along the Gulf of Mexico, the Atlantic coast from North Carolina to Florida, eastern Mexico, and in the Caribbean Islands (Haig and Oring, 1985). Approximately 35 percent of the total breeding piping plover population winters along the gulf coast from Florida to Texas and represents 56 percent of the Great Lakes/Great Plains population (Natureserve 2002, 2003).

All populations could potentially occur within the proposed action areas since it falls within the wintering range of the species. They arrive from their northern breeding grounds as early as late July and may be present for 8 to 10 months of the year. Inland breeders appear to migrate nonstop to the Gulf of Mexico or Atlantic Coast. Great Lakes and Northern Plains birds are rare at seemingly appropriate inland stopover places: Great Salt Plains National Wildlife Refuge, OK, and Cheyenne Bottoms National Wildlife Refuge, KS (Haig, 1986). Existing stopover records suggest that migration routes are predominantly south/southeast in the fall. In fall, birds depart Massachusetts breeding sites by late August (Haig, 2004). Some Manitoba and North Dakota, but others with nests hatching late July or early August stay into September. Generally, females go first, then unpaired males, males with fledglings, followed by unaccompanied juveniles. Peak return to Texas beaches is in August and September, although small numbers may arrive as late as November. Adults may arrive before juveniles as early captures in Texas were of adult birds (sex unknown) and juveniles were not recorded until early November; however, since sample size was small further research is needed.

Management and Protection

Hunting in the early 1900s resulted in a drastic reduction of the piping plover population. Ongoing destruction of historical nesting sites further reduced plover populations (USFWS 1988). The primary causes for decline of this species are listed as habitat loss and degradation and human disturbance. Loss of breeding habitat has resulted from recreation and commercial development of sandy beaches on the Great Lakes, Atlantic Coast, and Gulf of Mexico. Where breeding does occur on coastal beaches, inland lakes, and river sites, reproductive success has been reduced by disturbance from humans and pets. Additional habitat has been lost due to construction and operation of reservoirs and river channelization.

Dune stabilization projects that result in steep beach slopes, narrower beach widths, or increased vegetation to the water's edge, reduce piping plover habitat (Haig 1985). In at least one instance, stabilization of the backside of the dune on Padre Island, Texas, resulted in the destruction of essential sand flat habitat (USFWS ESIS). Additionally, increased urbanization has led to an increase in predation on the piping plover population (USFWS 1988). Recreational activities in localized areas along the gulf coast have been correlated with a decrease in piping plover use of those areas (Nicholls 1989).

Habitat loss is a problem on both breeding and wintering grounds. It occurs when nesting beaches or basins become unsuitable or unavailable to piping plovers through natural causes such as drought, vegetation encroachment, tides and floods, as well as through activities such as beach visitation, housing developments, cattle ranching and water management. Natural factors will undoubtedly continue to be an unpredictable challenge for piping plover recovery in the future, and habitat loss due to human activity will increase with demands for more resources, recreation and living space, as the human population continues to grow (National Recovery Plan).

Bald Eagle (*Haliaeetus leucocephalus*)

Status

The successful recovery of bald eagle populations within the continental United States resulted in the delisting of the species from the Endangered Species List by the FWS on August 9, 2007. The bald eagle may nest in some of the remaining large cypress trees within the project area. Though delisted, bald eagles and other raptors are still protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Following the National Bald Eagle Management (NBEM) Guidelines to minimize potential adverse impacts to bald eagles, a "no-work" distance would be established within 660 feet of any bald eagle nests occurring in the project area, during the breeding season, from October 1 thru May 15. In addition, the Division of Migratory Birds for the Southeast Region of the FWS would be contacted prior to start of project activities to update the status of known bald eagle nests and to ascertain if any new nest are discovered within or adjacent to the proposed disposal site. It is expected that the tentatively proposed plan is not likely to adversely affect the bald eagle.

Brown Pelican (*Pelecanus occidentalis*)

Status

The successful recovery of the brown pelican population within the continental United States resulted in the delisting of the species from the Endangered Species List bye the FWS on November 17, 2009. Though delisted, brown pelicans are still protected by the Migratory Bird Treaty Act. The brown pelican is a year-round resident of Louisiana that typically forages on fishes throughout the study area. This colonial nester has established a colony on Raccoon Point on Isles Dernieres, Queen Bess Island, Plover Island (Baptiste Collette), Wine Island, and islands in the Chandeleur chain. In winter, spring, and summer, nests are built in mangrove trees or other shrubby vegetation, although occasional ground nesting may occur. Small coastal islands and sand bars are typically used as loafing areas and nocturnal roosting areas. It is expected that the tentatively proposed plan is not likely to adversely affect the brown pelican.

Colonial Nesting Birds

Status

Colonial nesting birds may nest in the area. Colonial nesting marine birds and wading birds (waterbirds) share the characteristic of typically nesting in colonies. They represent several orders of waterbirds, (i.e. cormorants, herons, egrets, ibises, gulls, terns, and skimmers**)** and are important and conspicuous components of coastal ecosystems. With there tendency to nest in colonies disturbance and habitat modifications can affect large numbers of them at one time.

Colonial nesting wading birds (including, but not limited to herons, egrets, and ibis) and seabirds/waterbirds (including, but not limited to terns, gulls, black skimmers, and brown pelicans) should be avoided to reduce the risk of injuring birds. The nesting activity period generally extends from February 15 through September 15. No colonial nesting bird colonies are known to exist in areas that would be directly affected by the proposed action. The lack of suitable colonial nesting habitat within the directly affected area strongly suggests that no nesting colonies would be affected. The Corps has standard procedures in place to investigate construction sites for the presence of colonial nesting birds prior to project construction. With these procedures in place, and the low probability of encountering colonial bird nesting sites, the proposed action is not likely to adversely affect these species.

Effects of the Proposed Action

Pallid Sturgeon (*Scaphirynchus albus*)

Unpublished data suggests that a pallid sturgeon may have been captured in the past in the Delta National Wildlife Refuge near the Head of Passes of the Mississippi River (Walther, personal communication.). However, due to the similarities of pallid sturgeon and shovelnose sturgeon, this record could be considered as questionable. Other than this account no pallid sturgeon have been captured and identified within the reach of river that abuts the proposed MDWD. ERDC's current sampling effort has not yielded any pallid or shovelnose captures

south of RM 70 to date. Since the MDWD is located at RM 64.5, the risk of entrainment by this diversion structure is low. Though it may be possible for pallid sturgeon to inhabit the river as far south as the proposed MDWD, the population there is likely small if not non-existent. It is still plausible that a sturgeon feeding or otherwise occurring in the vicinity of the structure while it is operating may unwittingly be swept through the structure without even trying to offer any resistance, not realizing that once they go through the structure they cannot return on their own. The species evolved in an environment where there were no waterfalls or other natural obstructions that would have prevented upstream movement, no matter how far individual fish were swept downstream. So it may be possible that pallid (and shovelnose) sturgeon have no positive or negative rheotaxis in relation to anthropogenic structures such as the MDWD. Research at ERDC has been conducted on burst and long-term swimming speeds of pallid and shovelnose sturgeon. But, it is not known if the sturgeon's swimming ability is really a factor in the numbers that would be entrained during a diversion. Only the continuation of extensive field studies will be able to shed light on this subject. Given the results of our current sampling effort, CEMVN concludes that the risk to pallid sturgeon entrainment is low and that therefore the proposed MDWD may affect, but is not likely to adversely affect the species.

West Indian Manatee (*Trichechus manatus*)

Sightings of the West Indian manatee in Louisiana have primarily occurred in Lakes Pontchartrain and Maurepas, and associated coastal waters and streams (i.e., Amite, Blind, Tchefuncte, and Tickfaw Rivers) and a few rare sightings along the Gulf coast during the summer months (i.e., June through September); however, there is no known resident population in the State. To avoid potential impacts to manatees during restoration activities the following standard protective measures would be implemented;

- All contract personnel associated with the project should be informed of the potential presence of manatees and the need to avoid collisions with manatees, which are protected under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973.

- All construction personnel are responsible for observing water-related activities for the presence of manatee(s).

- Temporary signs should be posted prior to and during all construction/dredging activities to remind personnel to be observant for manatees during active construction/dredging operations or within vessel movement zones (i.e., work area), and at least one sign should be placed where it is visible to the vessel operator.

- Siltation barriers, if used, should be made of material in which manatees could not become entangled, and should be properly secured and monitored.

- If a manatee is sighted within 100 yards of the active work zone, special operating conditions should be implemented, including: no operation of moving equipment within 50 feet of a manatee; all vessels shall operate at no wake/idle speeds within 100 yards of the work area; and siltation barriers, if used, should be re-secured and monitored. Once the manatee has left

the 100-yard buffer zone around the work area on its own accord, special operating conditions are no longer necessary, but careful observations would be resumed.

- Any manatee sighting should be immediately reported to the U.S. Fish and Wildlife Service (337/291-3100) and the Louisiana Department of Wildlife and Fisheries, Natural Heritage Program (225/765-2821).

Also, to prevent entrapment of manatee inside of dredged material receiving areas that have dikes or other retention features that enclose an area of open water, the area would be inspected for the presence of manatee: 1) before complete closure of the confining features, and 2) again before material is discharged in to the receiving area. Any manatee that is sighted should be allowed to leave the area before work resumes.

Adherence to the before mentioned protection measures will help ensure that any manatee that wanders into the project area would not be adversely affected. The disturbance to the manatee would only be temporary during project construction, and would result in temporary displacement. The manatees would likely move to another area for foraging or resting purposes, and there would be other available areas to which the animals may relocate. Since Louisiana has no resident population of West Indian manatee and the protection measures will be adhered to, it is expected that the proposed MDWD is not likely to adversely affect the species.

Piping Plover (*Charadrius melodus*)

During construction activities associated with the project any piping plover within the area will be temporarily displaced. The proposed action will create 235 acres of marsh in areas that are currently open water which will provide temporary foraging habitat for the Piping Plover until the mud flats become vegetated. The placement of this material will expose marine worms, mollusks, crustaceans and other small marine animals within the area allowing for easy foraging access to plovers in the area. As the marsh becomes vegetated there is potential for an increase in the number of mudflats within these areas that are presently open water. It is expected that the proposed MDWD is not likely to adversely affect the species.

Conclusion

Based on currently available historical and catch data, a review of current literature and studies, and with the employment of avoidance measures recommended through guidelines set up during coordination with USFWS, the CEMVN, believes that pallid sturgeon, West Indian manatees, and piping plover populations are not likely to be adversely affected from creation and operation of the MDWD in the project location detailed in this assessment.

Literature Cited

Ackerman, B.B. 1995. Aerial surveys of manatees: a summary and progress report. Pages 13-33 *in* T.J. O'Shea, B.B. Ackerman, and H.F. Percival (eds.). Population Biology of the Florida Manatee. National Biological Service, Information and Technology Report No. 1. Washington, D.C.

Forbes and Richardson (1905), Schmulbach et al. (1975), Kallemeyn (1983), and Gilbraith et al. (1988).

Funk, J.L., and J.W. Robinson. 1974. Changes in the channel of the lower Missouri River and effects on fish and wildlife. Missouri Department of Conservation, Aquatic Series No. 11.

Haig, S.M. 1985. The status of the Piping Plover in Canada. Report to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), National Museum of Canada, Ottawa, Ontario.

Haig, S.M. and J.H. Plissner. 1992. The 1991 international piping plover census. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 200 pp.

Haig, S.M. 1986. Piping Plover distribution. Endangered Species Information System Workbook Part 1. U.S. Fish and Wildlife Service, Washington D.C.

Haig, S.M. and L.W. Oring. 1988a. Genetic differentiation of piping plovers across North America. Auk 105(4): 260-267pp.

Haig, Susan M., and Elliott-Smith, E. 2004. Piping Plover. The Birds of North America Online. (A. Poole, Ed.) Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Piping_Plover/.

Hartman, D.S. 1979. Ecology and behavior of the manatee (*Trichechus manatus*) in Florida. American Society of Mammalogists Special Publication No. 5. 153 pp.

Husar, S.L. 1977. The West Indian manatee (*Trichechus manatus*). U.S. Fish and Wildlife Service. Wildlife Resource Report No. 7: 1-22.

Killgore, K.J., J.J. Hoover, J.P. Kirk, S.G. George, B.R. Lewis, and C.E. Murphy. 2007. Age and growth of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology. 23:452-456.

Killgore, K.J., J.J. Hoover, S.G. George, B.R. Lewis, C.E. Murphy, and W.E. Lancaster. 2007. Distribution, relative abundance and movements of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology. 23:476-483.

Mayden, R.L., and B.R. Kuhajda. 1997. Threatened fishes of the world: *Scaphirhynchus albus* (Forbes and Richardson 1905) (Acipenseridae). Environmental Biology of Fishes 48: 420-421.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer.

Nicholls, J.L. 1989. Distribution and other ecological aspects of Piping Plovers (Charadrius melodus) wintering along the Atlantic and Gulf coasts. MS Thesis. Auburn University, Auburn, Alabama. 164 pp.

O'Shea, T.J. 1988. The past, present, and future of manatees in the southeastern United States: realities, misunderstandings, and enigmas. Pages 184-204 *in* Odum, R.R., K.A. Riddleberger, and J.C. Ozier (eds.). Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium. Georgia Department of Natural Resources. Social Circle, Georgia.

O'Shea, T.J., B.B. Ackerman, and H.F. Percival (eds.). 1992. Interim report of the technical workshop on manatee population biology. Manatee Population Research Report No. 10. Florida Cooperative Fish and Wildlife Research Unit. Gainesville, Florida. 83 pp.

USFWS. 1988. Great Lakes and Northern Great Plains Piping Plover Recovery Plan. US Fish and Wildlife Service, Twin Cities, MN. 160 pp.

USFWS. 2001. Florida manatee recovery plan. Southeast Region, U.S. Fish and Wildlife Service, Atlanta, Georgia. 144 pp. + Appendices.

USFWS. 2007. Pallid Sturgeon (*Scaphirhynchus albus*) 5-year review summary and evaluation. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 120pp.

USFWS. 2009. Biological Opinion. 2008 Operation of the Bonnet Carre Spillway. US Fish and Wildlife Service, Lafayette, LA.

USFWS. (n.d.) Endangered Species Information System (ESIS): Piping Plover (Charadrius melodus).

USFWS. Walther, David, Lafayette, LA USFWS Office. personal communication.

Appendix A-2

Biological Assessment
National Marine Fisheries Service

U.S. ARMY CORPS
OF ENGINEERS
NEW ORLEANS DISTRICT



September 2010

BIOLOGICAL ASSESSMENT for LCA - Medium Diversion at White Ditch

Prepared by: **U.S. Army Corps of Engineers**
New Orleans District

Lead Contact: **Thomas Parker**
U.S. Army Corps of Engineers, PD-RP

Physical Address:
7400 Leake Ave., Room 363
New Orleans, LA 70118

Mailing Address:
P.O. Box 60267
New Orleans, LA 70160-0267

Email: thomas.w.parker@usace.army.mil
Phone: (504) 862-2526
Fax: (504) 862-2088

Table of Contents

Introduction....22
Threatened, Endangered, and Proposed Threatened or Endangered Species....22
Critical Habitat....23
Previous Consultation....23
Purpose....23
Location of the Proposed Action....24
Proposed Action....26
Species Description....29
Gulf Sturgeon....29
Status....29
Species and Habitat Description....29
Management and Protection....30
Green Sea Turtle....32
Status....32
Species and Habitat Description....32
Management and Protection....33
Kemp's Ridley Sea Turtle....33
Status....33
Species and Habitat Description....34
Management and Protection....35
Loggerhead Sea Turtle....37
Status....37
Species and Habitat Description....37
Management and Protection....38
Effects of the Proposed Action....39
Gulf Sturgeon....39
Green Sea Turtle....40
Kemp's Ridley Sea Turtle....40
Loggerhead Sea Turtle....40
Conclusion....41
Literature Cited....42

Figures

Figure 1: Study Area Map.....25
Figure 2: Proposed Medium Diversion at White Ditch 27
Figure 3: Map of Proposed Medium Diversion at White Ditch.....28
Figure 4: Louisiana Estuarine Critical Habitat 31

[Cover Photo: Existing siphon at White Ditch]

Introduction

This Biological Assessment (BA) is submitted to the National Marine Fisheries Service (NMFS) by the U.S. Army Corps of Engineers, New Orleans District (CEMVN) in order to initiate formal consultation with NMFS regarding potential impacts to threatened and endangered species from construction and operation of the LCA Medium Diversion at White Ditch (MDWD) project. The following BA is promulgated in accordance with Section 7 (Interagency Consultation) of the Endangered Species Act of 1973, as amended (PL 93-205; 16 U.S.C. 1531 et. seq.). A separate BA has been prepared and will be submitted to the US Fish and Wildlife Service for species under their purview, including the Pallid Sturgeon (*Scaphirynchus albus*), West Indian Manatee (*Trichechus manatus*), and the Piping Plover (*Charadrius melodus*)

The purpose of this biological assessment is to evaluate the possible effects of the proposed construction and operation of the MDWD project on threatened, endangered and proposed threatened and endangered species and their critical habitats. Threatened, endangered and proposed threatened and endangered species are managed under the authority of the Federal Endangered Species Act (ESA) (PL 93-205, as amended). Under provisions of the ESA, Federal agencies shall use their authorities to carry out programs for the conservation of listed species, and shall insure any action authorized, funded, or implemented by the agency is not likely to: (1) adversely affect listed species or designated critical habitat; (2) jeopardize the continued existence of proposed species; or (3) adversely modify proposed critical habitat (16 USC 1536).

The species of concern that are known to inhabit the area are:

Threatened, Endangered, and Proposed Threatened or Endangered Species

Gulf Sturgeon (*Acipenser oxyrhynchus desotoi*), was listed as threatened on September 30, 1991 (56 FR 49653)

Green Sea Turtle (*Chelonia mydas*), was listed as threatened in U.S. waters, except for the Florida breeding population which was listed as endangered, on July 28, 1978 (43 FR 32800 32811)

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), was listed as endangered throughout its range, on December 2, 1970 (35 FR, 18320)

Loggerhead Sea Turtle (*Caretta caretta*) was listed as threatened through out its range on July 28, 1978 (43 FR 32800 32811)

The likelihood of encountering hawksbill or leatherback sea turtles in the project area is so remote that those species are not included in this list of species. No further discussion of these species will occur.

Critical Habitat

No critical habitat is currently designated for any of the threatened, endangered, or sensitive species within the project area.

Previous Consultation

There has been no coordination conducted for the proposed action described in this document.

Purpose

This LCA Medium Diversion at White Ditch (MDWD) project is to help restore areas where an altered supply and distribution of freshwater, lack of deltaic forming sediments, marsh subsistence and human development in the White Ditch area have resulted in degraded and unbalanced distribution of freshwater, brackish, and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, altered hydrology and changed salinity regimes.

Installation of the White Ditch diversion siphon was completed in 1963 with the objective of enhancing muskrat and oyster habitat. In the absence of an outfall management plan, the surrounding marsh received limited benefits from the diverted river water. Two 50-inch steel pipes divert water from the Mississippi River through the White Ditch, into the Belair Canal and then into the River aux Chenes, where it continues south and out of the project area. Usage of the siphons was abandoned for many years and they degraded into a non-usable condition. The siphons were recently refurbished and water was diverted into White Ditch as part of research efforts.

Wetlands in the project area are deteriorating for several reasons: 1) subsidence, 2) lack of sediment and nutrient deposition, 3) erosion via tidal exchange, 4) channelization, 5) saltwater intrusion and 6) lack of freshwater. Recent hurricanes and tropical storms have also caused significant damage to the project area. These activities have resulted in the loss of several thousand acres of previously solid, vegetated marsh. Deterioration will continue unless preventative measures are taken.

In the absence of supplemental freshwater and sediment from the Mississippi River, subsidence, sea-level rise, wave erosion, and saltwater intrusion will continue to be problems. Protection and enhancement of this area are dependent on providing a hydrologic and sediment regime that minimizes the physiological stress to wetland vegetation from saltwater intrusion and tidal energy and is conducive to the retention of locally provided freshwater and sediments

The historic geology of the project area indicates that the current course of the Mississippi River has remained the same for the last 700 years and has directly influenced the development of the entire area. The project area is located on the east side of the Mississippi

River and was formed between two natural levee ridge systems, River aux Chenes on the east and the Mississippi River on the west. There are also two unnamed bayou ridges found within the project area. These ridges formed along the old natural bayous which were distributary channels for the Mississippi River. These natural bayous once carried sediments and nutrients into the project area during high river stages when the natural ridges were seasonally overtopped.

In the historical setting, floodwater from the river would recede and sediments and nutrients would be deposited in the inter-distributary basins located between ridges. During normal or low river stages the ridges along the distributary channels served like levees and buffered the basin areas from the daily tidal influence. This buffering effect created a low energy freshwater environment in the inter-distributary basins, forming deep organic soils. Drainage to the area was provided by a high water event breaching the River aux Chenes ridge in the southern part of the project area. This event caused the development of the Bayou Garelle tributary channel.

The present day hydrology of the project area has been altered and no longer functions in a historically natural pattern. Historically, water moved very slowly through the system. Freshwater slowly exited the system through meandering pathways in the marsh and saltwater was slow to intrude. Presently, changes in the marsh allow water to rapidly pass through the system and saltwater is able to quickly intrude. The hydrologic balance within the marsh has been disturbed due to the following man-made changes:

1. The Mississippi River can no longer overflow its banks into the project area due to the Mississippi River protection levee. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns.
2. Channels have been dredged through natural ridges which has increased drainage and tidal exchange and exposed the soil to erosive forces.

This project was identified as a Near-term Critical Restoration Feature Recommended for Study and Future Congressional Authorization in the LCA Main Report dated January 21, 2005. In November 2007, the Water Resources Development Act of 2007 passed, authorizing this and other projects from the LCA Main Report. The MDWD feasibility study is anticipated to result in a Chief's Report containing a recommended plan to construct a Mississippi River diversion in the vicinity of White Ditch for the purposes of introducing freshwater, sediments, and nutrients into the study area.

Location of the Proposed Action

The MDWD project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana (see figure 1). The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats that has been heavily influenced by both man-made and natural processes. Channel construction, subsidence, erosion, saltwater intrusion, and storm-related damages have all significantly altered the natural environment, causing extensive losses of wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the forty-arpent canal, extending along the non-Federal back levee, the

Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound basin.

There are two discreet project locations that will be considered for the purposes of the feasibility study: The area along the Mississippi River where a freshwater diversion structure might be located; and the project area that could be influenced and benefited by the diverted freshwater. The area of interest where a diversion structure could be located occurs on the left descending bank of the Mississippi River, between White Ditch to the north (river mile 64.5) and the community of Phoenix to the south (river mile 59.8). This 4.7 mile stretch is unique in that there is no hurricane protection levee (back levee) on the marsh side that protects existing homes and infrastructure from elevated water levels (tidal or storm surge). The Mississippi River levee is the only flood protection structure that keeps river water from entering the project study area. This situation minimizes the amount of infrastructure that could be affected by construction of a diversion structure and allows for a broader array of measures to be considered in addressing problems in the project area.

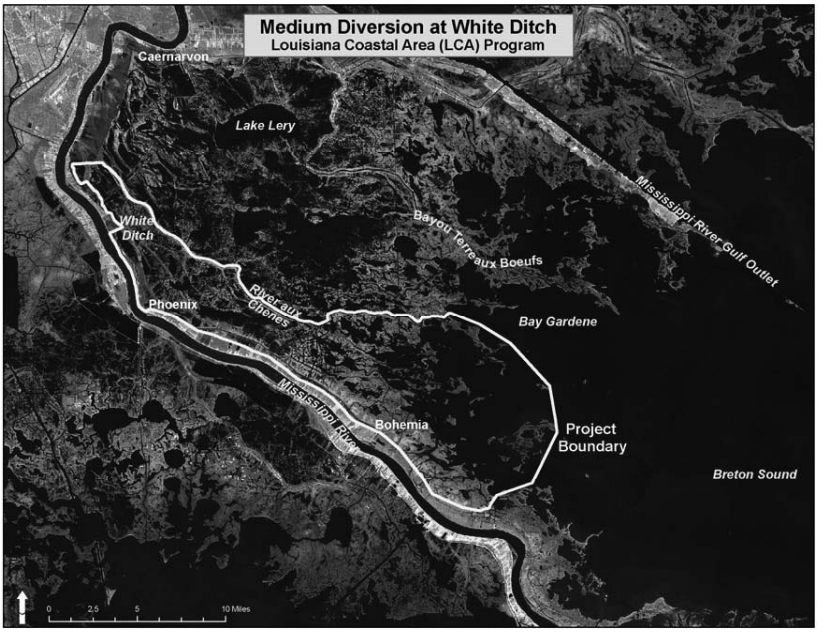


Figure 1: Study Area Map

Proposed Action

The tentatively selected plan proposes the construction of a medium sized diversion structure capable of diverting up to 35,000 cfs consisting of 10 15ft. x 15ft. box culverts with hydraulic operated sluice gates, and constructing an outfall channel to carry fresh water and sediment to the desired locations in the marsh. Additionally, there will be 32 acres of ridge and terrace creation and 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

The current operating plan for the tentatively selected plan at the White Ditch Diversion is limited to a diversion pulse of 35,000 cfs in March-April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year. This flow rate may not be experienced over the full 60 day period. The proposed 35,000 cfs diversion will be the largest man-made diverted flow for wetland building on the Lower Mississippi River, but the one to two month duration will be a modifying factor. The diversion should approximate five percent or less of the main channel flow for most years.

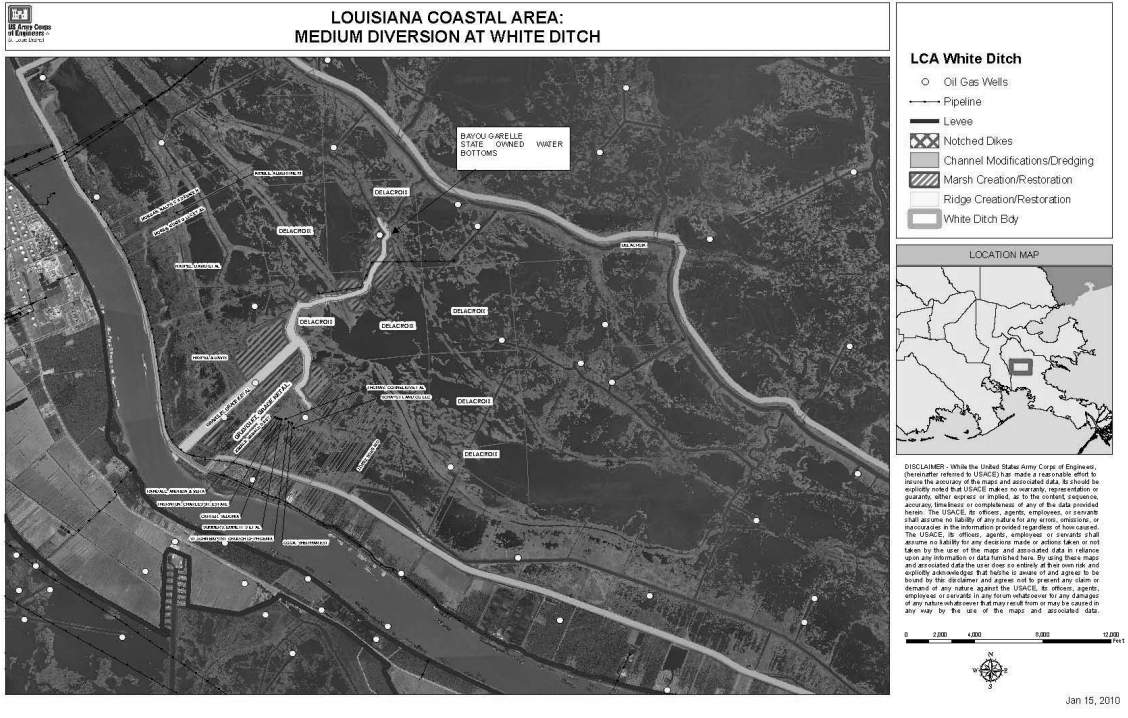


Figure 2: Proposed Medium Diversion at White Ditch

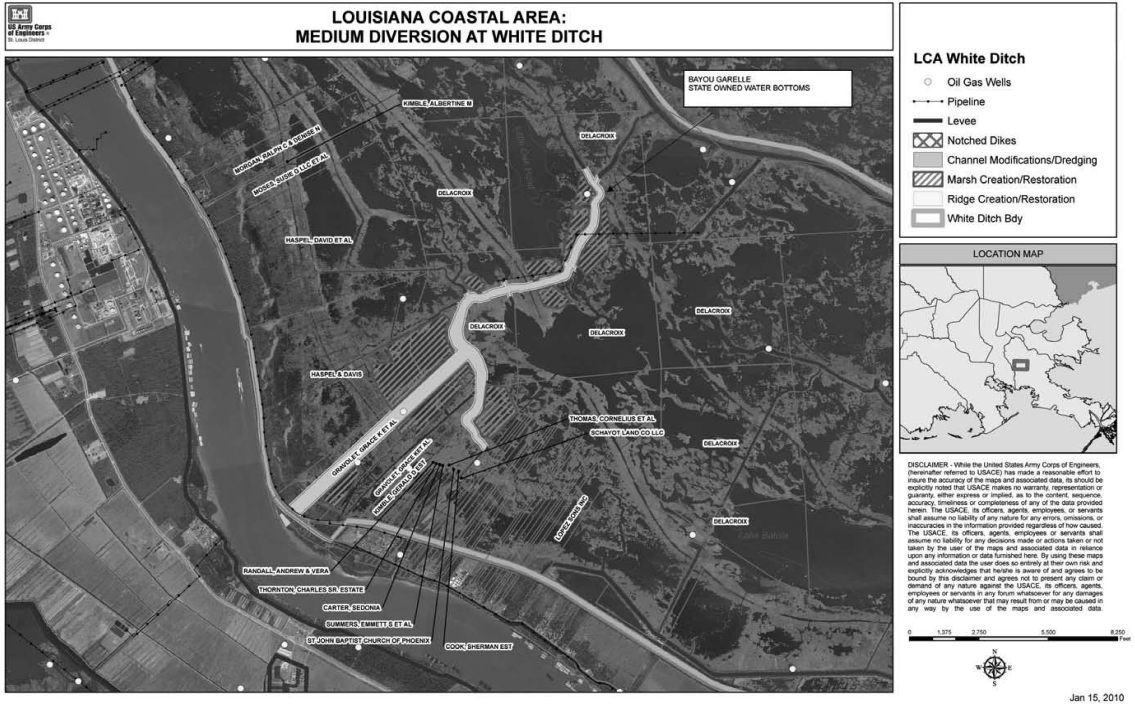


Figure 3: Map of Proposed Medium Diversion at White Ditch

Species Descriptions

Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)

Status

The Gulf sturgeon was Federally listed as threatened throughout its range on September 30, 1991 and is also listed as a threatened species in Louisiana. The present range of the species extends from east of the Mississippi River in Louisiana east to the Suwannee River in Florida (USFWS and NMFS 2003).

Species and Habitat Description

Gulf sturgeon are light brown to dark brown in color with a pale underside (USFWS & Gulf States Marine Fisheries Commission, 1995). They have elongate, fusiform bodies covered by naked skin imbedded with bony plates or scutes. The average adult Gulf sturgeon ranges in size from 120-225 cm in length with an average weight between 35-320 lbs. The largest recorded Gulf sturgeon was caught at Cow Horn Reef near the mouth of the Mississippi in September 1936. Its reported mass was 228.2 kg with a length of 274 cm (Reynolds, 1993). Size is dependant on the individual's gender, age, and spawning condition (USFWS, 1980; Huff, 1975). Females live longer than males and continue to grow with age, consequently they are larger and weigh more than males (Huff, 1975). Females reach sexual maturity between 8 and 17 years of age while males reach sexual maturity between the ages of 7 to 21 (Huff, 1975). Gulf sturgeon are long lived, having the possibility of reaching at least 42 years old (Huff, 1975).

Gulf sturgeon live in the estuaries and coastal shelf regions of the Gulf of Mexico during the cooler months from October to March. In March and early April, adult sturgeon start their migration into the freshwater rivers in search of spawning habitat. Non-ripe adults, juveniles and subadults also participate in this yearly migration, but usually lag behind the spawning adults, moving into the rivers anywhere from days to months later. Sexually mature, ripe males and females enter the rivers when the surface water temperatures reach 62-70^{o} F (Carr, Tatman, & Chapman, 1996). Fox et al. (2002), in their studies of Gulf sturgeon in the Choctawhatchee Bay, found that male sturgeon enter the river earlier than female sturgeon and move greater distances upstream. Males were also found to remain at the spawning grounds longer than females. Ripe specimens of both sexes entered the Choctawhatchee River earlier and moved significantly further upstream than non-ripe fish. After spawning, both males and females return to the lower river reaches and join their non-spawning counterparts in summer holding areas where they reside until the fall migration. After hatching, age-0 fish remain in riverine habitats through January, moving into the estuaries in February as age-1 fish (Sulak et al., 1998).

Fall migration after spawning and river temperatures drive the return of sturgeon to the Gulf of Mexico. When river temperatures approximate the fall temperatures of the Gulf of Mexico (usually in late October or early November), and surface temperatures drop between 62-72^{o} F, sturgeon leave the rivers (Chapman, 2001; Foster & Clugston, 1997) for their winter marine habitats. Sulak et al. (1999) reported that adult Gulf sturgeon in the Suwannee River spend up to several weeks of pre-migratory staging (late November to early December) in the

lower river and adjacent estuary. While it has been suggested that this kind of holding pattern prior to the sturgeon's movement between fresh and saline environments may be necessary due to osmoregulatory functions (Murphy & Skaines, 1994), some rivers, like the Pearl River, report sturgeon moving through the river/bay interface rapidly, requiring little if any time for acclimatization (Howard Rogillio, LDWF personal communication). Altinok et al. (1998) determined that, by age one, Gulf sturgeon have developed an active mechanism for osmoregulation and ion balance in euryhaline environments.

Distribution of Gulf sturgeon in Louisiana extends from the Mississippi River east to the Pearl River. The majority of these sturgeon have their origins in the Pearl River system, where the largest population occurs. However, Gulf sturgeon have historically inhabited many of the larger tributaries east of the Mississippi River, including some upstream of the Ross Barnett Dam (Morrow et al., 1996). As a result of the channelization of the Mississippi River through its extensive lock and levee system, any spawning habitat that may have existed in the Mississippi River for Gulf sturgeon has since been severely degraded. There is no evidence indicating a reproducing population in this river and no verified captures of Gulf sturgeon have occurred in the Mississippi River. The movements of foraging sturgeon along the coast may occasionally place them in the vicinity of the mouth of the Mississippi. At present there is no critical habitat identified in this area for Gulf sturgeon.

The Gulf sturgeon, *Acipenser oxyrinchus desotoi* (Vladykov, 1955), is a separate subspecies of the Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*. Gulf sturgeon differ from their Atlantic counterparts in relative head length, pectoral fin lengths, dorsal scute shape, as well as spleen length and position. In 1996, Ong et al. presented genetic evidence that Atlantic and Gulf sturgeon are different species using direct sequence analysis of the mitochondrial DNA control region. Gulf sturgeon are anadromous fish (migrating seasonally between fresh and saltwater) that range primarily from the Suwannee River in Florida to the Mississippi River in Louisiana (Morrow et al, 1996). Their distribution is limited to the Gulf of Mexico by the emergence of peninsular Florida, which led to the development of the separate species. This speciation is maintained by the thermal barrier of the Gulf Stream around south Florida (Huff, 1975). Similarly, the Mississippi River also appears to limit their movements in the Gulf of Mexico to east of the Mississippi River.

Management and Protection

Historically, Gulf sturgeon have supported both commercial and recreational fisheries throughout most of their range from the Mississippi River east to Tampa Bay (U.S. Commission of Fish and Fisheries, 1902, cited in Wooley and Crateau, 1985). Large-scale exploitation of Gulf sturgeon began around 1860, when it was discovered that smoked sturgeon could be substituted for smoked halibut and that Gulf sturgeon eggs could be made into high-quality caviar (Smith, 1990). Sturgeon have been harvested with gillnets, pound nets, otter trawls, harpoons, trammel nets, weirs, stake row nets, and seines (Huff, 1975; Smith, 1985; Van Den Avyle, 1984; Smith & Clugston, 1997). Gulf sturgeon populations have declined due to fisheries over-exploitation (Barkuloo, 1988), spawning habitat loss via dam construction, and deterioration of water quality in their natal rivers (Morrow et al., 1996). Sturgeon are particularly vulnerable to gill net fisheries and are also found in the bycatch of shrimp trawls. Turtle excluder devices (TEDs) are

thought to reduce sturgeon bycatch, though, to date no studies have been conducted to specifically evaluate this possibility. Even though sturgeon fishing regulations are in place, poaching of Gulf sturgeon still occurs (Collins et al., 2000). Restrictions applied to the sturgeon fisheries have not resulted in the restoration of population size. This may be due to the reduction of suitable spawning habitat. Poss (1998) notes that dredging operations reduce the deeper holes and hard substrate sturgeon require for spawning. Dams and low water sills prevent the movement of spawning adults to traditional spawning grounds. Low dissolved oxygen levels from eutrophication also contribute to spawning habitat degradation. Adults and subadults are not greatly affected by changes in salinity, dissolved oxygen, or high temperatures, however, eggs and larval stages of the sturgeon have low tolerance ranges for these criteria (Collins et al., 2000).

On March 19, 2003, the USFWS and NOAA Fisheries published a final rule in the Federal Register (Volume 68, No. 53) designating critical habitat for the Gulf sturgeon in Louisiana, Mississippi, Alabama, and Florida. Portions of the Pearl and Bogue Chitto Rivers, Lake Pontchartrain east of the Lake Pontchartrain Causeway, all of Little Lake, The Rigolets, Lake St. Catherine, and Lake Borgne within Louisiana were included in that designation, see Figure 4. The proposed MDWD falls well outside of this habitat designation. None of the primary constituent elements that are necessary to ensure the survival of the species currently exist within the proposed project area. With the implementation of the project, improvements in the hydrology and habitat within the area may begin to support some of these functions and possibly may improve habitat on the eastern Louisiana coast.

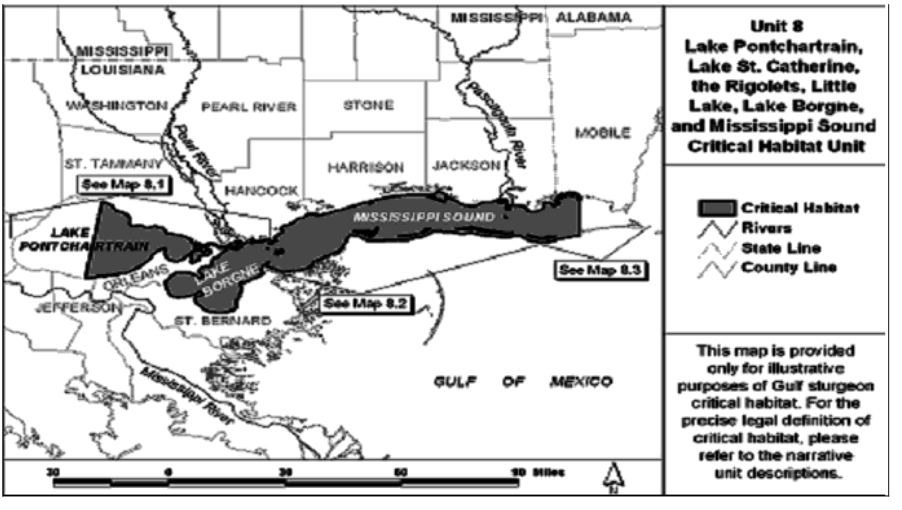


Figure 4: Louisiana Estuarine Critical Habitat

Green Sea Turtle (*Chelonia mydas*)

Status

The green sea turtle was listed as threatened in U.S. waters, except for the Florida breeding population which is listed as endangered, on July 28, 1978. Due to the inability to distinguish between these populations away from the nesting beach, green turtles are considered endangered wherever they occur in U.S. waters. Commercial harvest, habitat degradation, coastal development, disease, and predation have all contributed to the decline of the species.

Species and Habitat Description

The green sea turtle is one of the largest marine turtles with adult weights averaging between 250 to 450 pounds (Dundee 1989). This species can live upwards of 50 years and usually reaches sexual maturity between ages 20-50 years. The green sea turtle is considered to be unique in regards to other sea turtles in that it is mostly herbivorous in its adult stage typically feeding on underwater vegetation and algae (NOAA-1). On occasion, adult green sea turtles have been known to eat carrion and other marine invertebrates such as jellyfish (LDWF-2 & Dundee 1989). During the yearling stages, the species lives in and around offshore areas and its diet is primarily carnivorous (NOAA-1). In the Atlantic and Gulf of Mexico waters, the green sea turtle typically inhabits areas adjacent to the coastline and has been known to have a range spanning from Texas to as far north as Massachusetts. There are three types of environments that this species is known to inhabit: oceanic beaches generally used for nesting; convergence zones in the open ocean; and benthic feeding grounds in coastal areas (NOAA-1). In 1998, critical habitat for this species was designated in and around the Culebra Islands, which are situated off the eastern coast of Puerto Rico (NMFS 1998). One of the greatest impacts to this species has been the harvest of eggs, juveniles and adults on both nesting and feeding grounds. Additional threats, specifically in the U.S., include the erosion of the coastline and the barrier islands, which results in the loss of suitable habitat for this species (LDWF-2). Fishing and dredging operations, specifically hopper-type dredges, have also adversely impacted this species throughout the years.

In the western Atlantic, several major nesting assemblages have been identified and studied (Peters, 1954; Carr and Ogren, 1960; Parsons, 1962; Pritchard, 1969; Carr *et al*., 1978). In the continental United States, green turtle nesting occurs on the Atlantic coast of Florida (Ehrhart, 1979). Occasional nesting has been documented along the Gulf coast of Florida, at Southwest Florida beaches, as well as the beaches on the Florida Panhandle (Meylan *et al., 1995*). Most documented green turtle nesting activity occurs on Florida index beaches, which were established to standardize data collection methods and effort on key nesting beaches. The pattern of green turtle nesting shows biennial peaks in abundance, with a generally positive trend during the six years of regular monitoring since establishment of the index beaches in 1989, perhaps due to increased protective legislation throughout the Caribbean (Meylan *et al.,* 1995).

While nesting activity is obviously important in identifying population trends and distribution, the majority portion of a green turtle's life is spent on the foraging grounds. Green turtles are herbivores, and appear to prefer marine grasses and algae in shallow bays, lagoons and reefs (Rebel, 1974). Some of the principal feeding pastures in the Gulf of Mexico include inshore

south Texas waters, the upper west coast of Florida and the northwestern coast of the Yucatan Peninsula. Additional important foraging areas in the western Atlantic include the Indian River Lagoon System in Florida, Florida Bay, the Culebra archipelago and other Puerto Rico coastal waters, the south coast of Cuba, the Mosquito coast of Nicaragua, the Caribbean coast of Panama, and scattered areas along Colombia and Brazil (Hirth, 1971). The preferred food sources in these areas are *Cymodocea, Thalassia, Zostera, Sagittaria, and Vallisneria* (Babcock, 1937; Underwood, 1951; Carr, 1952; 1954).

Management and Protection

Green turtles are distributed circumglobally, mainly in waters between the northern and southern 20^{o} C isotherms (Hirth, 1971). Green turtles were traditionally highly prized for their flesh, fat, eggs, and shell, and fisheries in the United States and throughout the Caribbean are largely to blame for the decline of the species. Green turtles were once abundant enough in the shallow bays and lagoons of the Gulf to support a commercial fishery, which landed over one million pounds of green turtles in 1890 (Doughty, 1984). Doughty (1984) reported the decline in the turtle fishery throughout the Gulf of Mexico by 1902. Currently, green turtles are uncommon in offshore waters of the northern Gulf, but abundant in some inshore embayments. Shaver (1994) live-captured a number of green turtles in channels entering into Laguna Madre, in south Texas. She noted the abundance of green turtle strandings in Laguna Madre inshore waters and opined that the turtles may establish residency in the inshore foraging habitats as juveniles. Algae along the jetties at entrances to the inshore waters of south Texas was thought to be important to green turtles associated with a radio-telemetry project (Renaud *et al*., 1995). Transmitter-equipped turtles remained near jetties for most of the tracking period. This project was restricted to late summer months, and therefore may reflect seasonal influences. Coyne (1994) observed increased movements of green turtles during warm water months.

In the Southeast United States, major nest protection efforts and beach habitat protection are underway for most of the significant nesting areas, and significant progress has been made in reducing mortality from commercial fisheries in U.S. waters with the enforcement of TED regulations. Many coastal counties and communities in Florida have developed lighting ordinances to reduce hatchling disorientations. Important U.S. nesting beaches have been and continue to be acquired for long-term protection. The Fish and Wildlife Service and National Marine Fisheries Service have been funding research on the fibropapilloma disease for several years to expand our knowledge of the disease with the goal of developing an approach for remedying the problem. Due to the long range migratory movements of sea turtles between nesting beaches and foraging areas, long-term international cooperation is absolutely essential for recovery and stability of nesting populations (USFWS North Florida Fact Sheet).

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

Status

The Kemp's ridley sea turtle was listed as endangered throughout its range on December 2, 1970. Commercial harvest, habitat degradation, coastal development, disease, and predation have all contributed to the decline of the species.

Species and Habitat Description

Of the seven extant species of sea turtles of the world, the Kemp's ridley has declined to the lowest population level. Kemp's ridleys nest in daytime aggregations known as arribadas, primarily at Rancho Nuevo, a stretch of beach in Mexico. Most of the population of adult females nest in this single locality (Pritchard, 1969). When nesting aggregations at Rancho Nuevo were discovered in 1947, adult female populations were estimated to be in excess of 40,000 individuals (Hildebrand, 1963). By the early 1970s, the world population estimate of mature female Kemp's ridleys had been reduced to 2,500-5,000 individuals. The population declined further through the mid-1980s. Recent observations of increased nesting, suggest that the decline in the ridley population has stopped, and there is cautious optimism that the population is now increasing.

The Kemp's ridley sea turtle is the smallest of the sea turtles with adults reaching an approximate length of 2 to 2 ½ feet and weighing around 110 pounds (Dundee 1989). This species has a single claw located on its front flippers and usually has one to two claws located on its rear flippers (NOAA-3). The species' is carnivorous and usually feeds upon crabs, clams, and snails that inhabit the shallow coastal waters (Dundee 1989). During the months of May to October, this species can be found in and around the shore line of Louisiana with adults occupying areas around the mouth of Mississippi during the spring and summertime. As winter approaches, adults and juveniles generally head to warmer waters offshore. The Kemp's Ridley sea turtle's habitat is comprised of warm bays, coastal waters, sea grass beds, and sandy beaches utilized for nesting (LDWF-4). This species has been observed within the Sabine and Calcasieu Lakes as well as in Lake Borgne and areas around St. Bernard Parish (Dundee 1989). Similar to other sea turtles, threats to this species include the harvest of eggs and nesting adults, incidental trapping in fishing nets, and loss of suitable habitat. It has been suggested that sea turtles may burrow into the estuarine mud along the Gulf coast during the winter, essentially when water temperatures are too low for normal activity, but no dormant sea turtles have been reported in coastal Louisiana.

The nearshore waters of the Gulf of Mexico are believed to provide important developmental habitat for juvenile Kemp's ridley and loggerhead sea turtles. Ogren (1988) suggests that the Gulf coast, from Port Aransas, Texas, through Cedar Key, Florida, represents the primary habitat for subadult ridleys in the northern Gulf of Mexico. Stomach contents of Kemp's ridleys along the lower Texas coast had a predominance of nearshore crabs and mollusks, as well as fish, shrimp and other foods considered to be shrimp fishery discards (Shaver, 1991). Analyses of stomach contents from sea turtles stranded on upper Texas beaches apparently suggest similar nearshore foraging behavior (Plotkin, pers. comm.).

Research being conducted by Texas A&M University at Galveston has resulted in the intentional live-capture of 516 sea turtles from 1991-1997. Green turtles comprise over 95% of all sea turtle captures recorded by Texas A&M researchers from South Padre/Laguna Madre studies. Conversely, the Kemp's ridley dominates (92.2%) captures from more turbid, blue-crab laden waters of the upper Texas and Louisiana coasts. Capture statistics readily justify Sabine

and Calcasieu Passes being considered "index habitat" for the Kemp's ridley (Landrey et al., 1997).

The Texas A&M University research has resulted in the live-capture of 100s of Kemp's ridleys at Sabine Pass and the entrance to Galveston Bay. Between 1989 and 1993, 50 of the Kemp's ridleys captured were tracked by biologists with the NMFS Galveston Laboratory using satellite and radio telemetry. The tracking study was designed to characterize sea turtle habitat and to identify small and large scale migration patterns. Preliminary analysis of the data collected during these studies suggests that subadult Kemp's ridleys stay in shallow, warm, nearshore waters in the northern Gulf of Mexico until cooling waters force them offshore or south along the Florida coast (Renaud, NMFS Galveston Laboratory, pers. comm.).

Seasonal abundance of sea turtles utilizing nearshore waters of the northwest Gulf of Mexico varies with species and location. Kemp's ridleys are transient users of the coastal zone who venture toward tidal passes and into bays during May-August when food sources and other environmental factors are favorable. The May-August period has yielded over 80% of the sea turtle captures (N=516) recorded by Texas A&M researchers, over 75% of which were Kemp's ridleys (Landry *et al*., 1997).

Management and Protection

The recent nesting increase can be attributed to full protection of nesting females and their nests in Mexico, and the requirement to use turtle excluder devices in shrimp trawls both in the United States and Mexico. In 1966, conservation efforts for the Kemp's ridley were initiated on the beach near Rancho Nuevo in Tamaulipas, Mexico. This locale is the only place in the world where large nesting aggregations of this sea turtle were and are known to occur. From 1966 to 1987, conservation efforts focused on the area of Rancho Nuevo with one turtle protection camp. In 1978, the U.S. joined with Mexico at Rancho Nuevo in a bi-national effort to prevent the extinction of the Kemp's ridley. In 1988, this bi-national program expanded to the south and another camp was added. In 1989, a third camp was established when the program was expanded to the north of Rancho Nuevo. By 1997, a total of seven camps had been established along the Tamaulipas and Veracruz coasts to allow for increased nest protection efforts (USFWS North Florida Fact Sheet).

The Mexico government also prohibits harvesting and is working to increase the population through more intensive law enforcement, by fencing nest areas to diminish natural predation, and by relocating all nests into corrals to prevent poaching and predation. While relocation of nests into corrals is currently a necessary management measure, this relocation and concentration of eggs into a "safe" area is of concern since it makes the eggs more susceptible to reduced viability due to movement-induced mortality, disease vectors, catastrophic events like hurricanes, and marine predators once the predators learn where to concentrate their efforts (USFWS North Florida Fact Sheet).

In recent years, unprecedented numbers of Kemp's ridley carcasses have been reported from Texas and Louisiana beaches during periods of high levels of shrimping effort. NMFS established a team of population biologists, sea turtle scientists, and managers, known as the

Expert Working Group (EWG) to conduct a status assessment of sea turtle populations. Analyses conducted by the group have indicated that the Kemp's ridley population is in the early stages of recovery; however, strandings in some years have increased at rates higher than the rate of increase in the Kemp's population (Expert Working Group, June 1996). While many of the stranded turtles observed in recent years in Texas and Louisiana are believed to have been incidentally taken in the shrimp fishery, other sources of mortality exist in these waters. These stranding events illustrate the vulnerability of Kemp's ridley and loggerhead turtles to the impacts of human activities in nearshore Gulf of Mexico waters.

The EWG developed a population model to evaluate trends in the Kemp's ridley population through the application of empirical data and life history parameter estimates chosen by the EWG. Model results identified three trends in benthic immature Kemp's ridleys. Benthic immatures are those turtles that are not yet reproductively mature but have recruited to feed in the nearshore benthic environment, where they are available to nearshore mortality sources that often result in strandings. Benthic immature ridleys are estimated to be 2-9 years of age and 20-60 cm in length. Increased production of hatchlings from the nesting beach beginning in 1966 resulted in an increase in benthic ridleys that leveled off in the late 1970s. A second period of increase followed by leveling occurred between 1978 and 1989 as hatchling production was further enhanced by the cooperative program between the USFWS and Mexico's Instituto Nacional de Pesca (INP) to increase the nest protection and relocation program in 1978. A third period of steady increase, which has not leveled off to date, has occurred since 1990 and appears to be due to the greatly increased hatchling production and an apparent increase in survival rates of immature turtles beginning in 1990 due, in part, to the introduction of TEDs. Adult ridley numbers have now grown from a low of approximately 1,050 adults producing 702 nests in 1985, to greater than 3,000 adults producing 1940 nests in 1995 and about 3,425 nests in 1998.

The EWG was unable to estimate the total population size and current mortality rates for the Kemp's ridley population. However, they listed a number of preliminary conclusions. They indicated that the Kemp's ridley population appears to be in the early stage of exponential expansion. Over the period 1987 to 1995, the rate of increase in the annual number of nests accelerated in a trend that would continue with enhanced hatchling production and the use of TEDs. Nesting data indicated that the number of adults declined from a population that produced 6,000 nests in 1966 to a population that produced 924 nests in 1978 and a low of 702 nests in 1985. This trajectory of adult abundance tracks trends in nest abundance from an estimate of 9,600 in 1966 to 1,050 in 1985. The EWG estimated that in 1995 there were 3,000 adult ridleys. The increased recruitment of new adults is illustrated in the proportion of neophyte, or first time nesters, which has increased from 6% to 28% from 1981 to 1989 and from 23% to 41% from 1990 to 1994. The EWG's population model projected that Kemp's ridleys could reach the intermediate recovery goal identified in the Recovery Plan, of 10,000 nesters by the year 2020 if the assumptions of age to sexual maturity and age specific survivorship rates plugged into their model are correct. They determined that the data they reviewed suggested that adult Kemp's ridley turtles were restricted somewhat to the Gulf of Mexico in shallow near shore waters, and benthic immature turtles of 20-60 cm straight line carapace length are found in nearshore coastal waters including estuaries of the Gulf of Mexico and the Atlantic.

The EWG identified an average Kemp's ridley population growth rate of 13% per year between 1991 and 1995. Total nest numbers have continued to increase. However, the 1996 and 1997 nest numbers reflected a slower rate of growth, while the increase in the 1998 nesting level has been much higher. The population growth rate does not appear as steady as originally forecasted by the EWG, but annual fluctuations, due in part to irregular internesting periods, are normal for other sea turtle populations.

The area surveyed for ridley nests in Mexico was expanded in 1990 due to destruction of the primary nesting beach by Hurricane Gilbert. The EWG assumed that the increased nesting observed particularly since 1990 was a true increase, rather than the result of expanded beach coverage. Because systematic surveys of the adjacent beaches were not conducted prior to 1990, there is no way to determine what proportion of the nesting increase documented since that time is due to the increased survey effort rather than an expanding ridley nesting range. As noted by the EWG, trends in Kemp's ridley nesting even on the Rancho Nuevo beaches alone suggest that recovery of this population has begun but continued caution is necessary to ensure recovery and to meet the goals identified in the Kemp's ridley Recovery Plan.

Loggerhead Sea Turtle (*Caretta caretta*)

Status

The Loggerhead sea turtle was listed as endangered throughout its range on July 28, 1978. Commercial harvest, habitat degradation, coastal development, disease, and predation have all contributed to the decline of the species.

Species and Habitat Description

The threatened loggerhead is the most abundant species of sea turtle occurring in U.S. waters. The nearshore waters of the Gulf of Mexico are believed to provide important developmental habitat for juvenile loggerheads. Studies conducted on loggerheads stranded on the lower Texas coast (south of Matagorda Island) have indicated that stranded individuals were feeding in nearshore waters shortly before their death (Plotkin *et al.*, 1993).

The loggerhead sea turtle is also one the larger marine turtles with average adult lengths ranging from 3 to 7 feet and weighing approximately 300 to 1,100 pounds (Dundee 1989). This species usually reaches sexual maturity around age 35 and mating in the southeastern U.S. can occur between late March and early June. The habitat for loggerheads consists of three different zones throughout their lifetime: terrestrial zone, oceanic zone, and near shore or neritic zone (NOAA-5). The lifecycle of the loggerhead, from hatchling to adult, begins when hatchlings leave the ocean beach nesting site and migrate towards waters consisting of seaweed and sea grass cover. The juveniles head into the neritic zone during the ages of 7 to 12 and remain there maturing into adulthood. Coastal Areas not only provide an excellent food source for adults inhabiting the area, but they also allow for easy access to migratory routes (NOAA-5). Large nesting populations have been recorded along the coastal islands of the North and South Carolinas, Georgia, and the Gulf coasts of Florida. In Louisiana, this species has been found nesting on the Chandeleur Islands and Grand Isle in Terrebonne Parish (Dundee 1989). Threats

to this species are fairly similar to threats posed other species of sea turtles, which include incidental trapping in fishing nets, coastal erosion resulting in loss of nesting habitat, and harvesting of eggs and juveniles (NOAA-5 & LDWF-6).

Management and Protection

In the Southeast United States, major nest protection efforts and beach habitat protection are underway for most of the significant nesting areas, and significant progress has been made in reducing mortality from commercial fisheries in U.S. waters with the enforcement of TED regulations. Many coastal counties and communities in Florida, Georgia, and South Carolina have developed lighting ordinances to reduce hatchling disorientations. Important U.S. nesting beaches have been and continue to be acquired for long-term protection. The migratory nature of loggerheads severely compromises these efforts once they move outside U.S. waters, however, since legal and illegal fisheries activities in some countries are causing high mortality on loggerhead sea turtle nesting populations of the western north Atlantic region. Due to the long range migratory movements of sea turtles between nesting beaches and foraging areas, long-term international cooperation is absolutely essential for recovery and stability of nesting populations (USFWS North Florida Fact Sheet).

The EWG identified four nesting subpopulations of loggerheads in the western North Atlantic based on mitochondrial DNA evidence. These include: (1) the Northern Subpopulation producing approximately 6,200 nests/year from North Carolina to Northeast Florida; (2) the South Florida Subpopulation occurring from just north of Cape Hatteras on the east coast of Florida and extending up to Naples on the west coast and producing approximately 64,000 nests/year; (3) the Florida Panhandle Subpopulation, producing approximately 450 nests/year; and (4) the Yucatan Subpopulation occurring on the northern and eastern Yucatan Peninsula in Mexico and producing approximately 1,500-2,000 nests/year.

Genetic analyses of benthic immature loggerheads collected from Atlantic foraging grounds identify a mix of the east coast subpopulations that is disproportionate to the number of hatchlings produced in these nesting assemblages. Although the northern nesting subpopulation produces only approximately 9% of the loggerhead nests, loggerheads on foraging grounds from the Chesapeake Bay to Georgia are nearly equally divided in origin between the two subpopulations (Sears, 1994; Sears *et al*., 1995; Norrgard, 1995). Of equal interest, 57% of the immature loggerheads sampled in the Mediterranean were from the South Florida Subpopulation, while only 43% were from the local Mediterranean nesting beaches (Laurent *et al*., 1993; Bowen, 1995). Genetic work has not yet been done on nesting or foraging loggerheads in the Gulf of Mexico.

The EWG considered nesting data collected from index nesting beaches to index the population size of loggerheads and to consider trends in the size of the population. They constructed total estimates by considering a ratio between nesting data (and associated estimated number of adult females and therefore adults in nearshore waters), proportion of adults represented in the strandings, and in one method, aerial survey estimates. These two methods indicated that for the 1989-1995 period, there were averages of 224,321 or 234,355 benthic loggerheads, respectively. The EWG listed the methods and assumptions in their report, and

suggested that these numbers are likely underestimates. Aerial survey results suggest that loggerheads in U.S. waters are distributed in the following proportions: 54% in the southeast U.S. Atlantic, 29% in the northeast U.S. Atlantic, 12% in the eastern Gulf of Mexico, and 5% in the western Gulf of Mexico.

The EWG considered long-term index nesting beach datasets when available to identify trends in the loggerhead population. Overall, they determined that trends could be identified for two loggerhead subpopulations. The Northern Subpopulation appears to be stabilizing after a period of decline; the South Florida Subpopulation appears to have shown significant increases over the last 25 years suggesting the population is recovering, although the trend could not be detected over the most recent 7 years of nesting. An increase in the numbers of adult loggerheads has been reported in recent years in Florida waters without a concomitant increase in benthic immatures. These data may forecast limited recruitment to south Florida nesting beaches in the future. Since loggerheads take approximately 20-30 years to mature, the effects of decline in immature loggerheads might not be apparent on nesting beaches for decades. Therefore, the EWG cautions against considering trends in nesting too optimistically.

Briefly, the EWG made a number of conclusions regarding the loggerhead population. They concluded that four distinct nesting populations exist based on genetic evidence, although separate management is not possible because of insufficient information on the in-water distribution of each subpopulation. They concluded that the recovery goal of more than 12,800 nests for the Northern Subpopulation was not likely to be met. Currently, nests number about 6,200 and no perceptible increase has been documented. The recovery goal or "measurable increases" for the south Florida (south of Canaveral and including southwest Florida) appears to have been met, and this population appears to be stable or increasing. However, index nesting surveys have been done for too short a time; therefore, it is difficult to evaluate trends throughout the region. Recovery rates for the entire subpopulation cannot be determined with certainty at this time. However, caution is warranted because, although nesting activity has been increasing, catches of benthic immature turtles at the St. Lucie Nuclear Power Plant intake canal, which acts as a passive turtle collector on Florida's east coast, have not been increasing. The EWG recommended establishing index nest survey areas in the Gulf of Mexico to monitor those populations, which do not currently have recovery goals assigned to them.

Effects of Proposed Action

Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)

Sturgeon have been collected in Breton Sound to the west and east of Mississippi River Gulf Outlet (MRGO), and in a lagoon and two bayous connected to the MRGO. The Breton Islands are very similar to the islands along the Mississippi Gulf Coast used by sturgeon to forage around during the winter. Several sonic tagged sturgeon have been recorded by LDWF's remote tracking system off the northern-most tip of Chandeleur Island in Breton Sound, LA. However, these fish are considered to be unverified cases since they were isolated recordings, with only one reading per fish, recorded by a multidirectional hydrophone. USACE ERDC biologists located one sonic tagged Gulf sturgeon in the MR-GO near Bayou La Loutre in January of 2005 during telemetry searches of the channel. The fish was tracked moving from the

MR-GO into the surrounding marshes before its signal was lost. Use of the MR-GO and its bar channel by Gulf sturgeon would most likely be during migration to and from their winter habitats and during their marine feeding period. The proposed MDWD project area is located to the south of these sightings. Since Gulf sturgeon begin their migration to spawning habitat in March and April, consideration was given to the possibility that the increase in freshwater flow (35,000 cfs during March and April) could attract the species to the project area. It is possible, though unlikely, that the freshwater flow from the diversion could confuse Gulf sturgeon. If a Gulf sturgeon was disoriented and did make its way to the structure, then there is a potential for a small population to miss the opportunity to spawn during a given year. It is unlikely any individual sturgeon that finds itself in this position would be at risk for increased mortality. After April, flow within the structure would return to 1,000cfs and it is assumed that an sturgeon within the area would return to deeper waters in Breton Sound or the Gulf. This purely hypothetical assumption is neither supported nor refuted by current literature searches. Due to the small amount of recent and confirmed occurrences of Gulf sturgeon in the project area, CEMVN foresees minimal likelihood of impact to Gulf sturgeon populations from the proposed MDWD and therefore concludes the MDWD project would not adversely affect the species.

Green Sea Turtle (*Chelonia mydas*)

Given the lack of extensive sea grass beds and the low incidence of sightings in the proposed project areas, adverse impacts to the green sea turtle population are not expected. Additionally, the use of a hydraulic cutterhead-type dredge is not known to take sea turtles. With the low risk of affects to green sea turtles from the MDWD project, CEMVN concludes that the MDWD project would not adversely affect the species.

Kemp's Ridley Sea Turtle (*Lepidochelys kempii*)

Impacts to Kemp's ridley sea turtle population should be negligible or non-existent. During March and April when the proposed MDWD project is flowing 35,000cfs though the structure Kemp's Ridley are not expected to be in the Louisiana coastal area. The potential temporary removal of food sources by dredging operations may cause the Kemp's ridley sea turtle to forage elsewhere along the Gulf coast until the area is re-colonized by prey species. Coastal erosion and habitat loss is one limiting factor for the successful recovery of sea turtle populations in the Louisiana coastal zone. Coastal restoration efforts such as the MDWD project, should prove to be beneficial to the Kemp's ridley sea turtle. After assessing the MDWD project area along with the needs of the Kemp's ridley sea turtle, CEMVN concludes that the MDWD project is not likely to adversely affect the species.

Loggerhead Sea Turtle (*Caretta caretta*)

Habitat in Louisiana that is suitable for Loggerheads to nest on is typically associated with that of barrier islands. CEMVN believes that the proposed action will only temporarily disrupt foraging loggerhead sea turtles that may be in the area. Coastal erosion and habitat loss is one limiting factor for the successful recovery of sea turtle populations in the Louisiana coastal zone. Coastal restoration efforts such as the MDWD project, should prove to be beneficial to the loggerhead sea turtle. As previously stated, the use of a hydraulic cutterhead-type dredge is not

known to take sea turtles. After assessing the MDWD project area and the needs of the loggerhead sea turtle, CEMVN concludes that the MDWD project would not adversely affect the species.

Conclusion

Based on currently available historical and catch data, a review of current literature and studies, and with the employment of avoidance measures recommended through guidelines set up during coordination with NMFS, the CEMVN, believes that Gulf sturgeon and green, Kemp's ridley, and loggerhead sea turtles would not adversely affected from construction and operation of the MDWD in the project location detailed in this assessment.

LITERATURE CITED

Altinok, I.; Galli, S. M.; Chapman, F. A. 1998. Ionic and osmotic regulation capabilities of juvenile Gulf of Mexico sturgeon, *Acipenser oxyrhynchus desotoi*. Comparative Biochemistry and Physiology 120(A):609-616.

Carr, S. H.; Carr, T.; Chapman, F. A. 1996. First observations of young of the year Gulf of Mexico sturgeon (*Acipenser oxyrinchus de sotoi*) in the Suwannee River, Florida. Gulf of Mexico Science 14(1): 44-46.

Carr, S. H.; Tatman, F.; Chapman, F.A. 1996. Observations on the natural history of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus de sotoi*, Vladykov 1955) in the Suwannee River, southeastern United States. Ecology of Freshwater Fish 5: 169-174.

Chapman, F. A.; Carr, S. H. 1995. Implications of early life stages in the natural history of the Gulf of Mexico sturgeon, *Acipenser oxyrinchus desoitoi*. Environmental Biology of Fishes 43: 407-413.

Chapman, F. A.; Hartless, C. S.; Carr, S. H. 1997. Population size estimates of sturgeon in the Suwannee River, Florida, U.S.A. Gulf of Mexico Science 14(2): 88-91.

Chapman, F. A. 2001. Personal communication. FAC@mail.ifas.ufl.edu.

Dundee, Harold A. and Douglas A. Rossman. The Amphibians and Reptiles of Louisiana. Louisiana State University Press, Baton Rouge. © 1989.

Fox, D. A.; Hightower, J. E.; Parauka, F. M. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee River system, Alabama-Florida. Transactions of the American Fisheries Society 129: 811-826.

Hildebrand, H.H. 1963. Hallazgo del area de anidacion de la tortuga marina "lora," *Lepidochelys kempii* (Garman), en la costa occidental del Gulfo de Mexico. Ciencia, Mex. 22(4):105-112.

Hildebrand, H.H. Random Notes on Sea Turtles in the Western Gulf of Mexico. Western Gulf of Mexico Sea Turtle Workshop Proceedings, January 13-14, 1983. 1983 Oct: 34-41. Hirth, H.F. 1971. Synopsis of biological data on the green turtle *Chelonia mydas* (Linnaeus) 1758. FAO Fisheries Synopsis. 85:1-77.

Huff, J. A. 1975. Life history of Gulf of Mexico sturgeon, *Acipenser oxyfhynchus desotoi*, in Suwannee River, Florida. Florida Marine Research Publication 16, St. Petersburg. 33 pp.

Louisiana Department of Wildlife and Fisheries (LDWF-1). Green Sea Turtle (*Chelonia mydas*). 2005. Accessed 25 February 2008. <http://www.wlf.louisiana.gov/experience/threatened/greenseaturtle.cfm>

Louisiana Department of Wildlife and Fisheries (LDWF-2). Hawksbill Sea Turtle (*Eretmochelys imbricata*). 2005. Accessed 26 February 2008. <http://www.wlf.louisiana.gov/experience/threatened/hawksbillseaturtle.cfm>

Louisiana Department of Wildlife and Fisheries (LDWF-3). Kemp's Ridley Sea Turtle (*Lepidochelys kempii*). 2005. Accessed 26 February 2008. <http://www.wlf.louisiana.gov/pdfs/experience/naturalheritage/rareanimal/kempridleyseaturtle.pdf>

Louisiana Department of Wildlife and Fisheries (LDWF-4). Leatherback Sea Turtle (*Dermochelys coriacea*). 2005. Accessed 26 February 2008. <http://www.wlf.louisiana.gov/pdfs/experience/naturalheritage/rareanimal/kempridleyseaturtle.pdf>

Louisiana Department of Wildlife and Fisheries (LDWF-5). Loggerhead Sea Turtle (*Caretta caretta*). 2005. Accessed 26 February 2008. <http://www.wlf.louisiana.gov/experience/threatened/loggerheadseaturtle.cfm>

Morrow, J. V., Jr.; Killgore, K. J.; Kirk, J.P.; Rogillio, H.E. 1996. Distribution and population attributes of Gulf sturgeon in the lower Pearl River system, Louisiana. Proceedings of Annual Conference of the SEAFWA, 79-90.

Morrow, J. V., Jr.; Kirk, J.P.; Killgore, K. J.; Rogillio, H. E.; Knight, C. 1998. Status and recovery potential of Gulf sturgeon in the Pearl River system, Louisiana-Mississippi. North American Journal of Fisheries Management 18: 798-808.

Morrow, J. V., Jr.; Kirk, J.P.; Killgore, K. J.; Rogillio, H. 1999. Recommended enhancements to the Gulf sturgeon recovery and management plan based on Pearl River studies. North American Journal of Fisheries Management 19: 1117-1121.

Murphy, M. J.; Skaines, J. 1994. Habitat and movement of the Gulf sturgeon (*Acipenser oxyrhynchus desotoi*) in the Pascagoula River, Mississippi. Museum Technical Report No. 29. Mississippi Museum of Natural Science. Mississippi Department of Wildlife, Fisheries, and Parks. Jackson, MS. 20 pp.

NMFS, NOAA, U.S. Department of Commerce. 1998. Designated Critical Habitat; Green and Hawksbill Sea Turtles; Final Rule. Federal Register vol. 63, no. 170. Wednesday, September 2, 1998.

NOAA Fisheries, Office of Protected Resources (NOAA-1). Green Turtle (*Chelonia mydas*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 25 February 2008.

<http://www.nmfs.noaa.gov/pr/species/turtles/green.htm>

NOAA Fisheries, Office of Protected Resources (NOAA-2). Hawksbill Turtle (*Eretmochelys imbricata*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 26 February 2008. <http://www.nmfs.noaa.gov/pr/species/turtles/green.htm>

NOAA Fisheries, Office of Protected Resources (NOAA-3). Kemp's Ridley Turtle (*Lepidochelys kempii*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 26 February 2008. <http://www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm>

NOAA Fisheries, Office of Protected Resources (NOAA-4). Leatherback Turtle (*Dermochelys coriacea*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 26 February 2008. <http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.htm>

NOAA Fisheries, Office of Protected Resources (NOAA-5). Loggerhead Turtle (*Caretta caretta*). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Accessed 26 February 2008. <http://www.nmfs.noaa.gov/pr/species/turtles/loggerhead.htm>

NOAA Fisheries, Office of Protected Resources. Endangered Species Act- Section 7 Consultation Deeping of Galveston Bay Entrance Channel (Houston-Galveston Navigation Channels Project) Using a Hopper dredge. National Marine Fisheries Service

NOAA Fisheries. (n/d) Northern Florida Fact sheet for the Green Sea Turtle.

NOAA Fisheries. (n/d) Northern Florida Fact sheet for the Kemp's Ridley Sea Turtle.

NOAA Fisheries. (n/d) Northern Florida Fact sheet for the Loggerhead Sea Turtle.

Ogren, L.H. Biology and Ecology of Sea Turtles. 1988. Prepared for National Marine Fisheries, Panama City Laboratory. Sept. 7.

Plotkin, P.T. 1995. Personal Communication. Drexel University, Philadelphia, Pennsylvania.

Plotkin, P. and A.F. Amos. 1990. Effects of anthropogenic debris on sea turtles in the northwestern Gulf of Mexico. *in* R.S. Shomura and M.L. Godfrey (eds.). Proceedings of the Second International Conference on Marine Debris. NOAA Tech. Memo NMFS-SWFSC-154: 736-743.

Plotkin, P.T., M.K. Wicksten, and A.F. Amos. 1993. Feeding ecology of the loggerhead sea turtle *Caretta caretta* in the Northwestern Gulf of Mexico. Marine Biology 115: 1-15.

Pritchard, P.C.H. 1969. Sea turtles of the Guianas. Bull. Fla. State Mus. 13(2):1-139.

Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida and the Gulf of Mexico. Univ. Miami Press, Coral Gables, Florida.

Reynolds, C. R. 1993. Gulf sturgeon sightings, historic and recent - a summary of public responses. U.S. Fish and Wildlife Service. Panama City, Florida. 40 pp.

Rogillio, H. E. 1993. Status survey of Gulf sturgeon in Louisiana. Louisiana Department of Wildlife and Fisheries. Project E1-1. 6 pp.

Sears, C.J. 1995. Preliminary genetic analysis of the population structure of Georgia loggerhead sea turtles. Presented at the Fifteenth Annual Symposium of Sea Turtle Biology and Conservation, February 1995, Hilton Head, SC.

Sears, C.J., B.W. Bowen, R.W. Chapman, S.B. Galloway, S.R. Hopkins-Murphy, and C.M. Woodley. 1995. Demographic composition of the juvenile loggerhead sea turtle (*Caretta caretta*) feeding population off Charleston, South Carolina: evidence from mitochondrial DNA markers. Mar. Biol. 123:869-874.

Shaver, D.J. 1991. Feeding ecology of wild and head-started Kemp's ridley sea turtles in south Texas waters. Journal of Herpetology. Vol. 23. 1991.

Shaver, D.J. 1994. Sea turtle abundance, seasonality and growth data at the Mansfield Channel, Texas. In B.A. Schroeder and B.E. Witherington (compilers), Proceedings of the thirteenth annual symposium on sea turtle biology and conservation, NOAA Tech. Memo NMFS-SEFC-341: 166-169.

Sulak, K. J.; Clugston, J. P. 1998. Early life history stages of Gulf sturgeon in the Suwannee River, Florida. V127: 758-771.

Sulak, K. J.; Clugston, J. P. 1999. Recent advances in life history of Gulf of Mexico sturgeon, *Acipenser oxyrinchus dosotoi*, in the Suwannee river Florida, USA: A synopsis. Journal of Applied Ichthyology. 15: 116-128.

U.S. Fish and Wildlife Service. 1980. Information Report: Gulf of Mexico Sturgeon *Acipenser oxyrhynchus desotoi* (Vladykov). Jacksonville, Florida. 79 pp.

U.S. Fish and Wildlife Service and Gulf States Marine Fisheries Commission. 1995. Gulf Sturgeon Recovery Plan. Atlanta, Georgia. 170 pp.

Appendix A-3

Biological Opinion
U.S. Fish and Wildlife Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506

September 23, 2010

Colonel Edward R. Fleming
District Commander
U.S. Army Corps of Engineers
Post office Box 60267
New Orleans, LA 70160-0267

Dear Colonel Fleming:

This document is the Fish and Wildlife Service's (Service) biological opinion based on our review of the New Orleans District Corps of Engineers' (Corps), proposed Medium Diversion at White Ditch located in Plaquemines Parish, Louisiana, and its effects on the endangered pallid sturgeon (*Scaphirhynchus albus*) per section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). Your May 14, 2010, request for formal consultation was received on May 17, 2010. Additional information necessary to initiate consultation was provided by letter dated July 15, 2010, and received in this office on July 19, 2009.

This biological opinion (BO) is based on information provided in the May 14, 2010, biological assessment (BA), the July 15, 2010, letter providing supplemental information, the subsequent telephone conversation of August 27, 2010, regarding reasonable and prudent measures and methods for estimation of take, electronic mail between the Service and the Corps, and other sources of information. A complete administrative record of this consultation is on file at the Ecological Services office in Lafayette, Louisiana.

Consultation History

FWS Log No: 43440-2009-F-3314
Date Started: May 14, 2010 **Ecosystem**: Lower Mississippi River
Action Agency: U.S. Corps of Engineers, New Orleans District
Project Title: Medium Diversion at White Ditch
County: Plaquemines Parish

TAKE PRIDE IN AMERICA

The biological assessment (BA) was sent to us by members of the Army Corps of Engineers (Corps) on May 14, 2010. They determined that the project described herein was "Likely to affect, but not adversely affect" the listed pallid sturgeon. The U.S. Fish and Wildlife Service did not concur with this initial determination due to lack of information provided in the biological assessment and because of the reported catches of entrained pallid sturgeon in other diversions. The letter of nonconcurrence was sent by the Service to the Corps on July 1, 2010.

A meeting was held by the Corps on July 8, 2010, to discuss the path forward on the consultation. A timeline was established to ensure any missing information could be indentified and acquired in a timely manner.

Additional information and request to initiate formal consultation on the Medium Diversion at White Ditch and its possible affects on the pallid sturgeon was received on July 15, 2010. An electronic mail exchange between the Service and the Corps occurred on July 16, 2010, on three different methods that could be used to estimate take.

August 18, 2010, an e-mail was sent out by the Service to members of the Corps with a list of possible reasonable and prudent measures that could be incorporated to reduce possible take.

A follow-up conference call was held on August 27, 2010, with Thomas Parker, Jan Hoover and Jack Killgore of the Corps to discuss minimization measures and methods for estimating take.

A conference call with Dr. Boyd Kynard was held Sept 7, 2010 to further discuss bypass systems and fish passage.

Table 1. Species and critical habitat evaluated for effects and those where the Service has concurred with a not likely to be adversely affected determination.

SPECIES or CRITICAL HABITAT*	**PRESENT IN ACTION AREA**	**PRESENT IN ACTION AREA BUT NOT LIKELY TO BE ADVERSELY AFFECTED**
Piping Plover	*Present*	*Concur*
West Indian Manatee	*Present*	*Concur*

**The above species and critical habitat not impacted by this action will not be discussed further in this biological opinion.*

BIOLOGICAL OPINION

DESCRIPTION OF PROPOSED ACTION

Freshwater diversions have been an important tool to combat land loss along the coast of Louisiana.

Six spillways, diversions and siphons have been built, namely the Bonnet Carre Spillway (Rmi 160), Davis Pond diversion (Rmi 119), Violet Siphon (Rmi 83), Naomi siphon (Rmi 63), the White Ditch siphon (Rmi 64) and Caernarvon diversion (Rmi 81). Some of these have resulted in benefits to the marshes near the outfall areas; therefore, four more are being proposed including the diversion at White Ditch (Figure 1). The Violet and White Ditch siphons have the capacity of diverting up to 200 cfs with Naomi diverting up to 1,500 cfs. The diversions generally carry a much larger amount of water with Caernarvon having the capacity to carry up to 8,000 cfs and Davis Pond has the capacity to carry 10,650 cfs. The Bonnet Carre Spillway was designed for flood control and not marsh creation and has a far larger capacity at around 250,000 cfs.

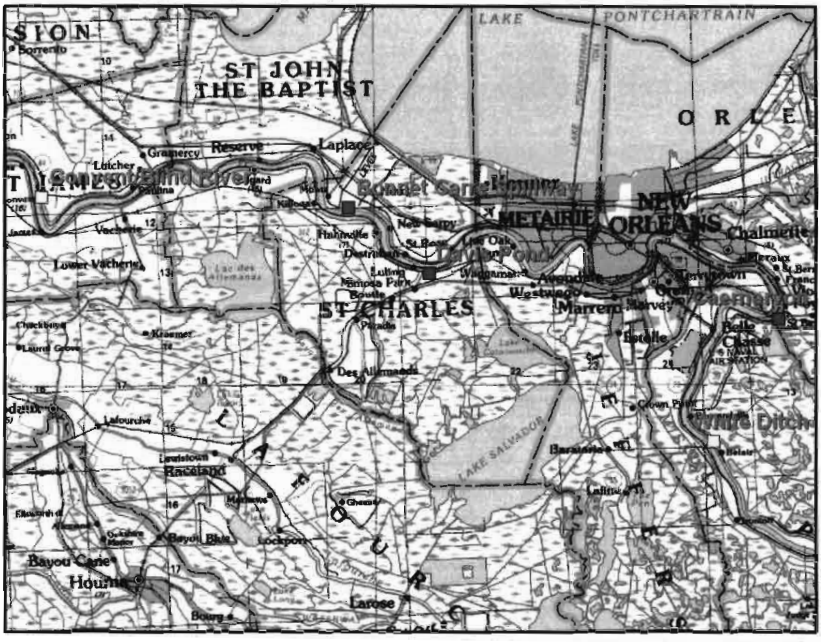


Figure 1. Existing and proposed diversions referenced in this document. The blue markers denote existing diversions while the yellow marks denote the proposed projects.

The Medium Diversion at White Ditch project (MDWD) is located between Mississippi River Miles 64.5 and 59.8 in the LCA subprovince 1 of Breton Sound in Plaquemines Parish, Louisiana. The influence area encompasses over 98,000 acres of intermediate and brackish intertidal wetlands that are home to a myriad of species of varying life stages. The boundaries are defined by the river Aux Chenes to the northeast and the levees along the left descending bank of the Mississippi River and extend out into Breton Sound (Figure 2). The Authorization for the project comes from Title VII of the Water Resources Development Act (WRDA) 2007 authorizes the Louisiana Coastal Area (LCA) ecosystem restoration program.

Degradation of the marsh has occurred over several years because of channel construction and levee construction reducing the natural over-topping of the river banks and resulting in altered hydrologic conditions. These changes in water regime have made the marsh more susceptible to storm damage, subsidence, soil erosion, and salt water intrusion. The White Ditch siphon at Rmi 64 (3 miles south of Belair, Louisiana) off the east descending bank of the Mississippi River was completed in 1963 for the purpose of increasing oyster and muskrat habitat by providing freshwater inputs during high water. However, no operational plan was put in place and thus the benefits of the siphon were limited. The siphon fell into disrepair and was only recently refurbished for research purposes. The proposed diversion will have a more controlled redirection of Mississippi River water into the marsh reducing salinity and increasing sediment inputs which should result in a more natural hydrologic condition.

The purpose of the proposed project is to restore freshwater and sediment inputs into this area of degraded marsh in the Breton Sound by diverted a large amount of Mississippi River water in the Marshes of the Breton Sound. Additionally, 31 acres of ridges will direct incoming water, and 385 acres of marsh will be created from the material removed from the 223 acre outfall canal. The constructed outfall channel would be approximately 7,200 feet long from the structure to Bayou Garelle. The intake and outfall channel would be dredged to a depth of -16 ft (NAVD) with a side slope ratio of 1:5. Bottom widths of the intake and out fall channels would be 365 ft and top widths would be 545 ft. The MDWD would be capable of diverting up to 35,000 cfs (4 percent of the rivers flow) through 10 15ft x15ft box culverts that could be opened and closed via hydraulic sluice gates (See appendix for engineering design of the control structure). This flow is at least 3 times that of the Davis Pond diversion and 4 times that of Caernarvon diversion. The current operational plan would take advantage of high river stages and high sediment loads in the spring and direct an annual spring pulse between March and April of the maximum 35,000 cfs followed by maintenance flow of 1,000 cfs for the remaining period of the annual cycle. This spring pulse plan was devised from data gathered from the Caernarvon Diversion which shows that some negative effects can occur from over-freshening the marshes during sensitive periods in the life cycles of marsh species. Though it has been noted in the Preliminary Draft Feasibility Study/SEIS that the effects of the White Ditch diversion will be monitored over time and adaptive management will be utilized to maximize benefits. The diversion is estimated to be 5 percent or less of the Mississippi River annual flow for most years.

Several locations for the structure were considered for the proposed White Ditch project and it was decided that the most cost effective plan would be to build the structure and channel somewhere between the existing White Ditch siphon (Rmi 64) and the town of Phoenix (Rmi 58.8) because of the lack of structures and a backing levee. The bend a few miles north of Phoenix (Figure 3.) was selected because of the build up of sediment forming a point bar in this location meant that a higher sediment load than other locations would be available for diversion through the structure. This is not the same location as the existing White Ditch Siphon and no other structures exist in the selected location which means that marsh will have to be excavated to build the outfall channel.

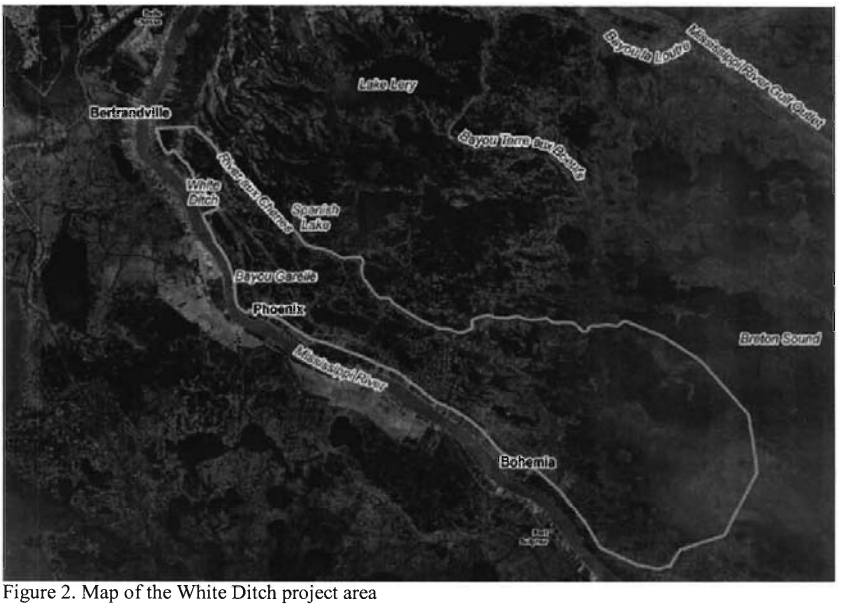


Figure 2. Map of the White Ditch project area

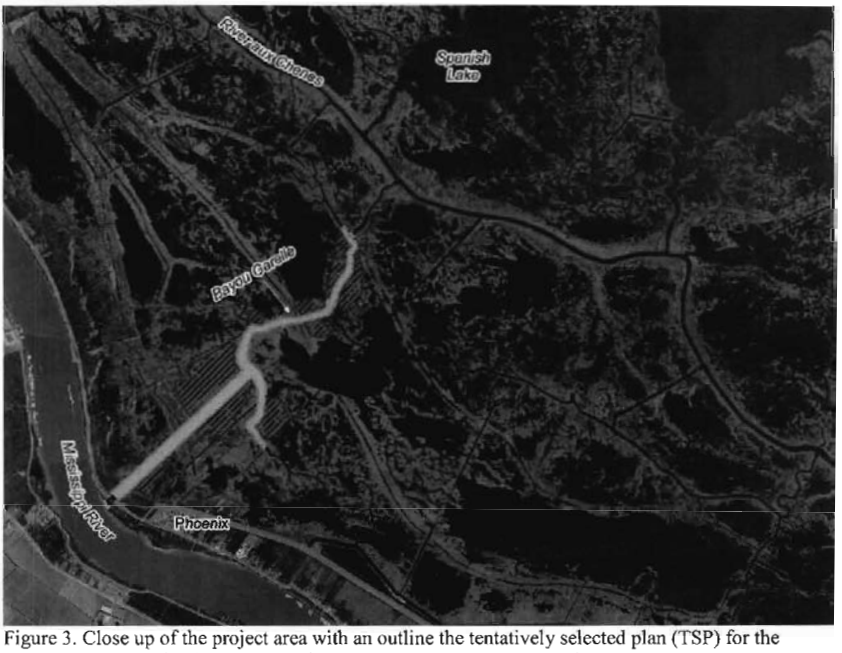


Figure 3. Close up of the project area with an outline the tentatively selected plan (TSP) for the conveyance channel to be constructed and the bordering areas of marsh creation (in green).

STATUS OF THE SPECIES/CRITICAL HABITAT

Species Description

Pallid Sturgeon are a bottom-oriented, large river obligate fish inhabiting the Missouri and Mississippi Rivers from Montana to Louisiana (Kallemeyn 1983, USFWS 2007) and the Atchafalaya River (Reed and Ewing 1993, USFWS 2007). It was proposed for listing as an endangered species on August 30, 1989 (54 FR 35901-35904) and was listed as endangered on October 9, 1990 (55 FR 36641-36647). The reasons for listing were the apparent lack of recruitment for over 15 years, and the habitat threats existing at the time of listing. Destruction and alteration of habitats by human modification of the river system is believed to be the primary cause of declines in reproduction, growth, and survival of the pallid sturgeon; however, commercial harvest, and hybridization in parts of its range also affected the population. Critical habitat has not been proposed or designated for the pallid sturgeon. The Service conducted a 5-year review of this species' endangered status in 2007

and determined that no status change was needed at that time.

Life History

Taxonomy and Genetics

The pallid sturgeon, one of the largest fish found in the Missouri-Mississippi River drainage, grows to lengths of over 6 feet (ft) (1.8 meters [m]), can weigh in excess of 80 pounds (lbs) (36 kilograms [kg]), and can be described as having a flattened, shovel-shaped snout, a long, slender, and completely armored caudal peduncle, and lacking a spiracle (Smith 1979). Though pallid sturgeon could potentially grow very large, most historical and recent published catches report pallid sturgeon weights of up to 30 lbs (Paul Hartfield, per comm.). As with other sturgeon, the mouth is toothless, protrusible, and ventrally positioned under the snout. The skeletal structure is primarily cartilaginous (Gilbraith et al. 1988). Pallid sturgeon are similar in appearance to the more common and darker shovelnose sturgeon (*S. platyrhynchus*) prompting a Similarity of Appearance rule passed in 2010 (75 FR 53598-53606). Pflieger (1975) reported the principal features distinguishing pallid sturgeon from shovelnose sturgeon as the paucity of dermal ossifications on the belly, 24 or more anal fin rays, and 37 or more dorsal fin rays. Forbes and Richardson (1905) noted that pallid sturgeon contain 20 to 22 ribs while the shovelnose sturgeon has only 10 to 11 ribs. The air bladder was also noted as being relatively smaller in the pallid sturgeon. Those authors recorded differences between the pallid and shovelnose sturgeon in the number of ventral radials, relative depth of lateral scutes, orbital space size, proportional lengths of inner and outer barbels, mouth width, proportion of head width to head length, and proportion of head length to body length.

While these morphological differences are commonly used to distinguish pallid sturgeon from shovelnose sturgeon (Bailey and Cross 1954, Keenlyne et al. 1994) visual differences can sometimes be difficult to note because of geographic variation, allometric growth, and hybridization between shovelnose and pallid sturgeon. Genetic testing can be another tool to further identify individuals though this technology needs further development. Since the pallid sturgeon was listed in 1990, however, geneticists and ichthyologists have worked to refine testing procedures and develop the materials to definitively distinguish and identify these two fish species. The following briefly summarizes the results of the more recent studies.

Campton et al. (2000) concluded that mitochondrial DNA (mDNA) analyses provide the first molecular genetic evidence for distinguishing Scaphirhynchus species. The results of that study indicate significant reproductive isolation between pallid and shovelnose sturgeon in areas of natural sympatry.

McQuown et al. (2000) developed a microsatellite database for use in genetic studies of various sturgeon species, including *Scaphirhynchus*. With the use of microsatellites, they found a high degree of polymorphism within each species.

Tranah et al. (2001) conducted a study utilizing five nuclear DNA microsatellite loci to measure

genetic variability within and among populations of pallid and shovelnose sturgeon at the northern and southern extremes of their sympatric ranges. Their results indicated that pallid and shovelnose sturgeon are genetically distinct at three sympatric locations. They also found evidence in the upper Missouri River (2 populations were genetically distinct from pallid sturgeon in the Atchafalaya River) suggesting that northern and southern pallid sturgeon populations are reproductively isolated. Furthermore, shovelnose sturgeons from the three populations were genetically indistinguishable and showed no population structure (Tranah et al. 2001). Tranah et al. (2001) also noted that sturgeon from the Atchafalaya River that were morphologically determined to be hybrids were genetically different from pallid sturgeon but were not statistically distinguishable from shovelnose sturgeon. However, Tranah (2001) states that morphologically intermediate Atchafalaya River sturgeon appeared to be genetically intermediate to pallid and shovelnose sturgeon, suggesting these individuals were possibly hybrids.

Simons et al. (2001) conducted a phylogenetic study of the genus *Scaphirhynchus*. They could not establish hierarchical relationships based on mtDNA that are consistent with morphological data; however, their results are consistent with the hypothesis of a low rate of evolution between *Scaphirhynchus* species, and reflect recent hybridization between shovelnose and pallid sturgeon. They state that such hybridization is probably due to habitat degradation, but provide no supporting information as to the specific mechanism or causes of hybridization between the two species.

USFWS (2007) summarized additional genetic information; the following three paragraphs present that survey. The presence of sturgeon that appear to be morphologically intermediate between pallid and shovelnose sturgeon, were presumed to represent pallid-shovelnose sturgeon hybrids (Keenlyne et al. 1994, Carlson et al. 1985) and spurred an effort to determine the genetic origins of these fish. Tranah et al. (2004) combined the data from Campton et al. (2000) and Tranah et al. (2001) and added 4 additional microsatellite loci to the data set to determine the genetic origins of 10 morphologically intermediate sturgeon collected from the Atchafalaya River. All fish were classified as pallid, shovelnose or hybrid sturgeon via the hybrid index method of Campton (1987). Results of Tranah et al. (2004) support earlier morphometric-based conclusions on the presences of hybrids (Keenlyne et al. 1994) suggesting intercrossing or gene flow between the two species is more pronounced in the middle Mississippi and Atchafalaya Rivers than elsewhere. Tranah et al. (2004) also suggested that while shovelnose and pallid sturgeon are distinct morphologically, they are undergoing hybridization in the lower Mississippi and Atchafalaya Rivers.

Morphometric data also may indicate hybridization in the lower Missouri River (Grady et al. 2001a; Grady et al. 2001b; Doyle and Starostka 2003) based on the presence of morphologically intermediate sturgeon. The extent to which these hybrids are going beyond the first generation (introgressive hybridization) is currently unknown. Tranah et al. (2004) suggest that female pallid sturgeon are mating with shovelnose sturgeon males and the hybrids are subsequently backcrossing with the more numerous shovelnose sturgeon. This finding should be treated as preliminary because a small number of fish classified morphologically as hybrids were examined. Allendorf et al. (2001) theorized that pallid and shovelnose sturgeon in the lower Mississippi River have not evolved reproductive isolation to the same degree as pallid and shovelnose sturgeon in the upper Missouri River and suggested there may be no pure pallid sturgeon in the lower Mississippi River because all

sturgeon located in that reach comprise a hybrid swarm. Although microsatellite studies have provided evidence of hybridization between pallid and shovelnose sturgeon in the Missouri, Mississippi, and Atchafalaya Rivers (Tranah et al. 2001; Heist and Schrey 2006a and b, Schrey and Heist 2007), these and other studies (Ray et al. 2007) have also demonstrated that shovelnose and pallid sturgeon remain genetically distinct from each other in the Missouri, Mississippi, and Atchafalaya Rivers, and a third group, hybrids/intermediates, are present.

Recent studies (Murphy et al., 2007, Kuhajda et al. 2007) have shown that at least some proportion of morphological variation in pallid sturgeon is due to allometric growth and/or geographic variation which has been mistaken for hybridization. Hartfield and Kuhajda (2009) found that the morphological variation considered as evidence of hybridization has been present in Mississippi River pallid sturgeon population for more than a century. They also found that hybridization rates between pallid and shovelnose sturgeon have been overestimated based on character indices because they do not account for allometric growth or for natural variation within or between populations within each species (Hartfield and Kuhajda 2009).

More information is needed on the evolutionary dynamics of intermediate forms between pallid and shovelnose sturgeon to understand the role and effects of hybridization on the status of pallid sturgeon (USFWS 2007, Hartfield and Kuhajda 2009).

Age, Growth and Reproduction

Pallid sturgeon, like most sturgeon species, are considered long lived species with slow growth and low reproductive rates. Studying the reproduction of these species has been difficult and exact details continue to elude researchers. Some recent studies have made an effort to explore pallid sturgeon reproduction (Deloney et al. 2009); however, even basic parameters such as spawning locations, substrate preference, water temperature, or time of year have not been well documented yet. Much of what has been learned about pallid sturgeon reproduction has been from tracking sexually mature sturgeon and captures of larval sturgeon. Age, growth and possible spawning events of captured fish can be determined from cross-sections of pectoral fin rays and sexual maturity of adult fish can be determined from visual inspection or use of an endoscope.

Fogle (1963) estimated growth rates (using cross sections of pectoral fin rays from six pallid sturgeon from Lake Oahe in South Dakota) were relatively rapid during the first 4 years, but that growth decreased to approximately 2.8- in. (70 mm) per-year between ages 5 and 10. Carlson and Pflieger (1981) presented data (n=8) from the Missouri and Mississippi Rivers in Missouri that showed slightly slower growth than from pallid sturgeon in South Dakota. Keenlyne and Jenkins (1993) found that male pallid sturgeon from Louisiana, Missouri, and North Dakota showed rapid growth from age-5 to age-7. The rapid growth slowed once the fish reached sexual maturity.

In 1998, a 66-lb (30-kg), 63-in (160-cm), female pallid sturgeon captured from North Dakota was aged following mortality. Dennis Scarneccia, with the University of Idaho, used techniques developed for white sturgeon and estimated the age at over 50 years and possibly as high as 60 (USFWS 2002).

Killgore et al. (2007a), aged pallid sturgeon from the Middle and Lower Mississippi River and found that fish of the same age but from the Lower Mississippi River were of a smaller size. However, as fish grew older, the size difference between the fishes from those two river reaches appeared to be reduced. In the Lower Mississippi River, size at sexual maturity (9 years) for females was estimated to be approximately 26.8 inches (680 mm), while males were approximately 24.4 inches (620 mm) at sexual maturity (7 years). Growth rates for fish greater than 11 years were much less than younger fish.

Kallemeyn (1983) reported that male pallid sturgeon reach sexual maturity at 21- to 23- in (53.3 to 58.4 cm); however, size and age of females at sexual maturity were unknown at that time. Conte et al. (1988) indicated that females of most sturgeon in North America do not mature until 7 years of age and typically require several years for eggs to mature between spawnings. The age of sexual maturity and intervals between spawning were estimated for nine pallid sturgeon by recording what were interpreted to be spawning events from pectoral fin ray cross sections. Sexual maturity for males was estimated to be 7 to 9 years, with 2- to 3- year intervals between spawning years. Females were estimated to reach sexual maturity in 15 to 20 years, with 3- to 10- year intervals between spawning years (Keenlyne and Jenkins 1993). Time of sexual maturity and the age intervals between spawning years is likely to be influenced by available forage, environmental conditions and other factors (USFWS 1993), and thus, likely varies to some degree between river reaches.

It can be difficult to isolate the exact cues for spawning because certain environmental factors can not be isolated; though it has been widely hypothesized that increases in discharge, photoperiod, and increases in water temperature may be possible cues that trigger upstream spawning migrations. Berg (1981) published that shovelnose sturgeon spawning migrations occur in response to increased flows in June. Similarly, Bramblett (1996) stated that discharge and photoperiod may be important environmental cues for the timing of movements for both shovelnose and pallid sturgeon; though, direct links between discharge and pallid sturgeon reproductive physiology have not been fully substantiated (Deloney et al. 2009). It has also been hypothesized that increases in water temperature may cue migrations and spawning events because water temperature changes are more predictable and usually coincide with changes in discharge, changes in photoperiod, and time of year (Deloney et al. 2009). Bramblett (1996) found a typical pattern of movement for pallid sturgeon was to move upstream into the Yellowstone River and out of the Missouri River in the early spring during increasing discharge and photoperiod; reside in the Yellowstone River during high discharge; and to move downstream, back into the Missouri River during late summer; though pallid sturgeon generally move long distances and it is unclear whether this movement is for spawning.

Pallid sturgeon are thought to spawn in the spring or early summer. All sturgeon species are multiple spawners, and release their eggs at intervals. Time of spawning for pallid sturgeon has not been well-documented, but is believed to occur sometime between March and July, depending on location (Forbes and Richardson 1905, Gilbraith et al. 1988; Keenlyne and Jenkins 1993). Sexually mature pallid sturgeon have been observed in the Yellowstone River in western North Dakota during late May and early June when water temperatures ranged from 60-65°F (15.5-18.5°C) (USFWS 2000). A male pallid sturgeon in the Missouri River near Williston, ND, was observed running milt in late May

1991 (USFWS 2000). Deloney et al. (2009) noted the recapture of two tagged female pallid sturgeon in 2007 in the lower Missouri River that had spawned out completely sometime between late April and mid-May near Sioux City, Iowa and Ponca State Park, Nebraska. Keenlyne and Jenkins (1993) estimate that spawning probably begins in March in the lower Mississippi and Atchafalaya Rivers; in late April or early May in the lower Missouri and middle Mississippi Rivers; and in late May or early June in the upper Missouri River. However, catches of one seven day and one nine day post-hatch larval sturgeons near Vicksburg, Mississippi on May 20 indicated that hatching occurred on the 13 and 11 of May (Snyder 1994 in Constant et al., 1997). Another larval sturgeon captured at White Castle, Louisiana was collected on the 15 of May (Zimpfer et al., 1988 in Constant et al., 1997). Other larval sturgeon recently captured between Greenville and Vicksburg, Mississippi indicate hatching occurred in early to mid-May (Paul Hartfield personal comment). Incubation time of spawned eggs can vary but usually lasts 3 to 5 days (Columbia Environmental Research Center 2008, Dean 2004). Because pallid sturgeon eggs are adhesive, the younger the larvae captured, the greater chance it was spawned near its site of capture. Based on these larval catches, that span almost twenty years, it is most probable that hatching occurs in early to late May in the Lower Mississippi River. More recently, the capture of *Scaphirhynchus* larvae and post-larvae in the Mississippi River during fall months, as well as spring, could be interpreted as an extended season or a second spawn in the lower latitudes of distribution (Paul Hartfield, USFWS, per. comm. 2006). Ongoing sampling efforts by ERDC (2010) documented young-of-year (< 56 days old) sturgeon throughout the entire summer. Tripp et al. (2009) documented female shovelnose sturgeon with ripe eggs and males that were milting and a single age-0 sturgeon in the fall.

The adhesive eggs are released in deep channels or rapids and are left unattended (Gilbraith et al. 1988). The larvae of *Scaphirhynchus* are pelagic, exhibiting swim-up and drift behavior immediately after hatching. Downstream drift of larval pallid sturgeon begins at day-0 at hatching and continues up to day-13, with a decline after day-8 (Kynard et al., 2002, 2005). Field studies of drift dynamics and behavior of larvae pallid sturgeon, conducted in a Missouri River side channel, suggested that they may drift 152 to 329 miles (mi) (245 to 530 kilometer [km]) depending on water velocity, during the first 11 days, and tend to become more benthic between days 11-17 (Braaten et al., 2008), suggesting that river distance and suitable habitat available below spawning areas may be important to survival of *Scaphirhynchus* larvae, and a key factor in recruitment success of river sturgeon.

Keenlyne et al. (1992) estimated fecundity for a female pallid sturgeon taken from the upper Missouri River. The authors found the mass of mature eggs weighed 69 oz (1,952 g), which represented 11.4 percent of total body weight. Total fecundity was estimated at 170,000 eggs for this female. Females may take up to 10 years between spawnings, depending on the quality and quantity of food available in their natural habitat (Keenlyne and Jenkins 1993). Therefore, fecundity of a female may vary considerably, with an individual female spawning only a few times during her normal life span (Duffy et al. 1996).

Gathering evidence of successful pallid sturgeon reproduction and recruitment has been difficult throughout the range of the species and captures have generally been low suggesting lack of reproduction or low recruitment. However, as knowledge of sturgeon spawning physiology has improved and the ability of sampling gear to detect larval sturgeon has improved, researchers have

begun to capture increasing numbers of larval sturgeon in the Middle Mississippi River and the Lower Mississippi River (Herzog, pers. comm., Hartfield pers. comm., Killgore, pers. comm.) and in the Missouri River. In 1998, the Missouri Department of Conservation (MDC) collected a young-of-the-year pallid sturgeon at approximate river mile 49.5 south of Cape Girardeau in the middle Mississippi River (Petersen and Herzog 1999). Hesse and Mestl (1993) collected two sturgeon larvae from the Missouri River adjacent to Nebraska between 1983 and 1991. Those larvae were among 147,000 fish larvae collected during filtration of 18,340,014 cu ft (519,400 cu m) of river water. Gardner and Stewart (1987) collected no sturgeon larvae in 339 samples from the Missouri River, or in 77 samples from tributary streams, where 3,124 and 5,526 fish larvae were collected, respectively. During the summer of 1998 and 1999, several pallid sturgeon larvae were collected from the lower Missouri River in Missouri (USFWS 2000) suggesting that pallid sturgeon are reproducing in the Missouri River. In three years of sampling in/near Lisbon Chute on the Missouri River, the Service's Columbia Missouri Fishery Resources Office collected over 10,000 small fishes utilizing seines, benthic trawls and fyke nets. In processing 9,855 of these fishes, 1 confirmed and 2 probable larval pallid sturgeon have been identified (USFWS 2000). Similarly, Deloney et al. (2009) tracked gravid females in the Missouri River and made observations on their readiness. Subsequent recaptures showed they had spawned out in the Missouri river near the apex of their upstream migrations. Larval collections performed as part of the same study had several age-0 larval sturgeon collected below the confluence of Big Sioux River into the Missouri River in Northwest Iowa. It is not clear whether the larvae were pallid sturgeon or shovelnose.

As captures of larval sturgeon have increased so has evidence of recruitment. In the Middle Mississippi River, pallid captures aged from 5 – 14 years; in the Lower Mississippi River, pallid captures aged from 3 – 21 years (Killgore et al. 2007a). Comparing Lower Mississippi River age-growth curves (Killgore et al. 2007a) to capture length data in the Lower Mississippi River and Atchafalaya River indicate multiple cohorts spanning almost 20 years (3 to 20 years). Annual capture of larval pallid, along with limited age data from the Lower Mississippi River indicate some level of regular annual recruitment of pallid sturgeon in the Lower Mississippi River. Similarly, recent work in the Atchafalaya River has revealed fish of several age groups, suggesting that some reproduction and recruitment may also occur in the Atchafalaya River. The only physical evidence of reproduction, however, was three gravid females (Constant et al. 1997). According to their data, pallid sturgeon collected in the Atchafalaya River and other areas of the Mississippi River have averaged less than 6.6 lbs (3 kg) and length-at-age estimates calculated according to Fogle (1963) indicated that even the smallest fish were over age 6, with the oldest perhaps over age 14. The age of fish susceptible to the sampling gear used in their study indicates the most recent recruitment of pallid sturgeon was from the 1988 year class (Constant et al. 1997).

In 1985, a shovelnose larva was collected at White Castle (approximately 30 miles upstream; River Mile 193) (Constant et al. 1997). Larval shovelnose sturgeon have also been collected in the vicinity of Vicksburg, Mississippi (River Mile 435) approximately 144 miles upstream of the diversion (Constant et al., 1997, Hartfield personnel comment 2009). Ongoing sampling efforts by ERDC documented YOY sturgeon between Rmi 80 and 160 over multiple years (ERDC 2010) with YOY sturgeon being captured as far south as Rmi 195.5. The size and location of some of those YOY would indicate a more southern spawning site (e.g., White Castle, Rmi 193) than previously believed.

This area would likely represent the most southern location of larger gravel deposits within the river.

Feeding

Carlson et al. (1985) determined composition of food categories, by volume and frequency of occurrence, in the diet of shovelnose sturgeon (n=234), pallid sturgeon (n=9), and hybrids (n=9). Although benthic macroinvertebrates characteristic of river habitats are important dietary components (Modde and Schmulbach 1977, Carlson et al. 1985), the occurrence of lake and terrestrial invertebrates in sturgeon stomachs suggest that drifting invertebrates may also be important forage organisms (Modde and Schmulbach 1977, Constant et al. 1997). Aquatic invertebrates (principally the immature stages of insects) compose most of the diet of shovelnose sturgeon, while adult pallid sturgeon and purported hybrids consume a greater proportion of fishes (mostly cyprinids) (Hoover et al., 2007). Grohs et al (2009) reported that pallid sturgeon in the Missouri River downstream of Fort Randall Dam, had high percent occurrences' of Diptera, Emphemeroptera and fish and that percent composition of fishes increased with pallid sturgeon body size. It was noted that between ages four and five in their study, pallid sturgeon shifted from predominately invertebrates to fishes. Other researchers also reported a higher incidence of fishes in the diet of adult pallid sturgeon than in the diet of shovelnose sturgeon (Cross 1967, Held 1969). Most piscivorous Missouri River species eat large quantities of aquatic insect larvae in early life and even as adults (Modde and Schmulbach 1977).

Movement

Pallid sturgeon exhibit seasonal variation in movement patterns based upon temperature and discharge (Bramblett 1996, Constant et al. 1997, Sheehan et al. 1998, Hurley 1996). The timing of pallid sturgeon movements and migration in the Lower Mississippi River may differ from that of other rivers (i.e. the Missouri River) and other portions of the Mississippi River (Constant et al., 1997). Migrations and movement in the Atchafalaya River was associated with water temperatures between 14^0 and 21^0 Celsius (C) (Constant et al,. 1997) and spring and early summer season (Schramm and Dunn 2008). Movement patterns also vary between spawning versus non-spawning years (Bramblett 1996). Bramblett (1996) reported an average home range of 48.8 mi (78 km) in the Yellowstone and upper Missouri Rivers while Sheehan et al. (1998) reported a home range of 21.2 mi (34 km) in the middle Mississippi River. Sheehan et al. (1998) speculated that because habitat in the Mississippi River is relatively uniform, large movements and home ranges may not be as beneficial in the Mississippi River as in the Yellowstone and Upper Missouri Rivers area, because study fish are not likely to encounter new habitats and thus have a smaller home range.

As large river fish, pallid sturgeon are capable of moving long distances in search of favorable habitat. Sheehan et al. (1998) noted one study fish moving along a 60.3 mi (97 km) stretch of river. Bramblett (1996) noted a maximum home range as large as 198.6 mi (319 km), with pallid sturgeon moving up to 13 mi/day (21 km/day) and shovelnose sturgeon moving up to 9 mi/day (15 km/day). Schramm and Dunn (2008) documented one fish in the Atchafalaya River moving 96 mi. Dean (2007) reported the capture of a pallid sturgeon in the Atchafalaya River that was produced at the Blind Pony State Fish Hatchery in Missouri and released in 1997. Hoover et al. (2007) hypothesized

that long-range movements during the spring may not just be associated with spawning but could also be associated with feeding.

Erickson (1992) found pallid sturgeon movement greater during the night while Bramblett (1996) observed greater movements during the day. The primary habitat difference suspected in those findings was turbidity. Erickson (1992) had secchi readings as high as 157 in. (400 cm) while Bramblett (1996) averaged 8 in (20 cm) and rarely exceeded 39 in (100 cm). Bramblett (1996) modeled the information from his study and found that predictive depth of pallid sturgeon was greater during the hours following sunrise and suggested that pallid sturgeon may be photophobic.

Hoover, et al. (2005) examined swimming performance of juvenile pallid sturgeon (maximum size 6.3 inches) at different velocities to determine possible entrainment by dredges. Minimum escape speeds for pallid sturgeon ranged from 1.6 to 1.7 feet per second (fps) and burst speeds were determined to range from 1.7 to 2.95 fps. Because they frequently failed to exhibit rheotaxis or orientation to the direction of flow (greater than 25 percent were non-swimmers); their ability to avoid entrainment based on swimming performance was determined to be relatively low. Adams (1999) also studied swim performance in juvenile pallid sturgeon. It was found that maximum sustained swimming speed was 0.328 fps and 0.82fps for their two groups of fish. The fish were found to transition to burst swimming speeds at 1.31 fps and 1.9 fps, respectively. White and Mefford (2002) examined swimming behavior and performance of shovelnose sturgeon ranging from 25.2 to 31.5 inches in length to aid in the design of a fish passage on the Yellowstone River. The ability of shovelnose sturgeon to navigate the length of the test flume was best (60 to 90 percent) over a smooth bottom followed by coarse sand, gravel and then cobble, but the small sample size and large variability precluded this from being a definitive conclusion. The greatest success at negotiating the flume was determined to occur between the range of 2 and 4 fps; however success at greater velocities, 6 fps, did occur. Failure to exhibit rheotaxis was also observed at velocities below 1.6 fps. Conversely, Adams et al. (1997) found all adult shovelnose to be positively rheotatic. Pallid sturgeon are believed to avoid areas that have no water velocity (Constant et al 1997) though Erickson (1992) observed individuals in low water velocities between .001 m/s to 0.3 m/s (DeLonay and Little 2002, cited in Quist 2004, Erickson 1992 cited in USFWS 2007, Backes et al., 1992, Constant et al. 1997). It's important to note that swim studies are often performed on hatchery fish or fish kept in tanks with low water velocity. Fish that are exercised and conditioned to higher water velocities can often sustain higher swim speeds (Boyd Kynard, personal comm. Sept 7, 2010).

Habitat use

The pallid sturgeon is adapted to the pre-development habitat conditions that historically existed in the Mississippi River and its tributaries. Those conditions can generally be described as large, free-flowing, warm water, turbid habitats with a diverse assemblage of physical attributes that were in a constant state of change (USFWS 1993; Mayden and Kuhajda 1997). Floodplains, backwaters, chutes, sloughs, islands, sandbars and main channel waters formed the large-river ecosystem that provided the macrohabitat requirements for all life stages of pallid sturgeon and other large-river fish. Within this range, pallid sturgeon tend to select main channel habitats (Sheehan et al., 1998, USFWS 2007) in the Mississippi River and main channel areas with islands or sand bars in the upper Missouri

River (Bramblett 1996, USFWS 2007). Pallid sturgeon typically remain in close contact with the substrate as this area provides food and refuge (Forbes and Richardson 1905, Schmulbach et al. 1975, Kallemeyn 1983, and Gilbraith et al. 1988).

The historic floodplain habitat of the Missouri and Mississippi Rivers provided important functions for the native large-river fish. Floodplains were the major sources of organic matter, sediments, and woody debris for the main stem rivers when flood condition flows crested their banks. The transition zone between the vegetated floodplain and the main channel included habitats with varied depths described as chutes, sloughs, or side channels. The chutes or sloughs between the islands and shore were shallower and had less current than the main channel. These areas provided valuable diversity to the fish habitat, and probably served as nursery and feeding areas for many aquatic species (Funk and Robinson 1974). The still waters in this transition zone allowed organic matter accumulations; important to macroinvertebrate production an important food source for both pallid sturgeon and shovelnose sturgeon (Carlson et al. 1985; Gardner and Stewart 1987). Flood condition flows connected those important habitats and allowed fish from the main channel to utilize those habitat areas and to exploit available food sources.

Pallid sturgeon were found to be more specific and restrictive in macrohabitat selection than shovelnose sturgeon (Bramblett 1996). According to that study, pallid sturgeon used river reaches with sinuous channel patterns, and islands and alluvial bars which generally have more diversity of depths, current velocities, and substrates than do relatively straight channels without islands or alluvial bars. The diversity of channel features such as backwaters and side channels was also higher. The subclimax riparian vegetation seres in those areas are indicative of a dynamic river channel and riparian zone (Johnson 1993).

Pallid sturgeon has have shown some preference in their selection of microhabitats and captures in the Mississippi River have been associated with islands, sand bars, gravel bars, and dikes in both the main channel and in secondary channels (USFWS 2007). In telemetry studies of pallid sturgeon on the middle Mississippi River, Sheehan et al. (1998) found a positive selection for main channel-border and downstream island-tips and also for depositional areas between wingdams and deep holes off wingdam tips. Those positive selections seem to correlate well with Carlson et al. (1985). Sheehan et al. (1998) speculated that areas between wingdam areas and downstream island-tips may be used as velocity refugia and/or feeding stations. Study sturgeon were found most often in main channel habitat; however, they exhibited selection against that habitat type. Their occurrence in such habitat was not surprising, considering that the main channel comprised approximately 65 percent of the available habitat in the study reach (Sheehan et al. 1998). Hurley (1996) also found that pallid sturgeon were selecting downstream island tips although they were not abundant within the study area.

Carlson et al. (1985) captured both pallid sturgeon and shovelnose sturgeon in gear-sets along sandbars on the inside of riverbends, and in deeply scoured pools behind wing dams, indicating overlap of habitat-usage by the two species. Four of 11 pallids, however, were captured in gear-sets in swifter currents where shovelnose sturgeon were less numerous. Although pallid sturgeon and shovelnose sturgeon habitat use and movements are similar in certain aspects, important differences

were noted by Bramblett (1996). Pallid sturgeon showed significant preferences during most times of the year for sandy substrates, particularly sand dunes, and avoided the gravel and cobble substrates preferred for spawning (Bramblett 1996). Constant et al. (1997) noted that pallid sturgeon spent considerable time associated with sand substrates. They noted that preference for sand substrates in low-slope areas suggests that pallid sturgeon use such areas as current refugia (e.g., use sand-wave troughs created as bed-material moves along the river bottom (Gordan et al. 1992)). Similarly, Shramm and Kuntz (2009) found that pallid sturgeon in the lower Mississippi River were associated with sand bar habitat and wing dikes, with sand bars preferred in spring and summer and island tips and wing dikes preferred in the fall and winter. The pallid sturgeon collected on the Yellowstone River in July 1991 by Watson and Stewart (1991) was over a bottom of mainly gravel and rock, which is the predominant substrate at that capture site. Reed and Ewing (1993) found sturgeon occurring in the man-made, rip-rap-lined outfall channels of the ORCC in Louisiana. Bramblett (1996) found that pallid sturgeon preferred sandy substrates, particularly sand dunes, and avoided substrates of gravel and cobble. In contrast, shovelnose sturgeon significantly preferred gravel and cobble substrates and avoided sand.

Constant et al. (1997) reporting on radio-tracked sturgeon, stated that they were most frequently found in low-slope areas and that such areas were used in proportion to their availability. No sturgeon were observed on extremely steep slopes. They found that sand made up over 80 percent of the substrate in low-slope areas where over 90 percent of pallid sturgeon were located. Constant et al. (1997) stated that the preference for sand substrates in low-slope areas suggest that pallid sturgeon use such areas as current refugia. Sand substrates were found to have lower invertebrate densities than substrates of silt-clay which were generally located on areas of steep slope which were exposed by swift currents. As such, it would have been energetically costly for pallid sturgeon to remain near those substrates for extended periods of time. Telemetry observations, however, showed 55 percent of sturgeon locations occurred within 32.8 feet (ft) (10 meters [m]) of steep slopes, suggesting that pallid sturgeon remained near areas of high food abundance (Constant et al. 1997).

Pallid sturgeon collected from the Missouri River above Garrison Reservoir in North Dakota during spring and fall seasons of 1988 to 1991 were found in deep pools at the downstream end of chutes and sandbars, and in the slower currents of near-shore areas. Those areas may have been providing good habitat for energy conservation and feeding (USFWS 1993). Sheehan et al. (1998) indicated that there were no shifts in habitat selection and avoidance by middle Mississippi River pallid sturgeon under three different discharge regimes (low, medium and high discharge ranges of 0 - 165 thousand cubic feet per second (Kcfs), 165 - 270 Kcfs and >270 Kcfs). Data collected by Constant et al. (1997) support prior observations that shovelnose sturgeon tolerate lower current velocities than pallid sturgeon (Carlson et al. 1985, Ruelle and Keenlyne 1994, Bramblett 1996). They (Constant et al. 1997) also found that pallid sturgeon catch-per-unit-effort (CPUE) declined following shutdown of the Old River Control Structure and that no pallid sturgeon were collected when velocity was reduced to zero, although shovelnose sturgeon CPUE was highest at this time. Pallid sturgeon are believed to avoid areas that have very little or no water velocity (DeLonay and Little 2002, Quist 2004, Erickson 1992, USFWS 2003) and leave areas that no longer have flows (Backes et al., 1992).

Turbidity levels where pallid sturgeon have been found in South Dakota range from 31.3 to 137.6 Nephelometric Turbidity Units (NTU) (Erickson 1992). Pallid sturgeon avoid areas without turbidity and current (Bailey and Cross 1954, Erickson 1992). That behavior contributes to the rationale for why pallid sturgeon are no longer found in the Missouri River reservoirs, and have not expanded into other rivers in the Mississippi drainage, even though access is available (Duffy et al. 1996).

Findings from a study on the Missouri River in South Dakota indicate that pallid sturgeon most frequently occupy river bottoms where velocity ranges from 0 to 2.40 feet per second (ft/s) (0 to 0.73 meters per second [m/s]) (Erickson 1992). Other studies in Montana found that pallids are most frequently associated with water velocities ranging from 1.51 to 3.15 ft/s (0.46 to 0.96 m/s) (Clancey 1990). Bramblett (1996) noted pallid sturgeon occupying bottom velocities ranging from 0 to 4.49 ft/s (0 to 1.37 m/s). Those velocities are commonly found throughout the species' range.

Pallid sturgeon were frequently found in water depths of 6.6 to 19.7 ft (2 to 6 m) in South Dakota (Erickson 1992). In Montana, pallid sturgeon were captured from depths between 3.9 and 12.1 ft (1.2 to 3.7 m) in the summer, but they were captured in deeper waters during winter (Clancey 1990). Other pallid sturgeon collected in the upper Missouri, Yellowstone, and Platte Rivers were captured in depths between 3.2 and 24.9 ft (1 to 7.6 m) (Watson and Stewart 1991, USFWS 1993). Bramblett (1996) found pallid sturgeon in depths from 2.0 to 47.6 ft (0.6 to 14.5 m), in contrast to Constant et al. (1997) who found pallid sturgeon at mean depths of 49.9 ft (15.2 m) and observed pallid sturgeon using depths of 23.0 and 68.9 ft (7 and 21 m) with greater frequency than the frequency of occurrence of those depths. The range of depth used by pallid sturgeon is likely related to the available habitat within the river segment (USFWS 2000). Because of the varying total depth of the rivers throughout its range the above depth information may have limited applicability to the Lower Mississippi River unless depth is expressed as a percent of the total river depth. The calculated percent of total river depth utilized by pallid sturgeon is approximately 70 (Bramblett 1996 cited in Constant et al., 1997, Constant et al., 1997). Using that percentage compared to water depths at the Bonnet Carre Spillway during the 2008 opening would indicate that pallid sturgeon should not be found on the batture in front of the structure during its operation. While the presence of *Scaphirhynchus* species on batture areas was previously reported (Hartfield personal comment), the usage of this habitat was never been quantified (incidental usage or actively used) and no records of river sturgeon use of the batture were known to be documented in literature, therefore, until the 2008 opening of the Bonnet Carre it was believed that batture usage by pallid sturgeon was incidental. Incomplete knowledge of the pallid's life history, especially in the Lower Mississippi River, does not preclude high water usage of the batture as a feeding habitat or velocity refugia.

Pallid sturgeon inhabit areas where the water temperature ranges from 32° - 86°F (0°C to 30°C), which is the range of water temperature on the Missouri and Mississippi Rivers. Sheehan et al. (1998) noted that sturgeon habitat use in the middle Mississippi River did not change with changes in temperature regimes and stated that temperature would not seem to have an affect on either habitat use or habitat selection by middle Mississippi River pallid sturgeon. Curtiss (1990) found no relation between surface water temperatures and depth used by shovelnose sturgeon on the Mississippi River, and no indication that shovelnose sturgeon were moving into deeper, cooler water (if available) as

water temperature increased. Sheehan et al. (1990) found that swimming ability decreased and mortality increased for some river species below 39° Fahrenheit (F) (4°Celsius [C]). Hurley (1996) evaluated the habitat associations and movement of pallid sturgeon in the middle Mississippi River at water temperatures below 39°F (4°C), and above 39°F (4°C) yet below 50°F (10°C). Below 39°F (4°C), study sturgeon were found in association with current-disrupting habitat features such as downstream island-tips, wing dams, the main channel, and main channel border. Once winter temperatures rose above 39°F (4°C), habitat use became more restricted with main channel border and main channel comprising 87 percent of all relocations. When water temperatures rose to above 50°F (10°C) but below 68°F (20°C) during the spring, 40 percent of the contact relocations were in habitats between wing dams (Sheehan et al. 1990).

Population Dynamics

Much of the following information was taken from USFWS (2000, 2007). Because the pallid sturgeon was not recognized as a distinct species until 1905, it was not listed in early commercial fishery reports, so little is recorded about its abundance prior to that time. Even as late as the mid-1900s, it was common for pallid sturgeon to be tallied in commercial catch records as either shovelnose or lake sturgeon (Keenlyne 1995). Correspondence and notes of researchers suggest that the pallid sturgeon was still fairly common in many parts of the Mississippi and Missouri River systems as late as 1967 (Keenlyne 1989). The literature indicates that declines in populations have occurred coincidentally with development of the Missouri and Mississippi River systems for flood control and navigation (Deacon et al. 1979, Keenlyne 1989). Forbes and Richardson (1905) and Bailey and Cross (1954) indicated that the species was never as common as the shovelnose sturgeon and their abundance can sometimes be reported in terms of a ratio of pallid sturgeon caught to shovelnose sturgeon caught.

Table 1. Historical records of pallid sturgeon catches. Duffy et al 1996

Efforts to Collect Pallid Sturgeon and Numbers Collected by Decade and Location 1905-1994.

DECADE	LOCATION	NUMBER OF EFFORTS	NUMBER OF PALLID REPORTED
1905-1954	**Mississippi River**	**3**	**15**
1954-1964	**Mississippi River**	1	3
	Lower Missouri River	1	3
	Upper Missouri River	15	210
1965-1974	**Mississippi River**	**1**	**1**
	Upper Missouri River	10+	354
1975-1984	**Mississippi River**	**1**	**6**
	Lower Missouri River	1	5
	Upper Missouri River	9	20+
1985-1994	**Mississippi River**	**1**	**1**
	Atchafalaya River	**2**	**25**
	Upper Missouri River	20	215
TOTAL	**Lower 4200 km**	11	59
	Upper 2000 km	54+	799+

Compiled from Duffy et al. 1996

During systematic sampling on the Missouri and Yellowstone Rivers in 1905, the Montana Department of Game, Fish and Parks collected 10 (2.2 percent) pallid sturgeon compared to 444 shovelnose sturgeon (Liebelt 1995). Reed and Ewing (1993) collected 11 (11 percent) pallid sturgeon, 18 purported hybrids and 74 shovelnose sturgeon in the vicinity of the ORCC in Louisiana. Between 1991 and 2007 over 3,000 river sturgeon were captured at the ORCC with over 600 individuals (greater than 20 %) being identified as pallid sturgeon (Dean 2007). In 2007, Watson and Stewart (1991) noted one (0.29 percent) pallid sturgeon out of 350 sturgeon from the lower Yellowstone River in Montana. Killgore et al., 2007b caught one pallid sturgeon for every six shovelnose in the Mississippi River between New Orleans (Rmi 100) and the Atchafalaya River (Rmi 319). Kirk et al., 2008, calculated a pallid to shovelnose ratio of 1:2.4 from sampling in the Mississippi River at approximately Rmi 146.

Bailey and Cross (1954) provided information based on their personal observations on the proportion of pallid sturgeon to shovelnose sturgeon from the Kansas River at Lawrence, Kansas (8 percent; number of specimens not reported), and the Missouri River in South Dakota, 3 of 62 specimens (5 percent). For the Mississippi River at New Orleans, 3 of 4 specimens (75 percent) were reported as being pallid sturgeon, however, these numbers are based upon specimens within collections, and therefore, those ratios may not reflect actual ratios within the river. Fisher (1962) recorded 4 of 13 river sturgeons (31 percent) from the Missouri River in Missouri as pallid sturgeon. Comparable commercial catch records are not available for the upper river reaches where commercial fishing was light or nonexistent.

Constant et al. (1997) noted that in surveys of commercial catch, shovelnose sturgeon accounted for between 52 percent and 98 percent of the total sturgeon catch, with the remainder composed of similar portions of hybrids (2 percent to 21 percent) and pallid sturgeon (0 percent to 26 percent). The higher percentage found by Constant et al., (1997) is comparable to the longer term percentage found by Dean (2007) who found that between 1991 and 2007 greater than 20 percent of over 3,000 river sturgeon captured at the ORCC were identified as pallid sturgeon. As previously mentioned Killgore et al., 2007b, found for every pallid sturgeon caught six shovelnose sturgeon were also caught in the Mississippi River between New Orleans (Rmi 100) and the Atchafalaya River (Rmi 319). A more recent survey performed by ERDC, caught one pallid and three shovelnose between Rmi 70 and Rmi 100.

Data for the Missouri River continue to indicate that wild pallid sturgeon in the upper Missouri River are large, mature, and likely old individuals, and provide little to no evidence supporting a naturally self-sustaining population. There appears to be no natural wild population surviving in the mid to lower Missouri River though some recent studies have had gravid females release eggs near Sioux City, Iowa and between Kansas City, Missouri and the confluence (Deloney et al. 2009). Sampling in the lower Missouri River to the confluence with the Mississippi River during the past decade continues to confirm a small population of wild pallid sturgeon in the lower Missouri River. Pallid populations in the Missouri River are being augmented with hatchery produced fish in order to ensure persistence of the species until threats are adequately addressed to promote a self sustaining population. Data collected after the Recovery Plan was developed indicate that pallid sturgeon numbers are higher in the Mississippi and Atchafalaya Rivers than initially documented in 1993. However, this increase in collections can be associated with increased sampling efforts and not quantified with catch-per-unit effort data. When this species was listed, there were only 28 recognized records of pallid sturgeon from the Mississippi River, with no recognized records from the Atchafalaya River.

Hatchery-reared Releases

In recent years, pallid sturgeon populations have been augmented by release of hatchery-reared fish. In 1994, the Missouri Department of Conservation (MDC) released approximately 7,000 fingerlings in the Missouri and Mississippi Rivers and an additional 3,000 fingerlings were stocked in 1997 (Graham 1997, 1999). Since stocking in 1994, approximately 86 pallid sturgeon returns have been reported, mostly in the Mississippi River downstream of St. Louis (Graham 1999). Thirty-five, 12- to 14-inch fish raised at Natchitoches NFH were stocked in the lower Mississippi River in 1998 (Kilpatrick 1999). In 2004, the Natchitoches NFH stocked approximately 3,500 fish in the Atchafalaya River and 6,500 were stocked in the Mississippi River (Dean, 2004). Also in 1998, 745 hatchery-reared yearling pallid sturgeon were released at three sites in the Missouri River above Fort Peck Reservoir (Gardner 1999) and another 750 yearling sturgeon were released near the confluence of the Yellowstone and Missouri Rivers (USFWS 2000).

Despite stocking efforts, pallid sturgeon remain rare compared to the shovelnose sturgeon. In 1997 and 1998, the MDC, Long Term Resource Monitoring Station at Cape Girardeau collected 7 pallid sturgeon (0.45 percent) compared to 1,549 shovelnose sturgeon in the middle Mississippi River

(Petersen 1999). All seven were hatchery-origin pallid sturgeon (USFWS 2000). Current data indicate that hatchery-reared pallid sturgeon are essential to preventing local extirpation in portions of the range in the upper Missouri River and have been used to reestablish pallid sturgeon in a small portion of the species' range in lower sections of the Missouri River. Deloney et al. (2009) had placed radio tags in 4 gravid females of hatchery origin and observed 3 of these tagged fish perform upstream migrations. Subsequent recaptures proved that they had released their eggs near the apex of these movements.

Status and Distribution

The historic distribution of pallid sturgeon as described by Bailey and Cross (1954) included the Missouri River, the Mississippi River from the mouth of the Missouri River to the Gulf of Mexico, and the lower reaches of the Platte, Kansas, and Yellowstone Rivers. Though a possible sighting of a pallid sturgeon has occurred as far south as the Head of Passes on the Mississippi River, it is unclear at what salinity level their southerly movements are curtailed. Records also indicated pallid sturgeon were present in the Mississippi River at Grafton, Illinois, (Forbes and Richardson 1905) and as far north as Keokuk, Iowa before that reach of the river was converted into a series of locks and dams for commercial navigation (Bailey and Cross 1954, Coker 1930). In 1992, this species was documented from the Atchafalaya River in central Louisiana (Reed and Ewing 1993, USFWS 2007). Today, pallid sturgeon remain scarce but are widely distributed throughout their range (Constant et al. 1997). No critical habitat has been designated for the pallid sturgeon at this time.

Distribution

Carlson and Pflieger (1981) stated that pallid sturgeon are rare but widely distributed in both the Missouri River, and in the Mississippi River downstream from the mouth of the Missouri River. A comparison of pallid sturgeon and shovelnose sturgeon catch records provides an indication of the rarity of pallid sturgeon. At the time of their original description, pallid sturgeon composed 1 in 500 river sturgeon captured in the Mississippi River at Grafton, Illinois (Forbes and Richardson 1905). Pallid sturgeon were more abundant in the lower Missouri River near West Alton, MO, representing one-fifth of the river sturgeon captured (Forbes and Richardson 1905). Carlson et al. (1985) captured 4,355 river sturgeon in 12 sampling stations on the Missouri River and Mississippi Rivers. Field identification revealed 11 (0.25 percent) pallid sturgeon. Grady (2001b) collected 4,435 river sturgeon in the lower 850 mi (1,367 km) of the Missouri River and 100 mi (161 km) of the middle Mississippi River from November 1997 to April 2000. Field identification revealed nine wild (0.20 percent) and nine hatchery-origin pallid sturgeon.

Today, pallid sturgeon, although variable in abundance, are ubiquitous throughout most of the free-flowing Mississippi River. When the pallid sturgeon was listed as endangered they were only occasionally reported from the following areas; from the Missouri River: (1) between the Marias River and Fort Peck Reservoir in Montana; (2) between Fort Peck Dam and Lake Sakakawea (near Williston, North Dakota); (3) within the lower 70 mi (113 km) of the Yellowstone River downstream of Fallon, Montana; (4) in the headwaters of Lake Sharpe in South Dakota; (5) near the mouth of the Platte River near Plattsmouth, Nebraska; and, (6) below river mile 218 to the mouth in the State of Missouri. Areas of most recent and frequent occurrence on the Mississippi River are: (7) near

Chester, Illinois; (8) Caruthersville, Missouri; and, (9) in the Atchafalaya River in Louisiana at the ORCC (USFWS 1993). Of 872 pallid sturgeon records prior to 1998, 70 percent were reported from the Missouri River; however, most historical collection efforts for the pallid sturgeon have been focused on the middle and upper Missouri River. Approximately 10 percent of the Missouri records were from below Gavins Point Dam; while the majority of records were from intensive sampling efforts in Montana, North and South Dakota, and include recaptures. In addition, 9 percent of the total records came from the Yellowstone River, 5 percent from the Mississippi River, 14 percent from the Atchafalaya River, and less than 2 percent from the St. Francis, Platte, Ohio, Kansas, and Yazoo Big Sunflower Rivers (USFWS 2000). The range of the pallid sturgeon has been split into 6 distinctive River Recovery and Priority Management Areas (RPMA). The status of pallid sturgeon in each RPMA is discussed below.

RPMA 1 (Upper Missouri)

RPMA 1 is defined in the pallid sturgeon recovery plan as the Missouri River from the headwaters of Fort Peck Reservoir upstream to the confluence of the Marias River, Montana (USFWS 1993). The status of wild pallid sturgeon in RPMA 1 has remained relatively unchanged since listing and continues to decline. According to data obtained from the National Pallid Sturgeon Database (USFWS 2006), a total of 52 wild pallid sturgeon (individual fish) has been collected in RPMA 1 during 15 years of sampling (1990-2005). The length frequency data suggests these are all adult fish. Current population estimates suggests that as few as 45 wild pallid sturgeon still remain in RPMA 1 (Bill Gardner, Montana Fish Wildlife and Parks (MFWP), pers. comm., 2005). There is an obvious absence of smaller sized wild pallid sturgeon despite utilization of sampling gear (gill nets, trammel nets, seines, and or trot-lines) capable of collecting smaller sized hatchery-reared pallid sturgeon. The size and age of surviving fish suggest that spawning, recruitment, or both, are severely limited or absent within this reach. However, the population is being supplemented with hatchery produced fish (USFWS 2006) in efforts to prevent local extirpation. Supplementation of RPMA 1 with hatchery produced pallid sturgeon has occurred sporadically since 1997, and is required to maintain the species within this RPMA. Based on recapture data from the National Pallid Sturgeon Database (USFWS 2006), pallid sturgeon from all stocking events have produced recaptures and are contributing to the current population structure.

RPMA 2 (Middle Missouri)

The Missouri River below Fort Peck Dam to the headwaters of Lake Sakakawea and the lower Yellowstone River up to the confluence of the Tongue River, Montana, is defined as RPMA 2. The wild pallid sturgeon population in RPMA 2 continues to decline. According to data compiled from the National Pallid Sturgeon Database (USFWS 2006), 527 wild pallid sturgeon captures occurred during 16 years of sampling (1990-2006). However, many of the adults were collected multiple times during those years. Removing recaptured pallid sturgeon from the query, indicates a total of 245 unique individual pallid sturgeon were collected during this timeframe. Available length frequency data indicate that these were essentially all adult fish. There is an obvious absence of smaller-sized wild pallid sturgeon despite utilization of sampling gear (gill nets, trammel nets, seines, and trot-lines) capable of collecting smaller sized pallid sturgeon. The size and associated age of

surviving fish suggest that spawning, recruitment, or both are severely limited within this reach. However, the population is being supplemented with hatchery-reared fish to prevent local extirpation (USFWS 2006). Recent population estimates suggests that approximately 136 wild adult pallid sturgeon still remain in RPMA 2 (Klungle 2004). The length frequency data indicate that, up until the time supplementation began, all collected pallid sturgeon were adults except for one small fish collected in 1993. This suggests that, like RPMA 1, spawning, recruitment, or both are limiting viability within this reach. Supplementation of RPMA 2 with hatchery produced pallid sturgeon has occurred sporadically since 1998 with various numbers being stocked depending on hatchery success for any given year (USFWS 2006). To date, pallid sturgeon from all stocking events have produced recaptures and are contributing to the current population structure.

RPMA 3 (Lower Missouri River)

RPMA 3 is the Missouri River from 20 miles (mi) (32 kilometers (km)) upstream of the mouth of the Niobrara River to Lewis and Clark Lake. There is no native wild population of pallid sturgeon known to survive in RPMA 3 and the current population consists entirely of hatchery stocked fish. According to the National Pallid Database (USFWS 2006), the last record of a wild species from this area, that was not translocated, was the collection of a single pallid sturgeon circa 1991. Prior to this (1952-1991), there was a small number of wild pallid sturgeon collected from this area. Research within RPMA 3 during 1998 and 1999 (prior to stocking hatchery-reared pallid sturgeon in this reach) did not document a single pallid sturgeon, but numerous shovelnose sturgeon were collected. A total of 102 pallid sturgeon has been collected in RPMA 3 during 2 years of sampling (2003-2005). All of these were hatchery-reared with the exception of a few translocated wild pallid sturgeon. These data suggest that prior to supplementation, pallid sturgeon were extremely rare or extirpated in RPMA 3. Supplementation of RPMA 3 with hatchery-reared pallid sturgeon has occurred sporadically with various numbers being stocked depending on hatchery success for any given year. Recent work by Shuman et al. (2005) indicates that these stocked pallid sturgeon are surviving and growing (mean growth of age-6 and older fish was <0.06 mm/day (mm/d), mean growth for ages 2-4 was 0.238 mm/d, and the youngest year class (2004) grew 1.249 mm/d) in this reach with all stocked year classes (1997-1999 and 2001 and 2002) being collected in their samples.

RPMA 4 (Missouri to Mississippi River)

The Missouri River downstream of Gavins Point Dam, South Dakota to the Missouri River/Mississippi River confluence, including major tributaries such as the Platte River, defines RPMA 4. Although pallid sturgeon captures in RPMA 4 continue to increase with fishing effort, population levels and trends, habitat use, and movement patterns remain unknown. In the late 1990s, the USFWS Columbia Fishery Resources Office collected larval sturgeon in the Lisbon Chute on the Missouri River. Three were confirmed as larval pallid sturgeon and seven others were identified as probable pallid sturgeon (Krentz 2000) (identification by Darrel Snyder, Colorado State University Larval Fish Laboratory). Larval sturgeon (species not confirmed) also have been documented in the Missouri River below Gavins Point Dam by Nebraska Game and Parks Commission (NGPC) (Gerald Mestl, NGPC, pers. comm., 2005) and the Missouri Department of Conservation (MDC) (Herzog et al. 2005) and in the lower Platte River (Hofpar 1997, Reade 2000). Some of these smaller fish may

have been pallid sturgeon, but accurately identifying these larval fish to species is difficult (Kuhajda et al. 2007). Recent studies also identify low numbers of unmarked pallid sturgeon (larger than fry) being collected from the lower Missouri River (Kennedy et al. 2006; Utrup et al. 2006). Augmentation with hatchery-reared pallid sturgeon has occurred sporadically since 1994 (USFWS 2006), and the collection of individuals from all stocked cohorts indicates that hatchery supplementation is contributing to the population (Barada and Steffensen 2006; Kennedy et al. 2006; Steffensen and Barada 2006; Utrup et al. 2006). Brood-stock collection for the hatchery propagation in 2009 produced 160 pallid sturgeon with 45 not known to be of hatchery origin were sent to the Blind Pony State Hatchery for evaluation; 16 of those fish were reproductively mature(Steffensen and Koch 2009). In 2010, pallid sturgeon were captured with 37 fish not suspected to be of hatchery origin were sent for evaluation, 19 were reproductively mature. Of a total 156 pallid sturgeon captured between 1999 and 2005, 51 are believed to be wild, 82 were of hatchery origin, and 24 were of unknown origin (Brannen and Wilhelm 2010). These fish were identified as wild if they did not possess a physical mark (i.e., coded wire tag or elastomere tag) indicating they were from a hatchery and were of a size class greater than what was associated with known hatchery-released fish. Fish labeled as hatchery origin had a distinguishing physical mark. Unknown individuals were consistent in length with known hatchery fish, but had no notable marks. These are considered unknown because certain marking techniques, like PIT tags, have been documented to fail. However, data within the National Pallid Sturgeon Database (USFWS 2006), for the period 1990-2005, notes 117 unique wild pallid sturgeon for RPMA 4. Available length frequency data for these fish indicates the majority to be adults. A few have been reported that are of sub-adult sizes (<600 mm), yet these sub-adult pallid sturgeon were all collected after supplementation commenced in 1994. Retrospective testing of the unmarked fish has revealed that 23 of the 24 unmarked pallid sturgeon were of hatchery origin, and the remaining unknown origin fish remained in that category because parental genetic samples were not available for all families released downstream of Gavins Point Dam and they could have originated from one of the unsampled families (DeHaan et al. 2008). The apparent lack of naturally produced or unknown origin pallid sturgeon in smaller size classes, coupled with higher relative abundances of hatchery origin pallid sturgeon and frequent captures of smaller size class shovelnose sturgeon, suggests that the sampling gear and effort being used are effective and that natural recruitment of pallid sturgeon is sporadic or limited in RPMA 4 (Barada and Steffensen 2006, Kennedy et al. 2006, Steffensen and Barada 2006, Utrup et al. 2006). These data also indicate that hatchery stocked fish are being collected and contributing to the population.

RPMA 5 (Mississippi River)

The Mississippi River from its confluence with the Missouri River to the Gulf of Mexico defines RPMA 5. While not identified in the Recovery Plan, the Mississippi River is often subdivided into two segments: the lower Mississippi River, extending 953 River miles (Rmi) (1,533.7 River kilometers (Rkm)) from the Gulf of Mexico to Cairo, Illinois; and the middle Mississippi River, extending 200 river miles (321.9 Rkm) from near Cairo, Illinois, to just above the mouth of the Missouri River confluence near St. Louis, Missouri. The availability of demographic data in RPMA 5 for pallid sturgeon has increased since the species was listed. Although pallid sturgeon captures in RPMA 5 continue to increase with fishing effort, population levels and trends, habitat use, and movement patterns remain unknown. Only 28 records of pallid sturgeon were recognized from the

Mississippi River when the species was listed in 1990 and the recovery plan was published in 1993 (USFWS 1993). During the past 6 years, over 300 pallid sturgeon (both sub-adult and adult size classes) have been collected from the Mississippi River. However, caution must be applied when looking at total catch because some of the collected pallid sturgeon reported by D. Herzog, (MDC) may also have been reported by Jack Killgore (U.S. Army Corps of Engineers (Corps) during their collaborative efforts. According to the National Pallid Sturgeon Database (USFWS 2006), 279 unique pallid sturgeon have been collected in RPMA 5 between 1990 and 2004. It is unclear what percentage of these may be hatchery origin pallid sturgeon with failed physical marks. Jack Killgore, Corps, (pers. comm., 2005) indicated that, between the winter of 2004 and the spring of 2005, 39% (7 of 18) of the pallid sturgeon sampled were hatchery stocked recaptures with a coded wire tag (CWT). Prior to 2004, pallid sturgeon were not checked for coded wire tags which were used to mark hatchery-reared pallid sturgeon stocked from Missouri's Blind Pony fish hatchery.

Middle Mississippi River

From 2002 through 2005, the Corps, Missouri Department of Conservation (MDC), and Southern Illinois University conducted a joint pallid sturgeon research project in the middle Mississippi River using trawling, gillnets, and trotlines as the primary sampling gears. A little over 64,000 hours of effort (combined for all gear types) was expended to catch a total of 148 pallid sturgeon as part of this project. Of the 148 pallid sturgeon collected, 12 individuals (8%) were hatchery origin fish determined by the presence of coded wire tags. This 8% is likely under representing the total number of hatchery origin fish in this sampling effort because scanning for coded wire tags was not a standard practice until 2004 (Jim Garvey, Southern Illinois University, pers. comm. 2006). Herzog et al. (2005) documented successful reproduction by the collection of larval pallid sturgeon in the middle Mississippi River, though the origin of these larval pallid sturgeon from within the middle Mississippi River is not known. Wild pallid sturgeon collected from this reach ranged between 500 and 1,000 mm fork length (FL; the length measured from the anterior most portion of the fish to the median caudal fin rays). Pallid sturgeon above 600 mm FL are believed to be of reproductive size, and the capture of small adult and sub-adult pallid sturgeon around and below this size may indicate that some level of recruitment is likely occurring in the middle Mississippi River or lower Missouri River, or could be a product of undetected marks in hatchery origin pallid sturgeon. Limited supplementation with hatchery reared pallid sturgeon has occurred in the middle Mississippi River (USFWS 2006).

Lower Mississippi River

ERDC sampled the lower Mississippi River (from the Chain of Rocks to south of New Orleans) from 2000 to 2006. During this time, 162 pallid sturgeon were collected from over 130 locations between Rmi 145 to 954 (Rkm 233 to 1535) (J. Killgore, Corps, pers. comm., 2005), with 3 recaptures. Sizes of pallid sturgeon collected range between 400 and 1,000 mm fork length (FL). This data set includes at least 30 "sub-adult" pallid sturgeon (i.e., <600 mm FL), showing some level of recruitment in the lower Mississippi River population. It is possible that recruitment of pallid sturgeon in RPMA 5 is higher than that reflected in sampling data. Over the past 3 years, monthly sampling in a 30 mile reach of the Lower Mississippi River (Rmi 580.9- Rmi 556.1) has resulted in

the capture of over 60 pallid sturgeon, with a single recapture, and only 2 confirmed hatchery fish (Schramm and Kuntz 2010, Hartfield pers. comm. 2010). Although morphologically distinct pallid sturgeon as small as 450 mm FL are occasionally captured, some young-of-year and sub-adult pallid sturgeon may be misidentified as shovelnose or hybrids. One recent study found that character indices do not correctly identify small upper Missouri River hatchery-reared juvenile pallid sturgeon (<250 mm standard length; the length from the tip of the upper jaw to the posterior end of the vertebral column that is most commonly used in taxonomic studies) from shovelnose or hybrid sturgeon, or reliably separate larger pallid sturgeon (up to 600 mm standard length) from hybrid sturgeon (Kuhajda and Mayden 2001). Measurements taken from 48, 10-month old hatchery-reared juvenile pallid sturgeon (309 to 413 mm FL) spawned from Atchafalaya River stock and reared at the Natchitoches NFH, incorrectly identified all but two of these hatchery-reared pallid sturgeon as hybrids, and the two exceptions were incorrectly identified as shovelnose sturgeon (Jan Dean, USFWS, pers. comm., 2005). These juvenile fish were reared from morphologically distinct pallid sturgeon confirmed by genetic analysis. Murphy et al. (2007) also have found greater morphological variation in specimens of pallid and shovelnose sturgeon from the Mississippi River than what is accounted for in current identification indices. These studies suggest that at least some young-of-year, sub-adult, or small adult pallid sturgeon can be misidentified in the field as hybrid or shovelnose sturgeon. Captures of pallid sturgeon in the Mississippi River have been associated with islands, sand bars, gravel bars, and dikes, in both the main channel and in secondary channels.

RPMA 6 (Atchafalaya River)

RPMA 6 is the Atchafalaya River from the Old River Control Complex (ORCC) to the Gulf of Mexico. Collection data from this RPMA reflects an improvement in our understanding of the pallid sturgeon population trend. Prior to listing in 1990, pallid sturgeon had not been documented from the Atchafalaya River. In 1991, seven pallid sturgeon were collected from the Atchafalaya River near the ORCC, in Concordia Parish, Louisiana (Reed and Ewing 1993). A few years later (1993-95) an additional 106 pallid sturgeon captures were reported (Constant et al. 1997). Over approximately 600 individual pallid sturgeon have been collected from the Atchafalaya River since 1991 (Dean 2007). A conservative approach to species identification was used, based upon morphometric measurements, to identify pallid versus intermediate or "hybrid" sturgeon, and thus actual number of pallid sturgeon captured from the ORCC is likely underrepresented in these data. There have been at least 37 wild adult pallid sturgeon recaptures in the ORCC area since 1991, of which 32 have been during 2004-2006 (J. Dean, USFWS, pers. comm., 2006). The length distribution of pallid sturgeon captures has remained relatively consistent over the past 7 years, although the population appears to be comprised of predominantly adult pallid sturgeon >650 mm FL (Figure 12). However, gears used to sample this area are larger mesh and may not reliably sample sturgeon smaller than 400 mm. It is currently unknown if this consistent length frequency distribution through time combined with the occasional collection of smaller pallid sturgeon, results from local reproduction and recruitment, the passage of sub-adult and/or adult pallid sturgeon from the Mississippi River through the ORCC into the Atchafalaya River, or is simply a product of gear selectivity/bias. Gill net collections at the ORCC regularly capture shovelnose sturgeon between 400 and 750 mm FL. The pallid sturgeon are larger, measuring (with occasional exceptions) above 650 mm FL. It has been noted in the discussion under

RPMA 5, above, that there are difficulties in separating juvenile *Scaphirhynchus* to species. This also is true in RPMA 6. For example, trawl sampling for 2 days below ORCC during June 2005, resulted in the capture of six young-of-year *Scaphirhynchus* (196 to 410 mm total length (the length measured from the anterior most portion of the fish to the tip of the caudal fin rays). Three of these fish were marked indicating they were hatchery-reared juvenile pallid sturgeon released during fall and winter of 2004, and the other three had no physical mark and were considered wild young-of-year sturgeon. A character index was used on all six fish and misidentified the three hatchery-reared pallid sturgeon as hybrids, and identified two of the unknown wild sturgeon as shovelnose and the other as a hybrid (Jan Dean, USFWS, pers. comm., 2005). Further investigation is required to determine if allometric growth is resulting in the misidentification of some juvenile or sub-adult pallid sturgeon as shovelnose or "hybrids/intermediates", and to document local reproduction and recruitment in RPMA 6. Based on limited catch data reported by Constant et al. (1997), the ratio of hybrid to shovelnose sturgeon in the Mississippi River is similar to that in the Atchafalaya River.

The ORCC forms a potential uni-directional barrier to fish movement between the Mississippi and Atchafalaya Rivers. The structures associated with the ORCC likely could allow movement of fish from the Mississippi River into the Atchafalaya River, but could constitute a velocity barrier for movement in the opposite direction. Data exists to indicate that passage from the Mississippi River into the Atchafalaya Rivers does occur (Reed per comm. 2006, Hartfield in litt 2006, USFWS 2007). However, passage or lack of passage in the opposite direction has not been documented but sampling to detect such passage while increasing has probably not been sufficient to disprove such passage.

Habitat Destruction/Modification

Destruction and alteration of big-river ecologic functions and habitats once provided by the Missouri and Mississippi Rivers is believed to be the primary cause of declines in reproduction, growth, and survival of pallid sturgeon (USFWS 1993). The physical and chemical elements of channel morphology, flow regime, water temperature, sediment transport, turbidity, and nutrient inputs once functioned within the big-river ecosystem to provide habitat for pallid sturgeon and other native species. Human alterations such as, dams, levees, and channelization fragment the habitat and change the natural functions of the river reducing it's capacity to support the historic populations of large riverine fishes.

Construction and operation of dams on the upper Missouri River and modification of riverine habitat by channelization of the lower main stem Missouri and Mississippi Rivers has resulted in the curtailment of range and destruction or modification of habitat. On the main stem of the Missouri River (1,154 mi) (1,857 km) today, approximately 36 percent of riverine habitat within the pallid sturgeon's range has been transformed from river to lake by construction of six massive earthen dams by the Corps between 1926 and 1952 (USFWS 1993). The other 64 percent has been channelized, or altered due to dam operations (USFWS 1993). Most of the major tributaries of the Missouri and Mississippi Rivers have also been altered to various degrees by dams, water depletions, channelization, and riparian corridor modifications.

The upper ends of the reservoirs in the upper basin may be influencing the recruitment of larval

sturgeon. Both the shovelnose and pallid sturgeon larvae have a propensity to drift after hatching (Kynard et al. 1998a, b). Migration routes to spawning sites on the lower Yellowstone River have been fragmented by low-head dams used for water supply intakes. Such habitat fragmentation has forced pallid sturgeon to spawn closer to reservoir habitats and has reduced the distance larval sturgeon can drift after hatching. Reservoir habitats may also place larval sturgeon at a greater risk of predation.

The channelized reach of the Missouri River downstream of Ponca, Nebraska, once a diverse assemblage of braided channels, sandbars, and backwaters, is now confined within a narrow channel of rather uniform width and swift current. Morris et al. (1968) found that channelization of the Missouri River reduced the surface area by approximately 67 percent. Funk and Robinson (1974) calculated that, following channelization, the length of the Missouri River between Rulo, Nebraska, and its mouth (~500 river miles) (310 km) had been reduced by 8 percent, and the water surface area had been reduced by 50 percent.

Missouri River aquatic habitat between and downstream of main stem dams has been altered by reductions in sediment and organic matter transport/deposition, flow modification, hypolimnetic releases, and narrowing of the river through channel degradation. Those activities have adversely impacted the natural river dynamics by reducing the diversity of bottom contours and substrates, slowing accumulation of organic matter, reducing overbank flooding, changing seasonal patterns, severing flows to backwater areas, and reducing turbidity and water temperature (Hesse 1987).

The pattern of flow velocity, volume, and timing of the pre-development rivers provided the essential life requirements of native large-river fishes like the pallid sturgeon and paddlefish. Hesse and Mestl (1993) found a significant relationship between the density of paddlefish larvae and two indices (timing and volume) of discharge from Fort Randall Dam. They concluded that when dam operations caused discharge to fluctuate widely during spring spawning, the density of drifting larvae was lower, and when annual runoff volume was highest, paddlefish larval density was highest. Hesse and Mestl (1987) also modeled these same two indices of discharge from Fort Randall Dam with an index of year-class strength. They demonstrated significant negative relationships between artificial flow fluctuations in the spring and poor year-class development for several native and introduced fish species including river carpsucker, shorthead redhorse, channel catfish, flathead catfish, sauger, smallmouth buffalo, and bigmouth buffalo. The sample size of sturgeon was too small to model in that study; however, a clear relationship existed between poor year-class development in most native species studied and the artificial hydrograph.

Levee construction along the lower Mississippi River, from the Ohio River to the Gulf, has eliminated major natural floodways and reduced the land area of the floodplain by more than 90 percent (Fremling et al. 1989). Fremling et al. (1989) also report that levee construction isolated many floodplain lakes and raised river banks. Bendway cutoffs to facilitate navigation have severed 15 meander loops between 1933 and 1942. These anthropogenic alterations (i.e., levee construction) effectively increased river stage and velocities at higher discharges by preventing overbank flows on the adjacent floodplains (Baker et al. 1991).

Free-flowing riverine conditions currently exist throughout the lower 2,000 mi (3,218 km) (60%) of the pallid sturgeon's historical range much of which is in the Mississippi River. The middle Mississippi River, from the mouth of the Missouri River to the mouth of the Ohio River, is principally channelized with few remaining secondary channels, sandbars, islands and abandoned channels and has been extensively diked. Navigation channels and flood control levees have reduced the size of the Mississippi Rivers floodplain there by 39 percent. However, recent studies and data from the Mississippi River (RPMA 5) suggests that riverine habitats are less degraded than previously believed, and that they continue to support diverse and productive aquatic communities, including pallid sturgeon. The 950 mile reach below the confluence of the Ohio River appears to be adequate for pallid sturgeon survival and recruitment and provides numerous complex secondary channel and island habitats known to be utilized by pallid sturgeon (P. Hartfield, per. comm.).

Commercial and Recreational Harvesting

Historically, pallid, shovelnose, and lake sturgeon were commercially harvested in all States on the Missouri and Mississippi Rivers (Helms 1974). The larger lake and pallid sturgeon were sought for their eggs which were sold as caviar, whereas shovelnose sturgeon were historically destroyed as bycatch. Commercial harvest of all sturgeon has declined substantially since record-keeping began in the late 1800s. Most commercial catch records for sturgeon have not differentiated between species and combined harvests as high as 430,889 lb (195,450 kg) were recorded in the Mississippi River in the early 1890s, but had declined to less than 20,061 lb (9,100 kg) by 1950 (Carlander 1954). Lower harvests reflected a decline in shovelnose sturgeon abundance since the early 1900s (Pflieger 1975).

Mortality of pallid sturgeon occurred as a result of illegal and incidental harvest from both sport and commercial fishing activities (USFWS 2000). Sturgeon species, in general, are highly vulnerable to impacts from fishing mortality due to unusual combinations of morphology, habits, and life history characteristics (Boreman 1997). Bettoli et al. (2008) conservatively estimated that 1.8% of the total sturgeon catch in Tennessee sturgeon caviar harvest were composed of pallid sturgeon. In addition, such illegal and incidental harvest may skew pallid sturgeon sex ratios such that hybridization with shovelnose is exacerbated. Killgore et al. (2007b) indicated that higher mortality rates for pallid sturgeon in the Middle Mississippi River could be attributed to incidental take by the commercial shovelnose fishery. In order to address incidental and illegal take of pallid sturgeon in caviar harvest, the Service has listed shovelnose as threatened, due to similarity of appearance to pallid sturgeon. The effects of this listing has effectively eliminated legal commercial harvest of sturgeon from river reaches where pallid sturgeon are known to occur.

Hybridization

Morphological variation between pallid sturgeon populations in the upper Missouri, lower Missouri, and Mississippi rivers has led to a hybridization debate. Upper Missouri River pallid sturgeon are characterized by large sizes in excess of 60 lb, and large pointed snouts, while pallid sturgeon from the lower Missouri, Mississippi, and Atchafalaya Rivers typically have shorter and rounder snouts and fish size rarely exceed 15 lb (6.8 kg) (Kuhajda and Mayden 2001, U.S. Fish and Wildlife Service 2007). Studies using mitochondrial DNA (Campton et al. 2000, Simons et al.

2001) and DNA microsatellite loci (Tranah et al. 2001, Schrey and Heist 2007, Ray et al. 2007) have demonstrated that genetic differences between shovelnose and pallid sturgeon occur throughout their sympatric range. However, several of these studies have also shown that genetic differentiation exists among pallid sturgeon from opposite ends of their range (Campton et al. 2000, Tranah et al. 2001) as well as between pallids inhabiting different geographic regions (upper Missouri, lower Missouri, Middle Mississippi, and Atchafalaya rivers) (Schrey and Heist 2007), and morphological variation within the pallid sturgeon range may be attributed to genetic structure of populations.

Bramblett (1996) found substantial differences in habitat use and movements between adult pallid and shovelnose sturgeon in less altered habitats in the Missouri River. Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms. Campton et al. (1995), and Sheehan et al. (1997) note that hybridization suggests that similar areas are currently being used by both species for spawning.

Carlson et al. (1985) studied morphological characteristics of 4,332 sturgeon from the Missouri and middle Mississippi Rivers. Of that group, they identified 11 pallid sturgeon and 12 pallid/shovelnose sturgeon hybrids. Suspected hybrids were observed in commercial fish catches on the lower Missouri and the middle and lower Mississippi Rivers (USFWS 2000). Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent phenomenon resulting from environmental changes caused by human-induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson et al. 1985). A study by Keenlyne et al. (1994) concluded that hybridization may be occurring in half the river reaches within the range of pallid sturgeon and that hybrids may represent a high proportion of remaining sturgeon stocks. Keenlyne et al. (1994) noted few hybrids showing intermediacy in all characteristics as would be expected in a first generation cross, indicating the hybrids are fertile and reproducing. Hartfield and Kuhajda (2009) stated that hybridization rates in the Mississippi River have been overestimated, and there is no direct evidence linking the morphological or genetic variation defined as hybridization between pallid and shovelnose sturgeon in the lower Missouri, Mississippi, or Atchafalaya rivers with recent anthropogenic activities. However, if hybridization is a recent phenomenon precipitated by engineering of the Mississippi and Missouri river channels, it would present a threat to the survival of pallid sturgeon through genetic swamping if the hybrids are fertile, and through competition for limited habitat (Carlson et al. 1985).

Hubbs (1955) indicated that the frequency of natural hybridization in fish was a function of the environment, and the seriousness of the consequences of hybridization depends on hybrid viability. Hybridization can occur in fish if spawning habitat is limited, if many individuals of one potential parent species lives in proximity to a limited number of the other parent species, if spawning habitat is modified and rendered intermediate, if spawning seasons overlap, or where movement to reach suitable spawning habitat is limited (Hubbs 1955). Any of those conditions, or a combination of them, could be causing the apparent breakdown of isolating mechanisms that prevented hybridization between these species in the past (Keenlyne et al. 1994). Hartfield and Kuhajada (2009) examined three of the five original specimens used to describe the pallid sturgeon and found that the character indices currently used to distinguish the fish identify some of the type specimens as hybrids. They also noted purported hybrid reports were highest in the least altered habitats within the species range

(Lower Mississippi River), and lowest in the most severely altered areas (Upper and Lower Missouri River). In conclusion, they stated they found no evidence directly linking habitat modification and hybridization particularly in the Mississippi River and no evidence that hybridization constitutes an anthropogenic threat to the pallid sturgeon.

Microsatellite studies (Tranah et al. 2004; Heist and Schrey 2006a) have provided some genetic evidence for hybridization between pallid and shovelnose sturgeon in the Missouri, Mississippi, and Atchafalaya Rivers. However, it is currently unknown if all morphologically intermediate sturgeon are hybrids, if some hybridization is natural, or if hybridization is a result of habitat or other environmental changes. If these intermediates represent the effect of natural intercrossing between the monophyletic pallid sturgeon and shovelnose sturgeon due to anthropogenic influences, then intercrossing may indeed be perceived as a threat to the species. However, if genetically intermediate sturgeon are the result of sympatric speciation and a polyphyletic evolutionary origin of pallid sturgeon (e.g., as suggested by Campton et al. 2000 as a competing, alternative hypothesis), then intermediate fish could be considered a natural occurrence, the previously-identified mechanisms suggested for causing hybridization may not exist, intermediate sturgeon are a component of natural evolutionary processes, and hybridization does not pose a threat to the species.

Contaminants

Although more information is needed, pollution is also likely an exacerbating threat to the species over much of its range. Pollution of the Missouri River by organic wastes from towns, packing houses, and stockyards was evident by the early 1900s and continued to increase as populations grew and additional industries were established along the river. Due to the presence of a variety of pollutants, numerous fish-harvest and consumption advisories have been issued over the last decade or two from Kansas City, MO, to the confluence of the Mississippi River. That distance represents about 45 percent of the pallid sturgeon's total range. In 2000, the State of Mississippi formed a Fish Advisory Task Force to develop procedures regarding fish consumption advisories for organochlorine compounds and other contaminants. A review of USGS National Water Quality Assessment Program (NAWQA) data showed a persistence of elevated organochlorine levels and levels of DDT in fish tissue that are higher than other sampled parts of the Mississippi River study area. As a result, the state has issued its own preliminary advisories based on USEPA guidelines (USGS NAWQUA).

PCBs, cadmium, mercury, and selenium have been detected at elevated, but far below lethal, concentrations in tissue of three pallid sturgeon collected from the Missouri River in North Dakota and Nebraska. Detectable concentrations of chlordane, DDE, DDT, and dieldrin also were found (Ruelle and Keenlyne 1994). The prolonged egg maturation cycle of pallid sturgeon, combined with bioaccumulation of certain contaminants in eggs, could make contaminants a likely agent adversely affecting eggs and embryo, and development or survival of fry, thereby reducing reproductive success.

In examining the similarities and differences between shovelnose and pallid sturgeon, Ruelle and Keenlyne (1994) concluded that, while the shovelnose may not meet all the traits desired for a surrogate, it may be the best available for contaminant studies. Conzelmann et al. (1997) reported that trace element concentrations in Atchafalaya River shovelnose sturgeon were generally higher

than in shovelnose sturgeon from other areas. Trace elements, many of which are essential for sustaining life, can adversely affect reproduction, development, and may ultimately be lethal if concentrations are excessive. Most trace element levels were unremarkable; however, cadmium, copper, lead, and selenium concentrations were elevated in ORCC samples and may warrant concern (Conzelmann et al. 1997).

Conzelmann et al. (1997) also reported that organochlorine pesticide (OC) concentrations are the main environmental concern in Louisiana's shovelnose sturgeon, and consequently, in the pallid sturgeon. Shovelnose OC concentrations were generally greater than were observed in fishes from other areas, and ORCC shovelnose sturgeon toxaphene levels were elevated compared to the National Contaminants Biomonitoring Program. Toxaphene possesses known carcinogenic, teratogenic, xenotoxic, and mutagenic properties; can cause suppression of the immune system; and may function as an endocrine system imitator, blocker, or disrupter (Colburn and Clements 1992). Those factors make toxaphene the greatest OC concern in ORCC shovelnose sturgeon and, by extension, the ORCC pallid sturgeon (Conzelmann et al. 1997). Further investigations are needed to identify contaminant sources in the Mississippi and Atchafalaya Rivers and to assess the role, if any, of contaminants in the decline of pallid sturgeon populations.

Entrainment

Another issue that is negatively impacting pallid sturgeon throughout its range is entrainment into water intake structures. The loss of pallid sturgeon associated with water intake structures has not been accurately quantified. The U.S. Environmental Protection Agency published final regulations on Cooling Water Intake Structures for Existing Facilities per requirements of Section 316(b) of the Clean Water Act. The rule making was divided into three phases. However, only Phase I and II appear applicable to inland facilities; Phase III applies to coastal and offshore cooling intake structures associated with coastal and offshore oil and gas extraction facilities. The following rule summaries are based on information found at the website <http://www.epa.gov/waterscience/316b/>. Phase I rules, completed in 2001, require permit holders to develop and implement techniques that will minimize impingement mortality and entrainment. Phase II, completed in 2004, covers existing power generation facilities that are designed to withdraw 50 million gallons per day or more with 25% of that water used for cooling purposes only. This rule, implemented through National Pollutant Discharge Elimination System permits, is intended to minimize negative affects associated with water cooling structures.

Section 316(b) of the Clean Water Act requires the U.S. Environmental Protection Agency to insure that aquatic organisms are protected from impingement or entrainment. As part of the Phase II ruling, some power plants have begun conducting required entrainment studies. Preliminary data on the Missouri River suggests that entrainment may be a serious threat that warrants more investigation. Initial results from work conducted by Mid-America at their Neal Smith power facilities found hatchery-reared pallid sturgeon were being entrained (Jordan in litt. 2006, Ledwin in litt. 2006, Williams in litt. 2006). Over a 5-month period, four known hatchery-reared pallid sturgeon have been entrained, of which two were released alive and two were found dead. Ongoing entrainment studies required by the Clean Water Act will provide more data on the effects of entrainment. However, addressing entrainment issues may not occur immediately and continued take of hatchery-

reared or wild pallid sturgeon will limit the effectiveness of recovery efforts. In addition to cooling intake structures for power facilities, concerns have been raised regarding entrainment associated with dredge operations and irrigation diversions. Currently little data are available regarding the effects of dredge operations. However, the Corps' St. Louis District, and the Dredging Operations and Environmental Research Program have initiated work to assess dredge entrainment of fish species and the potential effects that these operations may have on larval and juvenile *Scaphirhynchus*. Data for escape speed, station-holding ability, rheotaxis and response to noise, and dredge flow fields are being used to develop a risk assessment model for entrainment of sturgeon by dredges. Entrainment has been documented in the irrigation canal supplied by Intake Dam on the Yellowstone River (Jaeger et al. 2004) (see also 2.3.1.5. Habitat or ecosystem conditions [e.g., amount, distribution, and suitability of the habitat or ecosystem]). Given that entrainment has been documented to occur in the few instances it has been studied, further evaluation of entrainment at other water withdrawal points is warranted across the pallid sturgeon's range to adequately evaluate this threat. Entrainment of pallid sturgeon stocked in the Mississippi River into the Atchafalaya River via the ORCC has been documented by the capture of a tagged stocked sturgeon that was released into the Mississippi River.

Biological Opinions which allow the take of a pallid sturgeon(s) also represent a factor that should be considered when examining factors that could have an influence on the pallid sturgeon population. The table below presents all completed Biological Opinions for the Lower Mississippi River.

OPINIONS[1] (yr/number)	**SPECIES**	**NUMBERS[2]**	**HABITAT[3]**	
			Critical Habitat	**Habitat**
2003 Log: 4-7-3-702	Biological Opinion on Natchitoches National Fish Hatchery's Collection of Endangered Pallid Sturgeon from Louisiana Waters for Propagation and Research	90 adults/season for 5 season (harassment) 8 adults/season for 5 seasons (death)	NA	NA
2004 Log: 4-7-04-734	Modification to **revise** 2003 IT estimates for BO (4-7-3-702) on Natchitoches National Fish Hatchery's Activities	120 adults/season for 5 season (harassment) 14 adults/season for 5 seasons (death)	NA	NA
2004 Log: 4-7-04-1456 (also 4-7-05-22)	Programmatic Biological Opinion Addressing Effects of the Southeast Region's Section 10(a)(1)(A) Permitting on the Pallid Sturgeon (5-	28 adults in captive propagation/year (death) 2,500 to 15,000 captive year-class 90 days old or older (one-time loss-death) 200 larval/juvenile/year sampling	NA	NA

	years)	(death) 3, 5-inch or greater fish/year netting (death or injury) 3 fish/year external tagging (death or injury) 1 fish/year transport (death) 5 fish/year radio-tracking (death or injury)		
2009 Log: 43440-2008-IE-3120,FA-43440-2009-FE-2777	Emergency Consultation for the operation of the Bonnet Carre Spillway and it's effects on entrained pallid sturgeon	14 Pallid sturgeon were captured in the spillway and incidental take occurred in the form of harassment. The Service estimated that a take of 92 pallid sturgeon occurred.	NA	NA

[1] Biological opinions within the action area.
[2] Incidental take permitted over 5-year period.
[3] No critical habitat has been designated for the pallid sturgeon.
[4] The original estimates for the 2003 BO are not included as they were revised in 2004.
[5] Incidental take of captive larval fish for NFH subsequently cover in the programmatic BO so is only counted once.

Analysis of the species/critical habitat likely to be affected

The action under consideration is the construction and operation of the Medium Diversion at White Ditch. This opening will allow Mississippi River waters to flow through the control structure and into an outfall channel leading to ponds and marsh habitat. This will affect all life-stages of pallid sturgeon in the Mississippi River in the vicinity of the structure, because they could become entrained and it is not known if they are willing or able to move back through the structures to the river to complete essential life processes.

ENVIRONMENTAL BASELINE

Status of the species within the action area

The action under consultation occurs within the Lower Mississippi River area of RPMA 5. The range-wide status of the pallid sturgeon within the action area is discussed within the **Status and Distribution** section above. As noted in that section, Pallid sturgeon population size has not been quantitatively defined within the action area, however, collection efforts over the past decade show the species is widespread and not uncommon in the lower Mississippi River (LMR) from Rmi 954 to Rmi 100. Efforts to collect river sturgeon in the LMR have been relatively limited over the past decade, particularly considering the scope and scale of the available habitat. However, these collections have shown that pallid sturgeon occur throughout most of the 950 mile reach of the LMR

(Bettoli et al. 2008, Killgore et al. 2007a, Schramm and Mirick 2009, Hartfield, pers. obsv. 2001-2010), and the 200 mile reach of the Atchafalaya River (Constant et al. 1997, Herrala and Schramm 2010). Collections of pallid sturgeon in the LMR include over 200 individuals collected between the mouth of the Ohio River and Head of Passes (Killgore et al. 2007a; Hartfield, in litt. 2001-2010; Schramm and Kuntz 2010), ranging from 0 – 20 years of age (50 to >800 mm FL) (Killgore et al. 2007b, Hartfield pers. obsv. 2010). Over 600 pallid sturgeon ranging from 400 to >1000 mm FL have been collected from the Atchafalaya River distributary of the LMR (U.S. Fish and Wildlife Service 2007, Dean pers. comm. 2009).

Although pallid sturgeon population size in the LMR has not been quantified, available data suggest a substantial population when compared to fishing effort and fish species composition. Killgore et al. (2007a) found that pallid sturgeon comprised 2.2% of fish captured on winter set trotlines, and ranked 5th in frequency of capture out of 22 species collected. Recaptures of pallid sturgeon are also rare in the LMR. Killgore et al. (2007a) reported only 5 pallid sturgeon recaptures over 7 years. In another study that conducted 2 years of pallid sturgeon collection and telemetry efforts in a 30-mi reach of the Mississippi River, only a single pallid recapture occurred out of >60 pallid collected, even though telemetry results indicate most pallid sturgeon have remained within the sample reach (Schramm and Kuntz 2010).

There is also evidence that the LMR pallid sturgeon population can sustain removal of substantial numbers of individuals from the population. Bettoli et al. (2008) conservatively estimated that 2% of the commercially harvested sturgeon in the Tennessee reach of the LMR were pallid sturgeon (169 females over two seasons). Commercial harvest for sturgeon caviar has occurred annually in the Tennessee and Missouri reaches of the LMR for more than two decades. While baseline data on LMR pallid populations is lacking, the persistence of the species following more than two decades of harvest pressure on mature pallid sturgeon females, suggests the population is relatively robust. Additional evidence of population robustness has recently been noted in association with evidence of persistent and periodic entrainment losses of LMR pallid sturgeon. During an emergency opening of the Bonnet Carre Spillway during 2008, the Service estimated up to 92 pallid sturgeon were injured or killed due to entrainment. Bonnet Carre has been opened three times since the species was listed (1994, 1997, 2008). Other diversion structures that have been operating for one to five decades, are known (Old River Control Complex and Bonnet Carre) or suspected (Caernarvon and Davis Pond) to entrain pallid sturgeon. While episodes of commercial harvest or entrainment constitute substantial periodic or continuous localized loss of individuals to the pallid sturgeon population within the specific stream reaches, scientific collection efforts indicate the species is persisting within the commercially harvested and diversion reaches, and is not uncommon in the LMR (e.g., Killgore et al. 2007 a,b; Schramm and Kuntz 2010).

Factors affecting species environment within the action area

Historically, the section of the Mississippi River bordering the action area would have had many sand bars and side channels that would have been usable habitat for pallid sturgeon. This section of the river has been heavily modified for the purposes of navigation and has few of these natural features left. Contaminants in water, sediments, or prey species could float down river and be in the vicinity of the action area which could affect any pallid sturgeon present. The salt water wedge that may

occur seasonally because of channel alterations may also affect pallid sturgeon in the action area. A constructed sill to reduce salt water intrusion has been constructed at Rmi 64 which is above the tentatively selected location of the proposed diversion at White Ditch. It is unclear to what extent salt water deters pallid sturgeon.

EFFECTS OF THE ACTION

This section includes an analysis of the direct and indirect effects of the proposed action on the species and/or its critical habitat and its interrelated and interdependent activities.

Factors to be considered

The proposed medium diversion at White Ditch is planned to be operated continuously between March and April each year (a total of 61 days). The actually flow rate of the diversion will depend on numerous factors including tidal variations, swamp water requirements, local rainfall events, Mississippi River stage and other environmental elements. The maximum discharge is anticipated to occur for the full 60 days (approximately 16 percent of the year) that the diversion is completely open with maintenance flows of less than 1,000 cfs occurring the rest of the year. Examination of discharge data for the Caernarvon Freshwater Diversion between 2001 and 2010 indicates that it discharges below its maximum capacity from approximately 73 to 90 percent of the time.

A stage discharge relationship for the Mississippi River at the diversion site could not be located and most likely is not available. Typical discharge rates for the Mississippi River at the time of maximum diversion (35,000 cubic feet per second) could be up 700,000 cubic feet per second therefore, the maximum diversion flow represents approximately 2.5-4 percent of the flow in the river. For the range of river stages from 4 to 11 feet, the cross section of the diversion culverts (2,250 square feet at maximum capacity) is approximately 1 percent of the Mississippi River's cross section. At a stage of 11 the river at it deepest point is 130 feet.

The constructed outfall channel would be approximately 7,200 feet long from the structure to Bayou Garelle. The intake and outfall channel would be dredged to a depth of -16 ft (NAVD) with a side slope ratio of 1:5. Bottom widths of the intake and out fall channels would be 365 ft and top widths would be 545 ft. Average velocities in the White Ditch conveyance channel would likely be approximately 4 fps which in studies, has shown to the upper limit of sturgeon swimming capabilities; although, velocities in the Mississippi River at Phoenix are between 4 and 6 fps. The highest velocities would occur within the culverts during maximum diversion capacity, however, with velocities exceeding 15 fps. Maintenance flows would likely produce velocities in the culverts between 5 and 10 fps. Between 2002 and 2010 velocities within the Davis Pond Diversion Outfall Canal greater than 3 fps occurred less than 1 percent of the time. Nine of 12 tagged sturgeon released in that 11,000 feet long canal eventually ended up at the end of that canal in the ponding area. However, sporadic trips by sturgeon from the ponding area back into the outfall canal have been recorded with up to 4 months passing between such trips.

The floor of the culverts will be approximately level with both the inlet and transmission canal. Shovelnose and lake sturgeons have been documented to swim through the gates of the Upper Mississippi River locks and dams (Brooks, et al. 2009). Shovelnose sturgeon have been documented to swim over the Intake Diversion Dam on the Yellowstone River; the downstream side of this dam is basically a slope. Conversely, pallid sturgeons are not known to swim upstream over this structure. White and Meddford (2002) documented only 2 of 16 shovelnose sturgeon crossing over a 21-inch vertical baffle in velocities ranging from 0.8 to 4 fps.

Attempts to correlate spillway operation dates, duration or volumes of flow with the entrainment of lake sturgeon (*Acipenser fulvescens*) through the Little Long Generating Station Facilities were unsuccessful (Seyler et al., 1996), however, Adams et. al. (2007) utilized volumes to determine potential number of green sturgeon (*Acipenser medirostris*) entrained. Seyler et al., (1996) reported lake sturgeon undertaking post spawning downstream migrations are entrained through a spillway that diverts excess flows around the hydropower generating station. Annual recovery and relocation efforts were reported to be carried between 1990 and 1995. Recovery and relocation of green and white sturgeon has also been conducted at water diversions off the Sacramento River. Entrainment of more sturgeon was associated with higher flows; however uncertainty in the data has confounded this interpretation (USBRC 2008).

Analyses for effects of the action

Direct effects are those direct or immediate effects of a project on the species or its habitat. Indirect effects are those that are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Direct effects of the diversion are limited to the entrainment of all natant life stages of the pallid sturgeon as well as the loss of the point sand bar habitat that is located at the site of the proposed diversion which could potentially serve as a feeding site for pallid sturgeon. Entrainment behind diversions could mean the death of several individuals due to lack of the adequate pallid sturgeon habitat in the outfall channel and in the ponding area that is needed to feed, spawn, or carry out any other necessary life processes.

Indirect effects could be associated with the future loss of progeny from immature sturgeon that would never spawn. In other words, individuals who perish in the ponding area would be completely removed from the spawning populations in the lower Mississippi River, thus, impacting future populations. Other individuals who manage to survive in the channel would still be effectively removed from the spawning population as long as they remain behind the structure. The diversions are not anticipated to adversely impact water quality or any habitat utilized by pallid sturgeon for spawning or nursery.

Effects of the action on larval, fry, and juvenile fish

No larval or young-of year (YOY) *Scaphirhynchus* were collected by Nichols State University in the outfall areas of any diversion or freshwater siphon, however, the collection of larval sturgeon within

any habitat typically requires considerable efforts which often only results in the capture of a few specimens (Quist 2004). Evidence of larval and YOY *Scaphirhynchus* usage of this river reach has been documented since 1985, with recent data collections indicating a greater than previously though abundance (Constant et al. 1997, ERDC 2010; See also Age, Growth and Reproduction).

Kynard et al. (2002) and Braaten et al. (2008) reported longer larval drift times, thus greater distances traveled by pallid sturgeon larva when compared to shovelnose larva. Pallid sturgeon larvae were determined to travel at approximately the mean river velocity for the first 11 days after hatching and then slightly slower for the next 6 days because of the sturgeon's transition to a benthic life stage. Distances covered during larval drift are affected by water velocity, however water temperature can affect larval/fry development rates (warmer temperatures increase development rates) which would also affect drift distances. Higher water velocities are experienced with larger flood events (U.S. Army Corps of Engineers 2009). Water velocities in the Mississippi River south of Baton Rouge (River Mile 231) have been documented to range from 4.4 fps to 1.5 fps depending on the discharge. South of Baton Rouge the river channel is larger and the slope of the river decreases, thus velocities are slower than those above Baton Rouge (Wells 1980). Surface water velocities measured north of Baton Rouge range from 2.9 fps to 5.6 fps for discharges of 200,000 cubic feet per second (cfs) to 1million cfs, respectively. The Corps has computed surface water velocities of the Mississippi River at New Orleans (Rmi 107; approximately 56 mile downstream). For the highest mean monthly river stage at New Orleans the mean river velocity would be 6.1 fps at the surface and 5.4 feet per second at 60 percent of the rivers. If the most southern pallid sturgeon spawning sites are the previously hypothesized gravel bars located in the vicinity of Vicksburg (River Mile 435) approximately 272 miles upstream of the structure (Hartfield personal comment) and a mean water velocity of 5.4 fps (3.7 miles per hour) is assumed to occur from Vicksburg to the diversion, larvae could travel approximately 88 miles per day if entrainment into the eddies, the batture and other areas is assumed not to occur and could reach the diversion within 3 days. Sturgeon spawning further downstream would be susceptible to entrainment at an even sooner time.

The recent capture of *Scaphirhynchus* larvae and post-larvae in the Mississippi River during fall months, as well as spring, could be interpreted as an extended season or a second spawn in the lower latitudes of distribution (Paul Hartfield, USFWS, per. comm. 2006). Ongoing sampling efforts by ERDC (2010) documented young-of-year (< 56 days old) sturgeon throughout the entire summer.

It is probable that larval and juvenile fish that will encounter the flows of the diversion. The lack of any of those life stages being captured within in the outfall area of any existing diversion or siphon and the still relatively few records from within the river precludes even making a reasonable assumption as to the number of such sturgeon that would be likely to be entrained. Because of the believed inability of such small sturgeon to swim against velocities likely to be encountered within the culverts it is not likely that any of those size sturgeons could return to the river. Nor is it believed that all would survive the outfall areas where higher temperatures, lower dissolved oxygen levels and slow currents exist; survival within outfall canal may be possible as evidenced by the survival of older sturgeon in the Davis Pond ponding area, but the duration of the survival is unknown. Nonetheless, failure to capture any of these size sturgeons (gears they would be susceptible to were utilized) possibly indicates that those that were entrained they may have been swept downstream

from the immediate outfall or left the outfall areas as velocities decreased. Considering the above factors the Service believes that an unquantifiable number of larval could possibly be entrained and possibly a greater number of juveniles but still not a significant number of either life stages. However, almost all of those life stages that would be entrained would probably experience mortality.

Effects of the action on sub-adult and adult

The Service caught, tagged with sonic tags and released 17 *Scaphirhynchus* in the Davis Pond Outfall Canal. Six stationary receivers were positioned along the outfall canal and one in the river to detect sturgeon movement and determine their ability to navigate back into the river. Of the tagged sturgeon, four are believed to have lost their tags, three are still within the outfall canal and nine are in the ponding area. Sturgeon have moved freely within the outfall canal and between the ponding area and canal with trips between the later two areas occurring over several months. It was anticipated that sturgeon might be able to swim back to the river at lower river stages. However, at the date of the last data collection the river stages had not decreased to levels that would have reduced the velocity through the structure sufficient to allow this to occur; monitoring is ongoing to provide additional data.

Sampling by Engineering Research and Development Center (ERDC) (2010) found that the lowest 70 miles of the Mississippi River where the proposed White Ditch Diversion will be located did not produce any sturgeon, though the Rmi 70- 100 section produced three shovelnose and 1 pallid. Sampling efforts in these two sections were lower than the sampling efforts put forth in the higher sections of the river. Sampling at Caernarvon (Rmi 81) by Nicholls State also did not produce any sturgeon. Sampling will continue as river stages are safe enough to utilize trotlines and trawls. Sampling from July 2009 to June 2010 by Nicholls State University in the Davis Pond Outfall Canal captured 3 shovelnose sturgeon and one pallid. The Davis Pond (Rmi 119) Freshwater Diversion can discharge up to 10,650 cfs.

Sturgeon swimming burst speeds may allow them to swim against the velocities in the structure at the maintenance level at lower river stages. Burst speeds, however, cannot be maintained for long distances and the length of the culvert is approximately 434 feet. Therefore, any sub-adult or adult sturgeon that are entrained may only have a very small opportunity to swim against slower velocities and migrate back to the river, thus most sturgeon that are entrained may not be likely to return to the river.

With assistance from ERDC the Service utilized a hydrology based method to determine the number of sturgeon entrained during the opening of the Bonnet Carre Spillway. The hydrology method is based upon a proposed relationship between the volume of water diverted and the number of sturgeon entrained. The hydrology methodology is similar to those recommended to determine entrainment by power plants (Goodyear 1997). However, methods proposed by Goodyear could not be used because insufficient information for some model parameters. While the method below is similar to that used to determine take for the Bonnet Carre opening, changes were made based more recent information and data obtained from the operating Davis Pond Freshwater Diversion. In the take determination for

the Bonnet Carre the ratio of pallid to shovelnose in the river was utilized in the calculations. However, for this determination the ratio was taken from sturgeon captured in the operating diversion. While the ratios are fairly close (1.2 for the river and 1:4 for the diversion) the differences could possibly be explained by habitat usage and behavioral differences when sturgeon encounter areas of higher velocities. Use of pallid to shovelnose ratio to determine take was also previously utilized in the Final Biological Opinion for the Upper Mississippi River – Illinois Waterway System Navigation Feasibility Study (2004). The methodology currently utilized represents the Service's best efforts to determine entrainment, however, the Service recognizes that as more information about pallid sturgeon life history, behavior, and abundance becomes available these methods may need to be revised or totally replaced.

The Service based the effect of the action on sub-adult/adult pallid sturgeon on the following assumptions:

1) All fish entrained will not return to the river
2) Adult pallid and adult shovelnose sturgeon will be entrained at the same approximate pallid to shovelnose ratio that has been found to occur in the Davis Pond Outfall Canal.
3) With increases in the duration and volume of water diverted additional fish are entrained; entrainment is directly proportional to the duration or volume of diverted water.
4) All tagged fish in the vicinity of sampling efforts had equal probability of being captured.
5) The percentage of tagged sturgeon captured of all tagged sturgeon available for capture in the Davis Pond Outfall Canal represents the effectiveness of sampling efforts (i.e., percent success) in determining the total number of sturgeon entrained.

The Service recognizes that the assumptions made may not be totally accurate for all sturgeon entrained but believes that this represents a scenario that is most likely to be the response of a majority of the sturgeon that will be entrained and therefore represents utilization of the best available information.

The Service calculated the maximum take of sub-adult/adult pallid sturgeon in the following manner:

1) From July 2009 to June 2010 there were 20 tagged sturgeon located in the Davis Pond Outfall Canal in the vicinity of sampling efforts being conducted by Nicholls State University on days that they sampled. During this time 2 tagged sturgeon were captured (i.e., 10 percent successful recapture rate) and 4 untagged sturgeon were captured with one being a pallid sturgeon (i.e., 25 percent).

2) The ten percent successful recapture rate when applied to the 4 untagged sturgeon captured would estimate the number of entrained sturgeon to be 40 of which 25 percent are pallid sturgeon (i.e., 10 fish).

3) The total discharge through the Davis Pond structure during the sampling period (9.472×10^{10} cubic ft) was divided by the estimated number of pallid entrained (i.e., 10) to determine the amount of volume discharged per each entrained fish (9.472×10^{9} cubic ft).

(9.472x 10^{10} cfs)/10 entrained pallid sturgeon = 1 pallid sturgeon entrained per 9.472x 10^{9} cf

4) The proposed maximum discharge for each day was summed to determine the total volume of water diverted during one year of the structures operation (i.e., 1.84 x 10^{11} cubic ft). This total volume was divided by the volume of water discharged per each entrained fish (9.472 x 10^{9} cubic ft) to calculate the possible maximum number of fish entrained.

35,000 second-day-feet x 61 days x 86400 seconds per day + 1,000 second-day-feet x 304 days x 86400 seconds per day = 1.84 x10^{11} + 2.63 x10^{10}
= 2.11 x 10^{11} cfs diverted in 1 year
2.11 x 10^{11} cfs /9.472 x 10^{9} cfs = 22.25 fish per year (rounded to 23)

The Corp is required to analyze projects impacts and benefits over a project life of 50 years. It is estimated that 1150 pallid sturgeon would be entrained over the project life of the proposed White Ditch diversion.

Lacking a population model or sufficient data to develop such a model the Service previously examined age frequency information for shovelnose and pallid sturgeons (Killgore et al., 2007a, Morrow et al., 1998) to determine the likelihood that the 2008 Bonnet Carre opening jeopardized the continued existence of the pallid sturgeon. The Service will reutilize this examination to aid in this impact determination.

The Service recognizes behavioral and biological differences in all life stages between the two species but also recognizes that similarities that would allow inferences of population effects to be made from shovelnose sturgeon age frequency tables and extrapolated to the pallid sturgeon population with appropriate caution. Age frequency tables produced by Morrow et al., (1998) and Killgore et al., (2007a) for shovelnose and pallid sturgeon, respectively, combined cohorts of the same age over several years (3 years for shovelnose and 5 years for pallid) potentially masking any minor effects of the openings. However, it was felt that examination of the range of cohorts that would be impacted by past diversions may reveal any significant impacts even though the small number of sturgeon in those cohorts may make such an investigation tenuous. Cursory examination of age frequency by Killgore et al., (2007a) did not show any differences in age class strengths for pallid sturgeon.

Gear selectivity (i.e., primarily trotlines) adds an additional complication to the use of age frequency tables to determine any possible effect of Spillway openings. Shovelnose sturgeon were fully vulnerable to trotlines at age 7, while pallid sturgeon were fully vulnerable at age 11 (Morrow, et al., 1998, Killgore et al., 2007). Therefore, estimates of sturgeon abundance or cohort strength below those ages would include that bias. In addition, the data for the shovelnose study (Morrow et al, 1998) was collected in the vicinity of Rosedale, MS (Rmi 585), but data for the pallid sturgeon study (Killgore et al, 2007) was collected from approximately New Orleans, LA, (Rmi 95) to the Chain of Rocks (Rmi 954). While long distant migrations for both sturgeon species has been documented (See Movement) the probability that sturgeon collected from these areas were likely to have encountered the previous openings of the Spillway is unknown. Because data for the two species were collected

from two different time periods that did not overlap, the effect of each previous diversion could not be compared between the species.

Examination of the shovelnose cohort range that would have been spawned during the 1994 and 1979 openings does not contain a sufficient range in cohorts to make any determination of effect but does show some recruitment did occur (Table 5; see date below figure explanation). However, examination of the cohort that would have been affected by the 1983 operations appears to show a possible loss of a cohort. Without additional data or further investigation it is not known if this represents an actual loss of a year class and if the loss is a result of the operation of the structure coupled with the effects of the flood and other factors such as commercial harvesting that was allowed at that time or just a product of lower abundance of older age classes (Jack Killgore personal comment). The range of shovelnose cohorts that would have been approximately the same size during the 1983 operation as those entrained in the 2008 do not appear to be significantly reduced. Age classes subsequent to 1983 are well represented, including those that would include progeny of a 1983 cohort, indicating yearly recruitment occurred since 1983. Based on this limited information it appears possible that the 1983 opening could have affected the 1983 year class but overall any effect does not appear to have impacted future cohort abundance.

Table 5.

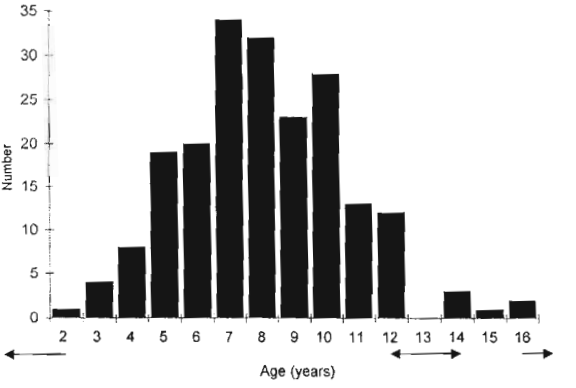


FIGURE 2.—Age frequency of 200 lower Mississippi River shovelnose sturgeon captured between 15 October 1995 and 12 March 1997.

Year of Opening	1994	1983	1979

The pallid sturgeon age distribution table (Table 6) has sufficient cohort ranges to examine the possible effects of the 1997, 1994, and 1983 openings. However, the examination was complicated

by the longer sampling period which lengthens the number of years that cohorts could have been present during the diversion. Examination of years when spawned fish would have been present during the diversion does not present any discernable impact. As with the shovelnose data, the 1983 cohort range also includes a year that had no individuals captured, however, other cohorts in the same range do not show any discernable effect. Also like the shovelnose data, without additional data or further investigation it is not known if this represents an actual loss of a year class and if the loss is a result of the operation of the structure coupled with the effects of the flood and other factors or just a product of lower abundance of older age classes (Jack Killgore personal comment). Examination of cohorts that would have been of the size range of pallid sturgeon entrained in the 2008 (24 to 34 inches) opening did not show any discernable negative effect from the 1994 and 1997 openings. No sturgeon large enough to be present in the 1983 opening were captured; in addition, the slower growth rates of older sturgeon could complicate the use of that size fish for this type of analysis. Comparison of the 1997, 1994 and 1983 days of operation suggest that the 1983 operation could have extended into the shovelnose and pallid sturgeon spring spawning season which means that the river discharge and the operation of the Bonnet Carre could have impacted that cohort size. Because the 2008 opening was of a shorter duration and diverted less water (Table 7) than the 1997, 1994, and 1983 openings and did not extend into the spring spawning season (Table 4) the Service believes that any impact from the opening would be similar but less than that of the 1997 operation. Examination of age distribution table does not show any discernable impact to the strength of any pallid sturgeon cohort from the 1997 opening. Furthermore, the age distribution of both species (Tables 5 and 6) indicates ongoing recruitment of juveniles and greater abundance (possibly survivorship) of all age classes but especially of spawning age individuals within the Lower Mississippi River (Table 6). This coupled with the relatively few recaptures of tagged pallid sturgeon (indicative of a relatively large population) and the increased number of larval and juveniles being captured in the Lower Mississippi River leads the Service to believe that the proposed operation of the small diversion at Convent/Blind River is not likely to jeopardize the pallid sturgeon.

Table 6.

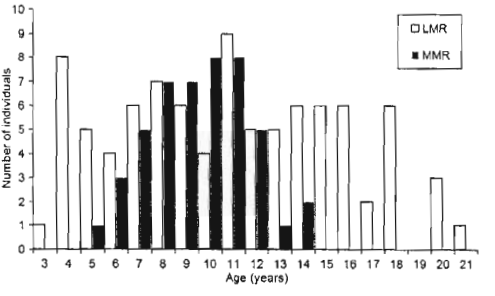
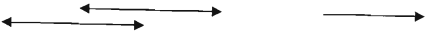


Fig. 1. Age distribution of pallid sturgeon in the lower Mississippi River (LMR) and middle Mississippi River (MMR)



Year of Opening 1997 1994 1983

Ongoing studies have demonstrated the greater abundance of pallid sturgeon within the southern portion of the Lower Mississippi River than in the more northern portions of its range. The ratio of pallid to shovelnose sturgeon from Rmi 179 to 80 ranges from 1:1 to 1:3 while a ratio of 1:22 has been tentatively calculated for Rmi 319 to 300 (ERDC 2010). Pallid sturgeon were the fifth most abundant fish based on sampling from the middle and lower Mississippi River (Killgore et. al, 2007). Recent data collected from the Lower Mississippi River indicates that they rank sixteenth in relative abundance (ERDC 2010).

Examination of cohort sizes that would have been exposed to the Bonnet Carre Diversion coupled with the relatively few recaptures of tagged pallid sturgeon (indicative of a relatively large population) and the increased number of all ages being captured in the Lower Mississippi River leads the Service to believe that the proposed operation of the small diversion at Convent/Blind River is not likely to jeopardize the pallid sturgeon.

Species' response to a proposed action

The Pallid Sturgeon Lower Basin Recovery Workgroup has identified information gaps essential to the consultation and recovery processes in the Lower Mississippi River Basin. These include: relative abundance of pallid sturgeon, demographics, feeding habits, habitat use, hybridization ratios, presence of fish diseases in the wild, population anomalies, and reliable separation and identification of pallid sturgeon, shovelnose sturgeon, and hybrids. A more recent information gap identified by the Lower Basin Work Group is the entrainment of adult and juvenile pallid sturgeon through the ORCC and potential entrainment through the existing coastal wetland restoration diversions. While recent publications have contributed to filling some of the former data gaps (e.g., Killgore et al., 2007, Hoover et al., 2007) incomplete knowledge of those areas remains. Therefore, the sturgeons' response to encountering the diversion flows (e.g., avoidance, actively sought) is unknown, which can affect the number of sturgeon believed to be "taken" by the structures operation. There are several hypotheses on possible sturgeon reactions to entrainment that must be considered to determine levels of take: only sturgeon located near the structure during its opening will be entrained (i.e., no increase in sturgeon entrained because of active avoidance); sturgeon actively swam into the structure seeking velocity refuge from main-channel flows and/or seeking food sources on the batture and/or in a perceived secondary channel (i.e., diversion); or sturgeon were entrained passively or actively during down-river migration. It is likely that the reaction to a diversion would vary with the life stage of the sturgeon, and actual adverse impacts may be due to a combination of any of the above hypotheses.

This biological opinion is based on direct and indirect effects that are anticipated to pallid sturgeon as a result of restoring Mississippi River flows via a water diversion. It is anticipated that approximately 23 pallid sturgeon per year (1150 over the project life of 50 years) will be lost from the population via entrainment. In the context of larval, fry and juvenile fish, it is anticipated that an unspecified number of pallid sturgeon will be entrained and also lost from the population.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section, because they require separate consultation pursuant to section 7 of the Act.

No additional State, local, and private actions have been identified in addition to the ongoing threats previously described in the Status and Distribution. These human-caused threats include industrial development and associated intakes and discharges, electrical generating facility construction and associated intakes and outfalls, dredging for sand, incidental harvesting, and poaching. The indirect effects of those actions include loss of habitat and water quality degradation. Such activities are likely to continue throughout the action area.

Future major construction activities in the Missouri and Mississippi River basins, along with new point-sources of pollution discharge would presumably have a Federal nexus (for example, they require Federal funding or permitting) and their potential adverse effects to pallid sturgeon would require section 7 consultation under the Act. Major construction activities in the Lower Mississippi River could include several other proposed coastal restoration freshwater diversions south of Baton Rouge and the continued operation of the Bonnet Carre Spillway and the ORCC; however, because they would all have a Federal nexus they would also not be considered as cumulative effects as described in the previous paragraphs.

CONCLUSION

After reviewing the current status of the pallid sturgeon, the effects of the current freshwater diversions and the proposed Medium Diversion at White Ditch, and the cumulative effects, it is the Service's biological opinion that construction and subsequent operation of a new freshwater diversion at White Ditch between RM 64 and 59 is not likely to jeopardize the continued existence of the species. No critical habitat has been designated for the pallid sturgeon; therefore, none will be affected.

INCIDENTAL TAKE STATEMENT

Section 9 of the Endangered Species Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

AMOUNT OR EXTENT OF TAKE ANTICIPATED

The following is a summary of the estimated incidental take previously discussed in the **Analysis for effects of the action** section. The Service believes incidental take in the form of harm (mortality associated with entrapment behind the structure) and harassment will result from the operation of the Medium Diversion at White Ditch. It includes mortality associated with entrapment behind the structure.

The Service estimated incidental loss (by death or serious injury) associated with entrapment behind the structure of 23 pallid sturgeon adults per year or 1150 adults over the project life of 50 years. In other words, 1150 fish will be harassed via entrainment with some proportion of those fish becoming injured and dying; as a result these fish and the others will be effectively removed from the Lower Mississippi River population. The Service anticipates the incidental take (direct death) of an unknown number of larval/juvenile pallid sturgeon due to entrainment but that number cannot be quantified. Larval and juvenile pallid sturgeon have been collected in trawls and it may be possible at the completion of ERDC's sampling to estimate take by calculating the number of fish collected per unit of water volume passing through the trawls.

EFFECT OF THE TAKE

In the accompanying biological opinion, the Service determined that this level of expected take is not likely to result in jeopardy to the pallid sturgeon.

REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the incidental take of pallid sturgeon by entrainment through the medium diversion at White Ditch.

1. Gate operations should minimize velocity through the structure by maximizing the open cross-section, especially at Mississippi River stages of 6 feet Mean Sea level or less (equates to velocities at the culvert face of 7.2 fps or less).
2. Any gate operation that would significantly increase or decrease the velocity (change greater than 500 cfs) should be implemented over several hours to allow fish sufficient time to migrate back to the river or swim away from the structure.
3. Once the end of the annual discharge period is reached minimal gate openings should be maintained for several days to allow passage of any sturgeon that may have emigrated downstream.
4. The downstream edge of the culverts should have a slope to act as a ramp and/or sufficient erosion protection that would prevent scour from forming a vertical ledge greater than 6 inches at the downstream end of the culvert.
5. In channel refuge consisting of several submerged wing dikes (or similar structures) on both banks should be constructed no further downstream than 75 feet from the structure. Minimal spacing between the structures should be 10 feet but can be moved to account for scour. The maximum suggested height is 24 inches, but the length extending into the channel is not yet determined.

6. The downstream side walls should be angled towards the culverts so they will guide fish back into the culverts at lower velocities.
7. The two outer most culverts should have fish passage baffles constructed on the floor of the culverts.
8. Monitoring to determine take and to reduce potential take by returning pallid sturgeon to the river should be undertaken

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps shall execute the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. Manuals (or other similar documents) written to guide the daily operations and maintenance activities of the diversion should be written in cooperation with the Service. Any proposed changes to such document would require re-initiation of consultation under Section 7 of the ESA.
2. Detailed design of wing dikes and the scour protection to prevent development of a vertical ledge should be coordinated with the Service. After construction annual inspection (i.e., measurements) should be taken at the downstream edge of the culvert to determine need to for maintenance. If maintenance is required funding should be immediately requested.
3. Design of downstream side walls and detailed design of the fish passage baffles should be coordinated with the Service.
4. Three days of sampling effort will be made each quarter. Sampling will consist of at minimum utilizing otter trawls, gillnets (i.e., 27.4 meter by 1.8 meter, six mesh panel ranging from 23 to 76 centimeters), and trotlines (61 meters long with 60 dropper lines at 0.9 meter intervals using 2/0 hooks baited with worms). Up to eight trotlines will be fished on the bottom overnight and two gillnets will also be fish overnight. All procedures and protocols for handling sturgeon should be followed and are available at: www.fws.gov/mountain-praire/endspp/protocols/PallidSturgeonHandlingProtocol2008B.pdf

All pallid sturgeon captures should be measured and tagged according to the protocol; if permitted and when feasible, ageing and endoscopy to determine sex and reproductive stage should also be conducted. All pallid sturgeon captured should be returned to the Mississippi River as soon as practicable. The number and size of each pallid sturgeon caught by date and gear type should be provided to the Service. Unsuccessful sampling efforts should also be reported by date and gear type.

Upon locating a dead or injured pallid sturgeon that may have been harmed or destroyed as a direct or indirect result of the proposed project, the Corps and/or contractor shall be responsible for notifying the Service's Lafayette, Louisiana, Field Office (337/291-3100) and the LDWF's Natural Heritage Program (225/765-2821). Care shall be taken in handling an injured sturgeon to ensure effective treatment or disposition and in handling dead specimens to preserve biological materials in the best possible state for later analysis. Disposition of dead sturgeon is also addressed in the protocols.

CONSERVATION RECOMMENDATIONS

Section 7(a) (1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

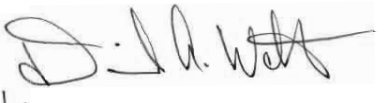
The Service has developed the following conservation recommendations to help minimize adverse effects and to development information that may further reduce adverse actions to the endangered pallid sturgeon.

1. Ongoing population studies for the Lower Mississippi River should be continued to aid the determination of future diversion impacts to the pallid sturgeon population.
2. Research possible designs of fish bypass or passage systems that may be incorporated in future projects or retrofitted into the current or existing projects should take.

REINITIATION NOTICE

This concludes formal consultation on the proposed action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take (i.e., the habitat acreage amount described herein) is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take shall cease pending reinitiation.

The above findings and recommendations constitute the report of the Department of the Interior. If you have any questions about this biological opinion, please contact Ms. Jennifer Hogue of this office at 337/291-3144.



James F. Boggs
Supervisor
Louisiana Field Office

LITERATURE CITED

Adams, S.R., G.R. Parsons, J.J. Hoover, and K. J. Killgore. 1997. Observations of Swimming ability in shovelnose sturgeon (Scaphirhynchus platorynchus). Journal of Freshwater Ecology. 12(4):631-633.

Adams, S.R., J.J. Hoover, and K. J. Killgore. 1999. Swimming Endurance of Juvenile Pallis Sturgeon, Scaphirhynchus albus. Copeia. 3:803-807.

Adams, S.R., and G.L. Adams, G.R. Parsons. 2003. Critical swimming speed and behavior of juvenile shovelnose sturgeon and pallid sturgeon. Transactions of American Fisheries Society. 132:392-397.

Allendorf, F.W., R.F. Leary, P. Spruell, and J.K. Wenburg. 2001. The problems with hybrids: setting conservation guidelines. Trends in Ecology and Evolution.116(11):613-622.

Baker, J., J.K. Killgore, and R. Kasul. 1991. Aquatic habitats and fish communities of the Lower Mississippi River. Aquatic Sciences 3(4)313-356.

Backes, K.M., W.M. Gardner, D. Scarnecchia, and P.A. Steward. 1992. Lower Yellowstone River pallid sturgeon study II and Missouri River pallid sturgeon creel survey. U.S. Bureau of Reclamation Grant Agreement No. 1-FG-60-01840, Modification 002.

Barada, A.J., and K.D. Steffensen. 2006. 2005 Annual Report, pallid sturgeon population assessment project and associated fish community monitoring for the Missouri River: Segment 8. Nebraska Game and Parks Commission, Lincoln, Nebraska.

Bailey, R.M., and F.B. Cross. 1954. River sturgeons of the American genus *Scaphirhynchus*: characters, distribution, and synonymy. Papers of the Michigan Academy of Science, Arts, and Letters 39:169-208.

Berg, R.K. 1981. Fish populations of the wild and scenic Missouri River, Montana. Montana Department of Fish, Wildlife and Parks. Restoration Project FW-3-R. Job 1-A.

Bettoli, P.W., M. Casto-Yerty, G.D. Scholten, and E.J. Heist. 2008. Bycatch of the endangered pallid sturgeon (*Scaphirhynchus albus)* in a commercial fishery for shovelnose sturgeon (*Scaphirhynchus platorhynchus)*. Journal of Applied Ichthyology. 1-4.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes 48:399-405.

Bramblett, R.G. 1996. Habitat and movements of pallid and shovelnose sturgeon in the Yellowstone and Missouri Rivers, Montana and North Dakota. Ph.D. Dissertation. Montana State University, Bozeman.

Bramblett, R.G., and R.G. White. 2001. Habitat use and movements of pallid sturgeon and shovelnose sturgeon in the Yellowstone and Missouri Rivers in Montana and North Dakota. Transactions of the American Fisheries Society. 130:1006-1026.

Brannen J., and J. Wilhelm. 2010. 2010 Nebraska Game and Parks Commission Broodstock Collection. Nebraska Games and Parks Commision. April 2010.

Braaten, P.J., D.B. Fuller, L.D. Holte, R.D. Lott, W. Viste, T.F. Brandt, and R.G. Legare. 2008. Drift dynamics of larval pallid sturgeon and shovelnose sturgeon in natural habitats of the upper Missouri River. North American Journal of Fisheries Management. 28:808–826.

Breder, C.M., Jr., and D.E. Rosen. 1966. Modes of reproduction in fishes. The Natural History Press. Garden City, New York.

Brooks, R.C., and J.E. Garvey. 2009. Fish passage in the Upper Mississippi River system. Fisheries and Illinois Aquaculture Center, Southern Illinois University. http://fishdata.siu.edu/pass08.pdf

Campton, D.E. 1987. Natural hybridization and introgression in fishes. *In* N. Ryman and F. Utter (ed), Population Genetics and Fishery Management. University of Washington Press. Seattle and London.

Campton, D.E., A.L. Bass, F.A. Chapman, and B.W. Bowen. 2000. Genetic distinction of pallid, shovelnose, and Alabama sturgeon: emerging species and the U.S. Endangered Species Act. Conservation Genetics 1:17-32.

Campton, D.E., A.I. Garcia, B.W. Bowen, and F.A. Chapman. 1995. Genetic evaluation of pallid, shovelnose and Alabama sturgeon (*Scaphirhynchus albus*, *S. platorhynchus*, and *S. suttkusi*) based on control Region (D-loop) sequences of mitochondrial DNA. Report from Dept. of Fisheries and Aquatic Sciences, Univ. of Florida, Gainesville, Florida.

Carlander, H.B. 1954. A history of fish and fishing in the Upper Mississippi River. Special Publication, Upper Mississippi River Conservation Commission. Iowa State University, Ames.

Carlson, D.M., and W.L. Pflieger. 1981. Abundance and life history of the lake, pallid, and shovelnose sturgeons in Missouri. Endangered Species Project SE-1-6, Missouri Department of Conservation, Jefferson City.

Carlson, D.M., W.L. Pflieger, L. Trial, and P.S. Haverland. 1985. Distribution, biology, and hybridization of *Scaphirhynchus albus* and *Scaphirhynchus platorynchus* in the Missouri and Mississippi River. Environmental Biology of Fishes. 14:51-59.

Clancey, P. 1990. Fort Peck pallid sturgeon study. Annual Report. Montana Fish, Wildlife, and Parks, Helena.

Coker, R.E. 1930. Studies of common fishes of the Mississippi River at Keokuk. U.S. Department of Commerce, Bureau of Fisheries Document 1972:141-225.

Colburn, T. and C. Clements (eds.) 1992. Chemically-induced alteration in sexual and functional development: the wildlife/human connection *in* M.A. Mehlman, ed. Advances in modern environmental toxicology, Volume XXI. Princeton Scientific Publishing Co., Inc. Princeton, New Jersey.

Columbia Environmental Research Center. 2008. U.S. Geological Survey FY 2008 Scope of Work. USGS, Biological Resources Division. www.moriverrecovery.org/.

Conner, J.V. and C. F. Bryan. 1974. Review and discussion of biological investigations in the lower Mississippi and Atchafalaya Rivers. School of Forestry and Wildlife Management. Louisiana State University and Louisiana Cooperative Fishery Unit, Baton Rouge.

Constant, G.C., W.E. Kelso, D.A. Rutherford, and C.F. Bryan. 1997. Habitat, movement and reproductive status of pallid sturgeon (*Scaphirhynchus albus*) in the Mississippi and Atchafalaya Rivers. Report prepared for the U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana.

Conte, F.S., S.I. Doroshov, P.B. Lutes, and E.M. Strange. 1988. Hatchery manual for the white sturgeon (*Acipenser transmontanus* Richardson) with applications to other North American Acipenseridae. Publication 3322, University of California, Davis.

Conzelmann, P., T. Rabot, and B. Reed. 1997. Contaminant evaluation of shovelnose sturgeon from the Atchafalaya River, Louisiana. U.S. Fish and Wildlife Service, Ecological Services. Lafayette, Louisiana.

Cross, F.B. 1967. Handbook of fishes of Kansas. Public Education Series 3, Museum of Natural History, University of Kansas, Lawrence.

Curtiss, G.L. 1990. Habitat use by shovelnose sturgeon in pool 13, upper Mississippi River, Iowa. M.S. Thesis. Iowa State University, Ames.

Deacon, J.E., G. Kobetich, J.D. Williams, and S. Contreras. 1979. Fishes of North America, endangered, threatened, or of special concern: 1979. Fisheries 4(2):29-44.

Dean, Jan. 2004. Pallid sturgeon at Natchitoches National Fish Hatchery – FY 2004. Unpublished paper in the Proceedings of the Lower Basin Pallid Sturgeon Workgroup - 2004.

Dean, Jan. 2007. Old River Control Complex sturgeon collections – FY 2007. Unpublished paper.

DeHaan, P.W., G.R. Jordan, and W.R. Ardren. 2008. Use of genetic tags to identify captive-bred pallid sturgeon (*Scaphirhynchus albus*) in the wild: improving abundance estimates

for an endangered species. Conservation Genetics. 9:691-697

DeLonay, A., and E.E.Little. 2002. Development of methods to monitor pallid sturgeon (Scaphirhynchus albus) movement and habitat use in the Lower Missouri River: Columbia, Mo., U.S. Geological Survey, p. 114 p.

DeLonay, A.J.,R.B. Jacobson, D.M. Papoulias, D.G. Simpkins, M.L. Wildhaber, J.M. Reuter, T.W. Bonnot, K.A. Chojnacki, C.E. Korschgen, G.E. Mestl, and M.J. Mac. 2009. Ecological requirements for pallid sturgeon reproduction and recruitment in the Lower Missouri River: A research synthesis 2005–08: U.S. Geological Survey Scientific Investigations Report 2009–5201, 59 p.

Doyle, W. and A. Starostka. 2003. 2002 annual report for the lower Mississippi River monitoring and assessment project. U.S. Fish and Wildlife Service, Columbia Missouri Fisheries Resources Office. January 2003.

Duffy, W.G., C.R. Berry, and K.D. Keenlyne. 1996. Biology of the pallid sturgeon with an annotated bibliography through 1994. Cooperative Fish and Wildlife Research Unit, Technical Bulletin 5. South Dakota State University, Brookings.

Elser, A.A., R.C. McFarland, and D. Schwehr. 1977. The effect of altered stream flow on fish of the Yellowstone and Tongue Rivers, Montana. Tech. Report 8:1-180.

Erickson, J.D. 1992. Habitat selection and movement of pallid sturgeon in Lake Sharpe, South Dakota. M.S. Thesis, South Dakota State University, Brookings.

Fisher, H.J. 1962. Some fishes of the lower Missouri River. American Midland Naturalist 68:424-429.

Fogle, N.E. 1963. Report of fisheries investigations during the fifth year of impoundment of Oahe Reservoir, South Dakota. D.J. Project F-1-R-12, Job 10-11-12, South Dakota Department of Game, Fish, and Parks.

Forbes, S.A., and R.E. Richardson. 1905. On a new shovelnose sturgeon from the Mississippi River. Bulletin of the Illinois State Laboratory of Natural History 7:37-44.

Fremling, C.R., J.L. Rasmussen, R.E. Sparks, S.P. Cobb, C.F. Bryan, and T.O. Claflin. 1989. Mississippi River fisheries: a case history. Pages 309-351 *in* D.P. Dodge, ed., Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci.

Funk, J.L., and J.W. Robinson. 1974. Changes in the channel of the lower Missouri River and effects on fish and wildlife. Missouri Department of Conservation, Aquatic Series 11, Jefferson City.

Gardner, B. 1999. Pallid sturgeon above Fort Peck Reservoir 1996-1998 *in* S. Krentz, editor. Pallid Sturgeon Recovery Update, Issue No. 10.

Gardner, W.M., and P. Stewart. 1987. The fishery of the lower Missouri River, Montana. Federal Aid to Fish and Wildlife Restoration, Project F-46-R-5, Study Number 3. Montana Dept. of Fish, Wildlife, and Parks, Helena.

Gilbraith, D.M., M.J. Schwalbach, and C.R. Berry. 1988. Preliminary report on the status of the pallid sturgeon, *Scaphirhynchus albus*, a candidate endangered species. Department of Wildlife and Fisheries Science, South Dakota State University, Brookings.

Goodyear, C.P. 1977. Mathematical methods to evaluate entrainment of aquatic organisms by power plants. FWS/OBS-76.20.3

Gordan, N.G., T.A. McMahon, and B.L. Finlayson. 1992. Stream hydrology. John Wiley and Sons, England.

Grady, J.M., L. Mauldin, B. Davison, and J. Milligan. 2001a. Missouri River pallid sturgeon survey Route 19 bridge replacement project Hermann, Missouri. Final Report prepared for the Missouri Highways and Transportation Commission. U.S. Fish and Wildlife Service, Columbia, Missouri.

Grady, J.M., J. Milligan, C. Gemming, D. Herzog, G. Mestl, and R.J. Sheehan. 2001b. Pallid and shovelnose sturgeons in the lower Missouri and middle Mississippi Rivers. Final Report for MICRA.

Graham, K. 1997. Missouri Department of Conservation successfully spawns pallid sturgeon *in* M. Dryer, ed., Pallid Sturgeon Recovery Update, Issue No. 9.

Graham, K. 1999. Pallid Sturgeon Reintroduction in Missouri *in* S. Krentz, ed., Pallid Sturgeon Recovery Update, Issue No. 10.

Grohs, K.L., R.A. Klumb, S.R. Chipps, and G.A. Wanner. 2009. Ontogentic patterns in prey use by pallid sturgeon in the Missouri River, South Dakota and Nebraska. Journal of Applied Ichthyology. 25(2):48-53.

Hartfield, P., D. Drennen, T. Slack, and R. Nasser. 2002. Sturgeon survey in the lower Mississippi River. *in* R. Wilson, ed., Pallid Sturgeon Recovery Update, Issue No. 12.

Hartfield, P. 2006. Missouri fish in Atchafalaya. Email message to multiple recipients.

Hartfield, P. and B.R. Kuhajda. 2009 Threat assessment: hybridization between pallid sturgeon and shovelnose sturgeon in the Mississippi River. Unpublished document, U.S, Fish and Wildlife Service, Jackson, Mississippi. 22pp.

Herrala, J., and H. Scramm. 2010. Short-term movements and habitat use of pallid sturgeon in the Mississippi and Atchafalaya rivers. Master's Thesis for Mississippi State University.

Heist, E.J., and A. Schrey. 2006a. Microsatellite tools for genetic identification of *Scaphirhynchus*. Interim Report. Southern Illinois University, Carbondale.

Heist, E.J., and A. Schrey. 2006b. Genetic analysis of middle Missouri River pallid sturgeon. report prepared by the Fisheries Research Laboratory, Southern Illinois University at Carbondale for the U.S. Fish and Wildlife Service.

Held, J.W. 1969. Some early summer foods of the shovelnose sturgeon in the Missouri River. Transactions of the American Fisheries Society 98:514-517.

Helms, D. 1974. Shovelnose sturgeon, *Scaphirhynchus platorynchus*, in the navigational impoundments of the upper Mississippi River. Tech. Series. Iowa State Conservation Commission 74-3.

Herzog, D.P., R. Hrabik, R. Brooks, T. Spier, D. Ostendorf, J. Ridings, J. Crites, C. Beachum, and R. Colombo. 2005. Assessment of *Scaphirhynchus* spp. spawning and rearing locations in the Middle Mississippi River: insights from collection of larval and young of the year fishes. *In* Evolution, Ecology and Management of *Scaphirhynchus*. St. Louis Missouri, January 11-13, 2005. Abstract.

Hesse, L.W. 1987. Taming the wild Missouri River: what has it cost? Transactions of the American Fisheries Society. Vol. 12, No. 2.

Hesse, L.W., and G.E. Mestl. 1987. Ecology of the Missouri River. Progress Report, D-J Project F-75-R. Nebraska Game and Parks Commission, Norfolk.

Hesse, L.W., and G.E. Mestl. 1993. The status of paddlefish in the Missouri River, Nebraska. Progress Report, D-J Project F-75-R, Nebraska Game and Parks Commission, Norfolk, Nebraska.

Hofpar, R.L. 1997. Biology of Shovelnose Sturgeon, *Scaphirhynchys platorynchus*, in the lower Platte River, Nebraska. Master's thesis. University of Nebraska, Lincoln.

Hoover, J. J., K.J. Killgore, D.G. Clarke, H. Smith, A. Turnage, and J. Beard. 2005. Paddlefish and sturgeon entrainment by dredges: Swimming performance as an indicator of risk, DOER-E22, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Hoover, J.J., S.G. George, and K.J. Killgore. 2007. Diet of shovelnose sturgeon and pallids sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology. 23:494-499.

Hrabik, R.A. 2002. Missouri Department of Conservation Fisheries Research, Assessment and Monitoring Section. *in* R. Wilson, ed., Pallid Sturgeon Recovery Update, Issue No. 12

Hubbs, C.L. 1955. Hybridization between fish species in nature. Systematic Zoology. 4:1-20.

Hurley, K.L. 1996. Habitat use, selection, and movements of middle Mississippi River pallid sturgeon and validity of pallid sturgeon age estimates from pectoral fin rays. M.S. Thesis. Southern Illinois University, Carbondale.

Jaeger, M.E., G.R. Jordan, and S. Camp. 2004. Assessment of the suitability of the Yellowstone River for pallid sturgeon restoration efforts, annual report for 2004 in K. McDonald (ed) Upper Basin Pallid Sturgeon Recovery Workgroup 2004 Annual Report. Helena, Montana.

Johnson, W.C. 1993. Divergent response of riparian vegetation to flow regulations on the Missouri and Platte Rivers. Pages 426-431 *in* L.W. Hesse, C.B. Stalnaker, N.G. Benson, and J.R. Zuboy, eds., Proceedings of the symposium on restoration planning for the rivers of the Mississippi River ecosystem. Biological Report 19. National Biological Survey, USDI, Washington DC.

Jordan, G.R. 2006. Another dead pallid at Mid-American Neal south unit. Email message to multiple recipients.

Kallemeyn, L.W. 1983. Status of the pallid sturgeon (*Scaphirhynchus albus*). Fisheries 8(1):3-9.

Kapuscinski, K. 2003. Population abundance estimation of wild pallid sturgeon in recovery-priority management area #2 of the Missouri and Yellowstone Rivers, 1991-2003. Draft Report. Montana Fish, Wildlife and Parks.

Keenlyne, K.D. 1989. A report on the pallid sturgeon. U.S. Fish and Wildlife Service, Pierre, South Dakota.

Keenlyne, K.D. 1995. Recent North American studies on pallid sturgeon, *Scaphirhynchus albus* (Forbes and Richardson). Pages 225-234 *in* A.D. Gerschanovich and T.I.J. Smith, eds., Proceedings of the international symposium on sturgeons, September 6-11, 1993. VNIRO Publ., Moscow, Russia.

Keenlyne, K.D., L.K. Graham, and B.C. Reed. 1994. Hybridization between the pallid and shovelnose sturgeons. Proc. South Dakota Academy of Science 73:59-66.

Keenlyne, E.M. Grossman, and L.G. Jenkins. 1992. Fecundity of the pallid sturgeon. Transactions of the American Fisheries Society 121:139-140.

Keenlyne, K.D., and L.G. Jenkins. 1993. Age at sexual maturity of the pallid sturgeon. Transactions of the American Fisheries Society. 122:393-396.

Kennedy, A.J., P.T. Horner, and V.H. Travnichek. 2006. 2005 Annual Report, Pallid sturgeon population assessment project and associated fish community monitoring for the Missouri River: Segment 10. Missouri Department of Conservation, Chillicothe, Missouri.

Kirk, J.P., K.J. Killgore, and J.J. Hoover. 2008. Evaluation of potential impacts of the Lake Maurepas Diversion project to Gulf and pallid sturgeon. (ERDC TR-08-19), U.S. Army

Engineer Research and Development Center, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/trel08-19.pdf

Killgore, K.J., J.J. Hoover, J.P. Kirk, S.G. George, B.R. Lewis, and C.E. Murphy. 2007a. Age and growth of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology. 23:452-456.

Killgore, K.J., J.J. Hoover, S.G. George, B.R. Lewis, C.E. Murphy, and W.E. Lancaster. 2007b. Distribution, relative abundance and movements of pallid sturgeon in the free-flowing Mississippi River. Journal of Applied Ichthyology. 23:476-483.

Kilpatrick, K. 1999. Pallid sturgeon spawned at Natchitoches NFH, Louisiana, during 1998 *in* S. Krentz, ed., Pallid Sturgeon Recovery Update, Issue No. 10.

Klungle, M. 2004. Field accomplishments/agency reports (RPMA 2). *In* K. McDonald (ed) Upper Basin Pallid Sturgeon Recovery Workgroup, 2004 Annual Report. Helena, Montana.

Krentz, S. 2000. Pallid sturgeon recovery update-the latest research and management actions for recovery. Issue 11. U.S. Fish and Wildlife Service, Bismark, North Dakota.

Kuhajda, B.R., and R.L. Mayden. 2001. Morphological comparisons of hatchery-reared specimens of *Scaphirhynchus albus, S. platorynchus,* and *S. albus* x *S. platorynchus* hybrids. University of Alabama, Tuscaloosa. 119 pp.

Kuhajda, B.R., Mayden, R.L., and R.M. Wood. 2007. Morphologic comparisons of hatchery-reared specimens of Scaphirhynchus albus, Scaphirhynchus platorynchus, and S.albus x S.platorynchus hybrids (Acipenseriformes: Acipenseridae). Journal of Applied Ichthyology. 23:324-347.

Kynard, B., E. Henyey, and M. Horgan. 1998a. Studies on pallid sturgeon: Turners Falls, Massachusetts: U.S. Geological Survey, Biological Resource Division, Conte Anadromous Fish Research Center, Turners Falls.

Kynard, B., E. Henyey, and M. Horgan. 1998b. Studies on early life behavior of shovelnose sturgeon: Turner Falls, Massachusetts: U.S. Geological Survey, Biological Resource Division, Conte Anadromous Fish Research Center, Turners Falls.

Kynard, B., E. Henyey, and M. Horgan. 2002. Ontogenetic behavior, migration, and social behavior of pallid sturgeon, *Scaphirhynchus albus*, and shovelnose sturgeon, *S. platorynchus*, with notes on the adaptive significance of body color. Environmental Biology of Fishes. 63:389-403.

Kynard, B., E. Parker, D. Pugh, and T. Parker. 2005. Experimental studies of pallid sturgeon dispersal and vertical swimming height during ontogeny. *In* Evolution, Ecology and Management of Scaphirhynchus. St. Louis Missouri, January 11-13, 2005. Abstract.

Liebelt, J. 1995. Preliminary report: Fort Peck pallid sturgeon study - 1994. Pages 81-84 *in* Proceedings of the first joint meeting of the Montana/North Dakota pallid workgroup and the fluvial arctic grayling workgroup. Montana Dept. of Fish, Wildlife and Parks, Helena.

Ledwin, J. 2006. Re: Fw: Another dead pallid at Mid-American Neal south unit. Email message to multiple recipients.

Louisiana Wildlife and Fisheries Commission. 1976. An inventory and study of the Lake Pontchartrain – Lake Maurepas estuarine complex. Technical Bulletin No. 19.

Mayden, R.L., and B.R. Kuhajda. 1997. Threatened fishes of the world: *Scaphirhynchus albus* (Forbes and Richardson 1905) (Acipenseridae). Environmental Biology of Fishes 48:420-421.

McQuown, E.C., B.L. Sloss, R.J. Sheehan, J. Rodzen, G.J. Tranah, and B. May. 2000. Microsatellite analysis of genetic variation in sturgeon: new primer sequences for *Scaphirhynchus* and *Acipenser*. Transactions of the American Fisheries Society. 129:1380-1388.

Modde, T.C., and J.C. Schmulbach. 1973. Seasonal changes in the drift and benthic macroinvertebrates in the unchannelized Missouri River in South Dakota. Proceedings South Dakota Academy of Science 51:118-125.

Modde, T.C., and J.C. Schmulbach. 1977. Food and feeding behavior of the shovelnose sturgeon in the unchannelized Missouri River. Transactions of the American Fisheries Society 106(6):602-608.

Moos, R.E. 1978. Movement and reproduction of shovelnose sturgeon, *Scaphirynchus platorynchus*, in the Missouri River, South Dakota. Ph.D. Dissertation, University of South Dakota, Vermillion.

Morris, L.A., R.N. Langemeier, T.R. Russell, and A. Witt, Jr. 1968. Effect of main stem impoundments and channelization upon the limnology of the Missouri River, Nebraska. Transactions of the American Fisheries Society 97:380-388.

Morrow, J.V., Jr., J.P. Kirk, J. Killgore, and S.G. George. 1998. Age, growth, and mortality of shovelnose sturgeon in the Lower Mississippi River. North American Journal of Fisheries Management. 18:725-730.

Mosher, T.D. 1998. Sturgeon and paddlefish sportfishing in North America. Pp. 51-66 *in* D.F. Williamson, G.W. Benz, and C.M. Hoover, eds., Proceedings of the symposium on the harvest, trade and conservation of North American paddlefish and sturgeon, May 7-8, 1998. Chattanooga, Tennessee.

Moyle, P.B., and J.J. Cech. 1982. Fishes: An introduction to ichthyology. Prentice-Hall,

Englewood Cliffs, New Jersey.

Murphy, C.E., J.J. Hoover, S.G. George, and K.J. Killgore. 2007. Morphometric variation among river sturgeons (*Scaphirhynchus* spp.) of the Middle and Lower Mississippi River. Journal of Applied Ichthyology. 23:313-323.

Peterson, M. 1999. Missouri's LTRM station captures seven pallid sturgeon *in* S. Krentz, ed., Pallid Sturgeon Recovery Update, Issue No. 10.

Peterson, M., and D. Herzog. 1999. Open River Field Station Report: Young-of-the-year pallid sturgeon collected in the Mississippi River. Missouri Department of Conservation, Long Term Resource Monitoring Station, Cape Girardeau.

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Department of Conservation, Jefferson City.

Quist, M.C. 2004. Background Information. Pallid Sturgeon Research Workshop. May 18-20, 2004. Bloomington, MN.

Ray, J.M., C.B. Dillman, R.M. Wood, B.R. Kuhajda, and R.L. Myden. 2007. Microsatellite variation among river sturgeons of the genus *Scaphirhynchus* (Actinopterygii: Acipenseridae): a preliminary assessment of hybridization. Journal of Applied Ichthyology. 23:304-312. .

Reade, C.N. 2000. Larval fish drift in the Lower Platte River, Nebraska. Master's thesis. University of Nebraska, Lincoln.

Reed, B. 2002. Louisiana pallid sturgeon activities 2001 i*n* R. Wilson, ed., Pallid Sturgeon Recovery Update, Issue No. 12.

Reed, B.C., and M.S. Ewing. 1993. Status and distribution of pallid sturgeon at the Old River Control Complex, Louisiana. Louisiana Dept. of Wildlife and Fisheries, Lake Charles.

Ruelle, R., and K.D. Keenlyne. 1994. The suitability of shovelnose sturgeon as a pallid sturgeon surrogate. U.S. Fish and Wildlife Service, Fish and Wildlife Enhancement, Pierre, South Dakota.

Schmulbach, J.C. 1974. An ecological study of the Missouri River prior to channelization. Brookings, South Dakota. Water Resources Institute. Project Number BJ-024-SDAK.

Schmulbach, J.C., G. Gould, and C.L. Groen. 1975. Relative abundance and distribution of fishes in the Missouri River, Gavins Point Dam to Rulo, Nebraska. Proceedings South Dakota Academy of Science 54:194-222.

Schramm, H.L., Jr. and W.O. Dunn, III. 2008. Summer movement and habitat use of pallid sturgeon in the Old River and the Atchafalaya River Report for 2007.

Schramm, H.L., Jr., and P. Mirick. 2009. Pallid sturgeon habitat use and movement in the lower Mississippi River. Annual report submitted to Arkansas Game and Fish Commission, Little Rock, Arkansas. Mississippi Cooperative Fish and Wildlife Research Unit, Mississippi State, Mississippi.

Schramm, H.L., and N.M. Kuntz. 2010. Pallid Sturgeon Habitat Use and Movment in the Lower Mississippi River 2009-2010. Annual Report submitted to the Arkansas Game and Fish Commission.

Schrey, A.W. and E.J. Heist. 2007. Stock structure of pallid sturgeon analyzed with microsatellite loci. Journal of Applied Ichthyology. 23:297-303.

Schultz, D. 2010. Entrainment of fish species by freshwater diversions of the Lower Mississippi River. Progress report for the period July 1, 2009 to June 30, 2010.

Seyler, J., J. Evers, S. McKinley, R.R., Evans, G. Prevost, R. Carson, and D. Phoenix. 1996. Mattagami River Lake Sturgeon entrainment: Little Long Generating Station Facilities. NEST Technical Report TR-031.

Sheehan, R.J., L.R. Bodensteiner, W.L. Lewis, D.E. Logsdon, and S.D. Scherck. 1990. Long-term survival and swimming performance of young-of-the-year river fishes at low temperatures: links between physiological capacity and winter habitat requirements. Pages 98-108 *in* Proceedings of the Restoration of Midwestern Stream Habitat Symposium, Dec. 3-5, 1990. Minneapolis, Minnesota.

Sheehan, R.L., R.C. Heidinger, K.L. Hurley, P.S. Wills, and M.A. Schmidt. 1997. Middle Mississippi River pallid sturgeon habitat use project: year 2 annual progress report, December 1997. Fisheries Research laboratory and Department of Zoology, Southern Illinois University, Carbondale.

Sheehan, R.J., R.C. Heidinger, K.L. Hurley, P.S. Wills, and M.A. Schmidt. 1998. Middle Mississippi River pallid sturgeon habitat use project: year 3 annual progress report, December 1998. Fisheries Research Laboratory and Department of Zoology, Southern Illinois University, Carbondale.

Shuman, D.A., R.A. Klumb, and S.T. McAlpin. 2005. Pallid sturgeon population assessment and associated fish community monitoring for the Missouri River: segments 5 and 6. July 25, 2005. U.S. Fish and Wildlife Service report submitted to U.S. Army Corps of Engineers, Yankton, South Dakota.

Simons, A.M., R.M. Wood, L.S. Heath, B.R. Kuhajda, and R.L. Mayden. 2001. Phylogentics of *Scaphirynchus* based on mitochondrial DNA sequences. 2001. Transactions of the American Fisheries Society. 130:359-366.

Smith, P.W. 1979. The fishes of Illinois. University of Illinois Press, Urbana.

Steffensen, K.D., and A.J. Barada. 2006. 2005 Annual report, pallid sturgeon population assessment project and associated fish community monitoring for the Missouri River: segment 9. Nebraska Game and Parks Commission, Lincoln, Nebraska.

Steffensen K., and J. Koch. 2009. 2009 Nebraska Game and Parks Commission Broodstock Collection. Nebraska Games and Parks Commision. April 2009.

Swenson, E.M. 1981. Physical effects of the 1979 opening of the Bonnet Carre Spillway. The Proceedings of the Louisiana Academy of Sciences. Vol. XLIX:121-131.

Todd, R.M. 1998. Sturgeon and paddlefish commercial fishery in North America. Pages 42-50 *in* D.F. Williamson, G.W. Benz, and C.M. Hoover, eds., Proceedings of the symposium on the harvest, trade and conservation of North American paddlefish and sturgeon, May 7-8, 1998. Chattanooga, Tennessee.

Tranah, G. J. 2001. Molecular genetic analysis of hybridization and population structure in endangered sturgeon and sucker species. Ph. D. Dissertation, University of California, Davis.

Tranah, G. J., H. L. Kincaid, C.C. Krueger, D.E. Campton, and B. May. 2001. Reproductive isolation in sympatric populations of pallid and shovelnose sturgeon. North American Journal of Fisheries management. 21:367-373.

Tranah, G., D.E. Campton, and B. May. 2004. Genetic Evidence for Hybridization of Pallid and Shovelnose Sturgeon: Journal of Heredity, v. 95, no. 6, p. 474–480.

Tripp, S.A., Q.E. Phelps, R.E. Colombo, J.E. Garvey, B.M. Burr, and D.P. Herzog, and R.A. Hrabik. 2009. Maturation and reproduction of shovelnose sturgeon in the Middle Mississippi River. North American Journal of Fisheries Management. 29:730-738.

US Army Corps of Engineers. 2009. River velocities at New Orleans, LA, related to Carrollton Gage. http://www.mvn.usace.army.mil/eng/edhd/velo_no.gif

US Army Corps of Engineers. 2004. Mississippi River Hydrographic Survey. http://www.mvn.usace.army.mil/eng/2007MissRiverBooks/Support/PDF/Hydrographic/55630S045.pdf

US Bureau of Reclamation. 2008. OCAP Biological Assessment. http://www.usbr.gov/mp/cvo/ocapBA_051608.html

USFWS. No Date. The pallid sturgeon draft annotated bibliography through 2003. Missouri River Fish and Wildlife Management Assistance Office. Bismarck, ND.

USFWS. 2000. Biological opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and

navigation project, and operation of the Kansas River reservoir system. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado, and Region 3, Fort Snelling, Minnesota

USFWS. 2002. Biological opinion on Natchitoches National Fish Hatchery's Collection of Endangered Pallid Sturgeon from Louisiana Waters for Propagation and Research. U.S. Fish and Wildlife Service, Lafayette, Louisiana.

USFWS. 2003. U.S. Fish and Wildlife Service 2003 amendment to the 2000 biological opinion on the operation of the Missouri River main stem reservoir system, operation and maintenance of the Missouri River bank stabilization and navigation project, and operation of the Kansas River reservoir system. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado and Region 3, Fort Snelling, Minnesota.

USFWS. 2004. Programmatic Biological Opinion Addressing Effects of the Southeast Region's Section 10(a)(1)(A) Permitting on the Pallid Sturgeon (5-years). US. Fish and Wildlife Service, Lafayette, Louisiana.

USFWS. 2006. Pallid sturgeon range-wide stocking and augmentation plan. U.S. Fish and Wildlife Service, Region 6, Denver, Colorado.

USFWS. 2007. Pallid Sturgeon (*Scaphirhynchus albus*) 5-year review summary and evaluation. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 120pp.

USFWS. 1993. Pallid sturgeon recovery plan. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 55pp.

Utrup, N., W. Doyle, C. Lee, A. Plauck, and T. Hill. 2006 . 2005 Annual report, pallid sturgeon population assessment project and associated fish community monitoring for the Missouri River: segment 14. U.S. Fish and Wildlife Service, Columbia, Missouri.

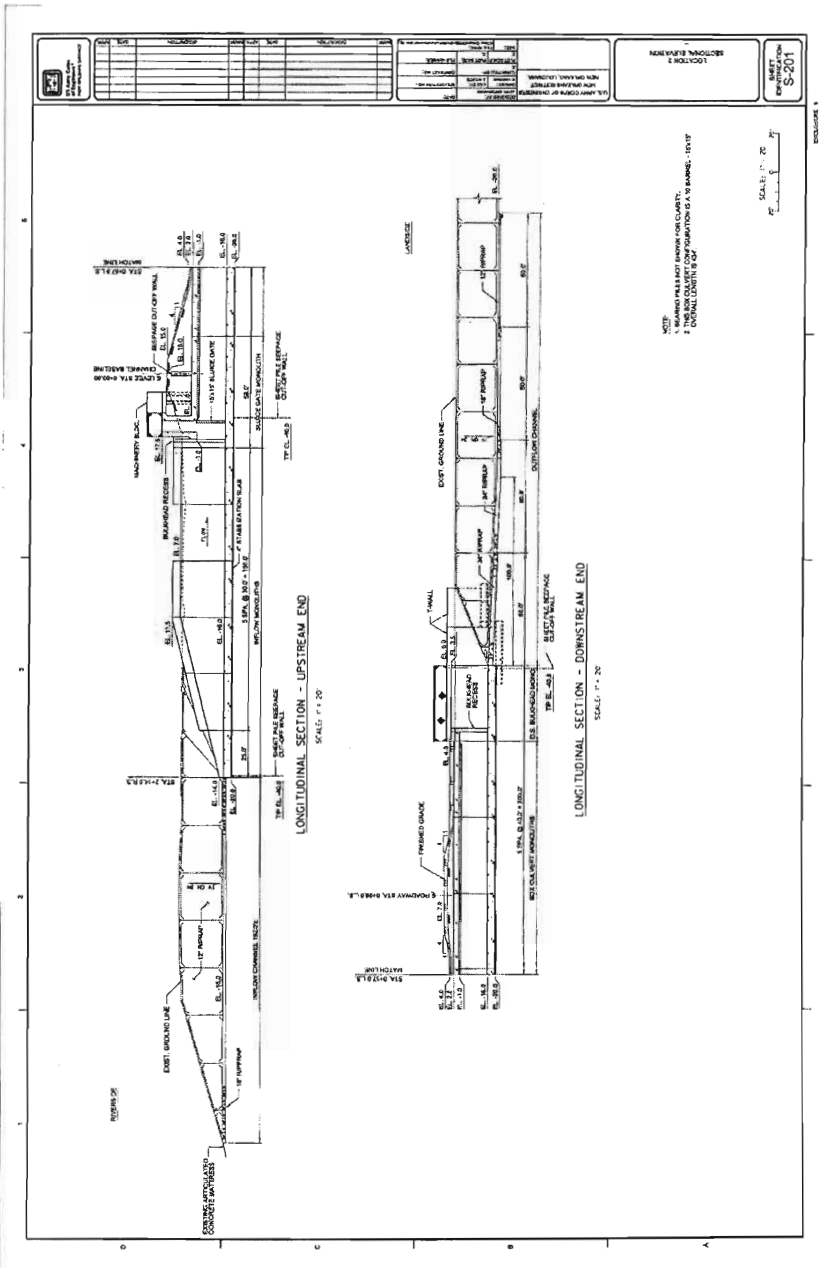
Watson, J.H., and P.A. Stewart. 1991. Lower Yellowstone River pallid sturgeon study. Department of Fish, Wildlife and Parks, Miles City, Montana.

Wells, F.C. 1980. Hydrology and water quality of the Lower Mississippi River. Louisiana Department of Transportation and Development. Water Resources Technical Report No. 21.

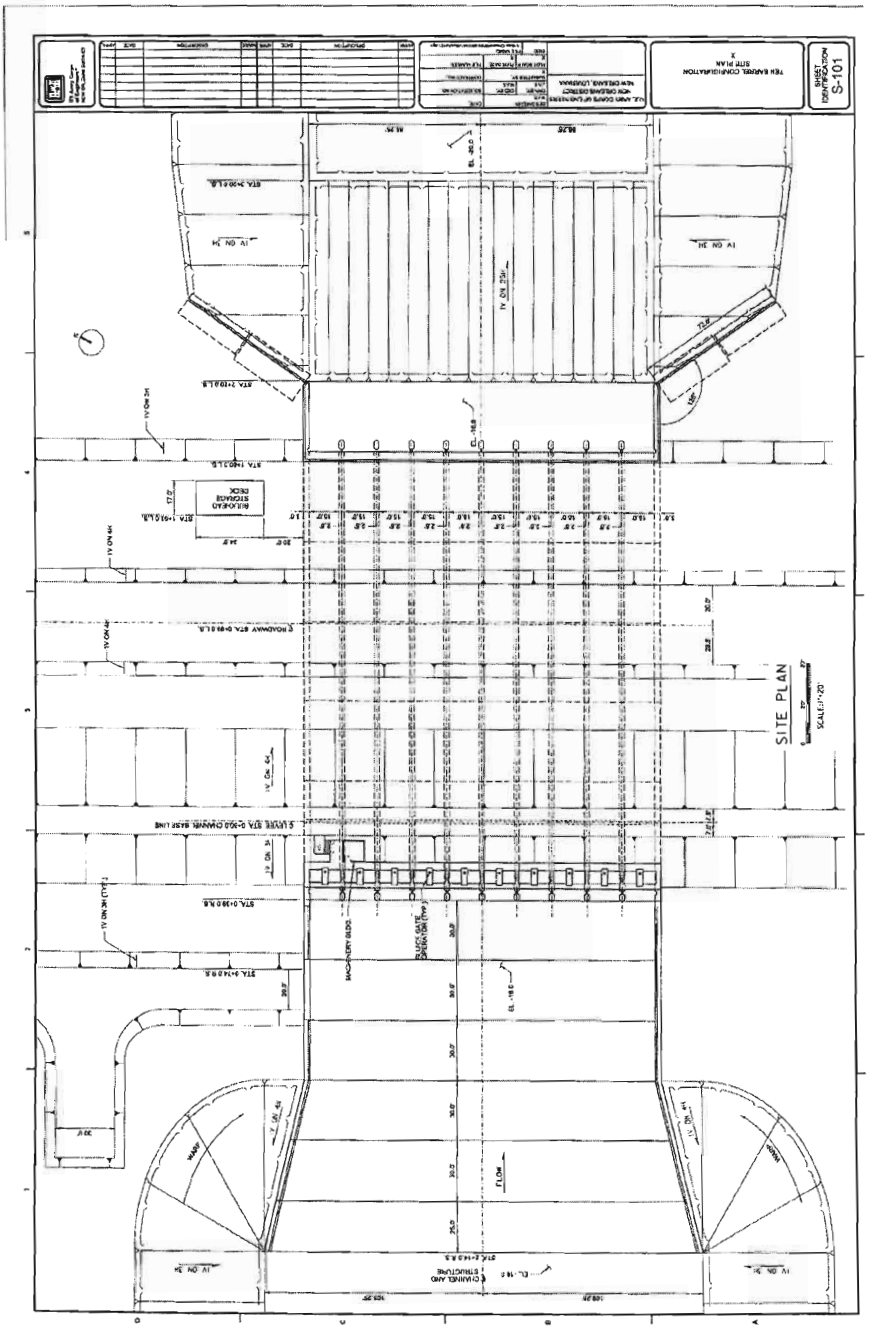
Williams, B.O. 2006. March 3, 2006 Meeting Notes. Email message to multiple recipients.

White, R.G. and B. Mefford. 2002. Assessment of behavior and swimming ability of Yellowstone River sturgeon for design of fish passage devices. http://www.usbr.gov/gp/mtao/loweryellowstone/assessment_of_behavior.pdf

APPENDIX


LONGITUDINAL SECTION - UPSTREAM END
SCALE: 1" = 20'
LONGITUDINAL SECTION - DOWNSTREAM END
SCALE: 1" = 20'
SECTIONAL ELEVATION
SHEET DESIGNATION
S-201
NOTE
1. BEARING PILES NOT SHOWN FOR CLARITY.
2. PILES ARE IN A 5 X 10 CONFIGURATION (5 X 10 BARREL - 15'x15' OVERALL LENGTH IS 49')

64


SITE PLAN
SCALE: 1"=20'
S-101
SHEET IDENTIFICATION
TRUMBULL CONSULTING ENGINEERS

Appendix A-4

Formal Section 7 Consultation Receipt
U.S. Fish and Wildlife Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506

July 16, 2010

Colonel Alvin B. Lee
District Engineer
U.S. Army Corps of Engineers
Post office Box 60267
New Orleans, LA 70160-0267

Dear Colonel Lee:

This letter acknowledges the U.S. Fish and Wildlife Service's (Service) July 15, 2010, receipt of your agency's July 15, 2010, letter requesting initiation of formal Section 7 consultation under the Endangered Species Act (Act) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.). That letter provided additional project and species information necessary to initiate consultation. The consultation concerns the effects of the proposed Louisiana Coastal Area, Medium Diversion at White Ditch, project. In the May 14, 2010, letter and attached Biological Assessment (BA), the Service received initial project and species information concerning potential impacts to the endangered sturgeon (*Scaphirynchus albus*). We responded via a July 1, 2010, letter indicating the need to initiation consultation and requesting additional information. All information required of you to initiate consultation was included with your agency's letters or is accessible for our consideration and reference.

Section 7 allows the Service up to 90 calendar days to conclude formal consultation with your agency and an additional 45 calendar days to prepare our biological opinion (unless we mutually agree to an extension). Therefore, we expect to provide you with our biological opinion no later than October 13, 2010. However, we recognize that the legislatively mandated study schedule (i.e., study completion within three years from authorization) was developed to respond to the significant and ongoing rapid loss of coastal wetlands, therefore, we remain committed to working closely with the Corps to meet those deadlines and ensure that the authorization of coastal restoration projects is achieved.

We appreciate the cooperation and coordination of your staff during the past several months. If you have any questions or concerns about this consultation or the consultation process in general, please contact Jennifer Hogue (337/291-3144) or David Walther (337/291-3122) of this office.

Sincerely,

James F. Boggs
Supervisor
Louisiana Field Office

cc: LDWF, Natural Heritage Program, Baton Rouge, LA
FWS, Ecological Services, Jackson, MS

Appendix B

U.S. Fish and Wildlife Service Coordination Act Report and Wetland Value Assessment Assumptions and Analysis

Final

Fish and Wildlife Coordination Act Report

Louisiana Coastal Area
Medium Diversion at White Ditch
Plaquemines Parish, Louisiana

PROVIDED TO
NEW ORLEANS DISTRICT
U.S. ARMY CORPS OF ENGINEERS
NEW ORLEANS, LOUISIANA

PREPARED BY
KEVIN ROY, SENIOR FIELD BIOLOGIST
AND
CATHERINE BREAUX, SENIOR FIELD BIOLOGIST

U.S. FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
LAFAYETTE, LOUISIANA

AUGUST 2010

U.S. FISH AND WILDLIFE SERVICE – SOUTHEAST REGION

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY ES-1

INTRODUCTION 1

DESCRIPTION OF THE STUDY AREA.....1

FISH AND WILDLIFE RESOURCES 3

ALTERNATIVES UNDER CONSIDERATION 7

EVALUATION METHOD 9

PROJECT IMPACTS 10

FISH AND WILDLIFE CONSERVATION AND MITIGATION MEASURES 13

SERVICE POSITION AND RECOMMENDATIONS 13

LITERATURE CITED 16
No table of contents entries found.

ATTACHMENTS

Attachment A - WVA Assumptions and Analysis A-1

FIGURES

Figure 1. Medium Diversion at White Ditch Study Area, Plaquemines Parish, Louisiana.....2
Figure 2. Tentatively Selected Plan for Medium Diversion at White Ditch Feasibility study, a 35,000cfs diversion near Phoenix , Louisiana.....8

TABLES

Table 1: Initial Array of Alternatives 7
Table 2: Benefits for Final Array of Alternatives, in Average Annual Habitat Units 9
Table 3: Potential Estimated Impacts (AAHU and Net Acres) for the Tentatively Selected Plan (35,000 cfs Diversion at White Ditch) 10

Executive Summary

The U.S. Fish and Wildlife Service (Service) has prepared this final Fish and Wildlife Coordination Act Report (FWCAR) for the proposed Louisiana Coastal Area (LCA), Medium Diversion at White Ditch Project (MDWD), Plaquemines Parish, Louisiana. The Corps of Engineers, New Orleans District (Corps) is preparing a draft Environmental Impact Statement and Feasibility Report.

This report contains a description of the existing fish and wildlife resources of the project area, discusses future with- and without-project habitat conditions, identifies fish and wildlife related impacts of the proposed project, and provides recommendations for the proposed project. This document constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). A draft report was provided to the Louisiana Department of Wildlife and Fisheries (LDWF) and the National Oceanic and Atmospheric Administration's, National Marine Fisheries Service (NOAA's NMFS) and their comments have been incorporated into this final report.

The White Ditch Diversion study area is located in Plaquemines Parish, Louisiana, east of the Mississippi River in the Breton Sound Basin. The diversion structure itself would be located along the east bank of the Mississippi River between the communities of Belair and Phoenix. The purpose of the diversion is to provide fresh water, nutrients, and sediments to the area between the Mississippi River and the River aux Chenes (former distributary of the Mississippi River). Diversion of Mississippi River water into the study area will facilitate sediment deposition, increase organic production, increase biological productivity, reduce marsh loss, and improve fish and wildlife habitat. The study area encompasses emergent marsh and shallow open water habitats. The primary area of benefit consists of marsh and open water habitats between the Mississippi River and River aux Chenes. A secondary area of benefit would occur east of the River aux Chenes. Study area wetlands support nationally important fish and wildlife resources including intermediate, brackish, and saline marshes.

During the alternatives analysis, the no-action alternative and several diversion alternatives were considered. Diversion sizes ranged from a 5,000 cubic feet per second (cfs) diversion to a 35,000 cfs diversion. Two locations along the Mississippi River and different types of diversion structures (e.g., box culverts, siphons, gated structures) were also investigated. Also investigated were certain types of outfall management features to distribute diversion flows more evenly throughout the study area. Outfall management features included enlargement of existing channels, plugs, weirs, and culverts. In addition, any material dredged to enlarge existing channels would be used beneficially to create marsh and forested ridge habitat.

The tentatively selected plan (TSP) diversion structure consists of ten 15 foot by 15 foot box culverts capable of passing flows as high as 35,000 cfs located in an area of the river with the potential for high sediment load to promote sediment distribution through the structure. The outfall management features consist of excavating 230 acres of marsh and shallow water area to create a new channel and enlarge existing channels and distributaries to better distribute diversion flows of up to 35,000 cfs. This excavated material will be placed on organic marsh soils and aquatic substrates to create approximately 31 acres of ridges lining the outfall channels

and following the historic Bayou Garelle distributary channel and 385 acres of created marsh in locations adjacent to the outfall channels and distributary network. There will be weirs placed as flow constrictors to retain as much fresh water and sediment as possible within the study area.

The TSP will benefit the fish and wildlife resources of the MDWD area by providing fresh water, nutrients, and sediments to the study area thus facilitating sediment deposition, increasing organic production, increasing biological productivity, and reducing marsh loss. Approximately 13,353 AAHUS and 35,146 net acres of fresh/intermediate, brackish, and saline marsh and ridge habitats would benefit by the proposed project at the end of the project life. The Service supports implementation of a 35,000 cfs diversion at White Ditch provided the following fish and wildlife recommendations are implemented concurrently with project implementation:

1. Future hydrological modeling should be conducted with longer-duration simulations (i.e., 13-month simulations) to allow more complete projections of salinity change within the study area. In addition, modeling of different operational plans should be conducted. We recommend the following operational plans be evaluated; 1) March-April open operation with a 1,000 cfs maintenance flow the remainder of the year, 2) March open operation with a 1,000 cfs maintenance flow the remainder of the year, and 3) March 1 to March 14 open operation with a 1,000 cfs maintenance flow the remainder of the year.

2. To determine potential impacts to marine fishery resources in the study area, models which simulate changes in nekton community composition based on changes in salinity should be utilized. For example, the Ecopath/Ecosim (www.ecopath.org) models have been utilized to simulate changes in the nekton community in the Caernarvon Diversion outfall area. Hydrological modeling output could be used as input for the Ecopath/Ecosim models or other similar models.

3. The best available data and modeling tools should be utilized to select a more precise location near Phoenix, Louisiana for the diversion structure to maximize the capture of suspended sediment. The State of Louisiana Office of Coastal Protection and Restoration (OCPR) is funding the development of a 3-dimensional river model which could greatly assist in determining the optimal location for the diversion structure.

4. The Service has concerns regarding the Monitoring and Adaptive Management Plan and its ability to ensure the goals and objectives are measured and achieved. The Corps should work with the Service, NOAA's NMFS, and the LDWF during future planning efforts to address our concerns.

5. If a proposed project feature is changed significantly or is not implemented within one year of the Endangered Species Act consultation letter, we recommend that the Corps reinitiate coordination with each office to ensure that the proposed project would not adversely affect any Federally listed threatened or endangered species or their habitat.

6. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of project features and timing of construction. A qualified biologist should inspect the proposed work site for the presence of undocumented wading bird nesting

colonies and bald eagles during the nesting season (i.e., February 16 through October 31 for wading bird nesting colonies, and October through mid-May for bald eagles).

7. To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present). In addition, we recommend that on-site contract personnel be informed of the need to identify colonial nesting birds and their nests, and should avoid affecting them during the breeding season.

8. If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

9. Land clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable.

10. Further detailed planning of project features (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service and other State and Federal natural resource agencies, and shall be provided an opportunity to review and submit recommendations on the all work addressed in those reports.

11. A report documenting the status of implementation, maintenance and adaptive management measures should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, U.S. Environmental Protection Agency (EPA), Louisiana Department of Natural Resources (LDNR), OCPR, and LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

12. The Service recommends a comprehensive examination of the river and all existing and proposed diversions to coordinate their operation and ensure that their operation will maximize their restoration capabilities. The ongoing Mississippi River Hydrodynamic and Delta Management Study should be utilized to address this issue. The Service and other natural resource agencies should be involved in this study.

13. The Service recommends establishment of a committee similar to the Caernarvon Interagency Advisory Committee to review the operation and its results of the MDWD and when necessary, provide recommendations regarding any future operational and maintenance changes. The Service and other natural resource agencies should be on this committee.

INTRODUCTION

The U.S. Army Corps of Engineers, New Orleans District (Corps) is preparing a draft Environmental Impact Statement (DEIS) for the proposed Louisiana Coastal Area (LCA), Medium Diversion at White Ditch Project (MDWD), Plaquemines Parish, Louisiana.

This report contains a description of the existing fish and wildlife resources of the project area, discusses future with- and without-project habitat conditions, identifies fish and wildlife-related impacts of the proposed project, and provides recommendations for the proposed project. This document constitutes the final report of the Secretary of the Interior as required by Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). A draft report was provided to the Louisiana Department of Wildlife and Fisheries (LDWF) and the National Oceanic and Atmospheric Administration's, National Marine Fisheries Service (NOAA's NMFS), and their comments have been incorporated into this final report.

DESCRIPTION OF THE STUDY AREA

The MDWD study area is located in Plaquemines Parish, Louisiana, east of the Mississippi River in the Breton Sound Basin (Figure 1). The diversion structure itself would be located along the east bank of the Mississippi River between the communities of Belair, Louisiana and Phoenix, Louisiana. The purpose of the diversion is to provide fresh water, nutrients, and sediments to the area between the Mississippi River and the River aux Chenes. Diversion of Mississippi River water into the study area will facilitate sediment deposition, increase organic production, increase biological productivity, reduce marsh loss, and improve fish and wildlife habitat. The study area encompasses emergent marsh and shallow open water habitats. The primary area of benefit consists of marsh and open water habitats between the Mississippi River and River aux Chenes. A secondary area of benefit would occur east of the River aux Chenes. Study area wetlands support nationally important fish and wildlife resources including fresh, intermediate, brackish, and saline marshes.

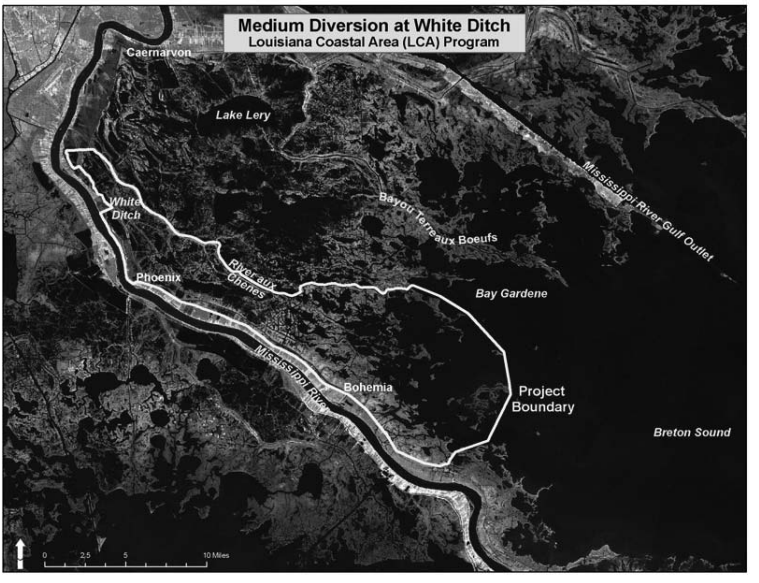
The project area encompasses over 98,000 acres of intermediate to saline intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the forty-arpent canal, extending south (i.e., paralleling the Mississippi River) along the non-Federal back levee, the Mississippi River Mainline levee, the New Orleans to Venice Federal back levee and along the left descending natural bank of the Mississippi River, then it proceeds to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes which forms the eastern boundary and returns back to the beginning point. The area has been significantly impacted by recent tropical storms and hurricanes and is somewhat isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound Basin.

There are two discrete project areas that were considered for the purposes of the feasibility study; the area along the Mississippi River where a freshwater diversion structure might be

located and the project area that could be influenced and benefitted by the diverted freshwater. The footprint of both of these areas depends upon the overall size and capacity of the diversion structure recommended.

The area where a diversion structure could be located occurs on the left descending bank of the Mississippi River, between Bertrandville to the north (river mile 69) and the community of Davant to the south (river mile 51). An area of particular interest for this study is the stretch between White Ditch (river mile 64.4) and Phoenix (river mile 59.7). This 4.7 mile stretch is unique in that there is no hurricane protection levee (back levee) on the marsh side that protects existing homes and infrastructure from elevated water levels (tidal or storm surge). The Mississippi River levee is the only flood protection structure that keeps river water from entering the project study area. This situation minimizes the amount of infrastructure that could be affected by construction of a diversion structure and allows for a broader array of measures to be considered in addressing problems in the project area. Channel construction, subsidence, erosion, saltwater intrusion, and storm-related damages have all significantly altered the natural environment, causing extensive losses of wetland habitats.

Figure 1. Medium Diversion at White Ditch Study Area, Plaquemines Parish, Louisiana.



FISH AND WILDLIFE RESOURCES

Wildlife Resources

The coastal wetlands in the study area provide important and essential fish and wildlife habitats, used for shelter, nesting, feeding, roosting, cover, nursery, and other life requirements. The coastal marshes of Louisiana provide winter habitat for more than 50 percent of the duck population of the Mississippi Flyway. Fresh and intermediate marshes support the greatest concentrations of wintering waterfowl in coastal Louisiana. Wintering waterfowl use is high in parts of the Breton Sound basin which includes the MDWD study area. Dabbling duck and diving duck numbers are increasing in the vicinity of existing freshwater diversions, such as in the Caernarvon area upriver of the study area.

Coastal Louisiana's wetlands also support millions of neotropical and other migratory avian species such as rails, gallinules, shorebirds, wading birds and numerous songbirds. Louisiana coastal wetlands provide neotropical migratory birds essential stopover habitat on their annual migration route. Wading bird colonies are present where suitable habitat is found in the area and numbers have been steady or increasing in those areas.

The wetlands of the study area provide habitat for many different furbearers, rabbits, and deer. Game mammals and furbearers are generally associated with forested wetlands. The wetlands of the Breton Sound basin were historically important for the production of furbearers. In recent years, fur production has been on a downward trend. This decline is largely attributed to saltwater intrusion and a corresponding reduction in carrying capacity for fur animals such as muskrat and nutria (Kerlin 1979).

According to Dundee and Rossman (1989), several amphibians and reptiles occupy a wide variety of habitats throughout the basin. American alligator abundance has been increasing in the upper portions of the basin and declining in the lower portions, but overall has declined as fresh marsh converted to intermediate and brackish marsh. The eastern portion of Plaquemines Parish, which includes the MDWD study area, suffered major habitat damage from Hurricanes Katrina and Rita in 2005, resulting in a severe reduction in alligator nest production in 2006.

Fisheries Resources

Louisiana’s coastal estuaries are the most productive in the Nation. The majority of the MDWD study area is considered estuarine habitat. Even though extensive areas of marsh have been lost in coastal Louisiana, commercial harvest and recreational catches of most estuarine fishery species have not diminished (NMFS 2006). It is important to note that recreational catch and commercial landings are fishery dependent data. The increase in Louisiana landings may reflect the expansion of the commercial fishing industry, the growing efficiency in harvest technologies, and the growing demand for seafood over the past century. One hypothesis to explain continued high fisheries production is that as marshes have deteriorated, tremendous amounts of organic detritus have been released into the estuarine system, consequently driving high levels of primary productivity. High primary productivity increases the resources available for secondary productivity. Additionally, an increase in marsh to water interface (i.e., marsh edge), and the

formation of shallow, protected lagoons and ponds, has resulted in prime areas for growth and development of estuarine species (Browder et al. 1985; Browder et al. 1989; Minello and Rozas 2002). At the same time, saltwater intrusion into previously low-salinity areas has increased the amount of estuarine area available to estuarine and marine fishery species (Chesney et al. 2000; Zimmerman et al. 2000). However, this intrusion can exacerbate marsh loss in those areas (Chabreck and Linscombe 1982; McKee and Mendelssohn 1989).

The American oyster is indigenous to coastal Louisiana and provides a rich ecological and commercial resource. This organism is unique in that it does not migrate like other estuarine species. Salinity plays a key role in oyster sustainability. Typically, they proliferate in salinities ranging from 5 to 15 parts per thousand. Fresher waters fail to support biological function, and more saline waters promote disease and predation. Production of oysters in Louisiana has been relatively stable for the last 50 years, with harvest from public beds replacing the decreasing harvest from private leases. The Louisiana oyster industry has been experiencing many stressors over the past several decades that threaten the long-term sustainability of both the industry and the resource. Increasing coastal land loss is reducing the amount of marsh that provides shelter to reefs, and saltwater intrusion is exacerbating disease and predation.

Essential Fish Habitat

The project is located within an area identified as Essential Fish Habitat (EFH) by the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA, Magnuson-Stevens Act; P.L. 104-297). The updated and revised 2006 generic amendment of the Fishery Management Plans for the Gulf of Mexico, prepared by the Gulf of Mexico Fishery Management Council, identifies EFH in the project area to be estuarine emergent wetlands, submerged aquatic vegetation, mud, sand, shell, and rock substrates, and estuarine water column. Under the MSFCMA, wetlands and associated estuarine waters in the project area are identified as EFH for various Federally managed species including: juvenile brown and white shrimp; eggs, larvae/postlarvae, and juvenile Gulf stone crab; and larvae/postlarvae, juvenile, and adult red drum.

In addition to being designated as EFH for these species, water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, such as striped mullet, Atlantic croaker, gulf menhaden, spotted seatrout, sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens Act by the GMFMC (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks). (NMFS 2008)

In the future without the project, estuarine marsh is the primary type of EFH impacted by continued wetland loss and deterioration. Although an increase in some types of EFH (i.e., mud bottom and estuarine water column) would occur, adverse impacts would occur to more productive types of EFH (i.e., estuarine emergent wetlands). The loss of estuarine emergent wetlands would result in negative impacts to juvenile brown and white shrimp; eggs,

larvae/postlarvae, and juvenile Gulf stone crab; and larvae/postlarvae, juvenile and adult red drum.

Threatened and Endangered Species and Species of Concern

Within the MDWD study area there are two endangered species, pallid sturgeon (*Scaphirhynchus albus*) and West Indian manatee (*Trichechus manatus*) under the Federal jurisdiction of the USFWS and/or the NMFS and several species of concern, including bald eagle (*Haliaeetus leucocephalus*), brown pelican (*Pelecanus occidentalis*) and other colonial wading birds protected under the Migratory Bird Treaty Act (40 Stat. 755, as amended; 16 U.S.C. 703 et seq.) and/or the Bald and Golden Eagle Act (54 Stat. 250, as amended, 16 U.S.C. 668a-d).

Species of Concern

Colonial nesting birds
The proposed project would be located in an area where colonial nesting waterbirds may be present. Colonies may be present that are not currently listed in the database maintained by the Louisiana Department of Wildlife and Fisheries. That database is updated primarily by monitoring the colony sites that were previously surveyed during the 1980s. Until a new, comprehensive coast-wide survey is conducted to determine the location of newly established nesting colonies, we recommend that a qualified biologist inspect the proposed work site for the presence of undocumented nesting colonies during the nesting season. To minimize disturbance to colonial containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present). In addition, we recommend that on-site contract personnel be informed of the need to identify colonial nesting birds and their nests, and should avoid affecting them during the breeding season.

Brown Pelican
Brown pelicans were delisted (due to recovery) on December 17, 2009, and are no longer protected under the ESA, but they are still protected by the Migratory Bird Treaty Act (MBTA). Brown pelicans may occasionally feed in the shallow estuarine waters found within the project area; however, no nesting colonies are known to occur there.

Bald Eagle
The project-area forested wetlands may provide nesting habitat for the bald eagle, which has officially been removed from the List of Endangered and Threatened Species as of August 8, 2007. Bald eagles nest in Louisiana from October through mid-May. Eagles typically nest in mature trees (e.g., bald cypress, sycamore, willow, etc.) near fresh to intermediate marshes or open water in the southeastern Parishes. Major threats to this species include habitat alteration, human disturbance, and environmental contaminants (i.e., organochlorine pesticides and lead).

Although the bald eagle has been removed from the threatened and endangered species list, it continues to be protected under the Migratory Bird Treaty Act (MBTA) and the Bald and Gold

Eagle Protection Act (BGEPA). The Service developed the National Bald Eagle Management (NBEM) Guidelines to provide landowners, land managers, and others with information and recommendations regarding how to minimize potential project impacts to bald eagles, particularly where such impacts may constitute "disturbance," which is prohibited by the BGEPA. Those guidelines recommend maintaining: (1) a specified distance between the activity and the nest (buffer area); (2) natural areas (preferably forested) between the activity and nest trees (landscape buffers); and (3) avoiding certain activities during the breeding season. The buffer areas serve to minimize visual and auditory impacts associated with human activities near nest sites. Ideally, buffers would be large enough to protect existing nest trees and provide for alternative or replacement nest trees. On-site personnel should be informed of the possible presence of nesting bald eagles within the project boundary, and should identify, avoid, and immediately report any such nests to this office. A copy of the NBEM Guidelines is available at: http://www.fws.gov/migratorybirds/issues/BaldEagle/NationalBaldEagleManagementGuidelines.pdf. If after consulting those guidelines you need further assistance in determining the appropriate size and configuration of buffers or the timing of activities in the vicinity of a bald eagle nest, please contact this office.

Threatened and Endangered Species

Pallid Sturgeon

Recent evidence raises the possibility that the Federally endangered pallid sturgeon could occur in the Mississippi River adjacent to the project area. The pallid sturgeon is an ancient species of fish that requires large, turbid, free-flowing riverine habitat with rocky or sand substrate. They are usually found on the bottoms of the rivers on sand flats or gravel bars, and apparently prefer areas with strong currents in or near the main channel. It is one of the largest and rarest fish in the Mississippi and Missouri River basins. Pallid sturgeon are opportunistic feeders that eat insects, crustaceans, mollusks, annelids, fish and eggs of other fish. Scant information exists on the range and habitat preferences of pallid sturgeon for this part of the Mississippi River. Most data are from populations in upper Missouri and other Midwest rivers, and also the Atchafalaya River in Louisiana, however, it is possible that limited numbers of the species also exists in the Red River. Surveys are currently being conducted to determine the presence/absence of this species in the lower reaches of the Mississippi River, including the reach adjacent to the MDWD study area.

West Indian Manatee

Federally listed as an endangered species, West Indian manatees occasionally enter Lakes Pontchartrain and Maurepas, and associated coastal waters and streams during the summer months (i.e., June through September). Manatee occurrences appear to be increasing, and they have been regularly reported in the Amite, Blind, Tchefuncte, and Tickfaw Rivers, and in canals within the adjacent coastal marshes of Louisiana. They have also been occasionally observed elsewhere along the Louisiana Gulf coast. The manatee has declined in numbers due to collisions with boats and barges, entrapment in flood control structures, poaching, habitat loss, and pollution. Cold weather and outbreaks of red tide may also adversely affect these animals.

If project construction has not been initiated within 1 year, follow-up consultation should be accomplished prior to making expenditures for construction. If the scope or location of the proposed work is changed, consultation should be reinitiated as soon as such changes are made.

ALTERNATIVES UNDER CONSIDERATION

During the alternatives analysis, the no-action alternative and several diversion alternatives were considered. Diversion sizes ranged from a 5,000 cubic feet per second (cfs) to a 100,000 cfs diversion. Five locations along the Mississippi River and different types of diversion structures (e.g., box culverts, siphons) were also investigated. Also investigated were certain types of outfall management features to better distribute diversion flows and retain as much fresh water and sediment as possible within the study area. Outfall management features included enlargement of existing channels, guide levees, distributaries, culverts, and channel constrictions. In addition, any material dredged to enlarge existing channels would be used beneficially to create marsh and ridge habitat.

Preliminary screening eliminated the 45,000, 75,000 and 100,000 cfs alternatives from further consideration as well as all but two diversion locations. Therefore, an initial array of alternatives was further evaluated for selection of a final array. Each diversion alternative was evaluated under the assumption that the diversion would be open at all times unless the flow of the Mississippi River dropped below 300,000 cfs. The initial array of alternatives is found in the table below. Diversion size indicates the maximum flow that could occur through the diversion structure.

Table 1: Initial Array of Alternatives.

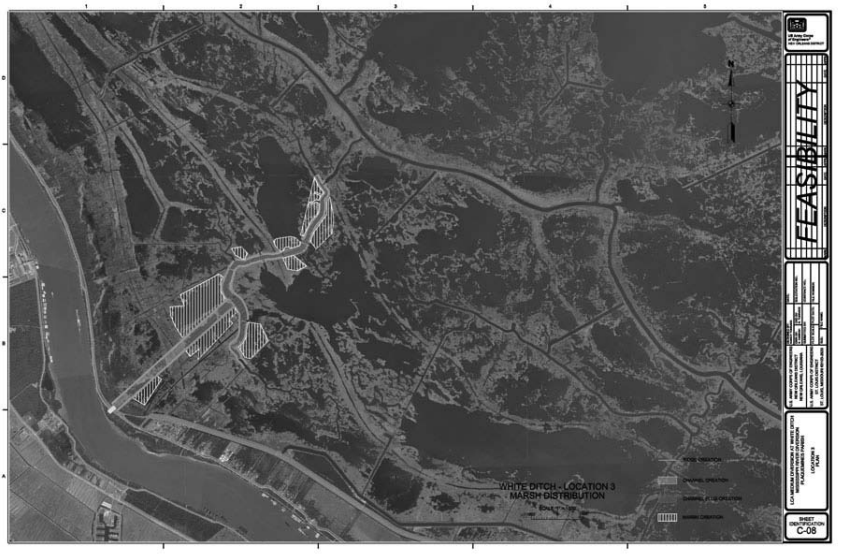
Location/Alternative	Maximum Diversion Flow
No Action	
Location 2 - White Ditch	5,000 cfs
Location 2 - White Ditch	10,000 cfs
Location 2 - White Ditch	15,000 cfs
Location 2 - White Ditch	35,000 cfs
Location 3 – Phoenix	5,000 cfs
Location 3 – Phoenix	10,000 cfs
Location 3 – Phoenix	15,000 cfs
Location 3 - Phoenix	35,000 cfs

The Medium Diversion at White Ditch Project Delivery Team (PDT) met on December 1, 2009, to select the final array of alternatives to be evaluated. Based on the results of the incremental cost/cost-effectiveness analysis, three alternatives were selected for the final array; 1) a 10,000 cfs diversion at Location 3, 2) a 15,000 cfs diversion at Location 3, and 3) a 35,000 cfs diversion at Location 3. Those three alternatives, along with the No Action Alternative, were selected for the final array. Subsequently, a 5,000 cfs diversion at Location 3 was added to the final array because it was determined to be a cost-effective alternative and was the least expensive.

The PDT met again on January 6, 2010, to review the results of the second incremental cost/cost-effectiveness analysis that was conducted on the final array. The purpose of that meeting was to select the Tentatively Selected Plan (TSP). Based on the results of the incremental cost/cost-effectiveness analysis and consideration of the Corps' Principles and Guidelines Criteria (i.e., acceptability, completeness, effectiveness, and efficiency), the 35,000 cfs diversion near Phoenix, Louisiana was selected as the TSP.

The TSP (Figure 2) diversion structure consists of ten 15 foot by 15 foot box culverts capable of flows as high as 35,000 cfs located in an area of the river with the potential for high sediment load to promote sediment distribution through the structure. The intent of the diversion is to have an operational plan which included a March-April diversion pulse (open structure) and a flow of 1,000 cfs during the remainder of the year as long as Mississippi River flows exceeded 300,000 cfs. This operational plan was selected over an open operation plan utilized earlier for several reasons; 1) a spring pulse reduces impacts from over-freshening that would occur to estuarine-dependent fisheries; 2) open operation, while achieving no net loss of wetlands, would not achieve the project goal of maintaining a gradient of marsh types in the study area, 3) a pulsed operation is preferred by the public/stakeholders because of its reduced impacts to marine fisheries and oyster production in the estuary. This operation would also closely resemble the natural overbank flooding the occurred prior to the construction of the Mississippi River levees.

Figure 2. Tentatively Selected Plan for Medium Diversion at White Ditch Feasibility Study, a 35,000 cfs diversion near Phoenix, Louisiana.



The outfall management features consist of excavating 230 acres of marsh and shallow water area to creating a new channel and enlarge existing channels and distributaries to better

distribute diversion flows of up to 35,000 cfs. This excavated material will be placed on organic marsh soils and aquatic substrates to create approximately 31 acres of ridges lining the outfall channels and following the historic Bayou Garelle distributary and 385 acres of created marsh in locations adjacent to the outfall channels and distributary. There will be weirs placed as flow constrictors to retain as much fresh water and sediment as possible within the study area (Figure 2).

EVALUATION METHOD

Direct impacts and benefits to coastal marsh habitats were quantified by acreage and habitat quality (i.e., average annual habitat units or AAHUs) by the Service and are presented in Table 1. The Service used the Wetland Value Assessment (WVA) methodology to quantify benefits/ impacts. The WVA is used to evaluate proposed Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) projects, and is similar to the Service's HEP, in that habitat quality and quantity (acreage) are measured for baseline conditions, and predicted for future without-project and future with-project conditions. As with HEP, the WVA provides a quantitative estimate of project-related impacts to fish and wildlife resources; however, the WVA is based on separate models for fresh/intermediate marsh, brackish marsh, and saline marsh. WVAs and assumptions for the TSP are available in Attachment A. WVA and assumption information on the final array of alternatives are available for review at the Service's Lafayette, Louisiana, field office.

To determine wetland benefits (net acres) for each alternative, the Sediment and Nutrient Delivery Model-Version 2 (SAND2), developed by the Engineering Research and Development Center (ERDC) and Mr. Ron Boustany of the Natural Resources Conservation Service (NRCS) was utilized by the Habitat Evaluation Team (HET). The SAND2 model estimates the benefits resulting from the introduction of sediments and nutrients into the study area. Model predictions are based on diversion flows into the project area and nutrient and sediment concentrations of the diversion water. The model derives an estimate of the wetland acreage sustained and/or created as a function of nutrients and sediments introduced into the system.

The final array was evaluated by the HET using the WVA (Table 2). The SAND2 model was run for each final alternative and results (wetland acres) utilized in the WVA. Each final alternative was evaluated under an operational plan which included a March-April diversion pulse (open structure) and a flow of 1,000 cfs during the remainder of the year as long as Mississippi River flows exceeded 300,000 cfs.

Table 2: Benefits for Final Array of Alternatives, in Average Annual Habitat Units (AAHUs).

Alternative	Maximum Diversion Flow	Net Average Annual Habitat Units
Location 3 – Phoenix	5,000 cfs	5,141
Location 3 – Phoenix	10,000 cfs	5,865
Location 3 – Phoenix	15,000 cfs	7,654
Location 3 – Phoenix	35,000 cfs	13,215

PROJECT IMPACTS

Construction of the 35,000 cfs diversion structure and associated outfall management features would have an initial negative impact on existing wetland vegetation within the construction footprint, primarily through the excavation of outfall channels and placement of excavated material on existing marsh. Implementation of the TSP would directly impact 651 acres of existing marsh, open water, and bottomland hardwood habitats. According to the WVA, the TSP would result in the direct loss of -45 AAHUs (-120 acres) at the end of 50 years, of intermediate marsh and bottomland hardwood habitats due to the channel excavation/enlargement, ridge construction, and diversion structure (Table 3). However, the placement of excavated material will create 228 net acres (155 AAHUs) of fresh marsh and 31 acres (27 AAHUs) of ridge which is expected to be suitable for the re-establishment of bottomland hardwoods (Table 3).

Table 3: Potential Estimated Impacts (AAHUs and Net Acres) for the Tentatively Selected Plan (35,000 cfs diversion).

Project Feature	**AAHUs**	**Net Acres**
Marsh Creation	155.20	228
Channel Enlargement	-31.25	-96
Ridge Footprint	-11.37	-19
Ridge Creation	27.36	31
Bottomland Hardwood	-2.50	-5
Total Net AAHUs and Net Acres	**137.44**	**139**
Diversion Benefits by Marsh Type	**AAHUs**	**Net Acres**
Fresh/Intermediate	8,802.11	21,472
Brackish	3,965.54	10,244
Saline	447.42	3,291
Total Net AAHUs and Net Acres	**13,215.07**	**35,007**
Total Net AAHUs and Net Acres	**13,352.51**	**35,146**

Operation of the 35,000 cfs diversion would provide an inflow of fresh water, sediments, and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. It was anticipated that a portion of the project area currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. No loss of marsh acreage is expected to occur in the project area with this alternative. Additionally, the SAND2 model runs conducted in support of the WVA, projected that the TSP would produce an overall net gain in fresh/intermediate, brackish, and saline marsh of approximately 35,006 acres and 13,215 AAHUs by year 50 after project

implementation (Table 3). Overall project benefits total 13,353 net AAHUs and 35,146 net acres at the end of the project life.

Wildlife Resources

Construction of the diversion structure and associated outfall management features of the 35,000 cfs alternative may disrupt or displace wildlife in the immediate vicinity. However, the long-term impact of construction is expected to be beneficial to overall habitat quality. The WVA analysis of project features projected a net benefit of 137 AAHUs (Table 3).

By the proposed diversion having a spring pulse (March-April), the salinity gradient is maintained while sustaining and enhancing existing marsh in the study area. The TSP would result in improved habitat conditions for several species of wildlife including migratory and resident waterfowl, shorebirds, wading birds, and furbearers. Migratory waterfowl utilizing the project area would benefit from a greater food supply resulting from the increased abundance and diversity of emergent, submerged, and floating-leaved species. Enhanced marsh and marsh edge would provide increased foraging opportunities for shorebirds and wading birds. Small fishes and crustaceans are often found in greater densities along vegetated marsh edge (Castellanos and Rozas 2001, Rozas and Minello 2001), and many of those species are important prey items for wading birds such as the great blue heron, little blue heron, great egret, black-crowned night-heron, and snowy egret.

Furbearers (such as muskrat) which feed on vegetation would benefit from the increased marsh acreage in the project area. Representative furbearers such as the mink, river otter, and raccoon have a diverse diet and feed on many different species of fishes and crustaceans. Those species often feed along vegetated shorelines which provide cover for many of their prey species.

The WVA analysis of the potential effects of the diversion projected a net benefit of 13,215 AAHUs for operation of the diversion, for a total projected net benefit of 13,353 AAHUs including benefits projected for the outfall management features (Table 3).

Fishery Resources

There would be negative impacts to fisheries resulting from channel and ridge construction of the TSP, but there would be positive impacts from marsh creation. The channel constrictions included as an outfall management feature would have some negative impact on fisheries access to the area.

Implementation of the TSP following the operational plan evaluated in the hydraulic modeling and WVA (open operation in March and April; 1,000 cfs the remainder of the year) is expected to freshen the entire project area and beyond River aux Chenes to a substantial portion of the Caernarvon subbasin while the diversion is at full flow and for several weeks after the return to maintenance flow operation. The overall effect of the diversion is that it is expected to decrease salinities throughout the project area and convert a substantial portion of the intermediate zone to fresh marsh within the first several years after project implementation. Water levels, velocities, and turbidity in outfall areas are all expected to increase during full flow conditions.

Entrainment of eggs, larvae or fry of Mississippi River fish species in the immediate vicinity of the diversion inflow may occur during operation of the structure.

High nutrient levels could result in blooms of algae and phytoplankton, and subsequent decomposition of these organisms could decrease dissolved oxygen levels of water bodies within the project area. These changes could result in localized adverse impacts to estuarine fishery productivity, particularly when the diversion is at full flow. The operational plan used to evaluate the TSP was developed to avoid or minimize these adverse impacts to marine fisheries and EFH while maximizing sediment and nutrient input to the extent practicable to meet project objectives.

Freshwater fishery species, such as crawfish, catfish, largemouth bass, and other sunfish should benefit from implementation of the diversion. Some fishery species would be impacted by anticipated decreases in salinity and water temperature, and increased turbidity during maximum flow periods. Less freshwater tolerant species, such as brown shrimp and spotted seatrout, may be displaced from the northwestern portion of the project area.

By following the operational plan to have a spring pulse (March-April) and flow 1,000 cfs during the remainder of the year, estuarine-dependent fisheries may be enhanced by helping combat high salinity spikes without an over-freshening while increasing organic production, increasing biological productivity and improving fisheries habitat. The introduction of freshwater to the MDWD project area would ensure that the project area continues to provide important nursery functions beyond the 50-year project life. However some species, such as oysters, may be slightly displaced to lower parts of the study area.

Historically, salinity appears to be the chief controlling factor in the number of plankton species present, while temperature, competition, and predation control the numbers of individuals present (Day et al. 1989). Therefore, introduction of large amounts of river water (pulsing) into estuarine systems may have dramatic short-term impacts on plankton populations in adjacent coastal waters (Hawes and Perry 1978).

Freshwater inflow is an important component of circulation and flushing processes in estuaries that assist in the transportation of planktonic organisms, nutrients, and detritus to the Gulf of Mexico. Over the long term, operation of the diversion is expected to help support the aquatic food web of marine fishery species.

It should be noted that the TSP represents a diversion that is several times greater in maximum flow capacity than any other diversion constructed to date in coastal Louisiana. At a maximum flow of 35,000 cfs, the TSP is more than three times greater than the Davis Pond Freshwater Diversion at 10,700 cfs. The effects on marine fishery species of diverting such large volumes of water are not completely understood and no effort to quantify those impacts has been undertaken thus far.

Essential Fish Habitat

Direct impacts of channel and ridge construction would disturb and displace managed species in the construction footprint. The marsh creation near the outfall would result in the loss of mud bottom and estuarine water column as emergent marsh would replace those habitat types. Although adverse impacts would occur to some types of EFH, more productive types of EFH (i.e., estuarine emergent wetlands) would be created and enhanced with the diversion. The accretion of sediment and input of nutrients is expected to benefit estuarine EFH within and beyond the immediate outfall area of the diversion. The TSP is projected to increase SAV (from 25% to 70% in fresh/intermediate marsh areas and from 15% to 40% in the brackish marsh areas during the project life) in the project area and decrease emergent marsh loss across all marsh zones (intermediate, brackish, and saline) by approximately 35,146 net acres over the 50 year planning horizon. These changes in the project area would not only increase the aerial extent of EFH, but would also improve the quality of EFH for several managed species.

Threatened and Endangered Species

Possible entrainment of the endangered pallid sturgeon in the Mississippi River in the immediate vicinity of the diversion inflow may occur during operation of the structure. In terms of potential impact to the sturgeon, the Corps is responsible for determining whether the proposed plan is likely (or not likely) to adversely affect any listed species and/or critical habitat, and for requesting the Service's concurrence with that determination. As such, by letter dated July 15, 2010, the Corps requested initiation of formal consultation in accordance with Section 7 of the ESA. Section 7 allows the Service 90 calendar days to conclude formal consultation and an additional 45 calendar days to prepare a biological opinion. Although this report constitutes the final report of the Secretary of Interior, formal Section 7 consultation will continue as a separate effort.

FISH AND WILDLIFE CONSERVATION AND MITIGATION MEASURES

Coastal marshes are considered by the Service to be aquatic resources of national importance due to their increasing scarcity and high habitat value for fish and wildlife within Federal trusteeship (i.e., migratory waterfowl, wading birds, other migratory birds, threatened and endangered species, and interjurisdictional fisheries). Because of the Services' close coordination with the USACE on this project, and because the project is expected to have an overall benefit to the marshes of the MDWD Area, the Service has no conservation measures to offer at this time.

SERVICE POSITION AND RECOMMENDATIONS

The TSP will benefit the fish and wildlife resources of the MDWD area by providing fresh water, nutrients, and sediments to the study area thus facilitating sediment deposition, increasing organic production, increasing biological productivity, and reducing marsh loss. Approximately 13,353 AAHUS and 35,146 net acres of fresh/intermediate, brackish, and saline marsh and ridge habitats would benefit by the proposed project at the end of the project life. The Service

supports implementation of a 35,000 cfs diversion at White Ditch provided the following fish and wildlife recommendations are implemented concurrently with project implementation:

1. Future hydrological modeling should be conducted with longer-duration simulations (i.e., 13-month simulations) to allow more complete projections of salinity change within the study area. In addition, modeling of different operational plans should be conducted. We recommend the following operational plans be evaluated; 1) March-April open operation with a 1,000 cfs maintenance flow the remainder of the year, 2) March open operation with a 1,000 cfs maintenance flow the remainder of the year, and 3) March 1 to March 14 open operation with a 1,000 cfs maintenance flow the remainder of the year.

2. To determine potential impacts to marine fishery resources in the study area, models which simulate changes in nekton community composition based on changes in salinity should be utilized. For example, the Ecopath/Ecosim (www.ecopath.org) models have been utilized to simulate changes in the nekton community in the Caernarvon Diversion outfall area. Hydrological modeling output could be used as input for the Ecopath/Ecosim models or other similar models.

3. The best available data and modeling tools should be utilized to select a more precise location near Phoenix, Louisiana for the diversion structure to maximize the capture of suspended sediment. The State of Louisiana Office of Coastal Protection and Restoration (OCPR) is funding the development of a 3-dimensional river model which could greatly assist in determining the optimal location for the diversion structure.

4. The Service has concerns regarding the Monitoring and Adaptive Management Plan and its ability to ensure the goals and objectives are measured and achieved. The Corps should work with the Service, NOAA's NMFS, and the LDWF during future planning efforts to address our concerns.

5. If a proposed project feature is changed significantly or is not implemented within one year of the Endangered Species Act consultation letter, we recommend that the Corps reinitiate coordination with each office to ensure that the proposed project would not adversely affect any Federally listed threatened or endangered species or their habitat.

6. Avoid adverse impacts to bald eagle nesting locations and wading bird colonies through careful design of project features and timing of construction. A qualified biologist should inspect the proposed work site for the presence of undocumented wading bird nesting colonies and bald eagles during the nesting season (i.e., February 16 through October 31 for wading bird nesting colonies, and October through mid-May for bald eagles).

7. To minimize disturbance to colonies containing nesting wading birds (i.e., herons, egrets, night-herons, ibis, and roseate spoonbills), anhingas, and/or cormorants, all activity occurring within 1,000 feet of a rookery should be restricted to the non-nesting period (i.e., September 1 through February 15, exact dates may vary within this window depending on species present). In addition, we recommend that on-site contract

personnel be informed of the need to identify colonial nesting birds and their nests, and should avoid affecting them during the breeding season.

8. If a bald eagle nest is discovered within or adjacent to the proposed project area, then an evaluation must be performed to determine whether the project is likely to disturb nesting bald eagles. That evaluation may be conducted on-line at: http://www.fws.gov/southeast/es/baldeagle. Following completion of the evaluation, that website will provide a determination of whether additional consultation is necessary and those results should be forwarded to this office.

9. Land clearing associated with project features should be conducted during the fall or winter to minimize impacts to nesting migratory birds, when practicable.

10. Further detailed planning of project features (e.g., Design Documentation Report, Engineering Documentation Report, Plans and Specifications, or other similar documents) should be coordinated with the Service and other State and Federal natural resource agencies, and shall be provided an opportunity to review and submit recommendations on the all work addressed in those reports.

11. A report documenting the status of implementation, maintenance and adaptive management measures should be prepared every three years by the managing agency and provided to the Corps, the Service, NMFS, U.S. Environmental Protection Agency (EPA), Louisiana Department of Natural Resources (LDNR), OCPR, and LDWF. That report should also describe future management activities, and identify any proposed changes to the existing management plan.

12. The Service recommends a comprehensive examination of the river and all existing and proposed diversions to coordinate their operation and ensure that their operation will maximize their restoration capabilities. The ongoing Mississippi River Hydrodynamic and Delta Management Study should be utilized to address this issue. The Service and other natural resource agencies should be involved in this study.

13. The Service recommends establishment of a committee similar to the Caernarvon Interagency Advisory Committee to review the operation and its results of the MDWD and when necessary, provide recommendations regarding any future operational and maintenance changes. The Service and other natural resource agencies should be on this committee.

LITERATURE CITED

Browder, J.A., H.A. Barley, and K.S. Davis. 1985. A probabilistic model of the relationship between marshland-water interface and marsh disintegration. Ecological Modeline 29:245-260.

Browder, J.A., L.N. May, A. Rosental, J.G. Gosselink, and R.H. Baumann. 1989. Modeling future trends in wetland loss and brown shrimp production in Louisiana using thematic mapper imagery. Remote Sensing of the Environment 28:45-59.

Castellanos, D.L. and L. P. Rozas. 2001. Nekton use of submerged aquatic vegetation, marsh, and shallow unvegetated bottom in the Atchafalaya River delta, a Louisiana tidal freshwater ecosystem. Estuaries. Vol. 24, No. 2, p. 184-197.

Chabreck, R.H., and G. Linscombe. 1982. Changes in vegetative types in Louisiana coastal marshes over a ten-year period. Louisiana Academy of Sciences 45:98-102.

Chesney, E.J., D.M. Balz, and R.G. Thomas. 2000. Louisiana estuarine and coastal fisheries and habitats: Perspectives from a fish's eye view. Ecological Applications 10:350-366.

Day, J. W., Jr., C. A. S. Hall, W. M. Kemp, A. Yanez-Arancibia. 1989. Estuarine Ecology. John Wiley and Sons, New York. 558 pp.

Dundee, H.A., and D.A. Rossman. 1989. The amphibians and reptiles of Louisiana. Louisiana State University Press, Baton Rouge. 300 pp.

Hawes, S. R., and H. M. Perry. 1978. Effects of 1973 floodwaters on plankton populations in Louisiana and Mississippi. Gulf Research Reports 6(2):109-124.

Kerlin, C.W. 1979. Letter to Jack A. Stephens, Director-Secretary St. Bernard Parish Planning Commission regarding the impact of the Mississippi River-Gulf Outlet (MRGO) on St. Bernard Parish's wetlands and water bodies (31 May). In Report of the Environmental Subcommittee to the MRGO Technical Committee, March 16, 2000. 20 pp.

McKee, K.L., and I.A. Mendelssohn. 1989. Response of a freshwater marsh plant community to increased salinity and increased water levels. Aquatic Botany 34:301-316.

Minello, T. J. and L. P. Rozas. 2002. Nekton in gulf coast wetlands: fine-scale distributions, landscape patterns, and restoration implications. Ecological Applications, 12(2), pp. 441-455.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. 2nd Edition. Van Nostrand Reinhold, New York, USA. 722 pp.

National Marine Fisheries Service (NMFS). 2006. Commercial Landings of Fish and Shellfish by U.S. Fishing Craft, 2006. Accessed 16 May, 2008 from http://www.st.nmfs.noaa.gov/st1/fus/fus06/02_commercial 2006.pdf.

National Marine Fisheries Service (NMFS). 2008. Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies, Gulf of Mexico Region. Habitat Conservation Division, St. Petersburg, Florida. August 2008.

Rozas, L. P. and T. J. Minello. 2001. Marsh terracing as a wetland restoration tool for creating fishery habitat. Wetlands. Vol. 21, No. 3, pp. 327-341.

U.S. Fish and Wildlife Service, Ecological Services, Lafayette, Louisiana. Final Fish and Wildlife Coordination Act Report, Near-Term Ecosystem Restoration Plan for the Louisiana Coastal Area. October 2004.

Zimmerman, R.J., T.J. Minello, and L.P. Rozas. 2000. Salt marsh linkages to productivity of penaeid shrimps and blue crabs in the ecology. Kluwer Academic Publishers, Dordrecht.

ATTACHMENT A

WETLAND VALUE ASSESSMENT ASSUMPTIONS AND ANALYSIS

Louisiana Coastal Area
Medium Diversion at White Ditch
Plaquemines Parish, Louisiana

Assumptions for Diversion WVAs

WVAs have been prepared to determine the benefits due to the diversion of water from the Mississippi River. The benefited area encompasses the authorized Medium Diversion at White Ditch study area. Benefits/impacts of the outfall management features (e.g., channel enlargement) are included in separate WVAs.

Habitats within the benefited area include intermediate, brackish, and saline marsh and associated open water. Habitat and land-water data were generated by USGS for the study area. Separate WVAs will be conducted for each marsh type and each diversion size (i.e., 5k, 10k, 15k, and 35k cfs). Acreages of marsh and water within each marsh type were determined using the 2006 TM/2001 marsh type data. Non-wetland habitat acreages and areas benefited/impacted by the outfall management features were removed from the analysis. TY0 for the study is 2015. Therefore, marsh loss was applied for 9 years to the 2006 marsh acreages to achieve baseline (2015) acreages. The 1985-2006 loss rate (-274.5 ac/yr) was determined by linear regression using land-water data for the entire study area. Marsh loss within each marsh type was assumed to be proportional to the percentage of each marsh type within the study area. The intermediate marsh area varies by diversion size because the acreage impacted by the outfall management features is different for each diversion size.

Diversion Size	Intermediat e Marsh	Intermediat e Water	Brackish Marsh	Brackish Water	Saline Marsh	Saline Water	**Total**
5k	19,909	15,277	11,935	6,425	6,922	36,845	**97,313**
10k	19,890	15,245	11,935	6,425	6,922	36,845	**97,262**
15k	19,846	15,215	11,935	6,425	6,922	36,845	**97,188**
35k	19,768	15,102	11,935	6,425	6,922	36,845	**96,997**

FWOP Intermediate Marsh Assumptions (same for all diversion sizes)

V1 – Background loss rate (-274.5 ac/yr) applied throughout the 50-yr project life.

V2 – A baseline value of 25% is proposed. That value is the mean of the SAV cover values from the Monsecour Siphon Project (2009), Bertrandville Siphon Project (2008), and White Ditch Siphon Project (2004) WVAs prepared by CWPPRA. Those WVAs encompass the majority of the intermediate area covered under this WVA. SAV cover is assumed to decrease over the project life to 15% as the area deteriorates. The percent marsh in the area drops from 57% to 41% which could allow greater fetch in open water areas and increase turbidity. In addition, salinity is assumed to increase somewhat from 4.4 ppt to 5 ppt as marsh deteriorates to the south and increase tidal influence and exchange in this area.

V3 – Based on an examination of 2008 aerial photography, the area is classified as consisting of interspersion classes 2 and 3. Class 2 is found within the upper portion of the area and along the western boundary adjacent to the flood protection levee. The remainder of the area appears to fit the Class 3 interspersion type. Acreages within each class were calculated using GIS. As the area deteriorates over time, a downward shift in interspersion classes should occur. Some Class 3 will shift into Class 4 and some Class 2 will shift to Class 3.

V4 – The baseline value of 30% was determined from surveys conducted by NRCS for the CWPPRA White Ditch Siphon Project. Those surveys encompassed a great deal of this area and offer the best baseline data available for determining this value. In addition, the mean value from the three CWPPRA project WVAs conducted in this area is 31%. As marsh deteriorates throughout this area, it was assumed that shallow open water would decrease slightly to 20%.

V5 – The baseline value of 4.4 ppt was determined from three Coastal Reference Monitoring System stations within the project area. That value is the mean during the growing season (March-November) from 2008-2009 and ranged from 3.7 ppt in the upper portion of the area to 5.7 near the lower end. Due to marsh deterioration to the south, salinity is assumed to increase somewhat to 5.0 ppt over the project life.

V6 – There are some areas that are under structural marsh management resulting in a reduction in fisheries access. According to the Monsecour Siphon Project WVA, a total of 1,175 acres are under management. The table below contains structure ratings for each area under management.

Acreage	Structure	Structure Rating
297 ac	Flap-gated culvert	0.2
696 ac	Weir with boat bay	0.5
182 ac	Plug	0.0001
	Weighted Access Value	**0.35**

The weighted access value for the entire area is 0.98.

FWOP Brackish Marsh Assumptions (same for all diversion sizes)

V1 – Background loss rate (-274.5 ac/yr) applied throughout the 50-yr project life.

V2 – A baseline value of 15% is proposed. That value is based on best professional judgment as no SAV cover data has been collected in this area and there are no previous project WVAs that have been conducted in this area. It is assumed that SAV cover would be somewhat less in this area as compared to the intermediate area which was assigned a cover value of 25%. SAV cover is assumed to decrease over the project life to 5% as the area deteriorates and salinities and tidal exchange increase. The percent marsh in the area drops from 65% to 49% which could allow greater fetch in open water areas and increase turbidity. In addition, salinity is assumed to increase somewhat from 6.6 ppt to 8.0ppt as marsh deteriorates to the south and increase tidal influence and exchange in this area.

V3 – Based on an examination of 2008 aerial photography, the area is classified as consisting of interspersion classes 1, 3, and 4. Class 1 is found along the western boundary adjacent to the flood protection levee and extends nearly to the southern study area boundary. Marshes within that area remain very well intact. The remainder of the area appears to fit either the Class 3 or Class 4 interspersion classes. Acreages within each class were calculated using GIS. As the area deteriorates over time, a downward shift in interspersion classes would occur.

V4 – The baseline value of 20% is proposed and based on best professional judgment. It is assumed that water depths are somewhat deeper in this area as compared to the intermediate area

which has a baseline value of 30%. Brackish marshes tend to be somewhat deeper than fresher marsh types which are located farther inland. As marsh deteriorates throughout this area, it was assumed that shallow open water would decrease from 20% to 10%.

V5 – The baseline value of 6.6 ppt was determined from three Coastal Reference Monitoring System stations. Two of those stations are actually located outside the project area but within brackish marsh in the Breton Sound Basin north of the study area. That value is the annual mean from 2008-2009 and ranged from 5.0 ppt to 9.9 ppt. Due to marsh deterioration to the south, salinity is assumed to increase somewhat to 8.0 ppt over the project life.

V6 – Based on an examination of aerial photography, there appear to be no restrictions to fisheries access in this area. Therefore, the access value is 1.0.

FWOP Saline Marsh Assumptions (same for all diversion sizes)

V1 – Background loss rate (-274.5 ac/yr) applied throughout the 50-yr project life.

V2 – A baseline value of 2% is proposed. That value is based on best professional judgment as no SAV cover data has been collected in this area and there are no previous project WVAs that have been conducted in this area. SAV cover is typically very low or non-existent within saline marshes and this area contains very large open water areas which typically contain no SAV. However, it is assumed that SAV cover may exist in some of the more isolated bodies of water. There is assumed to be no SAV cover at the end of the project life as only 9% of the area will be marsh.

V3 – Based on an examination of 2008 aerial photography, the area is classified as consisting of interspersion classes 4 and 5. The majority of the area is Class 5 with large open water areas and isolated remnants of marsh. However, some Class 4 is found in the southern and northern portions of the area. As the area deteriorates over time, the entire area would be Class 5.

V4 – The baseline value of 5% is proposed and based on best professional judgment. It is assumed that water depths are much deeper in this area as compared to the intermediate and brackish areas. This area consists of very large open water areas which are typically greater than 1.5 ft deep. As marsh deteriorates throughout this area, it was assumed that shallow open water would decrease from 5% to 1%. Perhaps there would still be some shallow water in the few remaining remnants of marsh.

V5 – One Coastal Reference Monitoring System station is located within the saline marsh area. Mean annual salinity for 2008-2009 was 10.3 ppt. However, that station is located within an isolated area of marsh and much of the saline zone encompasses large open water areas at the lower extent of the estuary where salinities are believed to be higher. Therefore, a baseline of 13 ppt was used to better represent average conditions across this large open area. Due to marsh deterioration in the area, salinity is assumed to increase to 15.0 ppt over the project life.

V6 – Based on an examination of aerial photography, there appear to be no restrictions to fisheries access in this area. Therefore, the access value is 1.0.

FWP Assumptions

V1 – Marsh acreages for each target year were taken from the SAND2 model output. Based on a review of hydrologic modeling output which provided predicted salinities across the project area, it was determined that a portion of the intermediate marsh area would transition to fresh marsh. That transition was assumed to occur at TY5 for all diversion sizes. The transition line from fresh to intermediate was determined by reviewing the salinity modeling results and reviewing habitat data for the Caernarvon Diversion outfall area to determine the range of fresh marsh in the outfall area. The fresh-intermediate marsh boundary was delineated at the approximate 1.0 ppt isohaline. Based on the modeling results, it was assumed that the intermediate-brackish and brackish-saline marsh boundaries would remain as shown on the 2001 Coastal Marsh Vegetative Type Map.

For the 5,000 cfs diversion, loss continues to occur according to SAND2 model output. Loss was distributed proportionately among the various marsh types.

For the 10,000 cfs diversion, SAND2 model output indicates no marsh loss with some marsh gain occurring over the project life. Results indicate that 1,675 acres of marsh gain would occur. It was assumed that all of this marsh gain would occur within the fresh marsh zone.

For the 15,000 cfs diversion, SAND2 model output indicates no marsh loss with substantial marsh gain occurring over the project life. Results indicate that 6,347 acres of marsh gain would occur. It was assumed that all of this marsh gain would occur in the fresh marsh zone.

For the 35,000 cfs diversion, SAND2 model output indicates no marsh loss and tremendous marsh gain over the project life. Results indicate that 21,282 acres of marsh gain would occur. It was assumed that marsh gain would occur throughout the project area across all four marsh zones. Beginning in the fresh marsh zone, marsh gain was allowed to continue in each marsh zone until the percent marsh reached approximately 98%. It was assumed that some open water would remain and that the area would not completely fill with marsh. Under that scenario, very little marsh gain occurs in the saline zone.

V2 – SAV cover was assumed to increase from baseline conditions for all diversion sizes in the fresh, intermediate, and brackish marsh zones. SAV cover was not assumed to increase as diversion size increased. It was assumed that maintenance flow conditions (1,000 cfs for all alternatives) would be more important than the diversion pulse in determining SAV cover. Based on research (Rozas et al., 2005) conducted in the Caernarvon Diversion outfall management area, an SAV cover value of 70% was assumed for the fresh and intermediate zones. That research indicated SAV cover of 66% in areas influenced by the diversion. Most sample sites occurred in the intermediate marsh zone. SAV cover was assumed to be 30% in the brackish zone based on best professional judgment. No increase in SAV cover was assumed to occur in the saline marsh zone.

V3 – Values were based on the amount of marsh projected (SAND2 model results) within each zone in comparison to the baseline values determined within each area.

V4 – Within the fresh/intermediate zone, shallow open water was assumed to decrease to 25% from the baseline value of 30% under the 5,000 cfs diversion because marsh loss continues to occur. However, shallow open water was assumed to increase with increasing diversion size which would deliver greater amounts of sediment. Since most of this zone fills with marsh under the 35,000 cfs diversion, it was assumed that most of the open water (95%) would be shallow. In the brackish zone, shallow open water was assumed to decrease to 15% from the baseline value of 20% under the 5,000 cfs diversion because marsh loss continues to occur. For the 10,000 and 15,000 cfs diversions, it was assumed that sediment delivery would keep pace with subsidence and maintain the baseline amount of shallow open water. As with the fresh/intermediate zone, most of the brackish zone fills with marsh under the 35,000 cfs diversion; therefore, a value of 95% was assumed.

In the saline zone, shallow open water was assumed to decrease to 2% from the baseline value of 5% under the 5,000 cfs diversion because marsh loss continues to occur. The 10,000 and 15,000 cfs diversions provide enough sediments and nutrients to stop marsh loss within this zone. Therefore, it was assumed that the baseline amount of shallow open water would be maintained. Under the 35,000 cfs diversion, some minor marsh growth is expected to occur within this zone. Because only the finest sediments would reach the saline zone and because of its openness to the bay, it was assumed that the percent shallow open water would remain at the baseline value of 5%.

V5 – Year-long hydrological model simulations were not run due to time constraints. Model runs consisted of a March-April open operation for all diversion sizes. During that period, even the 5,000 cfs diversion freshened all of the fresh-intermediate and brackish zones and reduced salinity in the saline zone to an average of approximately 1 ppt. Model results were also provided for a 65-day period after the open operation (pulse) ended and maintenance flow (1,000 cfs) was initiated. An additional model run was conducted with the model grid set initially at 7 ppt (cold start run) and maintenance flow of 1,000 cfs. That run was conducted to simulate the effect of the maintenance flow after salinities returned to "normal" after the open operation period. All modeling results were utilized to determine FWP salinities. Changes in salinity were assumed to occur at TY1 and remain throughout the project life.

Based on modeling results, fresh conditions (0 ppt) will exist throughout the fresh marsh area during the 2-month pulse and for approximately 2 months afterwards. During the rest of the growing season, salinities would range up to 1.5 ppt. A mean salinity during the growing season was then assumed to be approximately 0.5 ppt which is within the optimal range for fresh marsh.

For the intermediate marsh area, modeling results indicated 0 ppt during the 2-month pulse and for approximately one month afterwards. The following month, salinities average approximately 0.8 ppt. Salinities averaged approximately 3 ppt during the remaining 4 months of the growing season. The weighted mean salinity during the growing season is 1.6 ppt.

For the brackish area, salinities were 0 ppt during the pulse, 2 ppt in the following month, and 4 ppt the next month. Based on the results of the cold start run, salinity would average approximately 6.6 ppt during the remainder of the year. The weighted mean annual salinity is 5 ppt.

For the saline area, salinities averaged approximately 1 ppt during the pulse, 5 ppt in the month following and 10 ppt in the next month. Based on the results of the cold start run, salinity would average approximately 13 ppt during the remainder of the year. The weighted mean annual salinity is 10 ppt.

V6 – For all diversion sizes, only the fresh marsh area would experience a reduction in fisheries access due to the outfall management features (i.e., channel constriction structures). The channel constrictions resemble a rock weir with a boat bay and would therefore have an access value of 0.6. Based on an examination of aerial photography it was determined than an area of 13,962 acres, 13,911 acres, 13,837 acres and 13,647 acres would be impacted by the channel constrictions for the 5,000, 10,000, 15,000, and 35,000 cfs diversions, respectively. For each diversion size, the area impacted by the outfall management features was removed as those areas were evaluated under a separate WVA. In addition, an area of 1,175 acres has a FWOP access value of 0.35 (see FWOP discussion). That area would have an access value of 0.21 (0.35x0.6). The remainder of the fresh area has an access value of 1.0. The weighted access value for FWP for each diversion size is found in the table below.

Diversion Size	Access Value = 1.0	Access Value = 0.6	Access Value = 0.21	Weighted Access Value
5k	8,137	13,962	1,175	0.72
10k	7,538	13,911	1,175	0.71
15k	7,568	13,837	1,175	0.71
35k	7,647	13,647	1,175	0.72

Benefits Summary

Marsh Type	5,000 cfs	10,000 cfs	15,000 cfs	35,000 cfs
Fresh/Intermediate	3,505.05	3,862.13	5,650.28	8,802.11
Brackish	1,359.93	1,655.31	1,656.16	3,965.54
Saline	276.26	347.78	347.97	447.42
Net AAHUs	**5,141.24**	**5,865.22**	**7,654.41**	**13,215.07**

Literature Cited

Rozas, P.R., T.J. Minello, I. Munuera-Fernandez, B. Fry, B. Wissel. 2005. Macrofaunal distributions and habitat change following winter-spring releases of freshwater into the Breton Sound estuary, Louisiana (USA). Estuarine Coastal and Shelf Science 65 (2005) pp. 319-336.

WVA Assumptions for Project Features

WVAs were prepared to determine the benefits/impacts for the diversion structure and outfall management features. These WVAs are "footprint" WVAs in which the area directly benefited/impacted is used as the project area. Features include 1) ridge creation, 2) marsh creation, 3) outfall channels, 4) diversion structure, and 5) channel constrictions. Marsh and ridge are created using material from the outfall channels. Separate WVAs were done for each

feature and for each diversion size. There are no footprint impacts from the channel constrictions. However, they do impact fisheries access (V6) in the marsh and open water areas. The area impacted by each project feature is found in Table 1.

Habitats impacted are intermediate marsh, intermediate open water, and bottomland hardwoods. Shape files of the impacted areas (except for the diversion structure) were provided to USGS and habitat and land-water data were generated for each feature for each diversion size. Acreages of marsh and water were determined using 2006 TM/2001 marsh type data. The area impacted by the diversion structure was determined by Corps biologists. TY0 for the study is 2015. Therefore, marsh loss was applied for 9 years to the 2006 marsh acreages to achieve baseline (2015) acreages. The 1985-2006 loss rate (-0.28%/yr) was determined by linear regression using land-water data for the entire study area.

Table 1. Acreages impacted by habitat type for each project feature.

5,000 cfs Diversion - 2015 footprint acres	Ridge Creation	Marsh Creation	Outfall Channels	Diversion Structure
Intermediate marsh	22	59	63	
Water	10	80	97	
Bottomland hardwoods				2.5
Total	**32**	**139**	**160**	**2.5**

10,000 cfs Diversion - 2015 footprint acres	Ridge Creation	Marsh Creation	Outfall Channels	Diversion Structure
Intermediate marsh	22	64	73	
Water	10	112	101	
Bottomland hardwoods				2.5
Total	**32**	**176**	**174**	**2.5**

15,000 cfs Diversion - 2015 footprint acres	Ridge Creation	Marsh Creation	Outfall Channels	Diversion Structure
Intermediate marsh	22	99	82	
Water	10	136	107	
Bottomland hardwoods				5
Total	**32**	**235**	**189**	**5**

35,000 cfs Diversion - 2015 footprint acres	Ridge Creation	Marsh Creation	Outfall Channels	Diversion Structure
Intermediate marsh	22	151	110	
Water	9	234	120	
Bottomland hardwoods				5
Total	**31**	**385**	**230**	**5**

Ridge Creation Assumptions (same for all diversion sizes)
Under FWOP, the ridge footprint area consists of intermediate marsh and open water. Therefore the intermediate marsh model was used. Under FWP, no marsh exists as the entire footprint is ridge habitat. The coastal chenier/ridge model was used for FWP.

Marsh model - FWOP
V1 – Background loss rate applied throughout the 50-yr project life.

V2 – Baseline value was 5% from the Monsecour Siphon Project WVA which was prepared by CWPPRA in 2009. SAV cover is assumed to be somewhat higher in this area because most of the open water is adjacent to marsh edge which tends to be shallower and contain more SAV. SAV cover was assumed to decrease over the project life as marsh deteriorates in the area.

V3 – Baseline value determined from aerial photography. Marsh loss within this small footprint over the project life is not likely to result in a change in interspersion.

V4 – Based on this footprint being in shallow water next to marsh edge, it was assumed that a high percentage (90%) of the open water is less than 1.5 ft. It was assumed to decrease slightly over the project life as the area deteriorates.

V5 – Baseline value of 3.7 ppt was taken from the Monsecour Siphon Project WVA which determined the mean salinity during the growing season based on data from CRMS stations in the area. Salinity is assumed to increase somewhat over the project life as marsh deteriorates and tidal influence moves farther inland.

V6 – Based on aerial photography, there are no restrictions to fisheries access.

Ridge Model
Under FWP, 32 acres (31 acres for 35k diversion) of ridge habitat is created. It is assumed that the ridge will be planted with woody species and that no loss of ridge habitat will occur over the project life. The assumptions used for the ridge model have been developed by the CWPPRA Environmental Workgroup (EnvWG) for ridge restoration projects and assume plantings with 6 native species and recruitment of additional species over the project life. Cover values were based on best professional judgment of workgroup members. It is also assumed that control of Chinese tallow tree was implemented until planted species achieve adequate canopy cover to shade out invasive species and reduce competition. Also, maintenance plantings were assumed in case planted species experienced significant mortality.

V1 – Tree Canopy Cover – Canopy cover of 20% was assumed at TY8 because at that time many of the planted species would achieve sufficient height to provide some canopy cover. Assumed to increase to 80% by TY20 and remain at that value to TY50.
V2 – Shrub/Midstory Cover – A shrub/midstory layer would be present by TY3, increase to 65% by TY15, but then decrease somewhat as canopy cover increases.

V3 – Species Diversity – Six species would be planted initially and natural recruitment of other species would occur over the project life.

Marsh Creation Assumptions (same for all diversion sizes)
The marsh creation footprint consists of intermediate marsh and open water. Therefore the intermediate marsh model was used for FWOP. Under FWOP, the area deteriorates as no restoration action occurs. Under FWP, the entire footprint is filled with dredged material and marsh is created. The created marsh is considered fresh marsh with the diversion in operation and the fresh marsh model was used.

V1 – For FWOP, the background loss rate was applied throughout 50-yr project life. For FWP, assumptions for marsh creation projects developed by the CWPPRA EnvWG were assumed – a 50% reduction in the background loss rate was applied.

V2 – The baseline value was 5% from the Monsecour Siphon Project WVA which was prepared by CWPPRA in 2009. The baseline value is assumed to be somewhat higher (15%) because the Monsecour Siphon project area encompasses over 12,000 acres and extends southward into areas more open to tidal exchange and somewhat higher salinity. Under FWOP, cover is assumed to decrease over the project life as marsh deteriorates in the area. Under FWP, very little open water exists within the footprint, even at TY50. However, SAV cover is assumed to be high within the open water areas within the marsh creation platform due to the operation of the diversion. A cover value of 70% is suggested per research done in the Caernarvon Diversion outfall management area (Rozas et al., 2005).

V3 – Baseline value determined from aerial photography. Under FWOP, marsh loss within this small footprint over the project life is not likely to result in a change in interspersion. Under FWP, the marsh creation sites are classified as Class 5 at TY1, Class 3 at TY3, and Class 1 at TY5. Class 1 is maintained throughout the project life.

V4 – Based on surveys conducted by NRCS for the CWPPRA White Ditch Siphon Project, the percent shallow open water is 30%. Under FWOP, that value is assumed to decrease as the area deteriorates and subsidence occurs. Under FWP, the value is assumed to remain high as very little loss of the created marsh is expected to occur and water depths will likely be very shallow within the marsh platform.

V5 – Baseline value of 3.7 ppt was taken from the Monsecour Siphon Project WVA which determined the mean salinity during the growing season based on data from CRMS stations in the area. Salinity is assumed to increase somewhat under FWOP as marsh deteriorates and tidal influence moves farther inland. The FWP salinity is assumed to be 0.5 ppt as this area will be within the immediate outfall of the diversion. A mean salinity of 0.0 ppt was not assumed because there will be periods when the diversion is not in operation and salinities will likely increase during those periods.
V6 – Based on aerial photography, there are no restrictions to fisheries access under FWOP. Under FWP, the marsh creation platform will have no access at TY1 but will at TY3 as the platform subsides. The channel constrictions along River aux Chenes and at the end of the outfall channel will reduce fisheries access into the project area. Based on the design info provided, those structures are closest to a rock weir with a boat bay which has an access value of 0.6.

Outfall Channel Assumptions (same for all diversion sizes)
The channel footprint area consists of intermediate marsh and open water. Therefore the intermediate marsh model was used for FWOP. Under FWOP, marsh in the area deteriorates as no restoration action occurs. Under FWP, the entire footprint is dredged to create outfall channels and the footprint remains open water throughout the project life. Although there is no marsh, the fresh marsh model is used for FWP due to the fresher conditions resulting from diversion operation.

V1 – For FWOP, the background loss rate is applied throughout project life. Under FWP, no marsh exists.

V2 – SAV cover is assumed to be very low in this area because a large portion of the footprint is in an existing distributary channel. A baseline value of 5% is proposed and assumed to decrease (2%) as marsh around the area deteriorates. It is assumed that no SAV would exist FWP as the entire footprint will be an outfall channel.

V3 – Baseline value determined from aerial photography. Marsh loss within this small footprint over the project life is not likely to result in a change in interspersion. The entire footprint will be open water (Class 5) under FWP.

V4 – For baseline, it is proposed to use a value (20%) somewhat lower than used for the marsh creation footprint because a portion of the footprint is in an existing distributary channel which has little shallow water. It was assumed to decrease over the project life as the area deteriorates. Under FWP, the footprint will be an outfall channel with little water less than 1.5 feet deep. A value of 1% is suggested to account for shallow water along the channel edges.

V5 – Baseline value of 3.7 ppt was taken from the Monsecour Siphon Project WVA which determined the mean salinity during the growing season based on data from CRMS stations in the area. Salinity is assumed to increase somewhat over the project life as marsh deteriorates and tidal influence moves farther inland. Under FWP, salinity is assumed to average 0.5 ppt.

V6 – No restrictions to fisheries access are present under FWOP. The channel constrictions have an access rating of 0.6 for FWP.

Diversion Structure Bottomland Hardwoods Impacts
It is anticipated that construction of the proposed structure would impact adjacent bottomland hardwoods (BLH) in the amount of 2.5 acres under the 5,000 and 10,000 cfs alternatives and 5.0 acres under the 15,000 and 35,000 cfs alternatives. A WVA was not completed for the proposed structure location; however, a proportional calculation of Annual Average Habitat Units (AAHUs) was created utilizing data obtained from a WVA performed in 2008 for a borrow site (Q6a) with similar habitat characteristics located less than ½ mile south of the proposed White Ditch Medium Diversion structure site.

The reference site (i.e. borrow site Q6a) used for the BLH AAHU proportional calculation was a 16.0 acre site located on the flood side portion of the east bank Mississippi River Levee at River

Mile 60 (center point: Latitude 29°38'55.487"N, Longitude 89°56'58.861"W) in Plaquemines Parish, Louisiana. Similar to the White Ditch Diversion structure site, the reference site is an immature, semi-open, light-seeded tree species dominated, frequently flooded forest. Aerial photography from the White Ditch Diversion structure site and the reference site were compared and determined to have similar habitat features and site species composition.

On September 30, 2008, personnel from the Service and Corps of Engineers, New Orleans District, visited borrow site Q6a and delineated two plots. Plot 1 was located on a ridge on the river side of the proposed Q6a site of which approximately 6.5 acres or 41% of the proposed site occurs as a portion of the ridge. Plot 2 was located on a lower/slough portion of the proposed Q6a site of which approximately 9.5 acres or 59% of the proposed site occurs as a portion of the slough. Utilizing the WVA Bottomland Hardwood Model, an AAHU value was calculated for each plot, weighted accordingly for its respective size and location with respect to the overall borrow site, and subsequently combined to give a total AAHU value for the 16.0 acre site.

Q6a Borrow Site (16.00 Acres) ► **-8.01 AAHUs**

- Plot 1 = -6.41 AAHUs (41% of the site)
  = **-2.63 AAHUs**
- Plot 2 =-9.12 AAHUs (59% of the site)
  = **-5.38 AAHUs**

A proportional calculation was performed to determine the per acre AAHU value for the Q6a borrow site and the resulting per acre AAHU value was then multiplied by the respective acreages contained under each diversion alternative to obtain a final AAHU value.
-8.01 AAHUs / 16.0 acres = **0.50 AAHUs/acre**
-0.50 AAHUs x 2.5 acres = **-1.25 AAHUs** (5,000 and 10,000 cfs diversions)
-0.50 AAHUs x 5.0 acres = **-2.50 AAHUs** (15,000 and 35,000 cfs diversions)

Benefits Summary

Feature	5,000 cfs	10,000 cfs	15,000 cfs	35,000 cfs
Marsh Creation	54.59	72.52	92.19	155.20
Outfall Channel Impacts	-15.99	-19.08	-21.89	-31.25
Ridge Impacts	-11.33	-11.33	-11.33	-11.37
Ridge Creation	28.24	28.24	28.24	27.36
Bottomland Hardwood Impacts	-1.25	-1.25	-2.5	-2.5
Total Net AAHUs	**54.26**	**69.10**	**84.71**	**137.44**

Appendix C

NOAA Fisheries Service Coordination Letter

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue, South
St. Petersburg, Florida 33701

January 26, 2010 F/SER46/RH:jk
225/389-0508

Mr. James F. Boggs, Supervisor
Louisiana Field Office
U.S. Fish and Wildlife Service
646 Cajundome Blvd., Suite 400
Lafayette, Louisiana 70506

Dear Mr. Boggs:

NOAA's National Marine Fisheries Service (NMFS) has received your letter dated January 13, 2010, providing planning aid comments on the Louisiana Coastal Area, Medium Diversion at White Ditch project. Your letter provided a brief description of the resources in the project area and the alternatives that were considered. As was described in your letter, the Corps of Engineers has selected the 35,000 cubic feet per second (cfs) diversion as the tentatively selected plan.

Your letter transmitted a number of fish and wildlife conservation measures and recommendations. The second measure pertained to a recommendation to undertake modeling to simulate changes in nekton community composition based on predicted changes in salinity. Considering that the tentatively selected plan is more than four times larger in the quantity of diverted water during high flow periods than any river diversion constructed in Louisiana to date, NMFS concurs with that recommendation to assess the individual effects of this project along with those cumulatively in the Breton estuary. Lacking such a modeling effort, NMFS is concerned that any evaluation of likely impacts to be undertaken in the environmental impact statement would not be based on the best available science.

The second recommendation specifically identified the Ecopath/Ecosim model being used to simulate changes in the nekton community in the vicinity of the Caernarvon diversion. NMFS agrees that the Ecopath/Ecosim/Ecospace model has utility in this area to predict changes in fishery standing crop and productivity that could result from the installation and operation of a 35,000 cfs diversion near White Ditch. Other models such as the Comprehensive Aquatic Systems Model and to a lesser extent species specific Individual Based Models also have utility to predict changes in fishery communities that could occur from project implementation. Each of these three is being run for the Caernarvon project and therefore the time and cost may not be exorbitant to run them for this project. On a similar parallel path, statistical analysis of Louisiana Department of Wildlife and Fisheries fisheries independent data would allow for hindcasting and establishment of baseline conditions. As such, NMFS recommends those models and the dual, parallel path of statistical analysis of fisheries independent data be identified as alternative analytical methods in this recommendation, as well. Although this information is preferred to

2

make a reasoned choice among alternatives, a commitment by the Corps of Engineers to obtaining output from one or more of these methods for use in the Planning, Engineering, and Design phase to develop an operation plan and apply thereafter under an adaptive management plan is as acceptable. We recommend this option be identified.

NMFS appreciates the opportunity to provide comments on the planning aid recommendations you have provided in your letter. Other than the suggested revision to recommendation #2, NMFS concurs with the remaining comments and measures.

Sincerely,

Miles M. Croom
Assistant Regional Director
Habitat Conservation Division

c:
LA DNR, Consistency, Ducote
USACE, Planning, Dayan
F/SER46, Swafford
Files

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701

February 10, 2009 F/SER46/RH:jk
225/389-0508

Ms. Elizabeth Wiggins, Chief
Environmental Planning and Restoration Branch
New Orleans District
Department of the Army, Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Ms. Wiggins:

NOAA's National Marine Fisheries Service (NMFS) has received the public notice advertising a scoping meeting to be held for the Louisiana Coastal Area (LCA), Louisiana; Medium Diversion at White Ditch project. According to the public notice, the U.S. Army Corps of Engineers (COE) intends to undertake a feasibility study and prepare a supplemental environmental impact statement (SEIS) to evaluate a controlled diversion of 5,000 to 15,000 cubic feet per second (cfs) of Mississippi River water into the River aux Chenes area in Plaquemines Parish, Louisiana. This SEIS will be tiered off a programmatic EIS completed for the Louisiana Coastal Area Ecosystem Restoration Study completed in November 2004. The COE has requested the public and natural resource agencies provide recommendations on: 1) the environmental problems and needs that should be addressed in the document; 2) the important resources in the project area; and, 3) reasonable restoration alternatives to be considered in the feasibility study and SEIS.

Aquatic and tidally influenced wetland habitats in portions of the study area are designated as essential fish habitat (EFH) for various federally managed species, including white shrimp, brown shrimp, red drum, lane snapper, dog snapper, and Gulf stone crab. These species are managed by the Gulf of Mexico Fishery Management Council (GMFMC). The attached table lists life stages and subcategories of EFH for these species that would potentially be benefitted or impacted by this project. Primary categories of EFH in the study area include estuarine emergent wetlands; submerged aquatic vegetation; mud, sand and shell substrates; and estuarine water column. Detailed information on federally-managed fisheries and their EFH is provided in the 2005 generic amendment of the FMPs for the Gulf of Mexico prepared by the GMFMC. The generic amendment was prepared as required by the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act, P.L. 104-297).

In addition to being designated as EFH for the species listed in the attached table, water bodies and wetlands in the study area provide nursery and foraging habitats supportive of a variety of economically important marine fishery species, such as striped mullet, Atlantic croaker, gulf menhaden, spotted seatrout, sand seatrout, southern flounder, black drum, and blue crab. Some of these species also serve as prey for other fish species managed under the Magnuson-Stevens

Act by the GMFMC (e.g., mackerels, snappers, and groupers) and highly migratory species managed by NMFS (e.g., billfishes and sharks).

NMFS recommends the SEIS include separate sections titled "Essential Fish Habitat" and "Marine Fishery Resources" that identify the EFH and fisheries resources of the study area. These sections should describe the potential impacts, both positive and negative, to those resources that could be caused by the proposed river diversion. While NMFS believes that overall project implementation could be beneficial to protecting and restoring EFH and to maintaining the productivity of marine fishery resources, there are some potential localized adverse impacts to marine fishery productivity that could be caused by structure operations, especially during high flow periods. These impacts include: 1) displacement of less freshwater tolerant, or cold water intolerant, marine fishery species from large areas of wetlands and water bodies that serve as nursery and foraging areas; 2) destruction of productive oyster reefs that serve as habitat and a food source for some fishery species; 3) increased turbidity and associated decreases in coverage of submerged aquatic vegetation in some areas; and, 4) potential low dissolved oxygen levels in area water bodies caused by decomposition of large quantities of algae and/or phytoplankton resulting from high nutrient levels in diverted river water. The EFH and marine fishery resource sections of the SEIS should evaluate the potential for any or all of these impacts to occur as a result of the proposed diversion. NMFS recommends these sections of the document also discuss the potential beneficial effects of the proposed diversion on EFH and marine fishery resources. These effects include the maintenance of marsh habitats through the accretion of sediment and input of beneficial nutrients.

The EFH and marine fishery resources sections of the document also should describe and quantify the potential impacts and benefits of the proposed activities on EFH sub-categories (e.g., marsh, marsh edge, submerged aquatic vegetation/seagrass beds, mud bottoms, oyster reefs, and estuarine water column). The appropriate sections should describe the potential impacts and benefits of the diversion on the utilization of these sub-categories of EFH by those fishery species and life stages included in the enclosed table. The SEIS should evaluate alternatives to any activities that would result in an adverse impact to those resources to determine if there are less damaging methods to achieve the same result. The overall net benefits of the project on wetland habitats supportive of marine fishery resources should not preclude efforts to minimize the negative impacts of river diversion on fishery resources. Such alternatives to minimize adverse impacts of maximize beneficial effects includes: 1) reduced fresh water inflows during low river stages and periods less fresh water tolerant species may be found in the project area; 2) direct placement of sediment into the outflow channel during high flow periods to maximize delivery to area marshes; and, 3) placement of marsh terraces or silt fences to help trap sediments and reduce turbidity.

NMFS recommends the SEIS include a section titled "Cumulative Impacts" that evaluates project impacts and benefits with other similar projects proposed for, or implemented, in the area. Presently, the existing Caernarvon diversion located near Braithwaite can divert up to 8,000 cfs into the Breton Sound basin. In addition, Section 3083 of the Water Resources Development Act of 2007 authorized a river diversion at or in the vicinity of Violet, Louisiana. A 2,000 cfs diversion in the vicinity of Bertrandville and a project to replace and add siphons at White Ditch also are being designed under the auspices of the Coastal Wetlands Planning,

Protection and Restoration Act (CWPPRA). Although the latter two projects have yet to receive construction authorization, we recommend the cumulative impact section include them because they have been authorized under various COE programs and would impact/benefit the same general area. The SEIS should evaluate the relative need for 5,000 to 15,000 additional cfs into this area if the two CWPPRA projects are constructed. Considering that the four diversions identified in this project would impact large areas of the Breton Sound estuary, the SEIS should evaluate the cumulative impacts, including beneficial effects, of multiple diversions of Mississippi River waters on resources of concern.

Please note that our Protected Resources Division is responsible for all issues regarding threatened and endangered species and marine mammals for which NMFS is responsible. For information regarding those resources, please contact Mr. David Bernhart of our Protected Resources Division at (727) 824-5312. For additional information regarding EFH, marine fisheries, or National Environmental Policy Act issues, please contact Mr. Richard Hartman of our Habitat Conservation Division, Baton Rouge Office at (225) 389-0508, ext 203.

Sincerely,

for Miles M. Croom
Assistant Regional Administrator
Habitat Conservation Division

Enclosure

c:
FWS, Lafayette
EPA, Dallas
LA DNR, Consistency
F/SER46, Swafford
F/SER3, Bernhart
Files

EFH Requirements for Species Managed by the Gulf of Mexico Fishery Management Council: Ecoregion 3, Pensacola Bay, FL to Mississippi River Delta (South Pass) that occur in the study area.

Species	Life Stage	System[a]	EFH
Brown shrimp	larvae	M	<82 m; planktonic, sand/shell/soft bottom, SAV, emergent marsh, oyster reef
	juvenile	E	<18 m; SAV, sand/shell/soft bottom, SAV, emergent marsh, oyster reef
White shrimp	juvenile	E	<30 m; SAV, soft bottom, emergent marsh
Gulf stone crab	eggs	E/M	<18 m; sand/shell/soft bottom
	larvae/postlarvae	E/M	<18 m; planktonic/oyster reefs, soft bottom
	juvenile	E	<18 m; sand/shell/soft bottom, oyster reef
Red drum	larvae/postlarvae	E	all estuaries planktonic, SAV, sand/shell/soft bottom, emergent marsh
	juvenile	E/M	GOM <5 m W from Mobile Bay; all estuaries SAV, sand/shell/soft/hard bottom, emergent marsh
	adults	M/E	GOM 1-46 m W from Mobile Bay; all estuaries SAV, pelagic, sand/shell/soft/hard bottom, emergent marsh
Lane snapper	larvae	E/M	4-132 m; reefs, SAV
	juvenile	E/M	<20 m; SAV, mangrove, reefs, sand/shell/soft bottom
Dog snapper	juvenile	E/M	SAV, mangrove, emergent marsh

[a] E=estuarine, M=marine

Appendix D

404(b)(1) Water Quality Report

SECTION 404(b)(1) EVALUATION
MEDIUM DIVERSION AT WHITE DITCH
PLAQUEMINES PARRISH, LOUISANA

I. INTRODUCTION

A. Purpose and General Description.

This project was identified as a Near-term Critical Restoration Feature Recommended for Study and Future Congressional Authorization in the LCA Main Report dated January 21, 2005. In November 2007, WRDA passed, authorizing this and other projects from the LCA Main Report. The MDWD feasibility study is anticipated to result in a Chief's Report containing a recommended plan to construct a Mississippi River diversion in the vicinity of White Ditch for the purposes of introducing freshwater, sediments, and nutrients into the study area. This project will provide a source of river sediment, freshwater and nutrients to the River aux Chenes subbasin and other nearby portions of the upper Breton Sound Basin, to restore and protect marsh soils and vegetation and maintain a functional salinity regime.

The proposed 35,000 cfs diversion would be built just north of Phoenix Louisiana (see Figure 1). Ten 15-ft by 15-ft box culverts with hydraulic operated sluice gates would be placed in the Mississippi River levee. An outflow channel about 7,200 feet long, 545 feet wide and 16 feet deep would be dredged to carry the flow. In addition about 8,600 feet of Bayou Garelle would be deepened to allow passage of the diverted waters. All material removed from these channels would be used beneficially. Some would be placed immediately adjacent to the outfall canal and Bayou Garelle to guide the water and to create 31 acres of ridge habitat. The rest would be placed in open water and marsh adjacent to the channels to nourish/create 385 acres of marsh. The marsh nourishment/creation areas would be surrounded by containment berms built with material from within the areas. Rip-rap will be placed along the outfall channel in key places for stabilization. Rip-rap plugs would be placed in six major canals leading to River aux Chenes to prevent diverted sediment from leaving the project area. The material that is removed would be placed adjacent to the channel to nourish or create marsh. The diversion of fresh water, sediments and nutrients would benefit 98,000 acres of wetlands and estuarine waters.

B. Location.

The boundary of the project encompasses over 98,000 acres of intermediate, brackish, and intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the Forty-Arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning.

C. Authority.

Title VII of the Water Resources Development Act (WRDA) 2007 authorizes the Louisiana Coastal Area (LCA) ecosystem restoration program. Included within that authority are requirements for comprehensive coastal restoration planning, program governance, a Science and Technology Program, a program for the beneficial use of dredged material, feasibility studies for restoration plans, project modification investigations, and restoration project construction, in addition to other program elements. This authorization was recommended by the Chief of Engineer's Report, dated January 31, 2005.

D. General Description of Dredged and Fill Material.

(1) General Characteristics of Material

The material placed to build the Marsh Berms would come from adjacent marsh land. This material is primarily alluvium that was deposited by annual flooding of the Mississippi River along with varying amounts of organic matter. Once the Marsh Berms are constructed, the area within the berm perimeter will be filled with excavated material from the Outfall Channel and Bayou Garelle to create/nourish marsh. In addition, some material from the Outfall Channel would be placed adjacent and abutting to the channel to create ridges. This material is primarily alluvium that was deposited by annual flooding of the Mississippi River along with varying amounts of organic matter. The canal plugs and Outfall Channel stabilization would be done with rip-rap.

(2) Quantity of Material.

Approximately 3.8 million cubic yards of material will be use to create the berms. Approximately 5 million cubic yards of excavated spoil from the Outfall Channel will be used create/nourish marsh. There will be approximately 150,000 cubic yards of spoil used in the ridge restoration. About 250,000 tons of 400 lb rip rap will be placed in key locations along the channel to aid in stabilization. The plugs in the canals will be constructed with 1,000 tons of 400 pound rip rap and will not hinder boat traffic in the project area.

(3) Source of Material.

All material excavated and placed within the project area is present or former swamp floor native material deposited by historic and prehistoric annual flooding of the Mississippi River. No material would be brought into the project area from outside sources except material needed to stabilize the Outfall Channel and to construct the canal plugs.

E. Description of the Proposed Discharge Sites.

(1) Location and Size.

The marsh berms would be located at the edges of the marsh creation/nourishment areas. They would cover a few acres. The created/nourished marsh and berms combined would cover 385 acres located at various sites adjacent to the Outfall Channel and Bayou Garelle The canal ridges would cover 31 acres adjacent to the Outfall Channel. All these are indicated on Figure 1. The canal plugs would be placed where six major canals cross the River aux Chenes ridge. The channel stabilization rip-rap would be placed as necessary.

(2) Type of Site and Habitat.

Material to construct marsh berms, marsh, and canal ridges would. be placed on intermediate marsh or in open water. The rip-rap for Outfall Channel would be placed at the edge of the ridge adjacent to the channel. Rip-rap for the canal plugs would be placed in six canals.

(3) Timing and Duration of Discharge.

Construction of the diversion and associated outfall management features is anticipated to take 24–36 months.

F. Description of Disposal Method.

The marsh berms would be built by mechanical means (e.g. small bucket dredge). The marsh would be created with a hydraulic dredge and pump system. Ridge creation would be conducted along the outfall channel and Bayou Garelle by means of a mechanical dredge. The material would be compacted to meet applicable engineering standards. The channel plugs would be built by mechanical means.

II. FACTUAL DETERMINATIONS

A. Physical Substrate Determinations.

(1) Comparison of Existing Substrate and Fill.

Material placed to create marsh berms would be the same as exiting substrate. Material placed to create/nourish marsh and create the ridges would come from the Outfall Channel and would be essentially the same as the substrate – alluvium laid down by the Mississippi River. The material needed to construct the channel plugs would be rip-rap brought in from an outside source. The excavated material will be certified as clean fill to adjacent marsh land.

(2) Changes to Disposal Area Elevation.

The marsh berms would be constructed +6.0 NAVD88. Areas were assumed to have an elevation of -1.0 NAVD and will be filled to +3.0 NAVD with initial construction. Assumed compactions of 1.0 ft will occur within 10 years of completion of the marsh creation areas.

(3) Migration of Fill.

The berms, marsh and ridges are not expected to migrate.

(4) Duration and Extent of Substrate Change.

The marsh berms and channel ridges would be above 0 NAVD 88 for the 50-year project life. The marsh would likely reach 0 NAVD 88 in about 30 years.

(5) Changes to Environmental Quality and Value.

Direct impacts to environmental quality and value from placement for marsh and ridge creation are expected to result in a net benefit of 139.94 Average Annual Habitat Units (AAHUs) as calculated using the Wetland Values Assessment (WVA) methodology.

(6) Actions to Minimize Impacts.

Formulation of plans for the proposed placement focused on maximizing environmental benefits to meet project objects while avoiding or minimizing any incidental negative effects on aquatic areas and substrates.

B. Water Circulation, Fluctuation, and Salinity Determinations.

(1) Alteration of Current Patterns and Water Circulation.

Placement of marsh berms and marsh creation/nourishment will have very little effect on water circulation. Channel ridges will prevent north to south movement of water in the degraded marsh that can occur now. Construction of canal plugs will slow water moving toward the east.

(2) Interference with Water Level Fluctuation.

Disposal of dredged material or rip-rap during project construction is unlikely to interfere with water level fluctuation.

(3) Salinity Gradient Alteration.

Disposal of dredged material during project construction is not expected to influence salinity.

(4) Cumulative Effects on Water Quality.

a. Salinity.

Effects of the proposed action on salinity would occur once the project is constructed the introduction of Mississippi River water into the MDWD would reduce salinities in the project area. However, the reduction in salinity values within the project area are highly dependent on how the structure will be operated and the volume of water allowed to be diverted from the river. During diversion operation salinities would be lowered across the project areas. Depending on the intensity and duration of these operations, an effect on the salinities from the diversion within the project area could be seen for up to 3-months.

Placement of dredged material during project construction would not influence salinity. However, the purpose of this diversion is to introduce fresh water into the basin. During diversion operation at maximum flow, salinities would be lowered across the project area. The operation of the White Ditch Diversion would be coordinated with that of the Caernarvon Diversion in the northern portion of the Breton Basin.

b. Clarity.

Disposal associated with marsh berm construction, marsh creation/nourishment and ridge building would reduce water clarity. However, reduction in clarity caused by construction activities would be short duration and clarity would soon return to pre-construction levels. Operation of the White Ditch and Caernarvon Diversions would impact water clarity.

c. Color.

Placement of dredged material during construction would have no impact on the color of the water. Operation of the White Ditch and Caernarvon Diversions would impact water color.

d. Water Chemistry and Dissolved Gasses.

Materials excavated to provide features of the proposed action would contain variable concentrations of organic material. Decomposition of organic material within the placement sites may result in a local, temporary reduction in dissolved oxygen or release of ammonia. However, hydrologic exchange between the marsh and MDWD would reduce dissolved oxygen deficits and facilitate the transformation of ammonia into non-toxic nitrate. The introduction of river water into the Breton Sound Basin may increase dissolved oxygen concentrations, particularly during summer.

e. Temperature.

Placement of dredged material during construction would have no impact on temp. However, the diverted Mississippi River water could lower water temperature in much of the Breton Basin when the diversion is at full operation. No significant negative impacts are expected.

f. Nutrients.

An existing problem with the marsh within the Breton Sound Basin is a lack of nutrients. One of the objectives of the proposed action is to allow waters from the Mississippi River to supply nutrients to the marsh within the basin. The project is expected to have a positive impact on this parameter.

Placement of dredged material during construction would have no effect on nutrients. However, one of the objectives of the proposed diversion is to allow waters from the Mississippi River to supply nutrients to the marsh within the basin. This would be in addition to nutrients brought in by the Caernarvon Diversion.

(5) Changes to Environmental Quality and Value.

Deposition of dredged material may temporarily affect water quality by increasing turbidity/suspended solids in the construction area. However, operation of the White Ditch Diversion is expected to provide approximately 13,355 AAHUs in environmental habitat benefits over 50 years of operation.

(6) Actions Taken to Minimize Impacts.

Material dredged from the Outfall Channel would be used beneficially to create./nourish marsh and create ridge habitat.

C. Suspended Particulate / Turbidity Determinations.

(1) Alteration of Suspended Particulate Type and Concentration.

Material excavated from the existing White Ditch and the marsh is of similar physical and chemical quality to existing substrates within the marshes. Particulates suspended during project construction would dissipate after construction activities are complete.

(2) Particulate Plumes Associated with Discharge.

There would be essentially no particulate plumes associated with discharge during construction.

(3) Changes to Environmental Quality and Value.

Construction of the Outfall Channel would convert 223 acres of marsh to water. However, dredged material from the Outfall Channel would be used to create 31 acres of ridge and to create/nourish 385 acres of marsh. In addition, the diversion of Mississippi River water is expected to provide approximately 13,355 AAHUs of habitat benefit over 50 years.

(4) Actions to Minimize Impacts.

See (3) above.

D. Contaminant Determinations.

Fill material is former marsh sediment that would be returned to the marsh floor. A Phase I Environmental Site Assessment of the study revealed no potential sources of contamination at or near the construction areas.

E. Aquatic Ecosystem and Organism Determinations.

(1) Effects on Plankton.

During actual construction activities of project features there would be short-term direct impacts to plankton populations due to increases in turbidity, low DO, and introduction of dredged sediments into shallow open water areas. Plankton populations should return after construction.

(2) Effects on Benthos.

Disposal of dredged material to create marsh berms, create/nourish marsh and create ridges would eliminate benthos in the project footprint.

(3) Effects on Nekton.

Disposal effects on nekton are likely to be minor as the fish and shellfish could leave the disposal site.

(4) Effects on the Aquatic Food Web.

The marsh created/nourished by disposal from the Outfall channel would benefit the aquatic food web. In addition, operation of the diversion would have a beneficial effect on the aquatic food web in the project area. Nutrients and would be added to the food web, providing a benefit to local area fisheries.

(5) Effects on Threatened and Endangered Species.

No federally listed threatened or endangered species are known to occur within the project area boundary (USFWS, 2010).

(6) Effects on Other Wildlife.

Placement of dredged material may disrupt or displace wildlife in the immediate vicinity. However, any such impacts would be localized and temporary, and most wildlife species would move to an area with more favorable conditions and return after construction is completed.

(7) Actions to Minimize Impacts.

Placement of material excavated for construction of project features was designed in the context of beneficial use, to be used for marsh and ridge creation which will directly benefit the aquatic ecosystem.

F. Proposed Disposal Site Determinations.

Discussions pertaining to turbidity and suspended particulates are summarized under Section II. C in this document. Contaminants were discussed previously under Section II. D of this Evaluation. Implementation of the proposed project will have no significant adverse effects on municipal or private water supplies; recreational or commercial fisheries; water related recreation or aesthetics; parks; national monuments; or other similar preserves. Any adverse impacts will be minor and of short-term duration. An application for State water quality certification under Section 401 of the Clean Water Act is being submitted to the Louisiana Department of Environmental Quality.

G. Determination of Cumulative Effects on the Aquatic Ecosystem.

The project would have long-term positive effects to aquatic resources found on the site. Temporary turbidity impacts may occur on- and off-site during construction of project features, but would be short-term in duration. No long-term, negative cumulative impacts are anticipated to occur. Beneficial impacts are expected to occur on site for wetlands, wetland wildlife, and fish. Long-term productivity would be enhanced with implementation of the project.

H. Determination of Secondary Effects on the Aquatic Ecosystem.

Most fish and wildlife utilizing these water bodies should benefit from the physical conditions the White Ditch Diversion would create when operated to meet project objectives. However, indirect impacts to oyster leases could include increased rate of mortality and decrease in productivity in oyster leases located closest to the diversion site, during the period when the diversion is at full operational capacity and for up to 3 months after the return to maintenance flow conditions. This could result in a loss of revenue for commercial oyster harvesters. Over the 50-year planning horizon, potential beneficial effects to oyster populations could result if reduced salinities resulting from diversion operation were to increase the spatial extent of

habitats experiencing salinities in the optimal range (5–15 parts per thousand) for oyster production. Continued water quality and biological monitoring of the project area before and after project construction should assist in refining the operation plan as needed to meet project objectives for restoring marsh while maintaining a functioning salinity regime in the estuary.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. No significant adaptations of the guidelines were made relative to this evaluation

B. No practicable alternatives to the proposed discharges could be identified that would have less adverse impacts on the aquatic ecosystem.

C. Chemical constituents of the dredged material released during dredging and disposal operations are not expected to exceed LA Water Quality Standards.

D. The proposed action is compliant with the Endangered Species Act of 1973, as amended. The proposed action would not adversely affect endangered or threatened species or their critical habitats.

E. The proposed action is compliant with specified protection measures for marine sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972. All disposal sites and effects are inland waters. No effects would occur in ocean waters beyond the shoreline of the Gulf of Mexico.

F. Evaluation of Extent of Degradation of the Waters of the United States.

(1) Effects on Human Health and Welfare

a. Municipal and Private Water Supplies.

Implementation of the TSP may require replacement of a water supply pipeline at the diversion site to continue providing water services to the Point la Hache and Phoenix communities. Implementation of Alternative 4 may have a short term indirect impact on water services if replacement of a water supply pipeline is required at the diversion site.

b. Recreational and Commercial Fisheries.

There would be short-term direct impacts to recreational and commercial fishing due to increases in turbidity, low DO, and introduction of dredged sediments into shallow open water areas. The immediate area would be unavailable for fishing during construction.

c. Plankton.

There would be short-term direct impacts to plankton populations due to increases in turbidity, low DO, and introduction of dredged sediments into shallow open water areas. There would be long-term loss of shallow water habitats in some areas due to dredge disposal activities. However, overall, there is an abundance of shallow open water habitat in the project area available for use by plankton.

d. Fish.

Temporary conditions would likely displace more mobile fisheries species from the construction area. Following construction, displaced fish would likely return to the project area. However, the canal plugs could have some negative impact on fisheries access to the area.

e. Shellfish.

No measurable direct impacts to oysters are anticipated to result from placement of dredged material.

f. Wildlife.

Temporary low DO and turbidity caused by placement of dredged material is unlikely to affect wildlife.

g. Special Aquatic Sites.

Wetlands are the major special aquatic sites in the project area. Disposal of dredged material would create/nourish 385 acres of marsh.

(2) Effects on Life Stages of Aquatic Life and Other Wildlife Dependent on Aquatic Ecosystems.

Impacts to early life stages may occur during placement of dredged material, but they are expected to diminish after project completion. The created/nourished marsh would provide a nursery area for early life stages of many fish and shellfish.

(3) Effects on Aquatic Ecosystem Diversity, Productivity and Stability.

Disposal of dredged material would create/nourish marsh. The diversion would increase submersed aquatic vegetation, plankton, plant growth production of organic detritus. As a result, ecosystem diversity and productivity would be expected to increase. Enhancement of marsh habitats over the project life is expected to increase the long-term stability of the aquatic ecosystem in this area.

(4) Effects on Recreational, Aesthetic, and Economic Resources.

Disposal of dredged material would have very little impact on recreational, aesthetic, and economic resources. The diversion is an un-natural element and may work to decrease the scenic quality. However, the potential benefits of reclaimed land mass and marsh area, and the need to protect this marsh area outweigh the visual impacts of developing the diversion.

G. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem.

As stated in Section II. E. (7) of this evaluation, formulation of project plans and designs, evaluation of alternative plans, and development of operational scenarios for the TSP, have all been conducted with the objective of minimizing potential negative impacts to the aquatic ecosystem. Placement of material excavated for construction of project features was designed in the context of beneficial use, to be used for marsh and ridge creation which will directly benefit habitat for wildlife and fish in the immediate vicinity of construction.

IV. EVALUATION RESPONSIBILITY

A. Evaluation Prepared By:

B. Evaluation Review By:

The proposed plan for the **MEDIUM DIVERSION AT WHITE DITCH PLAQUEMINES PARRISH, LOUISANA,** which incorporates sites for dredging and excavation and the placement of fill, complies with the requirement of guidelines, and includes appropriate and practicable methods to minimize adverse effects to the aquatic ecosystem.

Date:

Alvin B. Lee
Colonel, U.S. Army
District Commander

Figure 1.


LOUISIANA COASTAL AREA:
MEDIUM DIVERSION AT WHITE DITCH
ALTERNATIVE 4 - LOCATION 3
Riveraux Chenes
Spanish Lake
Bayou Gareile
Mississippi River
Phoenix
LCA WHITE DITCH
Legend
Box Culvert
Channel Modifications/Dredging
Ridge Creation/Restoration
Marsh Creation/Restoration
Flow Constrictor
LOCATION MAP
DISCLAIMER - While the United States Army Corps of Engineers, (hereinafter referred to USACE) has made a reasonable effort to insure the accuracy of the maps and associated data, its should be explicitly noted that USACE makes no warranty, representation or guaranty, either express or implied, as to the content, sequence, accuracy, timeliness or completeness of any of the data provided herein. The USACE, its officers, agents, employees, or servants shall assume no liability of any nature for any errors, omissions, or inaccuracies in the information provided regardless of how caused. The USACE, its officers, agents, employees or servants shall assume no liability for any decisions made or actions taken or not taken by the user of the maps and associated data in reliance upon any information or data furnished here. By using these maps and associated data the user does so entirely at their own risk and explicitly acknowledges that he/she is aware of and agrees to be bound by this disclaimer and agrees not to present any claim or demand of any nature against the USACE, its officers, agents, employees or servants in any forum whatsoever for any damages of any nature whatsoever that may result from or may be caused in any way by the use of the maps and associated data.
3,000 1,500 0 3,000 6,000
Feet
N
W
E
S
3/16/2010

Appendix E

Louisiana Coastal Resources Program Consistency Determination

BOBBY JINDAL
GOVERNOR

ROBERT D. HARPER
SECRETARY

State of Louisiana

DEPARTMENT OF NATURAL RESOURCES

OFFICE OF COASTAL MANAGEMENT

July 29, 2010

Joan Exnicios
Chief, Environmental Branch
Corps of Engineers- New Orleans District
P.O. Box 60267
New Orleans, LA 70160-0267

RE: **C20100167,** Coastal Zone Consistency
New Orleans District, Corps of Engineers
Direct Federal Action
LCA Ecosystem Restoration Project: Medium Diversion at White Ditch, **Plaquemines Parish, Louisiana**

Dear Ms. Exnicios:

The above referenced project has been reviewed for consistency with the Louisiana Coastal Resources Program in accordance with Section 307 (c) of the Coastal Zone Management Act of 1972, as amended. The project, as proposed in this application, is consistent with the LCRP.

If you have any questions concerning this determination please contact Brian Marcks of the Consistency Section at (225) 342-7939 or 1-800-267-4019.

Sincerely yours,

Gregory J. DuCote
Administrator
Interagency Affairs/Field Services Division

GJD/JDH/bgm

cc: Nathan Dayan, COE-NOD
Bren Haase, OCPR
Dave Butler, LDWF
Frank Cole, OCM FI
Albertine Kimble, Plaquemines Parish

Post Office Box 44487 • Baton Rouge, Louisiana 70804-4487
617 North Third Street • 10th Floor • Suite 1078 • Baton Rouge, Louisiana 70802
(225) 342-7591 • Fax (225) 342-9439 • http://www.dnr.louisiana.gov
An Equal Opportunity Employer

CONSISTENCY DETERMINATION

Louisiana Coastal Use Guidelines

Medium Diversion at White Ditch
Plaquemines Parish, Louisiana

INTRODUCTION

Section 307 of the Coastal Zone Management Act of 1972, 16 U.S.C. 1451 et seq. requires that "each federal agency conducting or supporting activities directly affecting the coastal zone shall conduct or support those activities in a manner which is, to the maximum extent practicable, consistent with approved state management programs." In accordance with Section 307, a Consistency Determination has been prepared for the proposed construction of the Medium Diversion at White Ditch (MDWD) project in Plaquemines Parish, Louisiana (Figure 1). This project was identified as a Near-term Critical Restoration Feature Recommended for Study and Future Congressional Authorization in the Louisiana Coastal Area (LCA) Main Report dated January 21, 2005. The project is described in detail in the draft Integrated Feasibility Study and Environmental Impact Statement for the MDWD, Plaquemines Parish, Louisiana. The proposed action is located on the left descending bank of the Mississippi River, between the existing White Ditch diversion siphon to the north (river mile 64.5) and the community of Phoenix to the south (river mile 59.8) (Figure 2). Coastal Use Guidelines were written in order to implement the policies and goals of the Louisiana Coastal Resources Program (LCRP), and serve as a set of performance standards for evaluating projects. Compliance with the LCRP, and therefore, Section 307, requires compliance with applicable Coastal Use Guidelines.

PURPOSE AND NEED FOR THE PROPOSED ACTION

The altered supply and distribution of freshwater, lack of deltaic forming sediments, marsh subsistence and human development in the White Ditch area have resulted in degraded and unbalanced distribution of freshwater, brackish, and saltwater marsh habitats. Further, the degradation of the existing marshes has made them more vulnerable to the range of Gulf storm events; extreme and seasonal, resulting in accelerated degradation, altered hydrology changed salinity regimes.

Installation of the White Ditch diversion siphon was completed in 1963 with the objective of enhancing muskrat and oyster habitat. In the absence of an outfall management plan, the surrounding marsh received limited benefits from the diverted river water. Two 50-inch steel pipes divert water from the Mississippi River through the White Ditch siphon, into the Belair Canal and then into the River aux Chenes (Oak River), where it continues south and out of the

project area. Usage of the siphons was abandoned for many years and they degraded into a non-usable condition. The siphons were recently refurbished and water was diverted into White Ditch as part of research efforts.

Wetlands in the project area are deteriorating for several reasons: 1) subsidence, 2) lack of sediment and nutrient deposition, 3) erosion via tidal exchange, 4) channelization, 5) saltwater intrusion, and 6) lack of freshwater. Recent hurricanes and tropical storms have also caused significant damage to the project area. These activities have resulted in the loss of several thousand acres of solid, vegetated marsh. Deterioration will continue unless preventative measures are taken.

In the absence of supplemental freshwater and sediment from the Mississippi River, subsidence, sea-level rise, wave erosion, and saltwater intrusion will continue to be problems. Protection and enhancement of this area are dependent on providing a hydrologic and sediment regime that minimizes the physiological stress to wetland vegetation from saltwater intrusion and tidal energy and is conducive to the retention of locally provided freshwater and sediments.

The historic hydrology of the project area indicates that the current course of the Mississippi River has remained the same for the last 700 years and has directly influenced the development of the entire area. The project area is located on the east side of the Mississippi River and was formed between two natural levee ridge systems, River aux Chenes on the east and the Mississippi River on the west. There are also two unnamed bayou ridges found within the project area. These ridges formed along the old natural bayous which were distributary channels for the Mississippi River. These natural bayous once carried sediments and nutrients into the project area during high river stages when the natural ridges were seasonally overtopped. In the historical setting, floodwater from the river would recede and sediments and nutrients would be deposited in the inter-distributary basins located between ridges. During normal or low river stages the ridges along the distributary channels served like levees and buffered the basin areas from the daily tidal influence. This buffering effect created a low energy freshwater environment in the inter-distributary basins, forming deep organic soils. Drainage to the area was provided by a high water event breaching the River aux Chenes ridge in the southern part of the project area. This event caused the development of the Bayou Garelle tributary channel.

The present day hydrology of the project area has been altered and no longer functions in a historically natural pattern. Historically, water moved very slowly through the system. Freshwater slowly exited the system through meandering pathways in the marsh and saltwater was slow to intrude. Presently, changes in the marsh allow water to rapidly pass through the system and saltwater is able to quickly intrude. The hydrologic balance within the marsh has been disturbed due to the following man-made changes:

1. The Mississippi River can no longer overflow its banks into the project area due to the Mississippi River protection levee. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns.
2. Channels have been dredged through natural ridges which has increased drainage and tidal exchange and exposed the soil to erosive forces.

The MDWD project will provide opportunities to naturalize the distribution of freshwater and deltaic forming sediments—including those necessary for the creation of sustainable marsh communities, improve hydrologic distribution of freshwater, improve topographic diversity, reduce the negative impacts of Gulf storm events, and inhibit invasive species in the Breton Sound Basin.

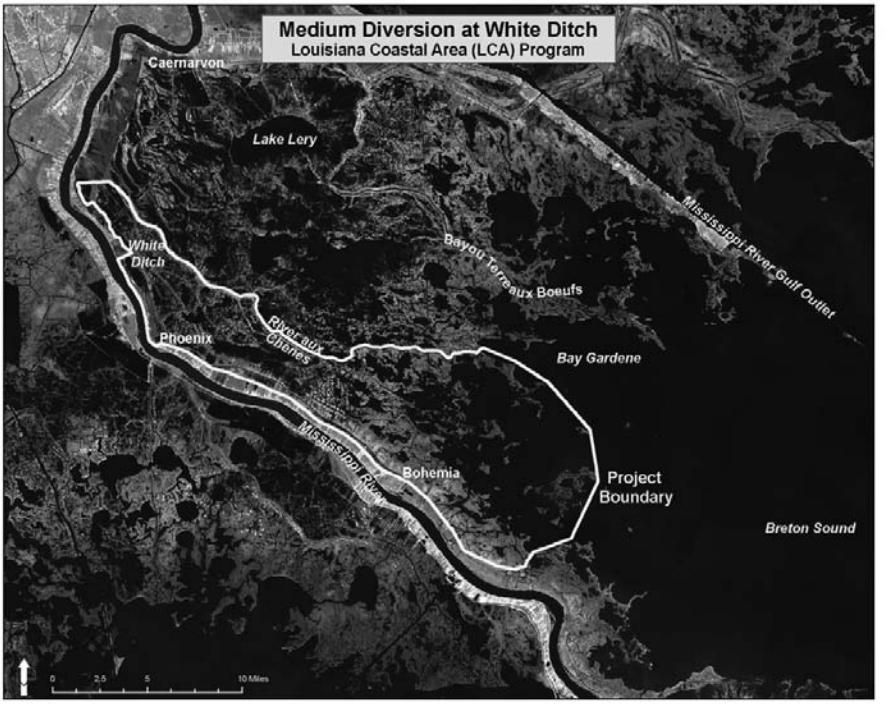


Figure 1. The Medium Diversion at White Ditch project area and Breton Sound Basin, Plaquemines Parish, Louisiana.

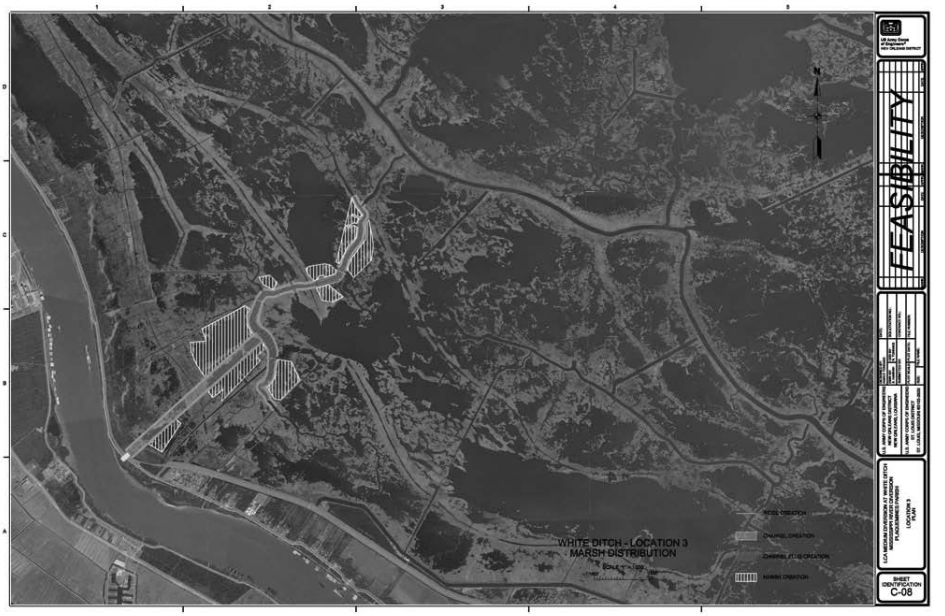


Figure 2. The Medium Diversion at White Ditch project area, Plaquemines Parish, Louisiana.

DESCRIPTION OF THE PROPOSED ACTION

The MDWD project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana (Figure 1). The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the forty-arpent canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound Basin.

The proposed action involves construction of a structure capable of diverting up to 35,000 cubic feet per second (cfs), which involves excavating a section of levee and constructing 10 each, sized 15' x 15', box culverts with hydraulic operated sluice gates replacing the roadway, and constructing a new outfall channel (i.e., main channel) and enlarging an existing channel (Figure

3) to carry fresh water and sediment to the desired locations in the receiving marsh. Dimensions of both the proposed outfall channel and the currently existing receiving channel to be enlarged are shown in Table 1.

The operating plan for the MDWD project is limited to a diversion pulse of 35,000 cfs in March-April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year. This flow rate may not be experienced over the full 60 day period. The proposed 35,000 cfs diversion will be the largest man-made diverted flow for wetland building on the Lower Mississippi River, but the one to two month duration will be a modifying factor. The diversion should approximate five percent or less of the main channel flow for most years.

Construction of the 35,000 cfs diversion and associated outfall management features would have an initial negative direct impact on existing wetland vegetation, wildlife and fisheries resources, and essential fish habitat within the construction footprint (approximately 283 acres of intermediate marsh; approximately 363 acres of open water; approximately 5 acres of bottomland hardwood habitat), primarily through the excavation and enlargement of outfall channels and placement of excavated material on deteriorating existing marsh and open water areas adjacent to the channels. However, the beneficial use-placement of excavated dredge material will provide a base for the regeneration of approximately 385 acres of wetland vegetation and associated fisheries, wildlife, and essential fish habitat (EFH), and approximately 32 acres of ridge and terrace creation suitable for the re-establishment of bottomland hardwoods. Operation of the proposed diversion structure would provide an inflow of freshwater, sediments and nutrients to the project area and support the re-establishment and nourishment of wetland vegetation in the project area. It is anticipated that a portion of the project area currently classified as intermediate marsh would be converted to fresh marsh within approximately 5 years following project implementation. No loss of acreage of all marsh types in the project area is expected to occur with the proposed diversion. Additionally, the MDWD is expected to produce an overall gain in marsh acreage of approximately 21,282 acres by year 50 after project implementation. An increase in wetland acreage would provide increased nesting, rearing, and foraging habitat for resident and migratory wildlife species. Wetlands creation would also provide valuable foraging, breeding, and nursery habitat, as well as other essential fish habitat, for finfish and shellfish in the project area. These changes in the project area would not only increase the aerial extent of EFH, but would also improve the quality of EFH for several managed species. Submerged aquatic vegetation (SAV) coverage in the fresh and intermediate zones of the areas affected by the diversion are expected to increase from 25% (baseline) to approximately 70%, while in the brackish zone SAV coverage is expected to increase from 25% to approximately 30%.



Figure 3. Cross-sectional map of the Medium Diversion at White Ditch, showing both the proposed main outfall channel and the enlarged existing channel. Channel dimensions at each cross-section are included in Table 1.

Table 1. Proposed dimensions for the 35,000 cfs Medium Diversion at White Ditch main outfall channel and existing receiving channel.

	Width at 0 (ft)	Bottom Elevation (ft)	Bottom Width (ft)	Side Slope (1v:_h)	Top Elevation (ft)	Top Width (ft)	Cross Sectional Area (ft^2)
Main Outfall Channel 23	x	-16	365	5	2	545	8190
1	190	-6	118	6	2	214	1328
2	300	-8	204	6	2	324	2640
3	x	-3	450	5	2	500	2375
4	450	-15	270	6	2	474	6324
5	425	-16	265	5	2	445	6390
6	x	-16	185	5	2	365	4950
7	80	-5	20	6	2	104	434
8	315	-15	165	5	2	335	4250
9	174	-6	102	6	2	198	1200
10	310	-14	170	5	2	330	4000
11	275	-14	135	5	2	295	3440
12	140	-4	92	6	2	164	768
13	140	-4	92	6	2	164	768
14	280	-11	148	6	2	304	2938
15	275	-10	155	6	2	299	2724
16	150	-4	102	6	2	174	828
17	100	-4	52	6	2	124	528
18	250	-8	154	6	2	274	2140
19	225	-8	129	6	2	249	1890
19 b.	85	-6	25	5	2	105	520
20	200	-6	104	8	2	232	1344
21	180	-4	116	8	2	212	984
22	150	-4	86	8	2	182	804

GUIDELINES APPLICABLE TO ALL USES

These guidelines are acknowledged and have been addressed through the preparation of responses to the guidelines contained within the specific use categories.

Guidelines 1.1 – 1.6: The guidelines have been read in their entirety, and all applicable guidelines would be complied with. The proposed project would be in conformance with all applicable water and air quality laws, standards and regulations, and with those other laws, standards and regulations which have been incorporated into LCRP, and is deemed in conformance with the program except to the extent that these guidelines would impose additional requirements. The proposed activity shall not be carried out or conducted in such a manner as to constitute a violation of the terms of a grant or donation of any lands or water-bottoms to the State or any subdivision thereof. Information regarding potential impacts of the proposed action is provided herein and in the accompanying feasibility study and environmental impact statement.

Guideline 1.7: Potential short- and long-term effects resulting from the diversion project include increased total suspended sediments, turbidity, and organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures; and the possible release of oxygen depleting substances as well as possibly increasing dissolved oxygen levels. Potential impacts would be minimized, as much as practicable, through the implementation of stormwater pollution prevention plans (SWPPPs) and other applicable best management practices (BMPs).

Generally, four water quality conditions could change with implementation of the proposed diversion:

1) Freshwater would be moved throughout the entire WDMD project area;
2) Salinities would decrease throughout the entire project area;
3) Sediments in the project area would increase allowing for marsh platform development, along with accompanying minor increases in trace metals associated with bed sediments; and
4) Nutrients in the project area could increase.

Introduction of river water into the Breton Sound Basin would immediately change the water chemistry of receiving areas. Change may be beneficial or detrimental, depending on human perceptions and the water uses. The change from a less fresh to a fresher system could be perceived as beneficial to wetland nourishment, but detrimental to recreational use because of water color changes, and possible changes in fish species assemblages in the recreational area. However, the changes in water chemistry would mimic natural conditions prior to the leveeing of the Mississippi River. Stabilization of salinity regimes would probably aid resource managers, commercial and recreational fisheries managers, and water users in making long-term decisions. Salinity could be either beneficial or detrimental, depending on the user group. Salinity is not necessarily a pollutant in coastal waters. Freshwater marshes however are sensitive to salinity levels, but the varying levels of salinity have positive impacts on various commercial and recreational fisheries. On balance, the stabilization of salinities, or the relocation of saltier water zones gulfward, would achieve the goals of the MDWD project. The reintroduction of streambed sediments into the MDWD project area may add some contaminants; these could

include primarily trace metals and hydrophobic organic compounds from Mississippi River streambed sediments.

Cumulative impacts to water quality would primarily be related to the incremental impact of all past, present, and future actions effecting water quality within the Basin such as: increase in freshwater areas; stabilization or decrease in salinities; increase in sediment introduction to the coastal zone, with accompanying minor increases in trace metals associated with bed sediments; increased total suspended sediments; increased turbidity; increased organic/nutrient enrichment of the water column; disturbance and release of possible contaminants; decrease in water temperatures along with fewer water temperature fluctuations; and increased dissolved oxygen levels. However the cumulative impacts to the water quality of the Breton Sound Basin resulting from this project would be a synergistic positive result over and above the additive combination of impacts and benefits of the other alternatives.

Any increases in suspended solids and turbidity levels due to dredging related activities in the immediate project area would be minor, temporary, and highly localized.

No adverse alteration or destruction of unique or valuable habitats, critical habitat for endangered species, important wildlife or fishery breeding or nursery areas, designated wildlife management or sanctuary areas, or forestlands is anticipated. No adverse cumulative or secondary impacts to the biological productivity of wetland ecosystems are anticipated. Adverse disruptions of coastal wildlife and fishery migratory patterns are not anticipated.

No adverse alteration or destruction of public parks, shoreline access points, public works, designated recreation areas, scenic rivers, or other areas of public use and concern is anticipated.

No increases in the potential for flood, hurricane or other storm damage, or increases in the likelihood that damage will occur from such hazards are anticipated.

No significant economic impacts on the locality or adverse disruptions of existing social patterns would occur due to the proposed action. No cultural, historical, or recreational resource sites would be impacted by construction. No proximal areas of special concern exist. No land loss, erosion, or subsidence would occur. This project would not result in reduced long-term biological productivity of the coastal ecosystem.

Guidelines 1.8 – 1.10: Acknowledged. Perceived adverse impacts listed above would clearly be outweighed by the human and environmental benefits the MDWD project would provide through the naturalization of the distribution of freshwater and deltaic forming sediments—including those necessary for the creation of sustainable marsh communities, improvements to hydrologic distribution of freshwater, improvements to topographic diversity, reduction in negative impacts of Gulf storm events, and the inhibition of invasive species in the Breton Sound Basin.

GUIDELINES FOR LEVEES

Guidelines 2.1 – 2.6: The proposed action would not involve the building of levees.

GUIDELINES FOR LINEAR FACILITIES

Guidelines 3.1 – 3.16: Acknowledged. Portions of the proposed diversion outfall channel will utilize a currently existing ditch/canal, which will reduce the length of newly constructed linear channel needed for the project and minimize adverse impacts to wetlands associated with channel excavation. Material excavated during construction of the main outfall channel (i.e., the linear facility) will be used to restore and create marsh and ridge habitat in the presently deteriorating wetlands and open water areas adjacent to the proposed channel.

The proposed main outfall channel will improve natural hydrologic and sediment transport patterns, sheet flow, and water quality, and will positively benefit the receiving wetlands and associated fish and wildlife habitat, in the MDWD project area and Breton Sound Basin.

GUIDELINES FOR DREDGED MATERIAL DEPOSITION

Guideline 4.1: Dredged materials removed during excavation and enlargement of the diversion outfall channels would be deposited in a manner that would avoid disruptions of water movement, flow, circulation and quality. Dredged material deposition is not expected to result in significant or persistent water quality impacts in the vicinity of construction activities. Any minor increases in suspended sediment and turbidity levels during dredged material deposition would be temporary and highly localized. Minor reductions in dissolved oxygen levels associated with dredged material deposition would be temporary.

Guideline 4.2: Dredged materials removed during excavation and enlargement of the diversion outfall channels will be used beneficially to provide a base for the regeneration of approximately 385 acres of wetland vegetation and associated fisheries, wildlife, and essential fish habitat (EFH), and approximately 32 acres of ridge and terrace creation suitable for the re-establishment of bottomland hardwoods. There are no nearby existing disposal areas or upland areas that could be practicably used.

Guideline 4.3: Dredged materials will not be disposed of in a manner which could result in the impounding or draining of wetlands or the creation of development sites.

Guideline 4.4: Approximately 283 acres of presently eroding wetlands will be impacted primarily through the excavation of outfall channels and placement of excavated material on adjacent deteriorating intermediate marsh. However, the beneficial use-placement of these excavated materials will provide a base for the regeneration of approximately 385 acres of emergent marsh vegetation and associated fisheries, wildlife, and essential fish habitat (EFH), and approximately 32 acres of ridge and terrace creation suitable for the re-establishment of bottomland hardwoods. Additionally, the MDWD is expected to produce an overall gain in

marsh acreage of approximately 21,282 acres by year 50 after project implementation.

Guidelines 4.5 – 4.6: Acknowledged.

Guideline 4.7: Not applicable.

GUIDELINES FOR SHORELINE MODIFICATIONS

Guidelines 5.1 – 5.9: Acknowledged.

GUIDELINES FOR SURFACE ALTERATIONS

Guidelines 6.1 – 6.14: Acknowledged. Surface alterations in the proposed project's construction footprint (approximately 283 acres of intermediate marsh; approximately 363 acres of open water; approximately 5 acres of bottomland hardwood habitat) will mainly entail the excavation of a new outfall channel, enlargement of an existing channel for improved conveyance, and placement of excavated material on deteriorating existing marsh. However, the beneficial use-placement of dredged material will produce approximately 385 acres of marsh platform for regeneration or colonization of emergent vegetation and associated fisheries, wildlife, and essential fish habitat (EFH), and approximately 32 acres of ridge and terrace creation suitable for the re-establishment of bottomland hardwoods.

GUIDELINES FOR HYDROLOGIC AND SEDIMENT TRANSPORT MODIFICATIONS

Guidelines 7.1 – 7.9: Acknowledged. The MDWD is designed to introduce fresh water to control salinities. The controlled diversion will also convey sediment and nutrients to the marshes of the MDWD project area and elsewhere in the Breton Sound Basin to enhance fish and wildlife habitat and productivity, and offset land loss. The operating plan for the MDWD takes advantage of sediment-rich high-river stages flowing through the structure, with a proposed diversion pulse of 35,000 cfs in March-April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year.

GUIDELINES FOR DISPOSAL OF WASTES

Guidelines 8.1 – 8.9: The proposed action would not involve the disposal of wastes; therefore, these guidelines are not applicable.

GUIDELINES FOR USES THAT RESULT IN THE ALTERATION OF WATERS DRAINING INTO COASTAL WATERS

Guideline 9.1: The proposed action will minimally affect water quality and flows in the Mississippi River, while providing benefits to the environment of the Breton Sound Basin through the diversion of fresh water, sediments, and nutrient inputs that should enhance fish and wildlife habitat and productivity, and reduce land loss.

Guidelines 9.2 – 9.3: Not applicable.

GUIDELINES FOR OIL, GAS, AND OTHER MINERAL ACTIVITIES

Guidelines 10.1 – 10.14: The proposed action would not involve oil, gas, and other mineral activities; therefore, these guidelines are not applicable.

CONSISTENCY DETERMINATION

The proposed Medium Diversion at White Ditch will provide additional freshwater, nutrients, and fine sediments to the area between the Mississippi River and the River aux Chenes ridges. The proposed action will restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration in the project area, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the Nation. Based on this evaluation, the U. S. Army Corps of Engineers, New Orleans District, has determined that the proposed action is consistent, to the maximum extent practicable, with the State of Louisiana's Coastal Resources Program.

Appendix F

State Historic Preservation Officer Coordination Letter

SCOTT ANGELLE
LIEUTENANT GOVERNOR

State of Louisiana
OFFICE OF THE LIEUTENANT GOVERNOR
DEPARTMENT OF CULTURE, RECREATION & TOURISM
OFFICE OF CULTURAL DEVELOPMENT

PAM BREAUX
SECRETARY

July 21, 2010

Ms. Joan Exnicios
Environmental Planning and Compliance Branch
New Orleans District, Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160-0267

Re: Management Summary of Phase I CRM Investigations
LA Division of Archaeology Report No. 22-3516
Management Summary: Phase I Cultural Resources Investigations of the White Ditch Diversion Area, Plaquemines Parish, Louisiana
R. Christopher Goodwin and Associates, Inc.

Dear Ms. Exnicios:

We are in receipt of your letter dated June 16, 2010, transmitting two copies of the above-cited report. We have completed our review and have the following comments to offer.

We concur with the findings presented in the management summary that four archaeological sites have been found within the project area for construction of a medium diversion area in Plaquemines Parish and the recommendations made in the report regarding each site. Namely, site 16PL15 lacks sufficient integrity to be eligible for the National Register of Historic Places (NRHP); 16PL16's eligibility for the NRHP is currently undetermined due to the presence of human remains that has thus far precluded subsurface investigations; 16PL193 is not eligible for the NRHP; and 16PL194 is also not eligible for the NRHP. In addition, the report considered the disputed location of French Fort De La Boulaye (16PL27), a National Historic Landmark. The project for which these investigations were conducted will not impact the originally reported site of this fort.

Technical comments concerning several items are included with this letter. Please address these as appropriate in the preparation of the draft report for this project and transmit two copies for our further review and comments. In addition, all site forms and site update forms submitted to the Louisiana Division of Archaeology must be accepted before a report can be finalized. Should you have any questions concerning our current comments, do not hesitate to contact Dennis Jones in the Division of Archaeology at (225) 342-6932 or by email at djones@crt.state.la.us.

Sincerely,



Phil Boggan
Deputy State Historic Preservation Officer
SH:DJ:s

C: Mr. Nathanael Heller, R. Christopher Goodwin and Associates, Inc.

TECHNICAL COMMENTS

1. Page 2, Figure 1. Please label some of the notable geographic features in this figure such as the Mississippi River, Oak River, Shell Bayou, etc. Please add an inset of the entire state of LA showing the location of the project area to this figure.

2. Page 3, Figure 2. Oak River is misnamed River aux Chien (Dog River) in this figure. River aux Chenes would be the proper name. Please add an inset of the entire state of LA showing the location of the project area to this figure.

3. Page 17. Please designate "Location 3" that was inspected for potential cultural resources in Figure 2. Is this the same location as the "single suspected archeological site location [that] was visited as planned in the task order…?"

4. Page 28. Did the human remains observed on the surface at 16PL16 indicate more than a single individual?

5. Page 43. Please include the locations of the Pointe a la Hache Oil and Gas Field, Location 3, and Phoenix, LA in Figure 2.

6. Page 49. Figure 2 should be referenced in the text for the location of 16PL194 and all other archaeological sites.

7. Page 50, Figure 37 and page 53. Mention is made in the text of a new location for the proposed flow constrictor near 16PL194. If possible please show this location in Figure 37. Despite the decision to avoid adverse effect on 16PL194, the Louisiana Division of Archaeology agrees with the recommendation in this management summary that this site contains potential for research as well as human remains. Should any future projects possibly affect this site, Phase II archaeological testing will be necessary to determine the site's eligibility for the NRHP.

ALABAMA-COUSHATTA TRIBE OF TEXAS
571 State Park Rd 56 • Livingston, Texas 77351 • (936) 563-1100

July 21, 2010

Gary Demarcay
New Orleans District, Corps of Engineers
Attn: CEMVN-PM-R
P.O. Box 60267
New Orleans, LA 70160-0267

Dear Mr. Demarcay:

On behalf of Mikko Oscola Clayton Sylestine and the Alabama-Coushatta Tribe, our appreciation is expressed on your efforts to consult us regarding the revised White Ditch Management Summary in Plaquemines Parish.

Our Tribe maintains ancestral associations throughout the state of Louisiana despite the absence of written records to completely identify Tribal activities, villages, trails, or grave sites. However, it is our objective to ensure significances of Native American ancestry, especially of the Alabama-Coushatta Tribe, are administered with the utmost attention.

Upon review of your June 23, 2010 submission, the proposed location exists beyond our scope of interest for the state of Louisiana. Therefore, no impacts to religious, cultural, or historical assets of the Alabama-Coushatta Tribe of Texas will occur in conjunction with this proposal.

Should you require additional assistance, please do not hesitate to contact us.

Respectfully submitted,

Bryant J. Celestine
Historic Preservation Officer

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

APRIL 1, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Mr. Scott Hutcheson
State Historic Preservation Officer
Office of Cultural Development
Department of Culture, Recreation and Tourism
P.O. Box 4427
Baton Rouge, Louisiana 70804

Dear Mr. Hutcheson:

Re: Initiation of Section 106 consultation for the White Ditch Diversion Project.

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that your records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

We are writing this letter to see if you have any specific concerns regarding this project or about the sites mentioned above. If you do, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chairman Mitchell Cypress
Seminole Tribe of Florida
6300 Sterling Rd.
Hollywood, FL 33024

Dear Chairman Cypress:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Willard Steele, Tribal Historic Preservation Officer and to Dawn Hutchins, Compliance Review Supervisor, Tribal Historic Preservation Office for any comments on the three sites mentioned above or any other interests the Seminole Tribe of Florida might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Willard S. Steele, Tribal Historic Preservation Officer
Dawn Hutchins, Compliance Review Supervisor
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chairman John Berrey
Quapaw Tribe of Oklahoma
P.O. Box 765
Quapaw, OK 74363

Dear Chairman Berrey:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Carrie Wilson, Quapaw Tribe of Oklahoma Historic Preservation Officer for any comments on the three sites mentioned above or any other interests the Quapaw Tribe of Oklahoma might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Carrie V. Wilson, Historic Preservation Officer

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chief Beasley Denson
Mississippi Band of Choctaw Indians
P.O. Box 6257
Choctaw, MS 39350

Dear Chief Denson:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Kenneth Carleton, Mississippi Band of Choctaw Indians Historic Preservation Officer for any comments on the three sites mentioned above or any other interests the Mississippi Band of Choctaw Indians might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Kenneth H. Carleton, Historic Preservation Officer
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Principal Chief Christine Norris
Jena Band of the Choctaw Indians
P.O. Box 14
Jena, LA 71342

Dear Chief Norris:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Lillie McCormack, Jena Band of Choctaw Indians Environmental Director for any comments on the three sites mentioned above or any other interests the Jena Band of Choctaw Indians might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

Cc: Lillie McCormick, Environmental Director

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chief Kevin Sickey
Coushatta Tribe of Louisiana
P.O. Box 818
Elton, LA 70532

Dear Chief Sickey:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Bertney and Linda Langley, Coushatta Tribe of Louisiana Cultural Contacts for any comments on the three sites mentioned above or any other interests the Coushatta Tribe might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Bertney and Linda Langley, Cultural Contacts
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chief Gregory E. Pyle
Choctaw Nation of Oklahoma
P.O. Box Drawer 1210
Durant, OK 74701

Dear Chief Pyle:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Terry Cole, Choctaw Tribe of Oklahoma, Director, Tribal Historic Preservation Officer for any comments on the three sites mentioned above or any other interests the Choctaw Tribe of Oklahoma might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Terry D. Cole, Director/THPO
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chairman Lonnie L. Martin
Chitimacha Tribe of Louisiana
P.O. Box 661
Charenton, LA 70523

Dear Chairman Martin:

Re: Initiation of Section 106 consultation for the White Ditch Diversion Project.

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Kimberly Walden, Chitimacha Tribe of Louisiana Cultural Director for any comments on the three sites mentioned above or any other interests the Chitimacha Tribe might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Kimberly S. Walden, Cultural Director w/atttachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 1, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chairperson LaRue Parker
Caddo Nation of Oklahoma
P.O. Box 487
Binger, OK 73009

Dear Chairperson Parker:

Re: Initiation of Section 106 consultation for the White Ditch Diversion Project.

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Robert Cast, Caddo Nation of Oklahoma Historic Preservation Officer.

We are writing this letter to see if you have any specific concerns regarding this project or about the sites mentioned above. If you do, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Robert Cast, Historic Preservation Officer

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

APRIL 1, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Principal Chief Oscola Clayton M. Sylestine
Alabama Coushatta Tribe of Texas
571 State Park Rd. 56
Livingston, TX 77351

Dear Principal Chief Sylestine:

Re: Initiation of Section 106 consultation for the White Ditch Diversion Project.

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Bryant Celestine, Alabama Coushatta tribe of Texas Historic Preservation Officer.

We are writing this letter to see if you have any specific concerns regarding this project or about the sites mentioned above. If you do, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Bryant J. Celestine
Historic Preservation Officer
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267

April 2, 2009

Planning, Programs, and
Project Management Division
Environmental Planning
And Compliance Branch
Attn: CEMVN-PM-RN

Chairman Earl J. Barbry, Sr.
Tunica-Biloxi Tribe of Louisiana
P.O. Box 1589
Marksville, LA 71351

Dear Chairman Barbry:

The U.S. Army Corps of Engineers, New Orleans District is studying the possibility of constructing a diversion canal along the Mississippi River in Plaquemines Parish, Louisiana. Subsidence, erosion, channelization, saltwater intrusion, storm damages and the absence of freshwater, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area (attachment), resulting in extensive wetland loss and ecosystem degradation. One of the objectives of this project is to provide additional freshwater, nutrients and fine sediment to the area between the Mississippi River and River aux Chenes ridges. Additional objectives include restoring functional hydrology and improving habitat conditions for fish and wildlife.

Attached is an aerial photograph with the proposed project boundary marked in orange. We have checked the Department of Archaeology web site and have noted that their records show four archaeological sites that are possibly within the proposed project area. These sites are 16PL15, 16PL16, 16PL25 and 16PL81.

The aerial photograph and site forms have been sent separately to Earl Barbry, Jr., Tunica-Biloxi Tribe of Louisiana Cultural Director for any comments on the three sites mentioned above or any other interests the Tunica-Biloxi Tribe of Louisianan might have in the area.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039.

Sincerely,

Joan Exnicios, Acting
Chief, Environmental Planning
And Compliance Branch

cc: Earl Barbry, Jr. Cultural Director
w/attachments

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Planning, Programs, and
Project Management Division
Environmental Planning
and Compliance Branch

Chairman Mitchell Cypress
Seminole Tribe of Florida
6300 Sterling Rd.
Hollywood, Florida 33024

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chairman Cypress:

A copy of this letter and the enclosures are being sent to the Seminole Tribe of Florida Tribal Historic Preservation Officer, Mr. Willard Steele and the Compliance Review Supervisor, Ms. Dawn Hutchins. If you wish to see the attachments, please contact Ms. Deere, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios
Chief, Environmental Planning
and Compliance Branch

Enclosure
Copy Furnished
Willard S. Steele, Tribal Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Principal Chief Enoch Kelley Haney
Seminole Nation of Oklahoma
P.O. Box 1498
Wewoka, Oklahoma 74884

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chief Haney:

A copy of this letter and the attachments are being sent to the Seminole Nation of Oklahoma Tribal Historic Preservation Officer Ms Natalie Deere. If you wish to see the attachments, please contact Ms. Deere, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Natalie Deere, Tribal Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chairman John Berrey
Quapaw Tribe of Oklahoma
P.O. Box 765
Quapaw, Oklahoma 74363

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chairman Berrey:

A copy of this letter and the enclosures are being sent to the Quapaw Tribe of Oklahoma Historic Preservation Officer Ms. Jean Ann Lambert. If you wish to see the attachments, please contact Ms.Lambert, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Jean Ann Lambert, Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chief Beasley Denson
Mississippi Band of Choctaw Indians
P.O. Box 6257
Choctaw, Mississippi 39350

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chief Denson:

A copy of this letter and the enclosures are being sent to the Mississippi Band of Choctaw Indians tribal Historic Preservation Officer, Mr. Kenneth Carleton. If you wish to see the attachments, please contact Mr. Carleton, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was

encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Kenneth H. Carleton, Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Principal Chief Christine Norris
Jena Band of the Choctaw Indians
P.O. Box 14
Jena, Louisiana 71342

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chief Norris:

A Copy of this letter and the attachments are being sent to the Jena Band of Choctaw Indians Tribal Historic Preservation Officer Mr. Michael Tarpley. If you wish to see the attachments, please contact Mr. Tarpley, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Michael Tarpley
Tribal Historic Preservation Officer
Lillie McCormick, Environmental Director

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chief Kevin Sickey
Coushatta Tribe of Louisiana
P.O. Box 818
Elton, Louisiana 70532

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chief Sickey:

A Copy of this letter and the attachments are being sent to the Coushatta Tribe of Louisiana Cultural Contacts Bertney and Linda Langley. If you wish to see the attachments, please contact Mr. or Ms. Langley, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe

erosion and subsidence and now only a small subsurface deposit of shell measuring approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M Exincios

Joan M. Exincios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Bertney and Linda Langley, Cultural Contacts

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chief Gregory E. Pyle
Choctaw Nation of Oklahoma
P.O. Box Drawer 1210
Durant, Oklahoma 74701

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chief Pyle:

A Copy of this letter and the enclosures are being sent to the Choctaw Nation of Oklahoma Tribal Historic Preservation Officer Mr. Terry Cole. If you wish to see the attachments, please contact Mr. Cole, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Terry D. Cole, Director/THPO

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chairman John Paul Darden, Chairman
Chitimacha Tribe of Louisiana
P.O. Box 661
Charenton, Louisiana 70523

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chairman Darden:

A Copy of this letter and the enclosures are being sent to the Chitimacha Tribe's Cultural Director Ms. Kimberly Walden. If you wish to see the enclosures, please contact Ms. Walden or if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was

encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Kimberly S. Walden, Cultural Director

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chairperson Brenda Shemayne Edwards
Caddo Nation of Oklahoma
P.O. Box 487
Binger, OK 73009

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chairperson Edwards:

A copy of this letter and the attachments are being sent to the Caddo Nation of Oklahoma Tribal Historic Preservation Officer Mr. Robert Cast. If you wish to see the attachments, please contact Mr. Cast, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe

erosion and subsidence and now only a small subsurface deposit of shell measuring approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Copy Furnished
Enclosure
Robert Cast, Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Principal Chief Oscola Clayton M. Sylestine
Alabama Coushatta Tribe of Texas
571 State Park Rd. 56
Livingston, Texas 77351

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Principal Chief Sylestine:

A copy of this letter and the attachments are being sent to the Alabama Coushatta Tribe of texas Historic Preservation Officer Mr. Bryant J. Celestine. If you wish to see the attachments, please contact Mr. Celestine, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M. Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosures
Copies Furnished
Bryant J. Celestine, Historic Preservation Officer

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

DEPARTMENT OF THE ARMY
NEW ORLEANS DISTRICT, CORPS OF ENGINEERS
P.O. BOX 60267
NEW ORLEANS, LOUISIANA 70160-0267
JUNE 23, 2010

Regional Planning and
Environmental Division, South
New Orleans Environmental Branch

Chairman Earl J. Barbry, Sr.
Tunica-Biloxi Tribe of Louisiana
P.O. Box 1589
Marksville, Louisiana 71351

Re: Management Summary, Phase I Cultural Resources Investigation for the White Ditch Diversion Area, Plaquemines Parish, Louisiana

Dear Chairman Barbry:

A Copy of this letter and the enclosures are being sent to the Tunica-Biloxi Tribe of Louisiana Cultural Director Mr. Earl Barbry, Jr. If you wish to see the attachments, please contact Mr. Barbry, or, if you wish you may contact Mr. Gary DeMarcay of my staff at (504) 862-2039.

Enclosed for your review is the Management Summary for the White Ditch Diversion Project. The US Army Corps of Engineers, New Orleans District (CEMVN) and the State of Louisiana proposes to construct a medium diversion near Phoenix, Louisiana in Plaquemines Parish. To build this project a diversion ditch will be constructed and five flow constrictors will be installed. The diversion is expected to divert approximately 35,000 cfs of Mississippi River water into the area south of River aux Chenes in order to replenish fresh water marsh. The diversion will be active seasonally with the greatest flow occurring only during the spring or during other times of high water.

This Phase I inventory was performed by R.C. Goodwin and Associates (Goodwin) under contract with CEMVN. The strategy for the Phase I survey was developed with Mr. Dennis Jones of your office during a helicopter flyover of the project area.

Two previously recorded sites and two new sites were investigated during the survey. In addition the reported location of Fort du Mississippi, also known as Fort De La Boulaye (16PL27) is discussed.

Site 16PL15 (Shell Bayou) was originally recorded on a site card in 1952. It is located on the western bank of Shell Bayou, a distributary that connects Spanish Lake to River aux Chenes. At the time of the recordation the site was described as a shell midden of unknown prehistoric age with a 20th century historic component. When originally recorded the site was described as a substantial shell ridge that extended into Shell Bayou. The site has since undergone severe erosion and subsidence and now only a small subsurface deposit of shell measuring

approximately 20 meters by 10 meters remain. A twenty centimeter level of crushed shell was encountered during shovel testing. No artifacts were recovered during the current investigation and apparently none were recovered when originally recorded. Goodwin recommends the site to be not eligible to the National Register of Historic Places. We agree with that recommendation.

Site 16PL16 (Orange Bayou) was also originally recorded in 1952. At that time the site was limited to the right descending bank of Orange Bayou at the intersection of River aux Chenes. It was described as a prehistoric shell midden dating to the Coles Creek and Mississippian periods. During the investigations for the subject project the site was found to be more extensive than originally thought. Rather than being limited to the right descending bank of Orange Bayou the site limits have been expanded to the east and west sides of Orange Bayou and to the south side of River aux Chenes. The Goodwin investigations demonstrated that the site dates to the Coles Creek and Mississippian Periods with the strongest component belonging to the Plaquemine culture, Barataria Phase.

Upon arrival at the site Goodwin noticed human remains scattered on the site's surface. Following the Louisiana Unmarked Human Burials Preservation Act of 1991 the Plaquemines Parish Sheriff's Office and the Plaquemines Parish Coroner's Office were notified and visited the site and examined the remains. It was determined that the human remains dated to the prehistoric period. Following this the CEMVN archaeologist, a representative from the Louisiana Division of Archaeology and the Cultural Director for the Chitimacha Tribe visited the site.

In consultation between CEMVN and the Chitimacha Tribe (the Tribe) the Tribe expressed the belief that the project will have minimal effect on the site and requested that the site not be disturbed by shovel testing. Furthermore, they wish to periodically visit the site to take the remains and place them in deep water and to monitor any effects that the project may have on the site.

Based on the Chitimacha's request, CEMVN did not conduct Phase II investigations to 16PL16 for National Register eligibility. The site is located on the edge of the Area of Potential Effect (APE) and will not be directly affected by construction and any rise in water levels will be seasonal and will not exceed normal rises in water levels caused by wind or tide.

Site 16PL193 is located in the vicinity of the proposed diversion intake pipes. This site is a residence built on the batture of the Mississippi River and is a wood frame structure, proportionally resembling a camelback double shotgun house. However, the entrances are oriented on the longer east elevation, rather than along the along the side oriented towards the river or the highway. Wooden clapboards serve as the exterior cladding for the building, but gaps in that cladding reveal the structure may have been covered at one time with vertical boards. The building is in poor condition and is open to the elements, with sections of the metal roof loose and/or missing, doors and windows are ajar, and portions of the flooring are missing. Besides the building, site 16PL193 includes the foundations of at least two small outbuildings, a

retaining wall fronting the Mississippi River and scatters of architectural debris and domestic refuse.

The artifacts collected from the surface and shovel tests appear to be less than 50 years old and shovel testing failed to locate any evidence of buried archaeological deposits or cultural features. Likewise, the structure is not notable in architectural style or type of building construction, nor is it a unique building. Furthermore, the materials and design integrity has been compromised by the use of replacement materials. Therefore, it is the opinion of Goodwin and CEMVN that the site is not eligible to the National Register.

Site 16PL194 is a shell midden located on the east bank of Bayou La Croix at the intersection with River aux Chenes. The site contains the brackish water clam *Rangia cuneata* and prehistoric ceramic artifacts. The site is visible in the water adjacent to the bank of Bayou La Croix. Both shell and artifacts extend for approximately 40 meters along the bank of the bayou and into the bayou for a distance of at least 10 meters. Examination of the adjacent bank of River aux Chenes did not indicate an extension of the site into that location. Sherds recovered from the water indicate that there is at least one component representing the Barataria Phase of the Plaquemine culture. The remnants visible of site 16PL194 indicate only a thin layer of shell and cultural material resting on the muddy base of the bayou, suggesting the site may be completely destroyed. Based on the results of Phase I investigations, CEMVN believes that there is little chance that submerged portions of 16PL194 exist and therefore CEMVN has determined that site 16PL194 is not eligible to the National Register of Historic Places. However, since construction of a flow constrictor is proposed for this location CEMVN has relocated the flow constrictor so as not to impact the site.

Fort De La Boulaye was listed as a National Historic Landmark (NHL) in 1960 based on work conducted in the 1930's by Maurice Ries, most notably the recovery of "hand-hewn logs" and a cannonball. The NHL listing places the location of the fort at the Gravolet Canal, where a low ridge intersects the historic canal.

In 1986 Goodwin conducted work to ground truth the location of the fort. That study included extensive primary and secondary source historic research, as well as extensive subsurface archaeology, modern and historic aerial photography analysis, historic map overlays, soil chemistry analysis and remote sensing. That study concluded that on the basis of negative results of the studies mentioned above the Gravolet Canal location is rejected and cannot be considered the site of the fort (Jeter et al. 1986:247). Since the fort is not at the Gravolet Canal location it cannot be impacted by the White Ditch Diversion.

Therefore, in compliance with 36 CFR Part 800.2(c)(1)(i) we request your concurrence with a determination of no adverse effect as per 36 CFR Part 800.5(b). Site 16PL16 is on the northern edge of the APE and has little chance of being impacted beyond what is normally caused by rise in water levels due to tidal and wind actions. Sites, 16PL194, is located along Bayou La Croix at the proposed location of one of five flow constrictors. CEMVN will move the location of the flow constrictor down the bayou away from this site and therefore will have no impact on 16PL194. Site 16PL193 is not eligible to the National Register and therefore is not

a historic property. Finally Fort De La Boulaye is not located at its recorded location and cannot be impacted by the proposed project.

Thank you for your help with this project. If you have any questions or require additional information, please contact Gary DeMarcay at (504) 862-2039 or by e-mail at gary.b.demarcay@usace.army.mil.

Sincerely,

Joan M Exnicios

Joan M. Exnicios
Chief, New Orleans Environmental Branch

Enclosure
Copy Furnished
Earl Barbry, Jr. Cultural Director

REFERENCES CITED

Jeter, Marvin R., Christopher Goodwin, Hershel Franks, Eric Poplin, Carol Poplin, Jill-Karen Yakubik, Peter Gendel, Russell Magnaghi, Mary Knill, Jeffrey Treffimger, Jack Hill and Wayne Grip

1986 *Archaeological Ressearch to Locate and Identify the French "Fort on the Mississippi" 16PL27(1700-1707), Plaquemines Parish, Louisiana.* R. Christopher Goodwin and Associates, Inc., New Orleans. Submitted to the US Army Corps of Engineers, New Orleans District.

Appendix G

Responses to Comments



-----Original Message-----
From: trentgillham@live.com [mailto:trentgillham@live.com]
Sent: Thursday, June 17, 2010 5:14 PM
To: MacInnes, Andrew D MVN
Subject: White ditch
My name is Trent Gillham and I think that you should do the new diversion project at white ditch, I visit often and enjoy the fishing and would love to be able to go there for a long time. Thank you and please do this.
Sent via Blackberry by AT&T

1

1. Your statement of support is noted.

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
3737 Government Street
Alexandria, LA 71302
(318) 473-7751
Fax: (318) 473-7626

June 18, 2010

Mrs. Joan M. Exnicios
Chief, Environmental Planning and
Compliance Branch
Department of the Army
New Orleans District, Corps of Engineers
P.O. Box 60267
New Orleans, Louisiana 70160-0267

RE: Louisiana Coastal Area-Ecosystem Restoration Project Medium Diversion at White Ditch Plaquemines Parish, Louisiana, and the Draft Environmental Impact Statement (DEIS), entitled Integrated Feasibility Study and Supplemental Environmental Impact Statement

Dear Mrs. Exnicios:

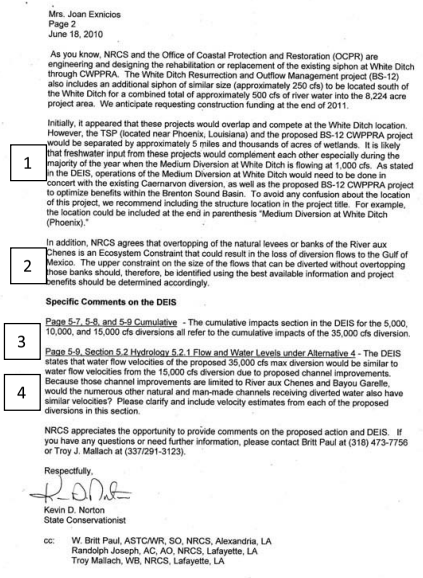
As requested in your public notice correspondence of May 21, 2010, referenced above, the Natural Resources Conservation Service (NRCS) has reviewed the information and offers the following comments.

The DEIS is well-written and generally provides an adequate description of the proposed project, the affected environmental resources, the anticipated project impacts to those resources, and the alternatives considered. NRCS agrees that wetlands in the project area will continue to deteriorate unless preventative measures are taken. The Mississippi River Protection Levee no longer allows the river to overflow its banks into the project area and the introduction of freshwater and sediments from the river have been eliminated. In addition, channels dredged through natural ridges has increased drainage and tidal exchange and exposed the soil to erosive forces. Recently, thousands of acres of vegetated marsh were converted to open water by hurricanes and tropical storms. Those acres are unlikely to recover without cooperative restoration efforts. This project was identified as a Near-term Critical Restoration Feature in the Louisiana Coastal Area (LCA) Ecosystem Restoration Study and NRCS continues to support it.

As described in the provided information, the Corps of Engineers has selected a max 35,000 cubic feet per second (cfs) diversion located just north of Phoenix, Louisiana, as the tentatively selected plan (TSP). The TSP would consist of ten 15-ft by 15-ft box culverts with hydrologic operated sluice gates placed in the Mississippi River levee. An outflow channel approximately 7,200 feet long, 545 feet wide, and 16 feet deep would be dredged to carry the flow to Bayou Garelle, which also would be deepened to accommodate the diverted river water. The current operating plan for the TSP is limited to a diversion pulse of 35,000 cfs in March-April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year.

Helping People Help the Land

An Equal Opportunity Provider and Employer



Mrs. Joan Exnicios
Page 2
June 18, 2010

As you know, NRCS and the Office of Coastal Protection and Restoration (OCPR) are engineering and designing the rehabilitation or replacement of the existing siphon at White Ditch through CWPPRA. The White Ditch Resurrection and Outflow Management project (BS-12) also includes an additional siphon of similar size (approximately 250 cfs) to be located south of the White Ditch for a combined total of approximately 500 cfs of river water into the 8,224 acre project area. We anticipate requesting construction funding at the end of 2011.

Initially, it appeared that these projects would overlap and compete at the White Ditch location. However, the TSP (located near Phoenix, Louisiana) and the proposed BS-12 CWPPRA project would be separated by approximately 5 miles and thousands of acres of wetlands. It is likely that freshwater input from these projects would complement each other especially during the majority of the year when the Medium Diversion at White Ditch is flowing at 1,000 cfs. As stated in the DEIS, operations of the Medium Diversion at White Ditch would need to be done in concert with the existing Caernarvon diversion, as well as the proposed BS-12 CWPPRA project to optimize benefits within the Brenton Sound Basin. To avoid any confusion about the location of this project, we recommend including the structure location in the project title. For example, the location could be included at the end in parenthesis "Medium Diversion at White Ditch (Phoenix)."

1

In addition, NRCS agrees that overtopping of the natural levees or banks of the River aux Chenes is an Ecosystem Constraint that could result in the loss of diversion flows to the Gulf of Mexico. The upper constraint on the size of the flows that can be diverted without overtopping those banks should, therefore, be identified using the best available information and project benefits should be determined accordingly.

2

Specific Comments on the DEIS

Page 5-7, 5-8, and 5-9 Cumulative - The cumulative impacts section in the DEIS for the 5,000, 10,000, and 15,000 cfs diversions all refer to the cumulative impacts of the 35,000 cfs diversion.

3

Page 5-9, Section 5.2 Hydrology 5.2.1 Flow and Water Levels under Alternative 4 - The DEIS states that water flow velocities of the proposed 35,000 cfs max diversion would be similar to water flow velocities from the 15,000 cfs diversion due to proposed channel improvements. Because those channel improvements are limited to River aux Chenes and Bayou Garelle, would the numerous other natural and man-made channels receiving diverted water also have similar velocities? Please clarify and include velocity estimates from each of the proposed diversions in this section.

4

NRCS appreciates the opportunity to provide comments on the proposed action and DEIS. If you have any questions or need further information, please contact Britt Paul at (318) 473-7756 or Troy J. Mallach at (337/291-3123).

Respectfully,

Kevin D. Norton
State Conservationist

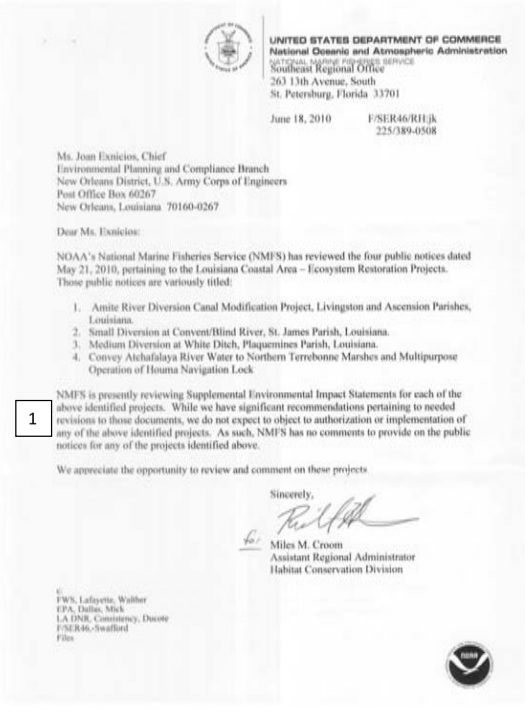
cc: W. Britt Paul, ASTC/WR, SO, NRCS, Alexandria, LA
Randolph Joseph, AC, AO, NRCS, Lafayette, LA
Troy Mallach, WB, NRCS, Lafayette, LA

1. Concur in Part: The Corps agrees that the naming schemes for each project could cause confusion to those unfamiliar with the project details. However, since LCA authorization is tied to WRDA 2007 which references the project by a specific name, we must keep that naming convention to avoid unnecessary legislative actions that could delay the project. The Corps will begin to anecdotally refer to the LCA project as being located in the Phoenix vicinity when discussing it with the public or other interested parties. The operation of White Ditch will be coordinated with the existing and new CWPPRA projects.

2. Concur: The Corps' preliminary hydraulic modeling of the project area determined that 35,000 cfs approximated the maximum flow that could be introduced to the project area without overtopping the River aux Chenes ridges. During the PED phase, additional survey and hydraulic modeling will be undertaken and these efforts may result in further refinements to the project design or operating plan.

3. Concur: Text has been corrected in the Final EIS.

4. The different diversion alternative sizes would have similar velocities in areas where there are channel improvements to be made. This is a product of planned design. There was a target range of velocity to keep sediments moving while not eroding the existing channels. For the different diversion alternatives, the proposed dredging and excavation of channels was done with this in mind yielding similar velocities for the different size diversions.



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue, South
St. Petersburg, Florida 33701

June 18, 2010 F/SER46/RH:jk
225/389-0508

Ms. Joan Exnicios, Chief
Environmental Planning and Compliance Branch
New Orleans District, U.S. Army Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Ms. Exnicios:

NOAA's National Marine Fisheries Service (NMFS) has reviewed the four public notices dated May 21, 2010, pertaining to the Louisiana Coastal Area – Ecosystem Restoration Projects. Those public notices are variously titled:

1. Amite River Diversion Canal Modification Project, Livingston and Ascension Parishes, Louisiana.
2. Small Diversion at Convent/Blind River, St. James Parish, Louisiana.
3. Medium Diversion at White Ditch, Plaquemines Parish, Louisiana.
4. Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock

1 NMFS is presently reviewing Supplemental Environmental Impact Statements for each of the above identified projects. While we have significant recommendations pertaining to needed revisions to those documents, we do not expect to object to authorization or implementation of any of the above identified projects. As such, NMFS has no comments to provide on the public notices for any of the projects identified above.

We appreciate the opportunity to review and comment on these projects

Sincerely,

for

Miles M. Croom
Assistant Regional Administrator
Habitat Conservation Division

c:
FWS, Lafayette, Walther
EPA, Dallas, Mick
LA DNR, Consistency, Ducote
F/SER46,-Swafford
Files

1. Comment is noted.

688

-----Original Message-----
From: Elizabeth Farizo [mailto:libbyfarizo@yahoo.com]
Sent: Friday, June 18, 2010 7:19 AM
To: MacInnis, Andrew D MVN
Subject: White Ditch Diversion Project
My name is Elizabeth F. I live in Plaquemines Parish and am 100% in favor of the White Ditch Diversion project.
Thanks for everything you're trying to do!

1

1. Your statement of support is noted.

689



-----Original Message-----
From: Jessica Farizo [mailto:jessicafarizo@yahoo.com]
Sent: Friday, June 18, 2010 7:16 AM
To: MacInnis, Andrew D MVN
Subject: white ditch
Hello, my name is Jessica Farizo. I live a few miles below white ditch. I love my home! I am definitely in favor of the white ditch diversion project.
Thanks!

1

1. Your statement of support is noted.

690



-----Original Message-----
From: farizosofdavant@aol.com [mailto:farizosofdavant@aol.com]
Sent: Friday, June 18, 2010 7:09 AM
To: MacInnis, Andrew D MVN
Subject: white ditch diversion
Andy
I am sending this email to you as both a land owner and as a land manager. I personally own property in Plaquemines parish and I know that on the level of a small land owner the only hope that I have to save my property from erosion and subsidence is to support your project at White Ditch/Phoenix.
I am also sending this correspondence to give you my opinion on this large diversion project as a land manager for Delacroix Corp. I have watched the property of Delacroix Corp. suffer from many different elements over the past 20 years. Erosion, subsidence and hurricanes are just a few harsh realities. I have also pleaded to many agencies and scientists over the years to place a sediment diversion in this area for almost 20 years. I am 100% in favor of this diversion project in the White Ditch/Phoenix area on the east bank of Plaquemines Parish. I recently attended the State of the Coast conference in Baton Rouge and the science is all there. Without introducing sediment into the marshes they will surely disappear.
Thanks for your efforts and again this is being sent to show you my support for a sediment diversion in the White Ditch/Phoenix area of Plaquemines Parish.
Michael Farizo

1

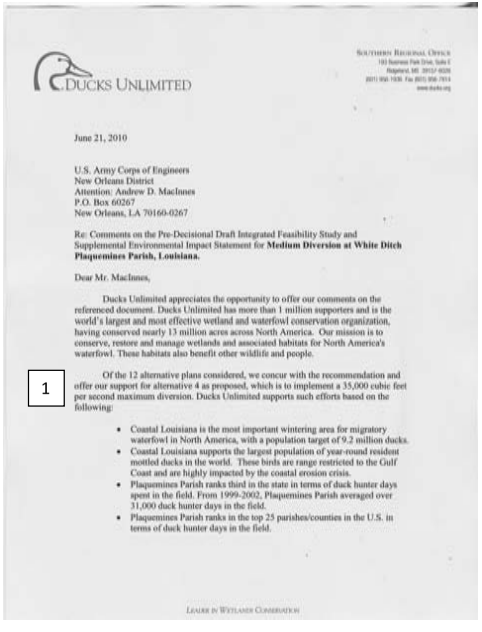
1. Your statement of support is noted.

691

-----Original Message-----
From: farizosofdavant@aol.com [mailto:farizosofdavant@aol.com]
Sent: Friday, June 18, 2010 7:08 AM
To: MacInnis, Andrew D MVN
Subject: white ditch
Andy
My name is Terri Lynn Farizo and I am sending this correspondence to you as my vote of support for a sediment diversion in White Ditch. I own marsh land in Davant and feel that this type of diversion is necessary to save my property.
Terri Lynn Farizo

1

1. Your statement of support is noted.



DUCKS UNLIMITED

SOUTHERN REGIONAL OFFICE
193 Business Park Drive, Suite E
Ridgeland, MS 39157-6026
(601) 956-1535 Fax (601) 956-7914
www.ducks.org

June 21, 2010

U.S. Army Corps of Engineers
New Orleans District
Attention: Andrew D. MacInnes
P.O. Box 60267
New Orleans, LA 70160-0267

Re: Comments on the Pre-Decisional Draft Integrated Feasibility Study and Supplemental Environmental Impact Statement for **Medium Diversion at White Ditch Plaquemines Parish, Louisiana.**

Dear Mr. MacInnes,

Ducks Unlimited appreciates the opportunity to offer our comments on the referenced document. Ducks Unlimited has more than 1 million supporters and is the world's largest and most effective wetland and waterfowl conservation organization, having conserved nearly 13 million acres across North America. Our mission is to conserve, restore and manage wetlands and associated habitats for North America's waterfowl. These habitats also benefit other wildlife and people.

1

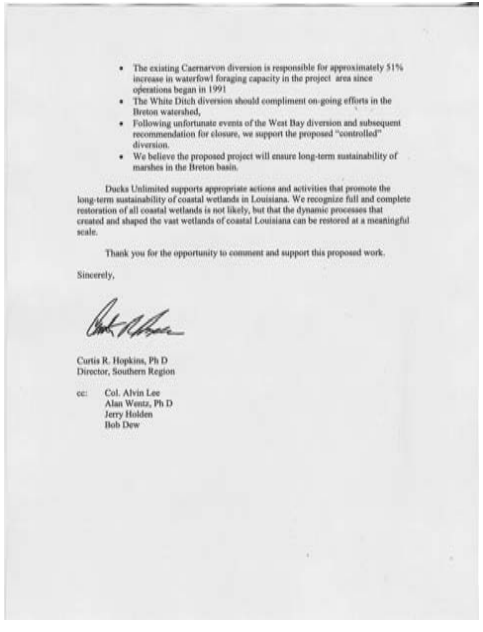
Of the 12 alternative plans considered, we concur with the recommendation and offer our support for alternative 4 as proposed, which is to implement a 35,000 cubic feet per second maximum diversion. Ducks Unlimited supports such efforts based on the following:

- Coastal Louisiana is the most important wintering area for migratory waterfowl in North America, with a population target of 9.2 million ducks.
- Coastal Louisiana supports the largest population of year-round resident mottled ducks in the world. These birds are range restricted to the Gulf Coast and are highly impacted by the coastal erosion crisis.
- Plaquemines Parish ranks third in the state in terms of duck hunter days spent in the field. From 1999-2002, Plaquemines Parish averaged over 31,000 duck hunter days in the field.
- Plaquemines Parish ranks in the top 25 parishes/counties in the U.S. in terms of duck hunter days in the field.

LEADER IN WETLANDS CONSERVATION

1. Your statement of support is noted.

693



- The existing Caernarvon diversion is responsible for approximately 51% increase in waterfowl foraging capacity in the project area since operations began in 1991
- The White Ditch diversion should compliment on-going efforts in the Breton watershed,
- Following unfortunate events of the West Bay diversion and subsequent recommendation for closure, we support the proposed "controlled" diversion.
- We believe the proposed project will ensure long-term sustainability of marshes in the Breton basin.

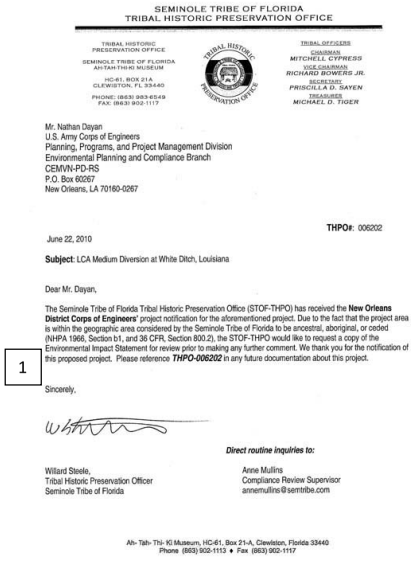
Ducks Unlimited supports appropriate actions and activities that promote the long-term sustainability of coastal wetlands in Louisiana. We recognize full and complete restoration of all coastal wetlands is not likely, but that the dynamic processes that created and shaped the vast wetlands of coastal Louisiana can be restored at a meaningful scale.

Thank you for the opportunity to comment and support this proposed work.

Sincerely,

Curtis R. Hopkins, Ph D
Director, Southern Region

cc: Col. Alvin Lee
Alan Wentz, Ph D
Jerry Holden
Bob Dew



SEMINOLE TRIBE OF FLORIDA
TRIBAL HISTORIC PRESERVATION OFFICE

TRIBAL HISTORIC PRESERVATION OFFICE
SEMINOLE TRIBE OF FLORIDA
AH-TAH-THI-KI MUSEUM
HC-61, BOX 21A
CLEWISTON, FL 33440
PHONE: (863) 983-6549
FAX: (863) 902-1117

TRIBAL OFFICERS
CHAIRMAN
MITCHELL CYPRESS
VICE-CHAIRMAN
RICHARD BOWERS JR.
SECRETARY
PRISCILLA D. SAYEN
TREASURER
MICHAEL D. TIGER

Mr. Nathan Dayan
U.S. Army Corps of Engineers
Planning, Programs, and Project Management Division
Environmental Planning and Compliance Branch
CEMVN-PD-RS
P.O. Box 60267
New Orleans, LA 70160-0267

THPO#: 006202

June 22, 2010

Subject: LCA Medium Diversion at White Ditch, Louisiana

Dear Mr. Dayan,

The Seminole Tribe of Florida Tribal Historic Preservation Office (STOF-THPO) has received the **New Orleans District Corps of Engineers'** project notification for the aforamentioned project. Due to the fact that the project area is within the geographic area considered by the Seminole Tribe of Florida to be ancestral, aboriginal, or ceded (NHPA 1966, Section b1, and 36 CFR, Section 800.2), the STOF-THPO would like to request a copy of the Environmental Impact Statement for review prior to making any further comment. We thank you for the notification of this proposed project. Please reference ***THPO-006202*** in any future documentation about this project.

Sincerely,

Direct routine inquiries to:

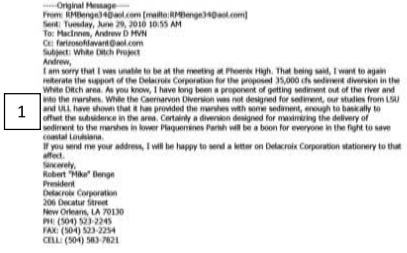
Willard Steele,
Tribal Historic Preservation Officer
Seminole Tribe of Florida

Anne Mullins
Compliance Review Supervisor
annemullins@semtribe.com

Ah- Tah- Thi- Ki Museum, HC-61, Box 21-A, Clewiston, Florida 33440
Phone (863) 902-1113 ♦ Fax (863) 902-1117

1

1. A copy of the DEIS has been sent to the Seminole Tribe of Florida as per their request.



-----Original Message-----
From: RMBenge34@aol.com [mailto:RMBenge34@aol.com]
Sent: Tuesday, June 29, 2010 10:55 AM
To: MacInnes, Andrew D MVN
Cc: farizzoMavant@aol.com
Subject: White Ditch Project

Andrew,

I am sorry that I was unable to be at the meeting at Phoenix High. That being said, I want to again reiterate the support of the Delacroix Corporation for the proposed 35,000 cfs sediment diversion in the White Ditch area. As you know, I have long been a proponent of getting sediment out of the river and into the marshes. While the Caernarvon Diversion was not designed for sediment, our studies from LSU and ULL have shown that it has provided the marshes with some sediment, enough to basically to offset the subsidence in the area. Certainly a diversion designed for maximizing the delivery of sediment to the marshes in lower Plaquemines Parish will be a boon for everyone in the fight to save coastal Louisiana.

If you send me your address, I will be happy to send a letter on Delacroix Corporation stationery to that effect.

Sincerely,

Robert "Hike" Benge
President
Delacroix Corporation
206 Decatur Street
New Orleans, LA 70130
PH: (504) 523-2245
FAX: (504) 523-2254
CELL: (504) 583-7821

1

1. Your statement of support is noted.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
1001 Indian School Road NW, Suite 348
Albuquerque, New Mexico 87104

TAKE PRIDE IN AMERICA

ER 10/476
File 9043.1

June 29, 2010

Joan Exnicios
Chief, Environmental Planning & Compliance Branch
New Orleans District
U.S. Army Corps of Engineers
PO Box 60267
New Orleans, Louisiana 70160-0267

Subject: Draft Supplemental Environmental Impact Statement (DSEIS) for the Medium Diversion at White Ditch, Integrated Feasibility Study, Louisiana Coastal Area (LCA) Ecosystem Restoration, Plaquemines Parish, Louisiana

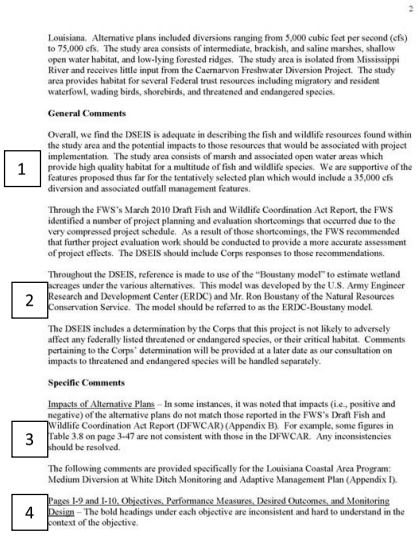
Dear Ms. Exnicios:

The U.S. Department of the Interior has reviewed the subject DSEIS. The following comments are provided by the U.S. Fish and Wildlife Service and the National Park Service.

Comments Provided by the U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service has reviewed the Pre-Decisional Draft Integrated Feasibility Study and Draft Supplemental Environmental Impact Statement (DSEIS) for the Medium Diversion at White Ditch, Louisiana Coastal Area Ecosystem Restoration, Plaquemines Parish, Louisiana, prepared by the U.S. Army Corps of Engineers (Corps). The purpose of that project is to provide additional fresh water, nutrients, and fine sediments to the area between the Mississippi River and River aux Chenes ridge. Diversion of Mississippi River water into the study area will facilitate sediment deposition, increase organic production, increase biological productivity, reduce marsh loss, and improve fish and wildlife habitat. The study area encompasses emergent marsh and shallow open water habitat on the east side of the Mississippi River near the community of Belair, Louisiana. The FWS submits the following comments in accordance with the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), the Bald and Golden Eagle Protection Act (BGEPA) (54 Stat. 250, as amended, 16 U.S.C. 668a-d), the Migratory Bird Treaty Act (MBTA) (40 Stat. 755, as amended; 16 U.S.C. 703 et seq.), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The Medium Diversion at White Ditch Project is proposed to be a freshwater diversion from the Mississippi River into an area of marsh that lies east of the Mississippi River near Phoenix,



2

Louisiana. Alternative plans included diversions ranging from 5,000 cubic feet per second (cfs) to 75,000 cfs. The study area consists of intermediate, brackish, and saline marshes, shallow open water habitat, and low-lying forested ridges. The study area is isolated from Mississippi River and receives little input from the Caernarvon Freshwater Diversion Project. The study area provides habitat for several Federal trust resources including migratory and resident waterfowl, wading birds, shorebirds, and threatened and endangered species.

General Comments

Overall, we find the DSEIS is adequate in describing the fish and wildlife resources found within the study area and the potential impacts to those resources that would be associated with project implementation. The study area consists of marsh and associated open water areas which provide high quality habitat for a multitude of fish and wildlife species. We are supportive of the features proposed thus far for the tentatively selected plan which would include a 35,000 cfs diversion and associated outfall management features.

1

Through the FWS's March 2010 Draft Fish and Wildlife Coordination Act Report, the FWS identified a number of project planning and evaluation shortcomings that occurred due to the very compressed project schedule. As a result of those shortcomings, the FWS recommended that further project evaluation work should be conducted to provide a more accurate assessment of project effects. The DSEIS should include Corps responses to those recommendations.

Throughout the DSEIS, reference is made to use of the "Boustany model" to estimate wetland acreages under the various alternatives. This model was developed by the U.S. Army Engineer Research and Development Center (ERDC) and Mr. Ron Boustany of the Natural Resources Conservation Service. The model should be referred to as the ERDC-Boustany model.

2

The DSEIS includes a determination by the Corps that this project is not likely to adversely affect any federally listed threatened or endangered species, or their critical habitat. Comments pertaining to the Corps' determination will be provided at a later date as our consultation on impacts to threatened and endangered species will be handled separately.

Specific Comments

Impacts of Alternative Plans – In some instances, it was noted that impacts (i.e., positive and negative) of the alternative plans do not match those reported in the FWS's Draft Fish and Wildlife Coordination Act Report (DFWCAR) (Appendix B). For example, some figures in Table 3.8 on page 3-47 are not consistent with those in the DFWCAR. Any inconsistencies should be resolved.

3

The following comments are provided specifically for the Louisiana Coastal Area Program: Medium Diversion at White Ditch Monitoring and Adaptive Management Plan (Appendix I).

Pages I-9 and I-10, Objectives, Performance Measures, Desired Outcomes, and Monitoring Design – The bold headings under each objective are inconsistent and hard to understand in the context of the objective.

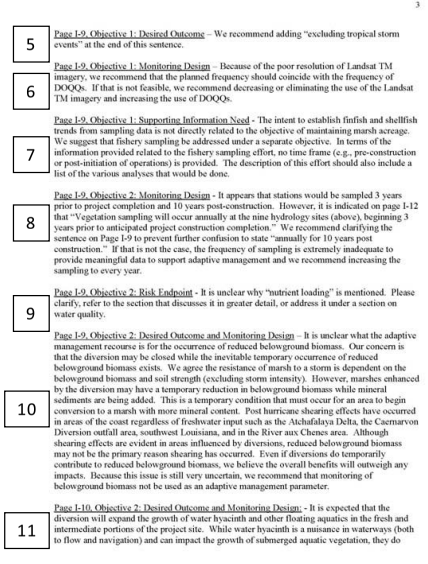
4

1. Your statement of support is noted.

2. Concur in Part: The document has been revised to change all references to this model to the "ERDC-SAND2 model".

3. Inconsistencies have been resolved where possible. Revised WVA numbers and impacted acres have been included at the end of Appendix B.

4. Your concern is noted. We may revisit the organizational structure and format during plan revision during PED.



3

5 Page I-9, Objective 1: Desired Outcome – We recommend adding "excluding tropical storm events" at the end of this sentence.

6 Page I-9, Objective 1: Monitoring Design – Because of the poor resolution of Landsat TM imagery, we recommend that the planned frequency should coincide with the frequency of DOQQs. If that is not feasible, we recommend decreasing or eliminating the use of the Landsat TM imagery and increasing the use of DOQQs.

7 Page I-9, Objective 1: Supporting Information Need - The intent to establish finfish and shellfish trends from sampling data is not directly related to the objective of maintaining marsh acreage. We suggest that fishery sampling be addressed under a separate objective. In terms of the information provided related to the fishery sampling effort, no time frame (e.g., pre-construction or post-initiation of operations) is provided. The description of this effort should also include a list of the various analyses that would be done.

8 Page I-9, Objective 2: Monitoring Design - It appears that stations would be sampled 3 years prior to project completion and 10 years post-construction. However, it is indicated on page I-12 that "Vegetation sampling will occur annually at the nine hydrology sites (above), beginning 3 years prior to anticipated project construction completion." We recommend clarifying the sentence on Page I-9 to prevent further confusion to state "annually for 10 years post construction." If that is not the case, the frequency of sampling is extremely inadequate to provide meaningful data to support adaptive management and we recommend increasing the sampling to every year.

9 Page I-9, Objective 2: Risk Endpoint - It is unclear why "nutrient loading" is mentioned. Please clarify, refer to the section that discusses it in greater detail, or address it under a section on water quality.

10 Page I-9, Objective 2: Desired Outcome and Monitoring Design – It is unclear what the adaptive management recourse is for the occurrence of reduced belowground biomass. Our concern is that the diversion may be closed while the inevitable temporary occurrence of reduced belowground biomass exists. We agree the resistance of marsh to a storm is dependent on the belowground biomass and soil strength (excluding storm intensity). However, marshes enhanced by the diversion may have a temporary reduction in belowground biomass while mineral sediments are being added. This is a temporary condition that must occur for an area to begin conversion to a marsh with more mineral content. Post hurricane shearing effects have occurred in areas of the coast regardless of freshwater input such as the Atchafalaya Delta, the Caernarvon Diversion outfall area, southwest Louisiana, and in the River aux Chenes area. Although shearing effects are evident in areas influenced by diversions, reduced belowground biomass may not be the primary reason shearing has occurred. Even if diversions do temporarily contribute to reduced belowground biomass, we believe the overall benefits will outweigh any impacts. Because this issue is still very uncertain, we recommend that monitoring of belowground biomass not be used as an adaptive management parameter.

11 Page I-10, Objective 2: Desired Outcome and Monitoring Design: - It is expected that the diversion will expand the growth of water hyacinth and other floating aquatics in the fresh and intermediate portions of the project site. While water hyacinth is a nuisance in waterways (both to flow and navigation) and can impact the growth of submerged aquatic vegetation, they do

5. Concur. Text added.

6. Response: The AM Framework Team believes that the use of Landsat Imagery is an appropriate method for monitoring this objective. The utilization of Landsat imagery is proposed primarily due to the frequency of collection (up to six times per year), and for cost efficiency. DOQQs do provide better spatial resolution, however collection of DOQQs at more frequent time intervals may be prohibitively expensive. The belief that Landsat images do not show changes well is debatable. Spectral and temporal resolution of these Landsat data actually provide the opportunity for change detection techniques which may not be possible with DOQQs. Additionally, the next satellite in the Landsat Program, scheduled for launch in December 2012, will carry a panchromatic band at 15m spatial resolution. This band enables panchromatic sharpening of the other 8 spectral bands, providing the value of increased spectral resolution, while improving the spatial resolution.

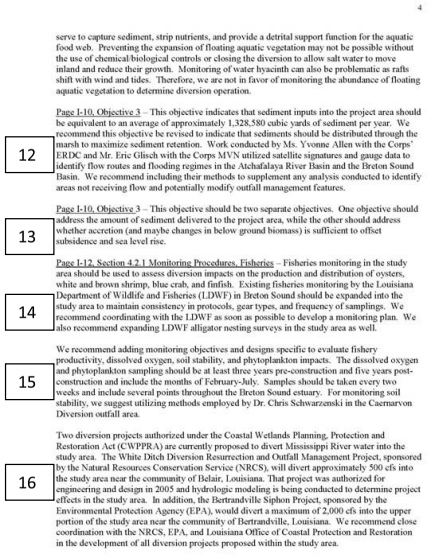
7. Response: In preparation of the Fisheries sections, the best available data was used to develop the existing conditions analysis. Based on the analysis, best professional judgement was used to define the predicted impacts. During PED, ECO-SIM models will be used to further analyze the predicted effects of the project on fisheries resources, including commercial species such as oysters. If impacts are significantly different that those described within this document, then a NEPA document may be prepared as appropriate. Although fisheries resources were not considered in the objectives of the project, these populations may be monitored before and after project completion. Since the primary objective of the project is marsh creation and restoration of natural deltaic processes, the results of fisheries monitoring will not necessarily influence the operational regime of the structure.

8. Response: We concur. Language was changed to clarify that vegetation sampling will be performed yearly beginning in PED for two years, during three years of construction, and ten years post construction.

9. Concur. Language revised to better reflect the concern over excess nutrients. Definition of risk endpoint and other applicable AM terms have been added to section 4.2.

10. Response: The LCA AM Framework team agrees with your concern and explanation. The effects of freshwater, sediment, and nutrient inputs from diversions on below ground biomass is debated in the scientific literature. The White Ditch Diversion project yields an opportunity to more closely examine this relationship. Although data gathered on below ground biomass may inform diversion operations, that data will not be the only data utilized to inform decisions on diversion operations. This issue will be more closely investigated during the plan revision during PED. As previously stated in the response to Page 1, Section 1,the USACE and State will continue to coordinate with federal agencies during the PED plan revision to address this issue.

11. Response: The AM Framework Team understands and agrees with many of the concerns relating to water hyacinth and believes this is primarily an O&M issue. However, the PMs do not believe eliminating this monitoring is a valid option due to intense public concerns over water hyacinth. This issue can be further discussed and refined during the plan revision in PED.



4

serve to capture sediment, strip nutrients, and provide a detrital support function for the aquatic food web. Preventing the expansion of floating aquatic vegetation may not be possible without the use of chemical/biological controls or closing the diversion to allow salt water to move inland and reduce their growth. Monitoring of water hyacinth can also be problematic as rafts shift with wind and tides. Therefore, we are not in favor of monitoring the abundance of floating aquatic vegetation to determine diversion operation.

12 Page I-10, Objective 3 – This objective indicates that sediment inputs into the project area should be equivalent to an average of approximately 1,328,580 cubic yards of sediment per year. We recommend this objective be revised to indicate that sediments should be distributed through the marsh to maximize sediment retention. Work conducted by Ms. Yvonne Allen with the Corps' ERDC and Mr. Eric Glisch with the Corps MVN utilized satellite signatures and gauge data to identify flow routes and flooding regimes in the Atchafalaya River Basin and the Breton Sound Basin. We recommend including their methods to supplement any analysis conducted to identify areas not receiving flow and potentially modify outfall management features.

13 Page I-10, Objective 3 – This objective should be two separate objectives. One objective should address the amount of sediment delivered to the project area, while the other should address whether accretion (and maybe changes in below ground biomass) is sufficient to offset subsidence and sea level rise.

14 Page I-12, Section 4.2.1 Monitoring Procedures, Fisheries – Fisheries monitoring in the study area should be used to assess diversion impacts on the production and distribution of oysters, white and brown shrimp, blue crab, and finfish. Existing fisheries monitoring by the Louisiana Department of Wildlife and Fisheries (LDWF) in Breton Sound should be expanded into the study area to maintain consistency in protocols, gear types, and frequency of samplings. We recommend coordinating with the LDWF as soon as possible to develop a monitoring plan. We also recommend expanding LDWF alligator nesting surveys in the study area as well.

15 We recommend adding monitoring objectives and designs specific to evaluate fishery productivity, dissolved oxygen, soil stability, and phytoplankton impacts. The dissolved oxygen and phytoplankton sampling should be at least three years pre-construction and five years post-construction and include the months of February-July. Samples should be taken every two weeks and include several points throughout the Breton Sound estuary. For monitoring soil stability, we suggest utilizing methods employed by Dr. Chris Schwarzenski in the Caernarvon Diversion outfall area.

16 Two diversion projects authorized under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) are currently proposed to divert Mississippi River water into the study area. The White Ditch Diversion Resurrection and Outfall Management Project, sponsored by the Natural Resources Conservation Service (NRCS), will divert approximately 500 cfs into the study area near the community of Belair, Louisiana. That project was authorized for engineering and design in 2005 and hydrologic modeling is being conducted to determine project effects in the study area. In addition, the Bertrandville Siphon Project, sponsored by the Environmental Protection Agency (EPA), would divert a maximum of 2,000 cfs into the upper portion of the study area near the community of Bertrandville, Louisiana. We recommend close coordination with the NRCS, EPA, and Louisiana Office of Coastal Protection and Restoration in the development of all diversion projects proposed within the study area.

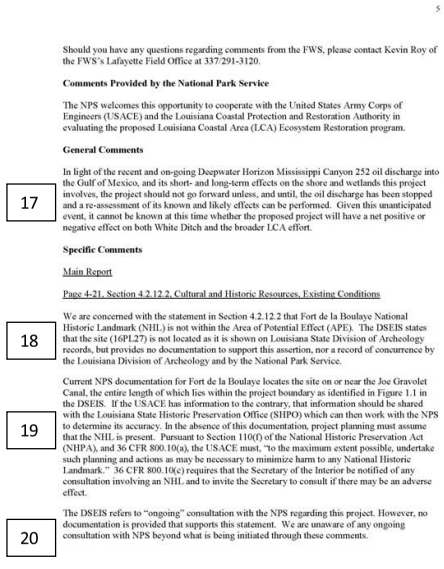
12. The 1,328,580 cubic yards of sediment represents an approximated threshold required to meet LCA Program goal of "No Net Loss". It is the approximate minimum amount of sediment needed to offset the current rate of relative sea level rise. Identification of this minimum and clear establishment of it as a goal was necessary to facilitate the decision on overall size of diversion structure and capacity of the outfall canal. The issue of sediment distribution within the marsh is a related but distinctly separate topic. The methods described in the comment will be considered as potential monitoring methods for adaptive management purposes during the PED phase. The Objective will not be revised. The LCA AM Framework team agrees that these types of analyses could be valuable. These analyses are complicated, but not impossible, for project areas obscured by vegetation structure. Because Landsat imagery is already proposed for utilization in this monitoring and adaptive management plan, this additional information can be easily evaluated relatively economically. If the PDT determines this information is necessary, then it can be added during plan modification during PED.

13. The 1,328,580 cubic yards of sediment represents an approximated threshold required to meet LCA Program goal of "No Net Loss". It is the approximate minimum amount of sediment needed to offset the current rate of relative sea level rise. Identification of this minimum and clear establishment of it as a goal was necessary to facilitate the decision on overall size of diversion structure and capacity of the outfall canal. The amount of sediment required is directly related to relative sea level rise and the 2 cannot be separated. The objective will not be split.

14. Response: This supporting information need was eliminated because it does not directly relate to Objective 1. In discussion with the PM, changes in fish and wildlife resources are not a project objective, and therefore it is not necessary to monitor fish and wildlife. This additional monitoring can be reconsidered during PED.

15. See response to comment #14 above.

16. Concur: Both CWPPRA projects have the potential for overlap with the LCA project. Close coordination is necessary to ensure each project is developed properly and is consistent with the most probable outcomes for future-without-project conditions. The LCA team will engage NRCS and EPA to give them an update on the LCA project.



5

Should you have any questions regarding comments from the FWS, please contact Kevin Roy of the FWS's Lafayette Field Office at 337/291-3120.

Comments Provided by the National Park Service

The NPS welcomes this opportunity to cooperate with the United States Army Corps of Engineers (USACE) and the Louisiana Coastal Protection and Restoration Authority in evaluating the proposed Louisiana Coastal Area (LCA) Ecosystem Restoration program.

General Comments

17 In light of the recent and on-going Deepwater Horizon Mississippi Canyon 252 oil discharge into the Gulf of Mexico, and its short- and long-term effects on the shore and wetlands this project involves, the project should not go forward unless, and until, the oil discharge has been stopped and a re-assessment of its known and likely effects can be performed. Given this unanticipated event, it cannot be known at this time whether the proposed project will have a net positive or negative effect on both White Ditch and the broader LCA effort.

Specific Comments

Main Report

Page 4-21, Section 4.2.12.2, Cultural and Historic Resources, Existing Conditions

18 We are concerned with the statement in Section 4.2.12.2 that Fort de la Boulaye National Historic Landmark (NHL) is not within the Area of Potential Effect (APE). The DSEIS states that the site (16PL27) is not located as it is shown on Louisiana State Division of Archeology records, but provides no documentation to support this assertion, nor a record of concurrence by the Louisiana Division of Archeology and by the National Park Service.

19 Current NPS documentation for Fort de la Boulaye locates the site on or near the Joe Gravolet Canal, the entire length of which lies within the project boundary as identified in Figure 1.1 in the DSEIS. If the USACE has information to the contrary, that information should be shared with the Louisiana State Historic Preservation Office (SHPO) which can then work with the NPS to determine its accuracy. In the absence of this documentation, project planning must assume that the NHL is present. Pursuant to Section 110(f) of the National Historic Preservation Act (NHPA), and 36 CFR 800.10(a), the USACE must, "to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark." 36 CFR 800.10(c) requires that the Secretary of the Interior be notified of any consultation involving an NHL and to invite the Secretary to consult if there may be an adverse effect.

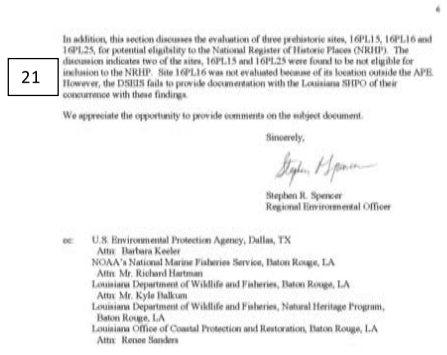
20 The DSEIS refers to "ongoing" consultation with the NPS regarding this project. However, no documentation is provided that supports this statement. We are unaware of any ongoing consultation with NPS beyond what is being initiated through these comments.

17. Non-Concur: Despite the significant impacts that could occur to the coastal wetlands of Louisiana due to the BP oil spill, it is not recommended that restoration projects be put on hold indefinitely until a damage assessment can be made. The problems facing coastal Louisiana have not changed since the spill and the LCA White Ditch recommended plan offers tremendous flexibility for operation depending on the needs of the estuary. Coastal restoration efforts must proceed ahead as quickly as possible to design and construct features and get them operational. Time lost due to a re-analysis of spill effects will only prolong the construction of restoration features.

18. The Corps is working with the National Park Service to delist this property and is currently waiting for direction from NPS. The evidence we are using is contained in a report titled *Archaeological Research t Locate and Identify the French "Fort on the Mississippi" 16PL27 (1700 -1707), Plaquemines Parish, Louisiana.*

19. See above response.

20. Consultation on this issue begin with the DEIS and coordination has occurred since.



6

In addition, this section discusses the evaluation of three prehistoric sites, 16PL15, 16PL16 and 16PL25, for potential eligibility to the National Register of Historic Places (NRHP). The discussion indicates two of the sites, 16PL15 and 16PL25 were found to be not eligible for inclusion to the NRHP. Site 16PL16 was not evaluated because of its location outside the APE. However, the DSHS fails to provide documentation with the Louisiana SHPO of their concurrence with these findings.

21

We appreciate the opportunity to provide comments on the subject document.

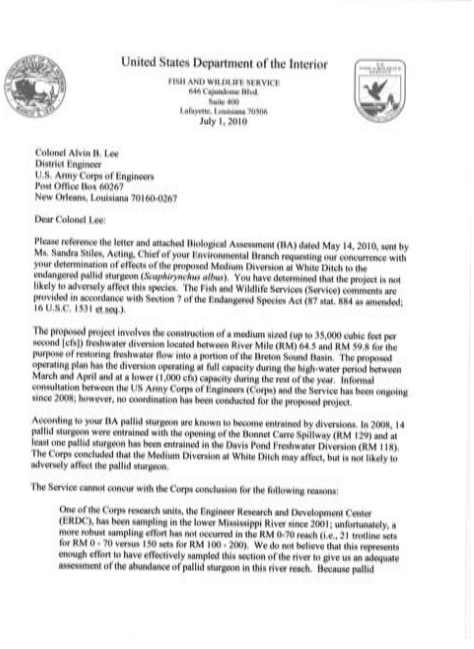
Sincerely,

Stephen R. Spencer
Regional Environmental Officer

cc: U.S. Environmental Protection Agency, Dallas, TX
Attn: Barbara Keeler
NOAA's National Marine Fisheries Service, Baton Rouge, LA
Attn: Mr. Richard Hartman
Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA
Attn: Mr. Kyle Balkum
Louisiana Department of Wildlife and Fisheries, Natural Heritage Program, Baton Rouge, LA
Louisiana Office of Coastal Protection and Restoration, Baton Rouge, LA
Attn: Renee Sanders

21. SHPO has until July 25 to respond to our determination of effect and eligibility. Recent conversations with SHPO indicate that there will be no problem.

(Letter from SHPO dated 21 July 2010 concurred with the findings of the cultural resources report is reproduced at the end of this appendix)



United States Department of the Interior

FISH AND WILDLIFE SERVICE
646 Cajundome Blvd.
Suite 400
Lafayette, Louisiana 70506
July 1, 2010

Colonel Alvin B. Lee
District Engineer
U.S. Army Corps of Engineers
Post Office Box 60267
New Orleans, Louisiana 70160-0267

Dear Colonel Lee:

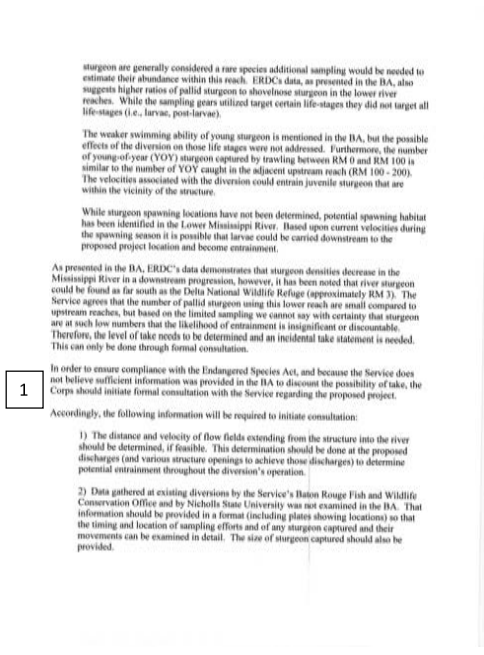
Please reference the letter and attached Biological Assessment (BA) dated May 14, 2010, sent by Ms. Sandra Stiles, Acting, Chief of your Environmental Branch requesting our concurrence with your determination of effects of the proposed Medium Diversion at White Ditch to the endangered pallid sturgeon (*Scaphirynchus albus*). You have determined that the project is not likely to adversely affect this species. The Fish and Wildlife Services (Service) comments are provided in accordance with Section 7 of the Endangered Species Act (87 stat. 884 as amended; 16 U.S.C. 1531 et seq.).

The proposed project involves the construction of a medium sized (up to 35,000 cubic feet per second [cfs]) freshwater diversion located between River Mile (RM) 64.5 and RM 59.8 for the purpose of restoring freshwater flow into a portion of the Breton Sound Basin. The proposed operating plan has the diversion operating at full capacity during the high-water period between March and April and at a lower (1,000 cfs) capacity during the rest of the year. Informal consultation between the US Army Corps of Engineers (Corps) and the Service has been ongoing since 2008; however, no coordination has been conducted for the proposed project.

According to your BA pallid sturgeon are known to become entrained by diversions. In 2008, 14 pallid sturgeon were entrained with the opening of the Bonnet Carre Spillway (RM 129) and at least one pallid sturgeon has been entrained in the Davis Pond Freshwater Diversion (RM 118). The Corps concluded that the Medium Diversion at White Ditch may affect, but is not likely to adversely affect the pallid sturgeon.

The Service cannot concur with the Corps conclusion for the following reasons:

One of the Corps research units, the Engineer Research and Development Center (ERDC), has been sampling in the lower Mississippi River since 2001; unfortunately, a more robust sampling effort has not occurred in the RM 0-70 reach (i.e., 21 trotline sets for RM 0 - 70 versus 150 sets for RM 100 - 200). We do not believe that this represents enough effort to have effectively sampled this section of the river to give us an adequate assessment of the abundance of pallid sturgeon in this river reach. Because pallid



sturgeon are generally considered a rare species additional sampling would be needed to estimate their abundance within this reach. ERDC's data, as presented in the BA, also suggests higher ratios of pallid sturgeon to shovelnose sturgeon in the lower river reaches. While the sampling gears utilized target certain life-stages they did not target all life-stages (i.e., larvae, post-larvae).

The weaker swimming ability of young sturgeon is mentioned in the BA, but the possible effects of the diversion on those life stages were not addressed. Furthermore, the number of young-of-year (YOY) sturgeon captured by trawling between RM 0 and RM 100 is similar to the number of YOY caught in the adjacent upstream reach (RM 100 - 200). The velocities associated with the diversion could entrain juvenile sturgeon that are within the vicinity of the structure.

While sturgeon spawning locations have not been determined, potential spawning habitat has been identified in the Lower Mississippi River. Based upon current velocities during the spawning season it is possible that larvae could be carried downstream to the proposed project location and become entrainment.

As presented in the BA, ERDC's data demonstrates that sturgeon densities decrease in the Mississippi River in a downstream progression, however, it has been noted that river sturgeon could be found as far south as the Delta National Wildlife Refuge (approximately RM 3). The Service agrees that the number of pallid sturgeon using this lower reach are small compared to upstream reaches, but based on the limited sampling we cannot say with certainty that sturgeon are at such low numbers that the likelihood of entrainment is insignificant or discountable. Therefore, the level of take needs to be determined and an incidental take statement is needed. This can only be done through formal consultation.

1 In order to ensure compliance with the Endangered Species Act, and because the Service does not believe sufficient information was provided in the BA to discount the possibility of take, the Corps should initiate formal consultation with the Service regarding the proposed project.

Accordingly, the following information will be required to initiate consultation:

1) The distance and velocity of flow fields extending from the structure into the river should be determined, if feasible. This determination should be done at the proposed discharges (and various structure openings to achieve those discharges) to determine potential entrainment throughout the diversion's operation.

2) Data gathered at existing diversions by the Service's Baton Rouge Fish and Wildlife Conservation Office and by Nicholls State University was not examined in the BA. That information should be provided in a format (including plates showing locations) so that the timing and location of sampling efforts and of any sturgeon captured and their movements can be examined in detail. The size of sturgeon captured should also be provided.

1. Concur: Formal consultation has been initiated with the USFWS. CEMVN letter requesting the initiation of formal consultation was submitted on July 15, 2010. USFWS response letter starting formal consultation was received on July 16, 2010.

3) Sampling data from the Mississippi River, especially from the lower two reaches (RM 0 to 70 and RM 70 to 100), should be provided in a format (including plate showing locations) so that the timing and location of sampling efforts and of any sturgeon captured can be examined in detail. The size of sturgeon captured should also be provided.

4) Justification (e.g., geomorphic, hydrodynamic, substrate) should be provided for the division of the river into the 3 different sampling reaches.

5) Calculate the average area of opening of the structure for flows of 1,000 cfs and 35,000 cfs as would vary with river stages throughout the year and an estimate of the number of days the structure will be at those areas based on the river's hydrograph.

6) Compare the above calculated (Number 5) average area of opening throughout the year with the Mississippi River channels cross sectional area at the proposed diversion location.

7) Compare main channel flow (cfs) to water diverted (cfs) to calculate percent of latitudinal flow diverted.

8) Provide a final copy of the Scope-of-Work (SOW) that details sampling design, techniques, and calculation of catch-per-unit-effort.

9) A detailed and current description of the proposed project (i.e., selection of a single project location) including a plat depicting the precise location and dimensions and a cross-section showing the bottom elevations of the structure and outfall channel.

The formal consultation process for the project cannot begin until we receive the above information, or a statement explaining why that information cannot be made available. We will confirm our receipt of that information; our notification letter to you will also outline the dates within which formal consultation on the proposed action should be complete and our biological opinion delivered.

Section 7 of the ESA allows the Service up to 90 calendar days to conclude formal consultation with your agency and an additional 45 calendar days to prepare our biological opinion. As a reminder, the ESA requires that after initiation of formal consultation, the federal action agency may not make any irreversible or irretrievable commitment of resources that limits future options. This practice insures agency actions do not preclude the formulation or implementation of reasonable and prudent alternatives that avoid jeopardizing the continued existence of endangered and threatened species or destroying or modifying their critical habitats.

707

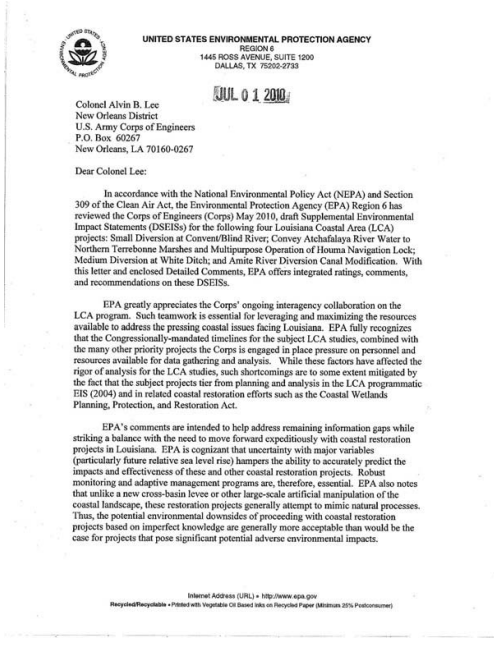
If you have any questions or concerns about this consultation or the consultation process in general, please feel free to contact David Walther of this office at 337/291-3122.

Sincerely,

James F. Boggs
Supervisor
Louisiana Field Office

cc: FWS, Ecological Services, Jackson, MS
FWS, Fish and Wildlife Resource Office, Baton Rouge, LA
ERDC, Vicksburg, MS
LDWF, Natural Heritage Program, Baton Rouge, LA
OPCR, Baton Rouge, LA

708



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

JUL 0 1 2010

Colonel Alvin B. Lee
New Orleans District
U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160-0267

Dear Colonel Lee:

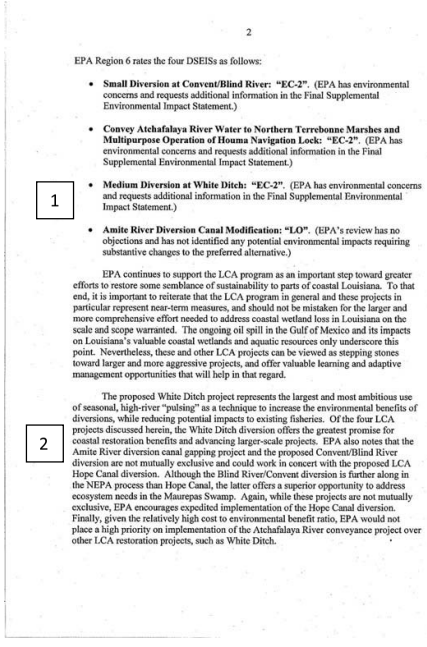
In accordance with the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, the Environmental Protection Agency (EPA) Region 6 has reviewed the Corps of Engineers (Corps) May 2010, draft Supplemental Environmental Impact Statements (DSEISs) for the following four Louisiana Coastal Area (LCA) projects: Small Diversion at Convent/Blind River; Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock; Medium Diversion at White Ditch; and Amite River Diversion Canal Modification. With this letter and enclosed Detailed Comments, EPA offers integrated ratings, comments, and recommendations on these DSEISs.

EPA greatly appreciates the Corps' ongoing interagency collaboration on the LCA program. Such teamwork is essential for leveraging and maximizing the resources available to address the pressing coastal issues facing Louisiana. EPA fully recognizes that the Congressionally-mandated timelines for the subject LCA studies, combined with the many other priority projects the Corps is engaged in place pressure on personnel and resources available for data gathering and analysis. While these factors have affected the rigor of analysis for the LCA studies, such shortcomings are to some extent mitigated by the fact that the subject projects tier from planning and analysis in the LCA programmatic EIS (2004) and in related coastal restoration efforts such as the Coastal Wetlands Planning, Protection, and Restoration Act.

EPA's comments are intended to help address remaining information gaps while striking a balance with the need to move forward expeditiously with coastal restoration projects in Louisiana. EPA is cognizant that uncertainty with major variables (particularly future relative sea level rise) hampers the ability to accurately predict the impacts and effectiveness of these and other coastal restoration projects. Robust monitoring and adaptive management programs are, therefore, essential. EPA also notes that unlike a new cross-basin levee or other large-scale artificial manipulation of the coastal landscape, these restoration projects generally attempt to mimic natural processes. Thus, the potential environmental downsides of proceeding with coastal restoration projects based on imperfect knowledge are generally more acceptable than would be the case for projects that pose significant potential adverse environmental impacts.

Internet Address (URL) • http://www.epa.gov
Recycled/Recyclable • Printed with Vegetable Oil Based Inks on Recycled Paper (Minimum 25% Postconsumer)

709



2

EPA Region 6 rates the four DSEISs as follows:

- **Small Diversion at Convent/Blind River: "EC-2".** (EPA has environmental concerns and requests additional information in the Final Supplemental Environmental Impact Statement.)
- **Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock: "EC-2".** (EPA has environmental concerns and requests additional information in the Final Supplemental Environmental Impact Statement.)
- **Medium Diversion at White Ditch: "EC-2".** (EPA has environmental concerns and requests additional information in the Final Supplemental Environmental Impact Statement.)
- **Amite River Diversion Canal Modification: "LO".** (EPA's review has no objections and has not identified any potential environmental impacts requiring substantive changes to the preferred alternative.)

EPA continues to support the LCA program as an important step toward greater efforts to restore some semblance of sustainability to parts of coastal Louisiana. To that end, it is important to reiterate that the LCA program in general and these projects in particular represent near-term measures, and should not be mistaken for the larger and more comprehensive effort needed to address coastal wetland loss in Louisiana on the scale and scope warranted. The ongoing oil spill in the Gulf of Mexico and its impacts on Louisiana's valuable coastal wetlands and aquatic resources only underscore this point. Nevertheless, these and other LCA projects can be viewed as stepping stones toward larger and more aggressive projects, and offer valuable learning and adaptive management opportunities that will help in that regard.

The proposed White Ditch project represents the largest and most ambitious use of seasonal, high-river "pulsing" as a technique to increase the environmental benefits of diversions, while reducing potential impacts to existing fisheries. Of the four LCA projects discussed herein, the White Ditch diversion offers the greatest promise for coastal restoration benefits and advancing larger-scale projects. EPA also notes that the Amite River diversion canal gapping project and the proposed Convent/Blind River diversion are not mutually exclusive and could work in concert with the proposed LCA Hope Canal diversion. Although the Blind River/Convent diversion is further along in the NEPA process than Hope Canal, the latter offers a superior opportunity to address ecosystem needs in the Maurepas Swamp. Again, while these projects are not mutually exclusive, EPA encourages expedited implementation of the Hope Canal diversion. Finally, given the relatively high cost to environmental benefit ratio, EPA would not place a high priority on implementation of the Atchafalaya River conveyance project over other LCA restoration projects, such as White Ditch.

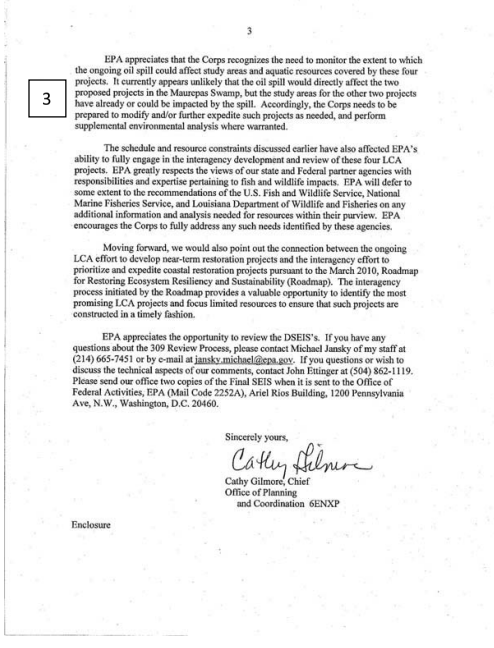
1

2

1. Scoring noted. Additional information has been provided in the Final SEIS.

2. Your statement of support is noted.

710



3

EPA appreciates that the Corps recognizes the need to monitor the extent to which the ongoing oil spill could affect study areas and aquatic resources covered by these four projects. It currently appears unlikely that the oil spill would directly affect the two proposed projects in the Maurepas Swamp, but the study areas for the other two projects have already or could be impacted by the spill. Accordingly, the Corps needs to be prepared to modify and/or further expedite such projects as needed, and perform supplemental environmental analysis where warranted.

The schedule and resource constraints discussed earlier have also affected EPA's ability to fully engage in the interagency development and review of these four LCA projects. EPA greatly respects the views of our state and Federal partner agencies with responsibilities and expertise pertaining to fish and wildlife impacts. EPA will defer to some extent to the recommendations of the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Louisiana Department of Wildlife and Fisheries on any additional information and analysis needed for resources within their purview. EPA encourages the Corps to fully address any such needs identified by these agencies.

Moving forward, we would also point out the connection between the ongoing LCA effort to develop near-term restoration projects and the interagency effort to prioritize and expedite coastal restoration projects pursuant to the March 2010, Roadmap for Restoring Ecosystem Resiliency and Sustainability (Roadmap). The interagency process initiated by the Roadmap provides a valuable opportunity to identify the most promising LCA projects and focus limited resources to ensure that such projects are constructed in a timely fashion.

EPA appreciates the opportunity to review the DSEIS's. If you have any questions about the 309 Review Process, please contact Michael Jansky of my staff at (214) 665-7451 or by e-mail at jansky.michael@epa.gov. If you questions or wish to discuss the technical aspects of our comments, contact John Ettinger at (504) 862-1119. Please send our office two copies of the Final SEIS when it is sent to the Office of Federal Activities, EPA (Mail Code 2252A), Ariel Rios Building, 1200 Pennsylvania Ave, N.W., Washington, D.C. 20460.

Sincerely yours,

Cathy Gilmore, Chief
Office of Planning
and Coordination 6ENXP

Enclosure

3

3. Concur.

711

DETAILED COMMENTS

ON THE DRAFT SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENTS FOR THE SMALL DIVERSION AT CONVENT/BLIND RIVER; CONVEY ATCHAFALAYA RIVER WATER TO NORTHERN TERREBONNE MARSHES AND MULTIPURPOSE OPERATION OF HOUMA NAVIGATION LOCK; MEDIUM DIVERSION AT WHITE DITCH, AND AMITE RIVER DIVERSION CANAL MODIFICATIONS FOR THE LOUISIANA COASTAL AREA

COMMENTS

1. Small Diversion at Convent/Blind River DSEIS, May 2010

In general, additional freshwater and sediments to Maurepas Swamp provided by the proposed diversion is positive for the swamp. A potential downside to diverting existing surface waters and sediments is pollutants in the diverted water could impact the Blind River and Lake Maurepas. While such concerns are manageable, EPA would recommend additional information and analysis pertaining to water quality.

The 2001 Diversion into the Maurepas Swamps study by Lee Wilson & Associates, as well as Batelle's Assessments of Ecological Risks of Contaminants from a Proposed Reintroduction of Mississippi River Water into Maurepas Swamp (Phase I and II, 2005 and 2008, respectively), are cited as support that long term adverse impacts to water quality in the Maurepas Swamp, the Blind River, and Lake Maurepas are not anticipated. Unfortunately, the study area for these documents appears limited to the LCA Small Diversion at Hope Canal project area. While these assumptions may be applicable to a single 1500 cfs diversion, the application of these assumptions to a project diverting twice the amount of water (as in Small Diversion at Convent/Blind River) must account for the difference in scope. EPA notes, however, that if the diverted water flows through the swamp rather than directly to the Blind River and Lake Maurepas, and if the area of swamp is sufficient to reduce pollutants adequately, then this may not be a significant concern.

The LCA Ecosystem Restoration Study Programmatic EIS (2004) recognizes these concerns and suggests that the LCA Plan needs to consider other activities, initiate an aggressive coordination plan with the stakeholders involved, and ensure that all activities including the LCA Plan complement each other. EPA recommends that use of studies for support of these projects acknowledge the limitations and applicability. Additionally, it is suggested that cumulative effects determinations clarify if the assumptions stated are applicable to an existing baseline with no Maurepas Swamp projects other than the single proposed project, or that the cumulative effect includes the additive effects of all related Maurepas Swamp projects.

There is likely continued interest on the part of some landowners to log cypress in the Maurepas Swamp. Given the degraded state of the swamp throughout much of this area, there is a high risk that any such logging would be unsustainable. Such logging could conflict with or undermine this and other proposed restoration efforts for the Maurepas Swamp. Accordingly, this project should include as a non-structural measure a commitment to full and effective enforcement of Clean Water Act Section 404 and/or Section 10 of the Rivers and Harbors Act as such laws pertain to logging, particularly where unsustainable.

The ongoing Corps of Engineers West Shore Lake Pontchartrain Hurricane Protection Study is reviewing different levee alignments in the vicinity of this proposed project. At least one of these levee alignments ("Alignment D") would further enclose the cypress swamp that would be benefited by this proposed diversion. There is no discussion of how these two projects would or would not work in concert to achieve the desired ecosystem restoration goals. EPA is concerned that levee alignments which enclose wetlands can result in significant direct, indirect, and cumulative adverse ecological impacts that would be contrary to the LCA Plan in general and this project in particular. The supplemental EIS should explain how any such levee work would be coordinated with the proposed for Convent/Blind River diversion, such that the former does not conflict with or undermine the latter.

Specific comments:

a. It is understood that the Romeville diversion (Alt 2) is the preferred alternative and if implemented will use existing St. James Parish drainage canals. Insufficient data is available to determine if this design addresses the concerns raised in the 2001 Lee Wilson report on Diversions into the Maurepas Swamps regarding diverted Mississippi River water reaching the Blind River directly with most diverted water directly delivered to Lake Maurepas as result. EPA recommends hydrologic modeling efforts to better identify/quantify how water (sediment and nutrients) moves through the system and within each hydrologic unit under the proposed operation plan along with determination of water levels and swamp flood elevations on a refined scale to be incorporated into the hydrologic modeling. Similar comments have been made by the United States Fish and Wildlife Service (USFWS) in its draft Fish and Wildlife Coordination Act report.

b. Page 4-32 through 4-27: Water Quality Concerns – Tables of water quality information do not provide adequate information to support decisions of environmental consequences i.e., data over ten years old suggests that Blind River has levels of copper where mean value is both acutely and chronically toxic to aquatic life. However, no 303(d) listing noted currently. EPA recommends that analytical data be appropriately annotated as to location of monitoring point, hardness of water at that monitoring point and applicable hardness dependent criteria at that point. Also note if analysis yielded total or dissolved pollutant.

c. Pages 4-32: Water Quality Concerns - Descriptions of conditions for Lower Mississippi River found on Page 4-32 suggest that volatile organic carbon (VOC) analysis was performed. Data is not presented nor is an explanation of results provided.

d. Page 4-32 : Water Quality Concerns - According to the DSEIS, the LDEQ 2006 Integrated Report both the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) designated uses were fully supported, while Fish and Wildlife Propagation (FWP) and Outstanding Natural Resource (ONR) uses are not supported. The suspected causes of impairment for the FWP designated use were mercury, nitrate/nitrite, non-native aquatic plants, total phosphorus (TP), and turbidity. The suspected sources for mercury were listed as atmospheric deposition and unknown sources. Site clearance (land development or redevelopment) and flow alterations from water diversions were listed as the suspected sources for nitrate/nitrite, dissolved oxygen (DO), and TP. The suspected causes of impairment for the ONR designated use were sedimentation/siltation and turbidity, which are believed to be caused by site clearance.

(1) In light of these impairments, the SEIS should more clearly describe the impacts on the Blind River from diverted Mississippi River water through the swamp and thus to the River. In light of an annual estimate of sediment load to Blind River and Maurepas Swamp of approximately 505,000,000 kg/yr (Page 5-51, Line 2) discuss how sediment loading in return flows (throughput from swamp to River) could affect water quality in the study area. Here again, hydrology is key with respect to such issues. Work on the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) Maurepas Diversion project suggests that if the diversion is routed through a swamp receiving area of sufficient size virtually all sediment will be deposited in the swamp.

(2) Page 3-104, Line 28 and Appendix I: In light of current mercury impairments in the Blind River and mercury levels in diverted Mississippi River water, the SEIS should more clearly describe additional mercury loading and methylation risks to the swamp as well as to the Blind River and Lake Maurepaus. Appendix I (Adaptive Management and Monitoring Plan)(Page 10) and DSEIS suggest nutrients are a risk (Page 3-104, Line 28); however, mercury is not mentioned as a risk. EPA recommends periodic monitoring for mercury increases in swamp (sediments, fish tissue) or receiving waters (Blind River/Lake Maurepaus; sediments, fish tissue), along with consideration of what/if any impacts to aquatic life, migratory birds and listed species might be associated with such water quality issues. (Battelle. 2007. Limited Phase II Assessment of Ecological Risks of Contaminants from a Proposed Reintroduction of Mississippi River Water into Maurepas Swamp. Report from EPA Region 6. EPA Contract No. 68-C-03-041, Work Assignment No 4-40.)

(3) Page 3-104, Line 28 and Appendix I: In light of current metals water column levels in the Blind River and metals levels in diverted Mississippi River water, the SEIS should more clearly describe additional metals loading risks to the swamp as well as to the Blind River and Lake Maurepaus. Appendix I (Adaptive Management and Monitoring Plan)(Page 10) and draft SEIS suggest nutrients are a risk (Page 3-104, Line 28); however, metals not mentioned as a risk . EPA recommends monitoring for metals increases in swamp (sediments, fish tissue).

e. Page 3-102, Line 3-102 and Appendix I: Objectives stated in DEIS on Page 3-102 (beginning at Line 34) and Appendix I (page 10) are not in sync. Ensure that monitoring design supports objective. For example, Objective 1 (EIS) suggests decreases in nitrogen and phosphorus and DO increases but has no monitoring design associated. Objective 1 (Appendix I) does not include water quality at all. Recommend a separate objective for water quality or include as a risk with monitoring design.

f. Page 4-36, Line 10: States **4.2.3.2 Blind River and Maurepaus Swamp.** See no information on the swamp.

g. Page 3 – 37, Line 17: blind river should be revised to Blind River.

h. Page 3-16, Table 3-1: Comments for TS-3 to TS-6 are wrong. Comments column narrative needs to shift down.

i. Beginning at Page 5-1, **5 Environmental Consequences**: Ensure continuity throughout this section regarding the complimentary projects of Hope Canal and Amite River Canal Diversions. The Hope Canal project is typically discussed in the "no action" alternative. Studies have been performed on the concept of a 1500 cubic feet per second (cfs) diversion impacts to the swamp (as part of the Maurepas Diversion project under the CWPPRA program), the Blind River and Lake Maurepas. Ensure that implications of these studies are applicable to the Convent/Blind Diversion, since this preferred alternative is for a proposed diversion of 3000 cfs.

j. Readability would be enhanced if the document would spell out the meaning of acronyms upon first usage, i.e., ADCIRC, PCR, SCR, and ONR.

2. Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock DSEIS, May 2010

WRDA 2007 included authorization for feasibility-level reports of six of the ten near-term elements in the 2004 LCA Report. Two of those six elements were determined to be hydrologically intertwined and the planning efforts were subsequently combined. Consequently, the projects known as Convey Atchafalaya to Northern Terrebonne Marsh and Multipurpose

5

Operation of the Houma Navigation Lock were integrated into the Pre-Decisional Draft Integrated Feasibility Study and EIS for the Convey Atchafalaya River Water to Northern Terrebonne Marshes and Multipurpose Operation of Houma Navigation Lock (LCA ARTM/MOHNL Project) and it is the later document, published in May 2010, to which these comments apply.

The objective of the project is to provide additional freshwater, nutrients, and sediments to the wetland communities of northwestern Terrebonne Basin, both north and south of the Gulf Intracoastal Waterway, which have exhibited accelerated wetland loss and ecosystem deterioration due to altered hydrology, reduced sediment and nutrient deposition, saltwater intrusion, tidally forced erosion, and subsidence. Currently, net primary productivity is declining and land loss is increasing, with existing fragmented emergent wetlands converting to shallow open water. According to United States Geological Survey (USGS) analyses, the overall rate of land loss in this area is 2,597 acres/year, or approximately 0.3 percent per year. If current conditions persist, it is predicted that 102,000 acres (18%) of remaining wetlands would decline over the next 50 years. Even more dramatic losses would be expected within several of the study subunits, with the loss of all emergent wetlands within the next 50 years.

As part of the feasibility study, multiple alternatives were developed incorporating a large array of treatment measures to be applied over the 1,100 square mile study area. The resulting Tentatively Selected Plan (TSP) is predicted to reduce the loss of 9,655 acres of marsh habitat (3,220 average annual habitat units (AAHUs)) at a cost of $311,030,000, including monitoring and adaptive management costs.

Of the alternatives studied, Alternative 2 is identified by the Corps and the interagency team as the TSP and it is also identified as the National Ecosystem Restoration Plan (NER). TSP fits the cost limitations of WRDA 2007 and is the most efficient plan from an incremental cost per average annualized habitat unit (AAHU) perspective. The TSP/NER plan involves construction of 56 structures and other water management features, as well as the opportunistic operation of the Houma Navigation Canal (HNC) Lock Complex, in an effort to address holistically the declining health of the Terrebonne marsh ecosystem, while meeting the planning objectives.

EPA supports the rationale provided for defining the NER plan and EPA further support the selection of Alternative 2 as the TSP. EPA does so in light of the urgency of addressing dramatic wetland habitat loss and degradation in the study area, while recognizing that there are a number of technical and design uncertainties yet to be worked through. The tight schedule under which this DSEIS was prepared resulted in publication of the document before all planning evaluations have been completed. While EPA believes this work should be completed prior to final plan approval, EPA does not believe that these analyses will alter the alternatives ranking. Therefore, EPA recommends that final approval of the TSP/NER plan be conditioned upon

completion of additional modeling and hydrology work needed prior to final project design and implementation of the plan. See the USFWS's May 2010 Draft Fish and Wildlife Coordination Act Report for details (Vol. III, Appendix B, pages 47-49).

EPA's support for the TSP is also predicated on the potential for adaptively responding to continually refined data, according to the management and monitoring plan (Vol. III, Appendix I). The incorporation of a monitoring plan and the commitment to adaptive management is a vital component for dealing with the uncertainties associated with the ecosystem modeling and for coordinating this project with other planned and future restoration and storm damage risk reduction projects in the area.

While this plan represents a valuable contribution to reducing the ecosystem degradation in the study area, a sustainable and resilient coastal ecosystem will quite likely require additional hydrologic manipulations. It is unlikely that this project alone will result in a sustainable ecosystem. The project features will not actively introduce additional sediment, nutrients, and freshwater from other sources. It will instead redistribute and more efficiently utilize existing freshwater within the system.

With that frame of reference, the project cost of $311,030,000 deserves careful consideration. Although the benefit area of the project is large and the ecosystem values to the nation are great, the cost is high and the benefits are incremental. These first cost benefits to the nation will only be realized if a future commitment is made to augment this project with additional hydrologic manipulations at a landscape scale.

This point cannot be overemphasized. As noted in the report, "[t]he project area is declining and imperiled. While the project cannot stop the natural processes of sea level rise, subsidence, and storm-caused erosion, the project can greatly slow down the disappearance of these landforms by decreasing the rate of decline of wetland habitat in the coastal system" (Vol. I, page 4-61).

Relative sea level rise (RSLR) evaluation curves were developed for three different sea level rise scenarios. The TSP/NER plan would provide benefits under the low and the intermediate RSLR scenarios. However, at the high RSLR rate, "marsh collapse is predicted to begin in 2017, when RSLR rate reaches 10 mm/yr. This rate represents a threshold believed to initiate rapid marsh collapse." None of the alternatives would prevent marsh collapse at the high RSLR rate. Once again, this is a large investment for benefits which will require additional treatment efforts to insure sustainability beyond the next seven years. This is too large an investment not to be part of a comprehensive plan of attack.

This project holds the promise of reducing additional wetland losses by some 9,655 acres. That is a far different scenario than "resulting in a net gain of 9,655 acres," as cited in various

sections throughout the reports, in both Volumes I and III. This is a significant correction which should be made in the Final EIS.

The correction should start at the top, with Objective 1: "Prevent, reduce, and/or reverse future wetland loss" and Objective 2: "Achieve and maintain characteristics of sustainable marsh hydrology." These goals are worthy of a more comprehensive approach with a larger scope than this near term project affords. As stated in the reports, the desired outcome seems to stop short of the objectives by establishing a measure of "reducing the rate of land loss compared to the pre-project condition." These outcomes appear to be achievable but they do not line up well with the more aggressive objectives. This is also a significant correction which should be made in the Final EIS.

Perhaps another project objective should be to optimize delta building, or at least to avoid negatively impacting ongoing Atchafalaya Delta building processes. The Atchafalaya River is building the only two actively growing deltas on the Louisiana coast. Although these active deltas are growing, they have not offset the land loss in this basin. However, they represent part of the ecosystem that is functioning in a positive trend and that should be valued and protected.

One of the more notable project uncertainties involves the construction and operation of the HNC lock complex for environmental purposes after the year 2025. The HNC lock complex is a feature of the Morganza to the Gulf project. If the lock complex is not constructed or if it is not operated as envisioned by this project, all benefits attributed to that feature will be unrealized. Accordingly, the Final EIS should provide an analysis of benefits (including the calculation of a benefit/cost ratio) both with and without the implementation of this feature.

The Final SEIS should clarify the implications for this project of the Corps' ongoing study to deepen the HNC channel. Also, the Final should clarify the lock closure conditions which were analyzed. In various sections of Volume III, those conditions are reported to include periods when the sector gates would not be closed, while other references infer that the modeling assumed constant closure. Finally, the Final SEIS should provide a plan for operating the sluice gates and it should explain how that operation would be anticipated to impact basin hydrology and consequent ecosystem health and sustainability.

Another area for further consideration involves statements in both Volumes I and III that the floating marshes in the upper Penchant Basin are currently stable and experiencing conditions where sufficient freshwater, nutrient, and sediment loads are being provided. Without further documentation, this conclusion would seem to overstate the current condition of these marshes. At a minimum, the vulnerability of these fragile marshes should be taken into account in the project planning. Based on a study conducted for EPA (Floating Marshes in the Barataria and Terrebonne Basins, Louisiana, Sept. 1994, Charles E. Sasser et al. (LSU-CEI-94-02)), notable changes to these marshes have occurred over the last several decades.

Six of the study sites in the Louisiana State University (LSU) project lie within the LCA ARTM/MOHNL Project study area. Based on habitat mapping and the results of other work by the same researchers, some floating marsh habitats have changed over the last several decades from one type of flotant to another type, or to open water. In the northern Terrebonne basin and upper Bayou Penchant basin, large areas of formerly *Panicum hemitomon* thick-mat flotant marsh converted to thin-mat *Eleocharis* flotant marshes or to open water. While much remains unknown as to what processes have operated on these areas to produce such dramatically different results, possible contributors include: altered hydrology due to canal construction and dredging; flux of organic material from the marsh due to hydrologic changes; nutria herbivory; nutrient dynamics due to altered hydrology; burning; and floods/storms.

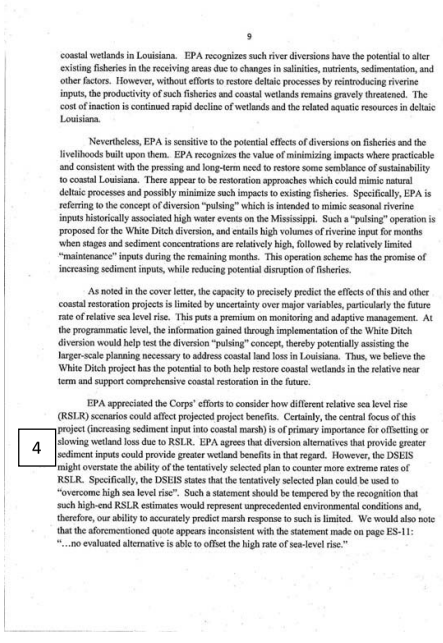
With regard to compensatory mitigation, the report states that "[t]emporary negative impacts to the marsh associated with excavation of canals and management structures will be compensated for by creation of new marsh of better quality as a result of the reintroduction of freshwater, nutrients, and sediments into the Study Area" (Vol. I, page 4-68 and Vol. III, Section 3, page 49). The more likely case is that marsh degradation will be slowed by these measures. Additional marsh creation should be considered, however, if excess dredged material is available beyond that which is required for canal bank construction. In addition, all actions identified in the Clean Water Act Section 404(b) evaluation to minimize impact should be incorporated into the final plan.

Finally, EPA suggests that, to the degree possible, the Final EIS include an updated assessment of the Deepwater Horizon oil spill impacts to the Terrebonne basin ecological resources subject to this project proposal. The baseline conditions should be modified as necessary and a projection of the potential for the TSP/NER plan, or any individual features of other alternatives, for remediating those impacts should be considered. The TSP/NEP plan should be modified if the incorporation of other features could reasonably be expected to provide incremental benefits to protect the marshes from further oil spill damage under non-storm and/or storm conditions.

As a partner with the Corps of Engineers and others in the restoration of coastal Louisiana, EPA offers these comments in an effort to promote the most effective long-term wetlands protection and restoration strategy for the study area. This near term project could provide a platform for a sustainable coastal ecosystem, when viewed in tandem with measures to provide additional inputs of sediments and flows.

3. Medium Diversion at White Ditch DSEIS, May 2010

As noted in our cover letter, EPA supports the proposed White Ditch diversion. It is consistent with our long-standing priority of re-establishing Mississippi River inputs to help undo to some extent the major disruption of deltaic processes that underlies the ongoing loss of



9

coastal wetlands in Louisiana. EPA recognizes such river diversions have the potential to alter existing fisheries in the receiving areas due to changes in salinities, nutrients, sedimentation, and other factors. However, without efforts to restore deltaic processes by reintroducing riverine inputs, the productivity of such fisheries and coastal wetlands remains gravely threatened. The cost of inaction is continued rapid decline of wetlands and the related aquatic resources in deltaic Louisiana.

Nevertheless, EPA is sensitive to the potential effects of diversions on fisheries and the livelihoods built upon them. EPA recognizes the value of minimizing impacts where practicable and consistent with the pressing and long-term need to restore some semblance of sustainability to coastal Louisiana. There appear to be restoration approaches which could mimic natural deltaic processes and possibly minimize such impacts to existing fisheries. Specifically, EPA is referring to the concept of diversion "pulsing" which is intended to mimic seasonal riverine inputs historically associated high water events on the Mississippi. Such a "pulsing" operation is proposed for the White Ditch diversion, and entails high volumes of riverine input for months when stages and sediment concentrations are relatively high, followed by relatively limited "maintenance" inputs during the remaining months. This operation scheme has the promise of increasing sediment inputs, while reducing potential disruption of fisheries.

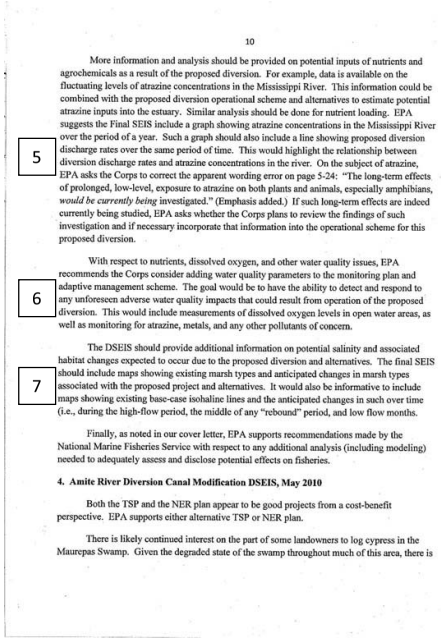
As noted in the cover letter, the capacity to precisely predict the effects of this and other coastal restoration projects is limited by uncertainty over major variables, particularly the future rate of relative sea level rise. This puts a premium on monitoring and adaptive management. At the programmatic level, the information gained through implementation of the White Ditch diversion would help test the diversion "pulsing" concept, thereby potentially assisting the larger-scale planning necessary to address coastal land loss in Louisiana. Thus, we believe the White Ditch project has the potential to both help restore coastal wetlands in the relative near term and support comprehensive coastal restoration in the future.

EPA appreciated the Corps' efforts to consider how different relative sea level rise (RSLR) scenarios could affect projected project benefits. Certainly, the central focus of this project (increasing sediment input into coastal marsh) is of primary importance for offsetting or slowing wetland loss due to RSLR. EPA agrees that diversion alternatives that provide greater sediment inputs could provide greater wetland benefits in that regard. However, the DSEIS might overstate the ability of the tentatively selected plan to counter more extreme rates of RSLR. Specifically, the DSEIS states that the tentatively selected plan could be used to "overcome high sea level rise". Such a statement should be tempered by the recognition that such high-end RSLR estimates would represent unprecedented environmental conditions and, therefore, our ability to accurately predict marsh response to such is limited. We would also note that the aforementioned quote appears inconsistent with the statement made on page ES-11: "…no evaluated alternative is able to offset the high rate of sea-level rise."

4

4. Concur. The sentence on Page ES-11 has been reworded to state, "…no evaluated alternative is able to entirely offset the high rate of sea-level rise."

720



10

More information and analysis should be provided on potential inputs of nutrients and agrochemicals as a result of the proposed diversion. For example, data is available on the fluctuating levels of atrazine concentrations in the Mississippi River. This information could be combined with the proposed diversion operational scheme and alternatives to estimate potential atrazine inputs into the estuary. Similar analysis should be done for nutrient loading. EPA suggests the Final SEIS include a graph showing atrazine concentrations in the Mississippi River over the period of a year. Such a graph should also include a line showing proposed diversion discharge rates over the same period of time. This would highlight the relationship between diversion discharge rates and atrazine concentrations in the river. On the subject of atrazine, EPA asks the Corps to correct the apparent wording error on page 5-24: "The long-term effects of prolonged, low-level, exposure to atrazine on both plants and animals, especially amphibians, *would be currently being* investigated." (Emphasis added.) If such long-term effects are indeed currently being studied, EPA asks whether the Corps plans to review the findings of such investigation and if necessary incorporate that information into the operational scheme for this proposed diversion.

5

With respect to nutrients, dissolved oxygen, and other water quality issues, EPA recommends the Corps consider adding water quality parameters to the monitoring plan and adaptive management scheme. The goal would be to have the ability to detect and respond to any unforeseen adverse water quality impacts that could result from operation of the proposed diversion. This would include measurements of dissolved oxygen levels in open water areas, as well as monitoring for atrazine, metals, and any other pollutants of concern.

6

The DSEIS should provide additional information on potential salinity and associated habitat changes expected to occur due to the proposed diversion and alternatives. The final SEIS should include maps showing existing marsh types and anticipated changes in marsh types associated with the proposed project and alternatives. It would also be informative to include maps showing existing base-case isohaline lines and the anticipated changes in such over time (i.e., during the high-flow period, the middle of any "rebound" period, and low flow months.

7

Finally, as noted in our cover letter, EPA supports recommendations made by the National Marine Fisheries Service with respect to any additional analysis (including modeling) needed to adequately assess and disclose potential effects on fisheries.

4. Amite River Diversion Canal Modification DSEIS, May 2010

Both the TSP and the NER plan appear to be good projects from a cost-benefit perspective. EPA supports either alternative TSP or NER plan.

There is likely continued interest on the part of some landowners to log cypress in the Maurepas Swamp. Given the degraded state of the swamp throughout much of this area, there is

5. The sentence should read "are currently being studied and during the PED phase this information along with all other pertinent Water Quality information will be used to develop monitoring plans and determine what the operational scheme for the proposed diversion".

6. Response: Improving water quality is not a stated objective of the White Ditch project. However, excess nutrification is a risk endpoint and nutrient monitoring is proposed. The concern for atrazine, metals and other pollutants are noted; however, the Adaptive Management Framework Team does not know how monitoring information on these parameters would yield any adaptive management actions. This additional monitoring can be reconsidered during PED.

7. Section 5.3.2.2.1 was revised to more accurately and adequately explain the anticipated changes to salinity regimes based on the year long modeling run. Figure 4.1 shows habitat changes over the past century. Figure 4.2 shows the existing habitat in the Breton Sound Area. A year long WVA analysis was not possible due to time constraints. Even if a WVA had been used predict habitat changes based on the year long run, it would difficult to accurately predict where these would occur. Therefore a map of predicted changes will not be included. Changes in isohaline lines are also very difficult to accurately predict and could vary every year. The regime modeled was one of a multitude that could have been considered. It could be misleading to include a map of isohaline lines based solely on one operating scenario. In fact, it is likely that actual operation regimes would be different than those modeled. Structure operations could be managed to achieve specific results.

a high risk that any such logging would be unsustainable. Such logging could conflict with or undermine this and other proposed restoration efforts for the Maurepas Swamp. Accordingly, this project should include as a non-structural measure a commitment to full and effective enforcement of Clean Water Act Section 404 and/or Section 10 of the Rivers and Harbors Act as such laws pertain to logging.

The Fish and Wildlife Coordination Act report dated April 2010 and attached at Appendix B is not discussed in the DEIS. Additionally, pages appear to be missing from the report at Attachment B, namely, the USFWS recommendations.

Finally, the cumulative impacts do not include the additive impacts that would be expected from construction of this project in conjunction with the other two Maurepas Swamp diversion projects – Hope Canal and Convent/Blind River.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701

July 1, 2010 F/SER46/RH
225/389-0508

Ms. Joan Exnicios, Chief
Environmental Planning & Compliance Branch
Planning, Programs & Management Division
New Orleans District, US Army Corps of Engineers
Post Office 60267
New Orleans, LA 70160-0267

Dear Ms. Exnicios:

The NOAA's National Marine Fisheries Service (NMFS) has reviewed the Pre-Decisional Draft Integrated Feasibility Study and Supplemental Environmental Impact Statement (SEIS) for the Louisiana Coastal Area Medium Diversion at White Ditch Project, Plaquemines Parish, Louisiana. This document was transmitted for our review by your letter dated May 21, 2010. As indicated in the transmittal letter, submittal of the document to NMFS initiates essential fish habitat (EFH) consultation as required by provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) (P.L. 104-297).

The tentatively selected plan (Alternative 4) calls for construction of ten, 15-foot-high by 15-foot-wide box culverts in the east levee of the Mississippi River near Phoenix, Louisiana. The culverts would divert river water and sediment into the River aux Chenes sub-basin and other portions of upper Breton Sound to restore and protect wetland vegetation and soils and maintain a functional salinity regime. Operational aspects of the plan include an annual pulse diversion of up to 35,000 cubic feet per second (cfs) during the March 1 to April 30 period of each year and 1,000 cfs monthly flows the remainder of the year. Project benefits based on the results of Wetland Value Assessment modeling include maintenance of 41,206 acres of existing wetlands that would otherwise be lost to subsidence and other natural and anthropogenic causes. Other components of the planned action include restoration of more than 20,000 acres of fresh, intermediate, brackish, and saline wetlands and the creation of 31 acres of ridge hardwood forest. Some of the material for wetland restoration and ridge creation would be obtained from the creation of a diversion channel that is estimated to impact more than 220 acres of existing wetlands and water bottoms.

NMFS previously provided planning aid comments on the project by letter dated February 10, 2009 and via electronic mail on February 1, 2010. The following comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) and 600.920 of the Magnuson-Stevens Act.

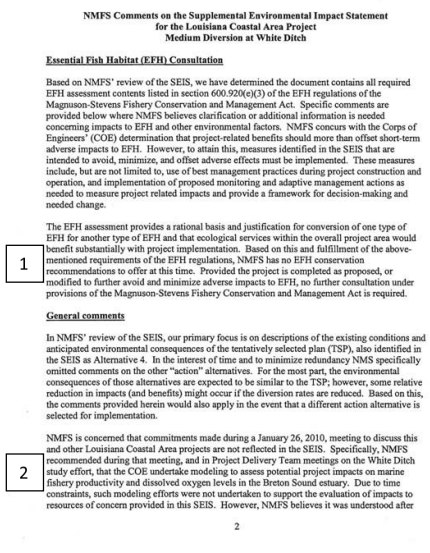
Thank you for considering these comments. If you wish to discuss this project further, please contact Mr. Richard Hartman at (225) 389-0508, extension 203.

Sincerely,

Miles M. Croom

Miles M. Croom
Assistant Regional Administrator
Habitat Conservation Division

8



NMFS Comments on the Supplemental Environmental Impact Statement for the Louisiana Coastal Area Project Medium Diversion at White Ditch

Essential Fish Habitat (EFH) Consultation

Based on NMFS' review of the SEIS, we have determined the document contains all required EFH assessment contents listed in section 600.920(e)(3) of the EFH regulations of the Magnuson-Stevens Fishery Conservation and Management Act. Specific comments are provided below where NMFS believes clarification or additional information is needed concerning impacts to EFH and other environmental factors. NMFS concurs with the Corps of Engineers' (COE) determination that project-related benefits should more than offset short-term adverse impacts to EFH. However, to attain this, measures identified in the SEIS that are intended to avoid, minimize, and offset adverse effects must be implemented. These measures include, but are not limited to, use of best management practices during project construction and operation, and implementation of proposed monitoring and adaptive management actions as needed to measure project related impacts and provide a framework for decision-making and needed change.

The EFH assessment provides a rational basis and justification for conversion of one type of EFH for another type of EFH and that ecological services within the overall project area would benefit substantially with project implementation. Based on this and fulfillment of the above-mentioned requirements of the EFH regulations, NMFS has no EFH conservation recommendations to offer at this time. Provided the project is completed as proposed, or modified to further avoid and minimize adverse impacts to EFH, no further consultation under provisions of the Magnuson-Stevens Fishery Conservation and Management Act is required.

1

General comments

In NMFS' review of the SEIS, our primary focus is on descriptions of the existing conditions and anticipated environmental consequences of the tentatively selected plan (TSP), also identified in the SEIS as Alternative 4. In the interest of time and to minimize redundancy NMS specifically omitted comments on the other "action" alternatives. For the most part, the environmental consequences of those alternatives are expected to be similar to the TSP; however, some relative reduction in impacts (and benefits) might occur if the diversion rates are reduced. Based on this, the comments provided herein would also apply in the event that a different action alternative is selected for implementation.

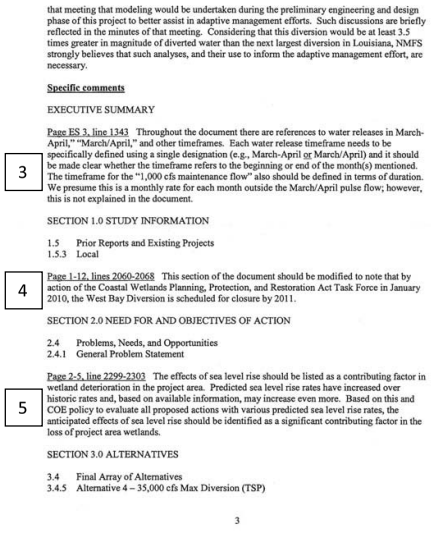
NMFS is concerned that commitments made during a January 26, 2010, meeting to discuss this and other Louisiana Coastal Area projects are not reflected in the SEIS. Specifically, NMFS recommended during that meeting, and in Project Delivery Team meetings on the White Ditch study effort, that the COE undertake modeling to assess potential project impacts on marine fishery productivity and dissolved oxygen levels in the Breton Sound estuary. Due to time constraints, such modeling efforts were not undertaken to support the evaluation of impacts to resources of concern provided in this SEIS. However, NMFS believes it was understood after

2

2

1. Comment is noted. The Corps will continue to work with the LADNR-OCPR and other State and Federal agencies during the PED phase of the project to identify and evaluate opportunities to avoid or minimize adverse impacts to EFH.

2. Concur: The document will be updated to include the phrasing "Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the Corps for the PED Phase. At this time a SOW is being developed as part of the Donaldsonville to the Gulf project to look a various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project."



that meeting that modeling would be undertaken during the preliminary engineering and design phase of this project to better assist in adaptive management efforts. Such discussions are briefly reflected in the minutes of that meeting. Considering that this diversion would be at least 3.5 times greater in magnitude of diverted water than the next largest diversion in Louisiana, NMFS strongly believes that such analyses, and their use to inform the adaptive management effort, are necessary.

Specific comments

EXECUTIVE SUMMARY

Page ES 3, line 1343 Throughout the document there are references to water releases in March-April," "March/April," and other timeframes. Each water release timeframe needs to be specifically defined using a single designation (e.g., March-April or March/April) and it should be made clear whether the timeframe refers to the beginning or end of the month(s) mentioned. The timeframe for the "1,000 cfs maintenance flow" also should be defined in terms of duration. We presume this is a monthly rate for each month outside the March/April pulse flow; however, this is not explained in the document.

3

SECTION 1.0 STUDY INFORMATION

1.5 Prior Reports and Existing Projects
1.5.3 Local

Page 1-12, lines 2060-2068 This section of the document should be modified to note that by action of the Coastal Wetlands Planning, Protection, and Restoration Act Task Force in January 2010, the West Bay Diversion is scheduled for closure by 2011.

4

SECTION 2.0 NEED FOR AND OBJECTIVES OF ACTION

2.4 Problems, Needs, and Opportunities
2.4.1 General Problem Statement

Page 2-5, line 2299-2303 The effects of sea level rise should be listed as a contributing factor in wetland deterioration in the project area. Predicted sea level rise rates have increased over historic rates and, based on available information, may increase even more. Based on this and COE policy to evaluate all proposed actions with various predicted sea level rise rates, the anticipated effects of sea level rise should be identified as a significant contributing factor in the loss of project area wetlands.

5

SECTION 3.0 ALTERNATIVES

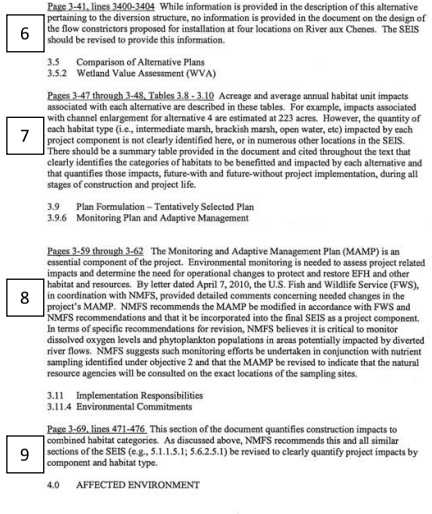
3.4 Final Array of Alternatives
3.4.5 Alternative 4 – 35,000 cfs Max Diversion (TSP)

3

3. Concur. The document has been edited to reduce or eliminate inconsistencies in terminology and labeling where possible.

4. Concur: The suggested change has been incorporated into the report document

5. Concur. A summary of the sea level rise effects has been added to Page 2-5 as a contributing factor to wetland loss and deterioration.



6

Page 3-41, lines 3400-3404 While information is provided in the description of this alternative pertaining to the diversion structure, no information is provided in the document on the design of the flow constrictors proposed for installation at four locations on River aux Chenes. The SEIS should be revised to provide this information.

3.5 Comparison of Alternative Plans
3.5.2 Wetland Value Assessment (WVA)

7

Pages 3-47 through 3-48, Tables 3.8 - 3.10 Acreage and average annual habitat unit impacts associated with each alternative are described in these tables. For example, impacts associated with channel enlargement for alternative 4 are estimated at 223 acres. However, the quantity of each habitat type (i.e., intermediate marsh, brackish marsh, open water, etc) impacted by each project component is not clearly identified here, or in numerous other locations in the SEIS. There should be a summary table provided in the document and cited throughout the text that clearly identifies the categories of habitats to be benefitted and impacted by each alternative and that quantifies those impacts, future-with and future-without project implementation, during all stages of construction and project life.

3.9 Plan Formulation – Tentatively Selected Plan
3.9.6 Monitoring Plan and Adaptive Management

8

Pages 3-59 through 3-62 The Monitoring and Adaptive Management Plan (MAMP) is an essential component of the project. Environmental monitoring is needed to assess project related impacts and determine the need for operational changes to protect and restore EFH and other habitat and resources. By letter dated April 7, 2010, the U.S. Fish and Wildlife Service (FWS), in coordination with NMFS, provided detailed comments concerning needed changes in the project's MAMP. NMFS recommends the MAMP be modified in accordance with FWS and NMFS recommendations and that it be incorporated into the final SEIS as a project component. In terms of specific recommendations for revision, NMFS believes it is critical to monitor dissolved oxygen levels and phytoplankton populations in areas potentially impacted by diverted river flows. NMFS suggests such monitoring efforts be undertaken in conjunction with nutrient sampling identified under objective 2 and that the MAMP be revised to indicate that the natural resource agencies will be consulted on the exact locations of the sampling sites.

3.11 Implementation Responsibilities
3.11.4 Environmental Commitments

9

Page 3-69, lines 471-476 This section of the document quantifies construction impacts to combined habitat categories. As discussed above, NMFS recommends this and all similar sections of the SEIS (e.g., 5.1.1.5.1; 5.6.2.5.1) be revised to clearly quantify project impacts by component and habitat type.

4.0 AFFECTED ENVIRONMENT

4

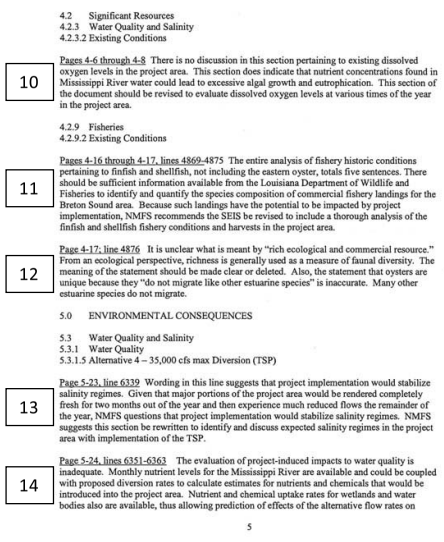
6. Concur. Additional information on the design of flow constrictors (now relabeled as notched weirs) has been added to the text of the document.

7. Revised WVA numbers and acres affected have been added to Appendix B of the final document.

8. Response: Section 1.3 of Appendix I states the intention of the USACE to engage NOAA/NMFS and other federal resource agencies as participants in the adaptive management program for this project. This engagement will include the selection of exact locations for sampling sites. The Adaptive Management Framework Team is not clear as to how this additional monitoring information will guide adaptive management decisions. Therefore, it has not been added. This additional monitoring can be reconsidered during PED.

9. Revised WVA numbers and acres affected have been added to Appendix B of the final document.

727



4.2 Significant Resources
4.2.3 Water Quality and Salinity
4.2.3.2 Existing Conditions

10 Pages 4-6 through 4-8 There is no discussion in this section pertaining to existing dissolved oxygen levels in the project area. This section does indicate that nutrient concentrations found in Mississippi River water could lead to excessive algal growth and eutrophication. This section of the document should be revised to evaluate dissolved oxygen levels at various times of the year in the project area.

4.2.9 Fisheries
4.2.9.2 Existing Conditions

11 Pages 4-16 through 4-17, lines 4869-4875 The entire analysis of fishery historic conditions pertaining to finfish and shellfish, not including the eastern oyster, totals five sentences. There should be sufficient information available from the Louisiana Department of Wildlife and Fisheries to identify and quantify the species composition of commercial fishery landings for the Breton Sound area. Because such landings have the potential to be impacted by project implementation, NMFS recommends the SEIS be revised to include a thorough analysis of the finfish and shellfish fishery conditions and harvests in the project area.

12 Page 4-17; line 4876 It is unclear what is meant by "rich ecological and commercial resource." From an ecological perspective, richness is generally used as a measure of faunal diversity. The meaning of the statement should be made clear or deleted. Also, the statement that oysters are unique because they "do not migrate like other estuarine species" is inaccurate. Many other estuarine species do not migrate.

5.0 ENVIRONMENTAL CONSEQUENCES

5.3 Water Quality and Salinity
5.3.1 Water Quality
5.3.1.5 Alternative 4 – 35,000 cfs max Diversion (TSP)

13 Page 5-23, line 6339 Wording in this line suggests that project implementation would stabilize salinity regimes. Given that major portions of the project area would be rendered completely fresh for two months out of the year and then experience much reduced flows the remainder of the year, NMFS questions that project implementation would stabilize salinity regimes. NMFS suggests this section be rewritten to identify and discuss expected salinity regimes in the project area with implementation of the TSP.

14 Page 5-24, lines 6351-6363 The evaluation of project-induced impacts to water quality is inadequate. Monthly nutrient levels for the Mississippi River are available and could be coupled with proposed diversion rates to calculate estimates for nutrients and chemicals that would be introduced into the project area. Nutrient and chemical uptake rates for wetlands and water bodies also are available, thus allowing prediction of effects of the alternative flow rates on

5

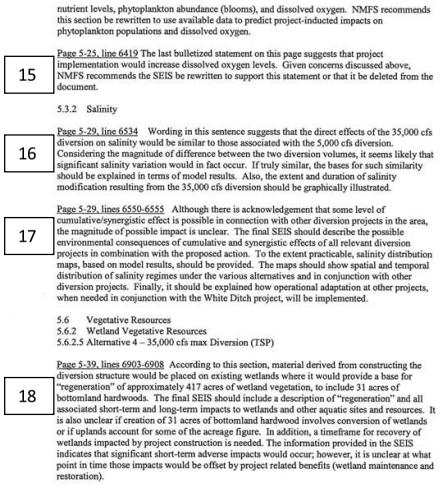
10. Dissolved oxygen levels throughout the project area are highly variable and dependent on many factors. Field monitoring protocols and techniques will be established in a monitoring plan developed cooperatively with appropriate stakeholders. This plan will address dissolved oxygen along with a multitude of other parameters within the project boundaries. Pre-project DO levels will be captured during PED to establish a baseline for adaptive management.

11. Additional text has been added to Section 4.2.9 of the final document.

12. Concur: Text has been revised.

13. The text referred to by the comment was removed Section 5.3.1.5.1. Salinity is discussed in much more detail in the following Section 5.3.2. 5.3.2.2.1 was revised to more accurately and adequately explain the anticipated changes to salinity regimes.

14. Pre-project monitoring would be scheduled during the PED phase of the project. This will allow for modeling and loading calculations for nutrients and other parameters determined to be of value to the project. This will be included in the monitoring plan developed cooperatively with appropriate stakeholders to ensure the best data is collected to aid in the adaptive management of the project.



nutrient levels, phytoplankton abundance (blooms), and dissolved oxygen. NMFS recommends this section be rewritten to use available data to predict project-inducted impacts on phytoplankton populations and dissolved oxygen.

15 Page 5-25, line 6419 The last bulletized statement on this page suggests that project implementation would increase dissolved oxygen levels. Given concerns discussed above, NMFS recommends the SEIS be rewritten to support this statement or that it be deleted from the document.

5.3.2 Salinity

16 Page 5-29, line 6534 Wording in this sentence suggests that the direct effects of the 35,000 cfs diversion on salinity would be similar to those associated with the 5,000 cfs diversion. Considering the magnitude of difference between the two diversion volumes, it seems likely that significant salinity variation would in fact occur. If truly similar, the bases for such similarity should be explained in terms of model results. Also, the extent and duration of salinity modification resulting from the 35,000 cfs diversion should be graphically illustrated.

17 Page 5-29, lines 6550-6555 Although there is acknowledgement that some level of cumulative/synergistic effect is possible in connection with other diversion projects in the area, the magnitude of possible impact is unclear. The final SEIS should describe the possible environmental consequences of cumulative and synergistic effects of all relevant diversion projects in combination with the proposed action. To the extent practicable, salinity distribution maps, based on model results, should be provided. The maps should show spatial and temporal distribution of salinity regimes under the various alternatives and in conjunction with other diversion projects. Finally, it should be explained how operational adaptation at other projects, when needed in conjunction with the White Ditch project, will be implemented.

5.6 Vegetative Resources
5.6.2 Wetland Vegetative Resources
5.6.2.5 Alternative 4 – 35,000 cfs max Diversion (TSP)

18 Page 5-39, lines 6903-6908 According to this section, material derived from constructing the diversion structure would be placed on existing wetlands where it would provide a base for "regeneration" of approximately 417 acres of wetland vegetation, to include 31 acres of bottomland hardwoods. The final SEIS should include a description of "regeneration" and all associated short-term and long-term impacts to wetlands and other aquatic sites and resources. It is also unclear if creation of 31 acres of bottomland hardwood involves conversion of wetlands or if uplands account for some of the acreage figure. In addition, a timeframe for recovery of wetlands impacted by project construction is needed. The information provided in the SEIS indicates that significant short-term adverse impacts would occur; however, it is unclear at what point in time those impacts would be offset by project related benefits (wetland maintenance and restoration).

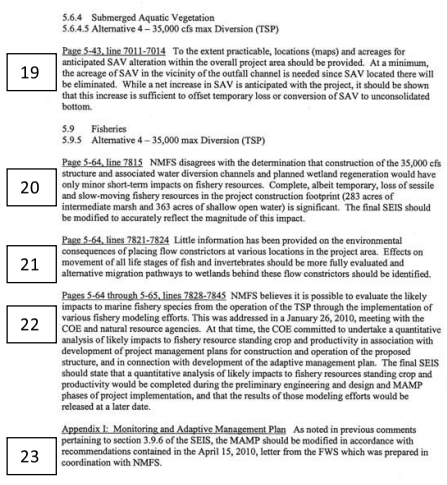
6

15. The last bullet on dissolved oxygen was removed from the final document.

16. Model results demonstrated that the results of the March-April pulse were fairly equivalent within the project area regardless of the size of the diversion. The 5,000cfs diversion, with supplementary flows from the Caernarvon diversion, can freshen the vast majority of the Breton Sound (0.0 - 5.0 ppt) as effectively as the 35,000 cfs diversion. The difference between the alternatives is seen outside of the project area where there is a difference in the distance freshwater moves out into the Breton sounds before being diluted by saltwater. Further modeling to better analyze this extent for the Recommended Plan are scheduled during PED to allow for better adaptive management of the diversion.

17. The MDWD team did not have enough time to fully describe the complete cumulative and synergistic effects of all relevant diversion projects. However; there is a separate LCA study that is scheduled to look at managing all the diversions on the lower river together in a fashion that will minimize impacts to navigation while reestablishing a healthy delta. Due to the size and scope of this effort, it is not realistic for the MDWD PDT to analyze such a project, but rather to have a separate study that will aide all current and upcoming ecosystem restoration projects along the Lower Mississippi River.

18. Concur. Additional detail concerning the timing of short-term adverse impacts is provided in the revised WVA assessment documentation included at the end of Appenidix B.



5.6.4 Submerged Aquatic Vegetation
5.6.4.5 Alternative 4 – 35,000 cfs max Diversion (TSP)

19 Page 5-43, line 7011-7014 To the extent practicable, locations (maps) and acreages for anticipated SAV alteration within the overall project area should be provided. At a minimum, the acreage of SAV in the vicinity of the outfall channel is needed since SAV located there will be eliminated. While a net increase in SAV is anticipated with the project, it should be shown that this increase is sufficient to offset temporary loss or conversion of SAV to unconsolidated bottom.

5.9 Fisheries
5.9.5 Alternative 4 – 35,000 max Diversion (TSP)

20 Page 5-64, line 7815 NMFS disagrees with the determination that construction of the 35,000 cfs structure and associated water diversion channels and planned wetland regeneration would have only minor short-term impacts on fishery resources. Complete, albeit temporary, loss of sessile and slow-moving fishery resources in the project construction footprint (283 acres of intermediate marsh and 363 acres of shallow open water) is significant. The final SEIS should be modified to accurately reflect the magnitude of this impact.

21 Page 5-64, lines 7821-7824 Little information has been provided on the environmental consequences of placing flow constrictors at various locations in the project area. Effects on movement of all life stages of fish and invertebrates should be more fully evaluated and alternative migration pathways to wetlands behind these flow constrictors should be identified.

22 Pages 5-64 through 5-65, lines 7828-7845 NMFS believes it is possible to evaluate the likely impacts to marine fishery species from the operation of the TSP through the implementation of various fishery modeling efforts. This was addressed in a January 26, 2010, meeting with the COE and natural resource agencies. At that time, the COE committed to undertake a quantitative analysis of likely impacts to fishery resource standing crop and productivity in association with development of project management plans for construction and operation of the proposed structure, and in connection with development of the adaptive management plan. The final SEIS should state that a quantitative analysis of likely impacts to fishery resources standing crop and productivity would be completed during the preliminary engineering and design and MAMP phases of project implementation, and that the results of those modeling efforts would be released at a later date.

23 Appendix I: Monitoring and Adaptive Management Plan As noted in previous comments pertaining to section 3.9.6 of the SEIS, the MAMP should be modified in accordance with recommendations contained in the April 15, 2010, letter from the FWS which was prepared in coordination with NMFS.

7

19. A total of 363 acres of open water habitat will be impacted by the ridge creation, marsh creation, and construction of outfall channels. That open water is assumed to have 25% SAV coverage which would amount to 91 acres of SAV habitat. Under FWP, 652 acres of fresh/intermediate open water exists at TY50 with 70% SAV coverage which amounts to 456 acres of SAV habitat.

20. Concur: Text has been revised in the Final EIS to better reflect the impact on fishery resources in the construction footprint.

21. Concur: Text has been revised in the Final EIS to provide additional detail on the anticipated impact of flow constrictors (now referred to as "notched weirs" in the document) on aquatic resources.

22. Concur: The document will be updated to include the phrasing "Fishery modeling and habitat change modeling will be performed during the PED phase. The cost and schedule for this will be incorporated into the PMP being developed by the Corps for the PED Phase. At this time a SOW is being developed as part of the Donaldsonville to the Gulf project to look a various models and develop a white paper on the best use of them. The intent of these models is to support adaptive management of this project."

23. Comment is noted.

1. Your statement of support is noted.

1

-----Original Message-----
From: Albertine Kimble [mailto:albertine_kimble@plaqueminesparish.com]
Sent: Thursday, July 01, 2010 9:15 AM
To: MacInnes, Andrew D MVN
Subject: White Ditch Diversion Project

Andrew, the White Ditch Diversion Project is a mandatory project for the salvation of existing wetlands and future wetlands. Why? To me, this area is just as bad off as the Barataria Basin across the river from this project site. No freshwater=Nothing. The operations of this diversion will be the key to saving this area. Mimicking the river as close as possible to like having NO levee. Fresh water is NOT Bad. It is just how much and how long. I know I always say look at the Ostrica locks down and this area is self explanatory what is happening there. Land is building own its own and no one even notices that. The river broke that old stupid levee own its own and the sediment is filling the areas like little island builders.(East Bank) Look at a map of the area and tell me what you see on the West Bank across from the same area, NOTHING, open water due to no siphon or diversion. This area is a goner. Yea, oysters are there but, even oysters need land for the spat to collect too. The most important aspect of the project is that it is a sediment delivery diversion, not just a freshwater diversion. On this project you get the miracle grow and the miracle (sediment) that will make all the difference in the world. I am a believer of making a project work, you can always find a solution for any problem with all the brain power that we have with every agency working together. If we do NOTHING we will have nothing, and time is crucial. Please while ya'll are at it. Save West Bay too all we need are weirs set up to slow the monster down. All that sediment is going in the wrong area, even that can be fixed. Long live the diversions to save a place that is the most dynamic area in the world and worth all the money we have to save. Living to save the Louisiana coast, Albertine M. Kimble

1

-----Original Message-----
From: savastano [mailto:savastano@bellsouth.net]
Sent: Thursday, July 01, 2010 4:21 PM
To: Dayan, Nathan S MVN
Cc: Billy Nungesser; don beshel; P J Hahn; MacInnes, Andrew D MVN
Subject:
COMMENTS ON Pre-Decisional Draft
Integrated Feasibility Study and Supplemental Environmental Impact Statement for
Medium Diversion at White Ditch Plaquemines Parish Louisiana May 2010
By Louisiana Coastal Area Ecosystem Restoration
The report was quite extensive but did not adequately address the problems that we have had with the Caernarvon Diversion. We need a small dredge in the Mississippi River to put silt into the marsh (a small diversion flow 5000 cfs at most). The proposed 35000 cfs will wash out and float the existing marsh in the area and deposit a minimum amount of silt. It will reduce the salinities in the area for long periods of time and long enough to kill oyster reefs, displace salt water fish habitat, introduce large quantities of invasive species (water hyacinths and pea vines), and finally it will kill off the brackish and salt marsh and replace it with fresh and intermediate marsh which is not sustainable in a salt water/storm environment. We lost 37% of our marsh in the Caernarvon influence area while only losing 12-13% in the White Ditch and Caernarvon Outfall areas which were least affected by the Caernarvon Diversion in the last 18 years. This proposed Medium White Ditch Diversion is a 35000 cfs version of the 8000 cfs Caernarvon Diversion and can result in the same kind of destruction, only faster and more extensively if operated as proposed.
Ken Savastano
504-682-0392

1. Chapter 3 and Section 3.5 specifically deal with why the recommended plan was chosen. Chapter 4 and 5 describe existing conditions and anticipated impacts. Appendix L describes in detail the engineering of the design. In essence, a large diversion can be run for a short duration and achieve the goals of the project while avoiding the scenario described in the comment. Hydraulic modeling shows that a smaller diversion has to be run for a much longer duration than a large diversion. It is the length and timing of diversion operations, not the size of the diversion, that have potential to cause the scenario described. The short march/april pulse of a large diversion coordinated with optimal river conditions greatly minimizes potential impacts to socioeconomic resources. The results of detailed modeling and analysis lead us to respectfully disagree with this comment. Regardless, the comment is appreciated



From: Whiteditch@aol.com [mailto:Whiteditch@aol.com]
Sent: Monday, July 05, 2010 2:14 PM
To: Dayan, Nathan S MVN
Subject: White Ditch Diversion
Dear Sir:
I was not able to make the meeting that was recently held at Phoenix High School but I would like to now voice my objection to the above project. I simply cannot understand, after all of the talks I had with Andy McGinnis, and other Corps representatives, why they still insist on the massive structure that is proposed. I live at the White Ditch and know for a fact that the White Ditch siphon, for all the years it has operated (since 1962) has not built one foot of land. In fact when it runs hard, I loose land. (Don't believe me; come on down and I'll show you.) The only sediment that occurs is about 500 feet from the outfall and it is very minimal. The Canarveron (sic) Diverson, in all its years of operation, has not built any land. To the contrary, it has (1) washed away land, (2) created a freshwater marsh that produces vegetation with no root system that dies with the least little tropical disturbance and (3) kills the brackish/saltwater vegetation which holds the land together. How do I know this??? Because I am here everyday and see the marsh everyday. I saw what happened after Katrina, Gustave and Ike. The marsh was like a barren wasteland because all the freshwater vegetation was killed by the saltwater. Where saltwater vegetation existed, the marsh (what was left of it) came back in fine fashion.
It is too late for siphons and diversions. We can't wait 25 or 50 years. (I have been waiting since 1962 for the White Ditch siphon to help and it has not.) The only answer, and the one everyone ignores, is to pump sand from the river into the marsh. Why that is so hard to understand is beyond me. No one has ever told me why that is not an option. It is a one time thing and you can build at least ten acres in a month.Anything else and you are wasting the taxpayers' money.
So for what its worth (and it obviously will be ignored like everything else I have said) these are my objections to your project. My land will be affected and not in a favorable way. I will loose land, I will have what is left of my marsh turned into a freshwater vegetation paradise that will die at the first east wind and leave my land like a parched desert. Do you know that after Ike, we did not even have enough marsh grass to make a decent duck blind? I just don't get it and never will. I live here, the corps and whoever do not. Please reconsider this project.
Very truly yours,
Judge Robert L Lobrano (retired)

1

1. Your statement of opposition is noted. Dredging and direct placement of river sediments was considered in the early stages of project planning but was eliminated from more detailed consideration for reasons of efficiency as noted in Table 3.3 of the Draft EIS.

LDEQ Comments regarding US ACOE Proposal to Establish a Medium Diversion at White Ditch
07/05/2010

-----Original Message-----
From: Chris Piehler [mailto:Chris.Piehler@LA.GOV]
Sent: Monday, July 05, 2010 2:51 PM
To: Dayan, Nathan S MVN
Cc: Chuck Berger
Subject: Mississippi River diversion at White Ditch

Mr. Dayan please accept the attached comment from the LDEQ on the captioned subject. Hard copy will be placed in tomorrow's mail.

Chris . M. Piehler, LDEQ

WQAD Administrator

225-219-3395

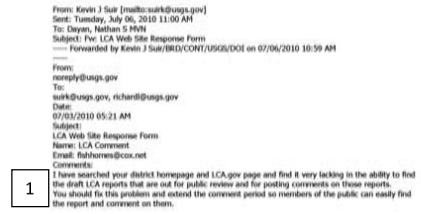
Louisiana Department of Environmental Quality (LDEQ) comments regarding the Corps of Engineers' draft supplemental environmental impact statement (SEIS) for the LCA-Medium Diversion at White Ditch, LA, May 2010

General Comments:

1

1. LDEQ supports the Corps' efforts to restore and maintain the ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges.

1. Comment is noted.



From: Kevin J Suir [mailto:suirk@usgs.gov]
Sent: Tuesday, July 06, 2010 11:00 AM
To: Dayan, Nathan S MVN
Subject: Fw: LCA Web Site Response Form
----- Forwarded by Kevin J Suir/BRD/CONT/USGS/DOI on 07/06/2010 10:59 AM -----

From:
noreply@usgs.gov
To:
suirk@usgs.gov, richardl@usgs.gov
Date:
07/03/2010 05:21 AM
Subject:
LCA Web Site Response Form
Name: LCA Comment
Email: fishhomes@cox.net
Comments:
I have searched your district homepage and LCA.gov page and find it very lacking in the ability to find the draft LCA reports that are out for public review and for posting comments on those reports. You should fix this problem and extend the comment period so members of the public can easily find the report and comment on them.

1

1. Your statement of concern is noted. However the schedule for the LCA 6 projects was extremely accelerated and did not allow time for extensions without risking loss of authorization.



July 6, 2010

Colonel Alvin Lee
Commander
New Orleans District U.S. Army Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160

Re: LCA Draft Feasibility Reports and Draft Environmental Impact Statements

Dear Colonel Lee:

Thank you for the opportunity to review and comment on the LCA Draft Feasibility Reports and Draft Environmental Impact Statements. Section 7006(e)(3) of the 2007 WRDA identifies six near-term restoration projects that Congress has authorized for construction subject to, among other things, completion of feasibility studies and a Chief's Report before December 31, 2010. The draft Feasibility Report covers five of those six projects:

- Medium Diversion at White Ditch
- Convey Atchafalaya to Northern Terrebonne Marsh/Multipurpose Operation of the Houma Navigation Canal (HNC) Lock (two projects merged)
- Small Diversion at Convent/Blind River
- Amite River Diversion Canal (ARDC) Modification

Although we were disappointed that the initial deadline of December 31, 2008 was missed, we commend the U.S. Army Corps of Engineers and the State of Louisiana in working diligently to meet the December 31, 2010 as directed by WRDA. It is imperative that these projects are constructed as quickly as possible and our organizations are available to assist to ensure the urgency of these projects is understood in Washington, D.C. and in the State.

We understand the need for additional analysis and the increasing uncertainty of the Terrebonne Basin Barrier Shoreline Project considering the Deepwater Horizon oil spill. However, the Deepwater Horizon oil spill has also shown the urgent need to restore and maintain our barrier island chains to protect the interior marshes from multiple threats, including massive oil spills and hurricanes. We request the USACE to distribute an updated timeline for completion to the public and that timeline ensures that this feasibility report is completed at the earliest possible time with the understanding that some details may have to be modified during the engineering, design and construction phase. We request that the Chief's Report also address an extended deadline for the

Terrebonne Basin Barrier Shoreline project that will not be meeting the required WRDA deadline due to these extraordinary circumstances.

We also applaud the USACE and the State of Louisiana for incorporating Monitoring and Adaptive Management Plans at the feasibility stage of project planning. We support the use of project funding to conduct monitoring and expand research and development on these restoration projects to provide lessons learned and flexibility in operations and management. We offer our assistance as the Monitoring and Adaptive Management Plans continue to develop.

Two of the four projects (ARDC Modifications and Atchafalaya to Terrebonne/HNC Lock) were restricted from providing large scale benefits due to the cost constraints authorized in WRDA 2007. The USACE and State of Louisiana boldly expanded the Medium Diversion at White Ditch beyond its cost authorization to adequately address the sustainability of the study area. We commend the USACE and State for this action. We would have liked to see the same initiative to address the concerns of the Maurepas and Terrebonne Basins. Many large-scale restoration measures were considered in these studies, but dismissed due to costs. The ARDC Modification Project only addressed one of the four identified degraded hydrologic units and the Atchafalaya to Terrebonne/HNC Lock Project only reduces the land loss rate by 10 percent over the 50 year period. Much larger scale restoration in these basins is needed. In these instances, the project did not truly meet the objectives of the project in the entire study area. A phased approach to project implementation should be provided that evaluates all needed restoration measures to meet the full objectives of the study without any cost constraints, identifies the critical first steps, and identifies phased project implementation based on available funding.

1

It is imperative that the USACE complete the Feasibility Reports and the Chief's Report for these LCA projects before the end of the year. Specific comments on each project are enclosed. We believe these comments could be addressed during the engineering, design, construction or adaptive management phases of the projects and will not delay the process.

The undersigned groups welcome the opportunity to discuss our recommendations at any time.

Sincerely,

Coalition to Restore Coastal Louisiana
Steven Peyronnin
Executive Director

Natalie Snider
Science Director

Lake Pontchartrain Basin Foundation
John Lopez, Ph.D.
Director of Coastal Sustainability

1. Your statement of support is noted.

Environmental Defense
Jim Tripp
General Counsel

Angelina Freeman, Ph.D.
Coastal Scientist

National Audubon Society
G. Paul Kemp, Ph.D.
Vice President, Gulf Coast Initiative

National Wildlife Federation
Karla Raettig
National Campaign Director

cc: Garret Graves, Coastal Protection and Restoration Authority
Steve Mathies, Louisiana Office of Coastal Protection and Restoration
Timothy Axtman, U.S. Army Corps of Engineers



Medium Diversion at White Ditch
LCA Draft Feasibility Report

A key component to restoration of Louisiana's coastal landscape is to reconnect the Mississippi River to the wetlands by mimicking natural processes that use the power of the Mississippi River to build land and maintain ecological integrity including habitats, communities, and storm buffering capacity. We strongly support the Medium Diversion at White Ditch and its objectives to provide freshwater, nutrients and sediments designed to restore degraded habitat and sustain a larger coastal ecosystem to support and protect the environment, economy, and culture of southern Louisiana.

Much has been learned recently about the design and operation of diversions in the Lower Mississippi River for coastal restoration, including the advantages of using pulsing as an operational strategy to maximize sediment capture (Allison and Meselhe, 2010). With rising sea levels and predictions for increased storm frequency/intensity, it is imperative that restoration projects are designed to maximize potential for offsetting projected land loss. Therefore, we commend and support the Tentatively Selected Plan (TSP) incorporating pulsing at 35,000 cfs (cubic feet per second) at high river flows to maximize sediment capture in the planning and operation of the diversion. The minimal amount of shoaling in the river expected from operation of the diversion in a pulsed fashion (1,000 cfs diversion that is pulsed at 35,000 cfs at the beginning of spring flood when suspended sediment concentrations are significantly elevated) is an additional advantage to this operational regime. Designing flexibility into this diversion project by providing pulsing capacity allows adaptation to unforeseen circumstances, as demonstrated by the Deepwater Horizon oil spill where river diversions were used to keep oil at bay. We applaud the Corps for evaluating a pulsed diversion in the analysis, and agree that the pulsed operation of the TSP maintains the medium diversion category authorization.

The sediment concentrations in the Mississippi River can vary significantly according to location, and a thorough analysis of site specific data and modeling would improve prediction of sediment efficiency and land building potential relative to diversion locations. Extensive sediment data collection and modeling is being undertaken in the White Ditch reach of the river in support of the Myrtle Grove Land Building Diversion. Using this type of data and modeling results in the benefits and drawbacks of location selection would provide a more robust analysis. We suggest incorporation of this additional data in Planning, Engineering, and Design.

The conveyance channel for the TSP accounts for almost half the total cost for the project. We agree that amending language from House/Senate subcommittees that

2

adjusts the project as authorized in WRDA 2007 for the increase in construction cost is warranted. However, we recommend reevaluating the conveyance channel and whether natural channel formation can be effectively utilized allowing the engineering to be scaled back (thereby reducing cost) to be investigated in Planning, Engineering, and Design. Natural channel formation could be incorporated into the Monitoring and Adaptive Management Plan and funding for channel modifications could be acquired on an as needed basis as a part of Operations and Maintenance.

References

Allison, M.A. and Meselhe, E.A., 2010. The use of large water and sediment diversions in the lower Mississippi River (Louisiana) for coastal restoration. Journal of Hydrology 387, 346-360.

2. Response: The AM Framework Team does not believe that natural channel formation vs. constructed conveyance channel is an adaptive management component. This is a decision that will further explored by the PDT during PED.

740



LCA – Medium Diversion at White Ditch
Public Comment

1

Comment: Reasons why this Diversion should not be built is because it will produce too much Freshwater into the estuary causing total destruction to the seafood industry particularly oysters. The Magnuson-Stevens Fishery Conservation & Management Act P.L. 94-297 states no Federal project shall cause Net Loss to marsh or resources without changing operation or replacing back to original habitat. This project will destroy marsh and oyster beds on the entire East Bank of Plaq Parish

Name Kenneth R. Fox Affiliation Ken A Oyster Co. Inc.
Street 36644 Hwy 39 Phone 504 682-0583
City, State, Zip Braithwaite, La 70040
E-mail

www.mvn.usace.army.mil www.lca.gov

Comments may also be submitted via e-mail to Nathan.S.Dayan@usace.army.mil. Written comments must be postmarked by Jul. 6, 2010.



LCA – Medi a Diversion at White Ditch
ublic Comment

1

Comment: Freshwater Water & Sediment are mandatory for the existance of the Coastline have to start for the future. Operations of this structure will be the most important aspect of the project. Location is perfect, Because the sediment load in this area is plentiful. Great project for Plaquemines Parish.

Name Albertine McKinnie Affiliation PPG - landowner hydrologist
Street 10653 Hwy 39 Phone 504. 439.0297
City, State, Zip Carville, La. 70040
E-mail bulgunairbeta@yahoo.com

www.mvn.usace.army.mil www.lca.gov

Comments may also be submitted via e-mail to Nathan.S.Dayan@usace.army.mil. Written comments must be postmarked by Jul. 6, 2010.

1. Your statement of opposition is noted.

1. Your statement of support is noted.

741

From: Diane Hewitt [mailto:Diane.Hewitt@LA.GOV]
Sent: Thu 7/8/2010 2:42 PM
To: Dayan, Nathan S MVN
Subject: DEQ SOV: 100603/1030 USACE DRAFT EIS - LCA - Vol. VI
July 8, 2010
Joan M. Exnicios, Chief
USACE Environ. Planning Branch
P.O. Box 60267
New Orleans, LA 70160-0267
nathan.s.dayan@usace.army.mil <mailto:nathan.s.dayan@usace.army.mil>
RE:
100603/1030
USACE DRAFT EIS - LCA - Vol. VI
(on disk)
Med. Diversion at White Ditch SEIS
Plaquemines Parish
Dear Ms. Exnicios:
The Department of Environmental Quality (LDEQ), Offices of Environmental Services and Environmental Compliance have received your request for comments on the above referenced project. Please take any necessary steps to obtain and/or update all necessary approvals and environmental permits regarding this proposed project.

1

There were no objections based on the information in the document submitted to us. However, the following comments have been included below. Should you encounter a problem during the implementation of this project, please notify LDEQ's Single-Point-of-contact (SPOC) at (225) 219-3640.
The Office of Environmental Services/Permits Division recommends that you investigate the following requirements that may influence your proposed project:
* If your project results in a discharge to waters of the state, submittal of a Louisiana Pollutant Discharge Elimination System (LPDES) application may be necessary.
* If the project results in a discharge of wastewater to an existing wastewater treatment system, that wastewater treatment system may need to modify its LPDES permit before accepting the additional wastewater.
* LDEQ has stormwater general permits for construction areas equal to or greater than one acre. It is recommended that you contact the LDEQ Water Permit Division at (225) 219-3181 to determine if your proposed improvements require one of these permits.
* All precautions should be observed to control nonpoint source pollution from construction activities.
* If any of the proposed work is located in wetlands or other areas subject to the jurisdiction of the U.S. Army Corps of Engineers, you should contact the Corps directly to inquire about the possible necessity for permits. If a Corps permit is required, part of the application process may involve a water quality certification from LDEQ.
* All precautions should be observed to protect the groundwater of the region.
* Please be advised that water softeners generate wastewaters that may require special limitations depending on local water quality considerations. Therefore if your water system improvements include water softeners, you are advised to contact the LDEQ Water Permits to determine if special water quality-based limitations will be necessary.
* Any renovation or remodeling must comply with LAC 33:III.Chapter 28.Lead-Based Paint Activities, LAC 33:III.Chapter 27.Asbestos-Containing Materials in Schools and State Buildings (includes all training and accreditation), and LAC 33:III.5151.Emission Standard for Asbestos for any renovations or demolitions.
* If any solid or hazardous wastes, or soils and/or groundwater contaminated with hazardous constituents are encountered during the project, notification to LDEQ's Single-Point-of-Contact (SPOC) at (225) 219-3640 is required. Additionally, precautions should be taken to protect workers from these hazardous constituents.

1. Comment is noted.

Currently, Plaquemines Parish is classified as an attainment parish with the National Ambient Air Quality Standards.
Please forward all future requests to Ms. Diane Hewitt, LDEQ/Performance Management/ P.O. Box 4301, Baton Rouge, LA 70821-4301, and your request will be processed as quickly as possible.
If you have any questions, please feel free to contact me at (225) 219-4079 or by email at diane.hewitt@la.gov <mailto:diane.hewitt@la.gov> . Permitting questions should be directed to the Office of Environmental Services at (225) 219-3181.
Sincerely,
Diane Hewitt
Performance Management
LDEQ/Community and Industry Relations
Business and Community Outreach Division
Office of the Secretary
P.O. Box 4301 (602 N. 5th Street)
Baton Rouge, LA 70821-4301
Phone: 225-219-4079
Fx: 225-325-8208
E-mail: diane.hewitt@la.gov



United States Department of Agriculture

NRCS

Natural Resources Conservation Service
3737 Government Street
Alexandria, LA 71302

318-473-7751
318-473-7626

July 16, 2010

Ms. Charlene Carmack
Anaylsis (CEMVR-PD-E)
U. S. Army Corps of Engineers

RE: LCA Medium Diversion at White Ditch – Plaquemines Parish, Louisiana

Ms. Carmack:

In response to your request for NRCS evaluate the LCA Medium Diversion at White Ditch site location to identify impacts to prime farmland, I have reviewed Farmland Classification for this area. All of the soils within the project area are classified as "Not Prime Farmland". Therefore, the activities associated with the project are not subject to the rules and regulations of the Farmland Protection Policy Act (FPPA)—Subtitle I of Title XV, Section 1539-1549

A completed *Form AD-1006 – Farmland Conversion Impact Rating* is included with this response. The farmland classification report is also attached.

Respectfully,

ACTING FOR

Kevin D. Norton
State Conservationist

Attachment

cc: Michael C. Truaclair, DC, FO, NRCS, Boutee, LA

Helping People Help the Land

An Equal Opportunity Provider and Employer

1

1. Confirmation from NCRS that no prime farmland will be impacted by the proposed project and copy of AD 1006 with Section II completed.

744



U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*

Name of Project: LCA Midbasin Diversion at White Ditch	Date Of Land Evaluation Request: June 15, 2010
Proposed Land Use: Natural area - fish and wildlife habitat	Federal Agency Involved: U.S. Army Corps of Engineers
	County and State: Plaquemines Parish, LA

PART II *(To be completed by NRCS)*

Does the site contain Prime, Unique, Statewide or Local Important Farmland? (If no, the FPPA does not apply - do not complete additional parts of this form)	YES ☐ NO ☐	Acres Irrigated / Average Farm Size
Major Crop(s)	Farmable Land In Govt. Jurisdiction: Acres	Amount of Farmland As Defined in FPPA: Acres
Name of Land Evaluation System Used	Name of State or Local Site Assessment System	Date Land Evaluation Returned by NRCS: July 15, 2010

PART III *(To be completed by Federal Agency)*

	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Converted Directly	144.0	159.0	203.0	284.0
B. Total Acres To Be Converted Indirectly				
C. Total Acres In Site	144.0	159.0	203.0	284.0

PART IV *(To be completed by NRCS)* Land Evaluation Information

A. Total Acres Prime And Unique Farmland				
B. Total Acres Statewide Important or Local Important Farmland				
C. Percentage Of Farmland in County Or Local Govt. Unit To Be Converted				
D. Percentage Of Farmland in Govt. Jurisdiction With Same Or Higher Relative Value				

PART V (To be completed by NRCS) Land Evaluation Criterion
Relative Value of Farmland To Be Converted (Scale of 0 to 100 Points)

PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(Criteria are explained in 7 CFR 658.5 b. For Corridor project use form NRCS CPA 106)*

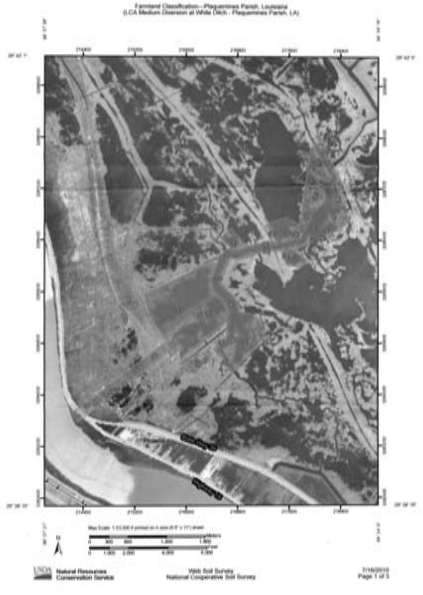
	Maximum Points	Site A	Site B	Site C	Site D
1. Area In Non-urban Use	(15)				
2. Perimeter In Non-urban Use	(10)				
3. Percent Of Site Being Farmed	(20)				
4. Protection Provided By State and Local Government	(20)				
5. Distance From Urban Built-up Area	(15)				
6. Distance To Urban Support Services	(15)				
7. Size Of Present Farm Unit Compared To Average	(10)				
8. Creation Of Non-farmable Farmland	(10)				
9. Availability Of Farm Support Services	(5)				
10. On-Farm Investments	(20)				
11. Effects Of Conversion On Farm Support Services	(10)				
12. Compatibility With Existing Agricultural Use	(10)				
TOTAL SITE ASSESSMENT POIN	160				

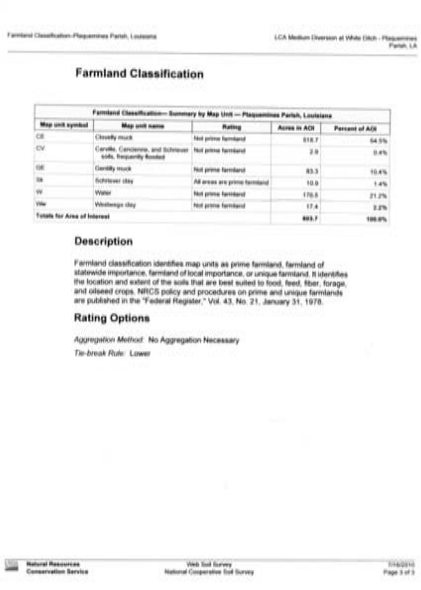
PART VII *(To be completed by Federal Agency)*

Relative Value Of Farmland *(From Part V)*	100				
Total Site Assessment *(From Part VI above or local site assessment)*	160				
TOTAL POINTS (Total of above 2 lin	260				

Site Selected	Date Of Selection	Was A Local Site Assessment Used? YES ☐ NO ☐
Reason For Selection		
Name of Federal agency representative completing this form		Date

(See instructions on reverse side) Form AD-1006 (03-02)


Farmland Classification - Plaquemines Parish, Louisiana
(LCA Medium Diversion at White Ditch - Plaquemines Parish, LA)
Natural Resources Conservation Service
Web Soil Survey
National Cooperative Soil Survey



Farmland Classification-Plaquemines Parish, Louisiana LCA Medium Diversion at White Ditch - Plaquemines Parish, LA

Farmland Classification

Farmland Classification— Summary by Map Unit — Plaquemines Parish, Louisiana

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CE	Clovelly muck	Not prime farmland	518.7	64.5%
CV	Carville, Cancienne, and Schriever soils, frequently flooded	Not prime farmland	2.9	0.4%
GE	Gentilly muck	Not prime farmland	83.3	10.4%
Sk	Schriever clay	All areas are prime farmland	10.9	1.4%
W	Water	Not prime farmland	170.5	21.2%
Wle	Westwego clay	Not prime farmland	17.4	2.2%
Totals for Area of Interest			803.7	100.0%

Description

Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978.

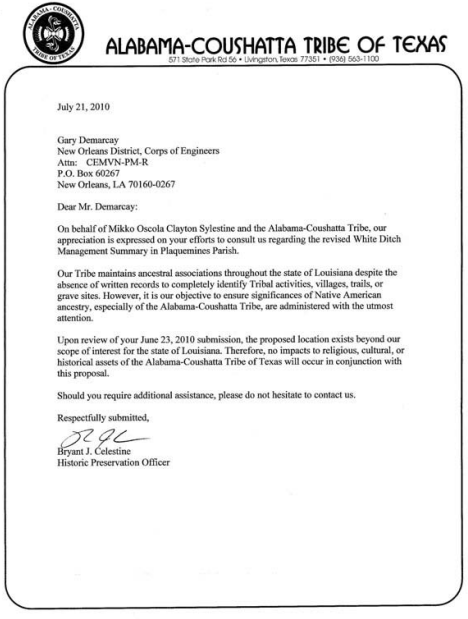
Rating Options

Aggregation Method: No Aggregation Necessary

Tie-break Rule: Lower

Natural Resources Conservation Service Web Soil Survey National Cooperative Soil Survey 7/16/2010 Page 3 of 3

748



ALABAMA-COUSHATTA TRIBE OF TEXAS

571 State Park Rd 56 • Livingston, Texas 77351 • (936) 563-1100

July 21, 2010

Gary Demarcay
New Orleans District, Corps of Engineers
Attn: CEMVN-PM-R
P.O. Box 60267
New Orleans, LA 70160-0267

Dear Mr. Demarcay:

On behalf of Mikko Oscola Clayton Sylestine and the Alabama-Coushatta Tribe, our appreciation is expressed on your efforts to consult us regarding the revised White Ditch Management Summary in Plaquemines Parish.

Our Tribe maintains ancestral associations throughout the state of Louisiana despite the absence of written records to completely identify Tribal activities, villages, trails, or grave sites. However, it is our objective to ensure significances of Native American ancestry, especially of the Alabama-Coushatta Tribe, are administered with the utmost attention.

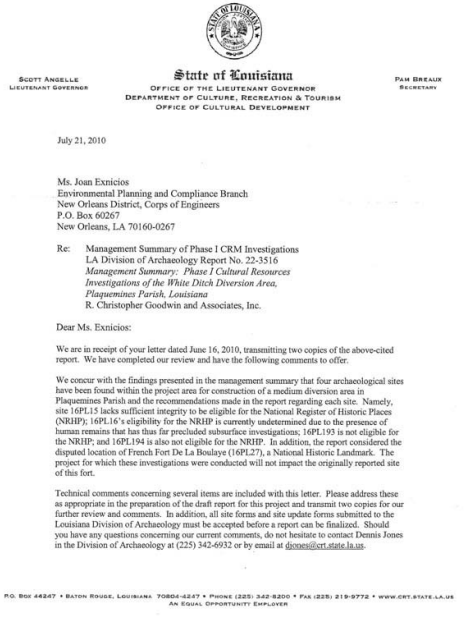
Upon review of your June 23, 2010 submission, the proposed location exists beyond our scope of interest for the state of Louisiana. Therefore, no impacts to religious, cultural, or historical assets of the Alabama-Coushatta Tribe of Texas will occur in conjunction with this proposal.

Should you require additional assistance, please do not hesitate to contact us.

Respectfully submitted,

Bryant J. Celestine
Historic Preservation Officer

1. Comment on cultural resources report submittal indicating that the project location exists beyond their scope of interests and therefore no impacts to tribal assets are anticipated.



SCOTT ANGELLE
LIEUTENANT GOVERNOR

State of Louisiana
OFFICE OF THE LIEUTENANT GOVERNOR
DEPARTMENT OF CULTURE, RECREATION & TOURISM
OFFICE OF CULTURAL DEVELOPMENT

PAM BREAUX
SECRETARY

July 21, 2010

Ms. Joan Exnicios
Environmental Planning and Compliance Branch
New Orleans District, Corps of Engineers
P.O. Box 60267
New Orleans, LA 70160-0267

Re: Management Summary of Phase I CRM Investigations
LA Division of Archaeology Report No. 22-3516
Management Summary: Phase I Cultural Resources Investigations of the White Ditch Diversion Area, Plaquemines Parish, Louisiana
R. Christopher Goodwin and Associates, Inc.

Dear Ms. Exnicios:

We are in receipt of your letter dated June 16, 2010, transmitting two copies of the above-cited report. We have completed our review and have the following comments to offer.

We concur with the findings presented in the management summary that four archaeological sites have been found within the project area for construction of a medium diversion area in Plaquemines Parish and the recommendations made in the report regarding each site. Namely, site 16PL15 lacks sufficient integrity to be eligible for the National Register of Historic Places (NRHP); 16PL16's eligibility for the NRHP is currently undetermined due to the presence of human remains that has thus far precluded subsurface investigations; 16PL193 is not eligible for the NRHP; and 16PL194 is also not eligible for the NRHP. In addition, the report considered the disputed location of French Fort De La Boulaye (16PL27), a National Historic Landmark. The project for which these investigations were conducted will not impact the originally reported site of this fort.

Technical comments concerning several items are included with this letter. Please address these as appropriate in the preparation of the draft report for this project and transmit two copies for our further review and comments. In addition, all site forms and site update forms submitted to the Louisiana Division of Archaeology must be accepted before a report can be finalized. Should you have any questions concerning our current comments, do not hesitate to contact Dennis Jones in the Division of Archaeology at (225) 342-6932 or by email at djones@crt.state.la.us.

P.O. BOX 44247 • BATON ROUGE, LOUISIANA 70804-4247 • PHONE (225) 342-8200 • FAX (225) 219-9772 • WWW.CRT.STATE.LA.US
AN EQUAL OPPORTUNITY EMPLOYER

1. The SHPO concurs with the findings in the LA Division of Archeology Report No. 22-3516, *Management Summary: Phase I Cultural Resources Investigations of the White Ditch Diversion Area, Plaquemines Parish, Louisiana,* R. Christopher Goodwin and Associates, Inc.

750

Appendix H

Value Engineering Study Report

A Summary of the Value Engineering Study report is listed below. Additional technical information and data is on file and available on request.

Value Engineering Study Report
Medium Diversion at White Ditch
Prepared by Value Management Strategies, Inc.
June 2009

Medium Diversion at White Ditch

Presently, loss of area in the marsh allows water to rapidly pass through the system and salt water is able to quickly intrude. The absence of an outfall management plan related to the White Ditch diversion siphon results in the surrounding marsh receiving limited benefits from the diverted river water. Also, the lack of marsh-forming sediments from the Mississippi River has accelerated the degradation of all marsh types. Sediment needs in the project area are extensive and plan strategies that increase diversion flows to provide required sediment transport may not be sufficient to provide the necessary sediment.

Key VE alternatives identified to address these issues are as follows:

- Maximize sediment introduction
  - Design diversion structures to maximize sediment introduction
  - Install sediment introduction system into White Ditch diversion structure
- Diversion control structure size and location
  - Construct a combination spillway with capacity controls to medium diversion levels
  - Construct diversion structure approximately seven miles south of Phoenix
- Address fresh water source and transport
  - Optimize flow conveyance in White Ditch to feed areas immediately adjacent to the south of existing channel

General/Plan Formulation

- Develop Plan Strategies that account for much higher levels of global sea level (GSL) rise

  One issue addressed by the VE team spans all three projects and has ramifications throughout the LCA program. Currently, work is underway by the USACE, National Oceanic and Atmospheric Administration (NOAA), and United States Geological Survey (USGS) to investigate the glacial melt contribution to future GSL rise. Project benefits depend upon habitats maintained above sea level. Consequently, benefits beyond the 50-year planning horizon will be lost if subsidence and GSL rise exceed the current assumptions. The rate of GSL rise in the future is currently unknown, but could be much greater than the current assumptions. As such, the projects should develop specific Plan Strategies that consider the range of possible future GSL rates.

- Provide clarification and address the Water Resources Development Act of 2007 (WRDA 2007) regarding specified authorized funding limits and the extent of planning development of LCA projects

Each LCA project has a specific level of funding to accomplish the authorized project goals and objectives as described in the LCA Program. However, during the plan formulation phase of the studies, stipulations (cost and/or size, as well as time) should not serve as planning constraints. Consideration of all reasonable alternatives to achieve the goals and objectives of the project, regardless of the time, cost, and/or size, is required by USACE policy. The USACE policy guidance requires identification of a National Ecosystem Restoration (NER) plan that maximizes ecosystem restoration benefits compared to costs, in addition to the identification of a Tentatively Select Plan (TSP). In some cases, the NER plan may differ from the TSP by exceeding the authorization stipulations resulting in time, cost, and/or size serving as constraints for the plan selection phase of the study. This forces the TSP to be an alternative that would accomplish the ecosystem benefits within the WRDA authorization.

SUMMARY OF VE ALTERNATIVE CONCEPTS

The table below summarizes all of the alternative concepts developed by the VE team. The items in red text were identified by the VE team as items of particular note and key recommended strategies for the Project Development Team (PDT) to consider.

SUMMARY OF VE ALTERNATIVE CONCEPTS
Medium Diversion at White Ditch

Number	Description
	Medium Diversion at White Ditch
WD-1	**Design diversion structures to maximize sediment introduction**
WD-2	**Optimize quantity of freshwater diverted at White Ditch in combination with other proposed diversion projects**
WD-3	**Construct diversion structure approximately seven miles south of Phoenix**
WD-4	**Construct a combination spillway with capacity controls to medium diversion levels**
WD-5	**Install sediment introduction system into White Ditch diversion structure**
WD-6	Optimize flow conveyance in White Ditch
WD-7	Identify and incorporate impacts effects of subsidence due to fluid withdrawal into project analysis
	General/Plan Formulation
G-1	**Develop Plan Strategies accounting for rise in sea level**
G-2	**Provide clarification and address the WRDA 2007 regarding specified authorized funding limits and the extent of planning development of LCA projects**
G-3	Define plan alternatives that can be optimized within project authorization
G-4	Amend project authorizations to include additional federal funding for "first phase" adaptive management measures
G-5	Establish permanent trust fund for project maintainability
G-6	Identify impacts of multiple diversion structures on Mississippi River and fresh water and sediment requirements of project areas
G-7	Incorporate comprehensive monitoring of project benefits before, during, and after completion of diversion measures
G-8	Identify and address potential real and perceived drainage impact of proposed diversion flows
G-9	Redefine project constraints versus project issues
G-10	Revisit weighted matrix method of ranking initial alternatives and plan elements
G-11	Redefine structural versus non-structural items
G-12	Develop salt tolerant bald cypress variety for use in coastal swamp restoration efforts
G-13	Use Ascension Parish wastewater effluent to replenish cypress forests
G-14	Use self-regulating tide gates for flap gates
G-15	Consider using vinyl sheet pile in guide levees for proposed diversion outlet channels
G-16	Consider effects of nutria in project analysis

Appendix I

Monitoring and Adaptive Management Plan

Louisiana Coastal Area (LCA) Program:
Medium Diversion at White Ditch Project
Feasibility-Level Monitoring and Adaptive Management Plan

September 2010





TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1
1.1 Authorization for Adaptive Management in the LCA Program 1
1.2 Procedure for Drafting Adaptive Management Plans for LCA Projects 1
1.3 LCA Communication Structure for Implementation of Adaptive Management 3
2.0 PROJECT ADAPTIVE MANAGEMENT PLANNING 4
2.1 Project Goals and Objectives 5
2.2 Management and Restoration Actions 5
2.3 Conceptual Ecological Model for Monitoring and Adaptive Management 5
2.4 Sources of Uncertainty 6
3.0 RATIONALE FOR ADAPTIVE MANAGEMENT 6
3.1 Adaptive Management Program for the Medium Diversion at White Ditch Project 7
4.0 MONITORING 7
4.1 Rationale for Monitoring 8
4.2. Monitoring Plan for the Medium Diversion at White Ditch Project 9
4.2.1 Monitoring Procedures 11
4.2.2 Use of Monitoring Results and Analysis 13
5.0 DATABASE MANAGEMENT 13
5.1 Description and Location 13
5.2 Data Storage and Retrieval 14
5.3 Analysis, Summarizing, and Reporting 14
6.0 ASSESSMENT 14
6.1 Assessment Process 14
6.2 Variances and Success 14
6.3 Frequency of Assessments 15
6.4 Documentation and Reporting 15
7.0 DECISION MAKING 15
7.1 Decision Criteria 16
7.2 Potential Adaptive Management Measures 16
7.3 Project Close-Out 17
8.0 COSTS FOR IMPLEMENTATION OF MONITORING AND ADAPTIVE MANAGEMENT PROGRAMS 17
8.1 Costs for Implementation of Monitoring Program 17
8.2 Costs for Implementation of Adaptive Management Program 19
9.0 LITERATURE CITED 20

List of Figures

Figure 1. Set-up Phase of the LCA Adaptive Management Framework.

Figure 2. Implementation Phase of the LCA Adaptive Management Framework.

Figure 3. LCA Communication Structure for Implementation of Adaptive Management.

List of Tables

Table 1. Preliminary Cost Estimates for Implementation of the Monitoring Program for the LCA Medium Diversion at White Ditch Project.

Table 2. Preliminary Cost Estimates for Set-up of Adaptive Management Program for the LCA Medium Diversion at White Ditch Project.

Table 3. Preliminary Cost Estimates for Implementation of Adaptive Management Program for the LCA Medium Diversion at White Ditch Project.

List of Attachments

Annex 1. LCA Medium Diversion at White Ditch Project Conceptual Ecological Model

1.0 INTRODUCTION

This document outlines the feasibility level monitoring and adaptive management plan for the Louisiana Coastal Area (LCA) Medium Diversion at White Ditch project. The LCA Adaptive Management Framework Team developed this monitoring and adaptive management plan with assistance from the Project Delivery Team (PDT). This plan identifies and describes the monitoring and adaptive management activities proposed for the Medium Diversion at White Ditch 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.

1.1 Authorization for Adaptive Management in the LCA Program

The LCA Ecosystem Restoration Study Chief's Report (2005) states (for the 15 near-term features aimed at addressing the critical restoration needs)

> *" …the feasibility level of detail decision documents will identify specific sites, scales, and adaptive management measures, and will optimize features and outputs necessary to achieve the restoration objectives…to ensure that LCA ecosystem restoration objectives are realized, monitoring and adaptive management must be a critical element of LCA projects."*

Section 7003(a) of Water Resources Development Act of 2007 (WRDA 2007) stipulates:

> *"The Secretary may carry out a program for ecosystem restoration, Louisiana Coastal Area, Louisiana, substantially in accordance with the report of the Chief of Engineers, dated January 31, 2005*."

Additionally, Section 2039 of WRDA 2007 directs the Secretary of the Army to ensure that, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration, the recommended project includes a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires that an adaptive management plan be developed for all ecosystem restoration projects.

At the programmatic level, knowledge gained from monitoring one project can be applied to other projects. Opportunities for this type of adaptive management are common within the LCA, Ecosystem Restoration Study (USACE 2004), which also builds upon lessons learned in other related efforts such as the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). Oversight by the LCA Science and Technology (S&T) Program and the LCA Adaptive Management Planning Team provides the basic structure to ensure that knowledge gained is effectively shared across programs and projects.

1.2 Procedure for Drafting Adaptive Management Plans for LCA Projects

The U.S. Army Corps of Engineers, Mississippi Valley Division, New Orleans District (USACE MVN), Louisiana Office of Coastal Protection and Restoration (OCPR), and the LCA S&T Office collaborated to establish a general framework for adaptive management to be applied to all LCA projects. The framework for adaptive management is consistent with the previously mentioned implementation guidance, as well as with the guidance provided by the U.S. Fish and

Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration's (NOAA) "Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process" in Federal Register vol. 65, No. 106 35242. The LCA adaptive management framework includes both a set-up phase (Figure 1) and an implementation phase (Figure 2).

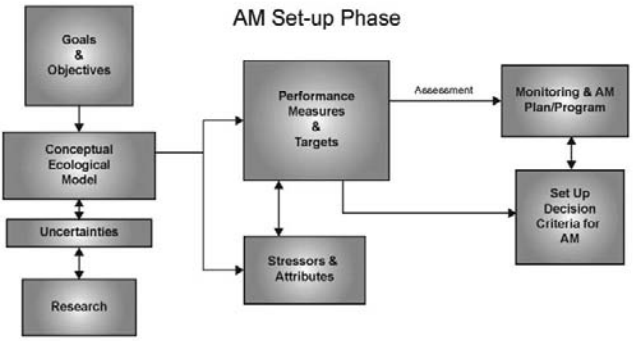


Figure 1. Set-up Phase of the LCA Adaptive Management Framework.

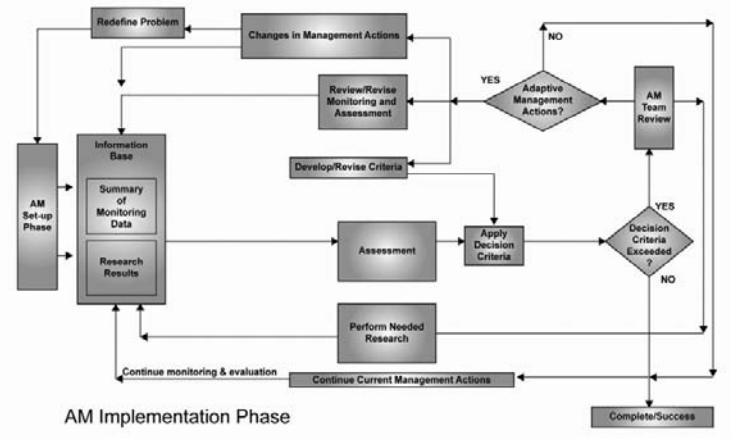


Figure 2. Implementation Phase of the LCA Adaptive Management Framework.

1.3 LCA Communication Structure for Implementation of Adaptive Management

To execute an adaptive management strategy for the LCA Ecosystem Restoration Study, a communication structure has been identified (Figure 3). The structure establishes clear lines of communication between LCA Program Management, an Adaptive Management Planning Team, the S&T Program, PDTs and stakeholders. Successful implementation will require the right resources being coupled at the right time to support the framework components.

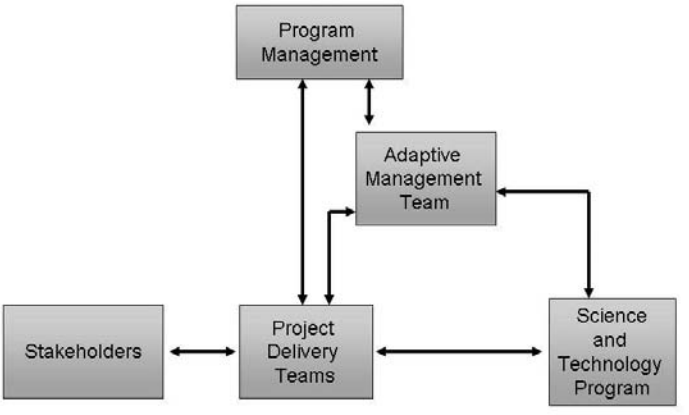


Figure 3. LCA Communication Structure for Implementation of Adaptive Management.

As part of the LCA Program communication structure for implementation of adaptive management (Figure 3), an LCA Adaptive Management Planning Team will be established. This team will be led jointly by a Senior Planner from the USACE and a counterpart from the OCPR. Other team members include USACE and State support staff and representatives from USFWS, NOAA, Natural Resources Conservation Service (NRCS), and Louisiana Department of Wildlife and Fisheries (LDWF). These members will be selected on the basis of their knowledge of ecosystem restoration, coastal Louisiana ecosystems and adaptive management. Other resources and expertise will be brought in as needed. This team will be responsible for recommending project and program adaptive management actions to the LCA Management Team.

The LCA Science and Technology (S&T) Program was established by the USACE and the State of Louisiana (the non-Federal sponsor) to effectively address coastal ecosystem restoration needs and to provide a strategy, organizational structure, and process to facilitate integration of science and technology into the adaptive management process. Under the Adaptive Management Framework, there are five primary elements in the LCA S&T Program, and each element differs in emphasis and requirements. These elements include: (1) science information needs, (2) data

acquisition and monitoring, (3) modeling, (4) research, and (5) data management and reporting (assessment).

Under the LCA S&T Program, an Assessment Team will be established. This team will be led by the S&T Director and a representative of the U.S. Geological Survey (USGS) who will also serve as direct liaisons between the S&T Assessment Team and the LCA Adaptive Management Planning Team. Other members will be identified from Federal and State agencies. Responsibilities of this team include analysis and reporting of data to the LCA Adaptive Management Planning Team and the LCA Program Management Team.

2.0 PROJECT ADAPTIVE MANAGEMENT PLANNING

Specific LCA PDTs assisted the LCA Adaptive Management Framework Team in developing the monitoring and adaptive management plan for each specific project. The members of the Adaptive Management Framework Team for this project were Tomma Barnes, USACE-MVN; Steve Bartell, E2 Consulting Engineers; Laura Brandt, USFWS; Craig Fischenich, USACE/Engineer Research and Development Center; Barbara Kleiss, USACE Mississippi Valley Division; Carol Parsons Richards, OCPR; Greg Steyer, USGS National Wetlands Research Center; and John Troutman, OCPR.

The resulting adaptive management plan for the Medium Diversion at White Ditch project describes and justifies whether adaptive management is needed in relation to the tentatively selected plan (TSP) identified in the Feasibility Study. The plan also identifies how adaptive management would be conducted for the project and who would be responsible for this project-specific adaptive management program. 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.

The Adaptive Management Plan for this project reflects a level of detail consistent with the project Feasibility Study. The primary intent was 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 project.

The following adaptive management plan section (1) identifies the restoration goals and objectives identified for the Medium Diversion at White Ditch project, (2) outlines management actions that can be undertaken to achieve the project goals and objectives, (3) presents a conceptual ecological model that relates management actions to desired project outcomes, and (4) lists sources of uncertainty that would recommend the use of adaptive management for this project. Subsequent sections describe monitoring, assessment, decision-making, and data management in support of adaptive management.

The level of detail in 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 similarly estimated using currently available information. Uncertainties will be addressed in the preconstruction, engineering, and design (PED) phase, and a detailed monitoring and adaptive management plan, including a detailed cost breakdown, will be drafted as a component of the design document.

2.1 Project Goals and Objectives

During initial stages of project development, the project delivery team, with stakeholder input, developed restoration goals and objectives to be achieved by the Medium Diversion at White Ditch project. These goal and objectives were subsequently refined through interactions with the LCA Adaptive Management Framework Team. The overarching goal of this project is to restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them, by reversing the trend of degradation and deterioration in the area between the Mississippi River and the River aux Chenes ridges. The intent is to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the Nation. The specific restoration objectives of the Medium Diversion at White Ditch project are to:

- Maintain the current area of marsh habitat, of all types (41,206 acres), which provide life-requisite habitat conditions for native coastal marsh fish and wildlife.
- Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish, and saline marsh are present and existing areas of marsh acres are maintained.
- Restore sediment inputs into the into the project area equivalent to an average of approximately 1,328,580 cubic yards of sediment per year.

2.2 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).

The TSP is Alternative 4, which is also the National Ecosystem Restoration (NER) plan. This alternative is located at Phoenix, Louisiana and includes ten 15-foot x 15-foot box culverts capable of diverting up to 35,000 cfs. Additionally, 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments. The NER Plan has a primary operating regime of a maximum 35,000 cfs pulse during March and April with a maximum 1,000 cfs maintenance flow throughout the remainder of the 12-month cycle (May–February). Optional operating regimes include a maximum 35,000 cfs pulse from March through May with a maximum 1,000 cfs maintenance flow throughout the remainder of the 12-month cycle (June–February) and a maximum 35,000 cfs pulse in March with a maximum 1,000 cfs maintenance flow throughout the remainder of the 12-month cycle (April–February).

2.3 Conceptual Ecological Model for Monitoring and Adaptive Management

As part of the planning process, members of the Medium Diversion at White Ditch project PDT developed a conceptual ecological model to represent current understanding of ecosystem structure and function in the project area, identify performance measures, and help select parameters for monitoring (Annex 1). The model illustrates the effects of important natural and

anthropogenic activities that result in different ecological stressors on the system. The effects of concern can be measured for selected performance measures defined as specific physical, chemical, and biological attributes of the system.

2.4 Sources of Uncertainty

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. Below is a list of uncertainties associated with restoration of the coastal wetland systems included in the Medium Diversion at White Ditch project.

- Ability of hydrologic model to predict project impacts/benefits
- Ability of Wetland Value Assessment (WVA) model to predict project impacts/benefits
- Ability of Modified Boustany model to predict project impacts/benefits
- Unknown sediment quantities in river
- Response of ecosystem to pulsed and/or sustained freshwater, sediment, and nutrient inputs
- Correct engineering and design to address project objectives
- Correct operational regime to achieve project objectives

Potential climate change issues, such as sea level rise, in addition to regional subsidence rates are significant scientific uncertainties for all LCA 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.

3.0 RATIONALE FOR ADAPTIVE MANAGEMENT

The primary incentive for implementing an adaptive management program is to increase the likelihood of achieving desired project outcomes given the identified uncertainties. All projects face uncertainties with the principal sources of uncertainty including (1) incomplete description and understanding of relevant ecosystem structure and function, (2) imprecise relationships between project management actions and corresponding outcomes, (3) engineering challenges in implementing project alternatives, and (4) ambiguous management and decision-making processes.

Given these 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. In the case of the Medium Diversion at White Ditch, the adaptive management program will use the results of continued project monitoring to manage the diversion in order to achieve the previously stated project goals and objectives. Adaptive management establishes the critical feedback of information from project monitoring to inform project management and promote learning through reduced uncertainty.

Several questions were considered to determine whether adaptive management should be applied to the Medium Diversion at White Ditch project:

1) Are the ecosystems to be restored sufficiently understood in terms of hydrology and ecology, and can project outcomes be accurately predicted given recognized natural and anthropogenic stressors?

2) Can the most effective project design and operation to achieve project goals and objectives readily identified?

3) Are the measures of this restoration project 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. The Framework Team and the PDT decided that the project meets these qualifications, and, therefore, is a candidate for adaptive management.

For this project, there are a number of uncertainties associated with ecosystem function and how the ecosystem components of interest will respond to the restoration project. In addition, there are associated uncertainties about the best design and operation for the project. Using an adaptive management approach during project planning provided a mechanism for building flexibility into project design and for providing new knowledge to better define anticipated ecological responses. This also enabled better selection of appropriate design and operating scenarios to meet the project objectives. Additionally, an adaptive management approach will help define project success and identify outcomes that should realistically be expected for the project.

3.1 Adaptive Management Program for the Medium Diversion at White Ditch Project

An Adaptive Management Program for the Medium Diversion at White Ditch project is needed to ensure proper implementation of adaptive management. The Program will also facilitate coordination of projects within the LCA Program and coordination among PDTs, the LCA S&T, and LCA Program Management. The LCA Adaptive Management Planning Team will lead all LCA project and program adaptive management recommendations and actions. This team is responsible for ensuring that monitoring data and assessments are properly used in the adaptive management decision-making process. If this team determines that adaptive management actions are needed, the team will coordinate a path forward with project planners and project managers. Other PDT members may be solicited as needed; for instance, if the adaptive management measure is operational, operations and hydraulics representatives might be asked to participate.

The LCA Adaptive Management Planning Team is also responsible for project documentation, reporting, and external communication. Table 2 lists the cost estimates for these adaptive management activities.

4.0 MONITORING

Independent of adaptive management, an effective monitoring program will be required to determine whether the project outcomes are consistent with original project goals and objectives. The power of a monitoring program developed to support adaptive management lies in the establishment of feedback between continued project monitoring and corresponding project

management. A carefully designed monitoring program is central component of the project adaptive management program.

4.1 Rationale for Monitoring

Monitoring must be closely integrated with all other LCA adaptive management components because it is the key to the evaluation and learning components of adaptive management. Project and system level objectives must be identified to determine appropriate indicators to monitor. In order to be effective, monitoring designs must be able to distinguish between ecosystem responses that result from project implementation (i.e., management actions) and natural ecosystem variability. In coastal Louisiana, there are many existing restoration and protection projects already constructed, and many more are being planned under different authorizations and programs. In combination, these projects will ultimately influence much of coastal Louisiana. Monitoring must therefore be conducted across a range of carefully selected scales to assess short-term project performance and to characterize longer-term, system-wide trends and conditions.

Achieving monitoring objectives will require monitoring that focuses on different spatial and temporal scales. Spatially, a project might achieve local objectives, but have little or no measurable effect at larger scales. Temporally, monitoring designs need to consider the amount of time it could take for slowly changing ecological variables to respond to management actions. Additionally, monitoring should be designed to measure the persistence of near-term effects. Larger-scale effects will generally take longer to develop and longer to detect than more localized effects.

Monitoring for large scale effects can be more difficult than for local effects because the ecological linkages become more complicated as factors outside project boundaries influence processes and biota that affect desired project outcomes. The benefits of improved habitat in one location may be counteracted by degradation at another location, thus showing no overall benefit at large scales. In addition, monitoring at large scales can involve changes in underlying conditions over time or space and be very labor intensive. When possible, specific monitoring and large scale information needs should be interrelated. In some cases, large scale monitoring may be just an extension of local monitoring in space and time, but it may also involve designs and procedures that are separate from site specific monitoring and extend beyond the purview of the project teams.

When possible, specific monitoring and large scale information needs should be integrated with existing monitoring efforts that are underway in coastal Louisiana. For example, the CWPPRA program has been monitoring restoration and protection projects in coastal Louisiana since 1990 (Steyer and Stewart 1992, Steyer et al. 1995). The monitoring program incorporates a system-level wetland assessment component called the Coast-wide Reference Monitoring System (CRMS-Wetlands, Steyer et al. 2003). CRMS-Wetlands provides system-wide performance measures that are evaluated to help determine the cumulative effects of restoration and protection projects in coastal Louisiana. LCA monitoring plans will incorporate existing monitoring networks to the extent practicable and participate in the implementation of CRMS-Wetlands. Such participation can maintain the data consistencies necessary to conduct project and programmatic adaptive management.

4.2. Monitoring Plan for the Medium Diversion at White Ditch Project

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 following discussion outlines key components of a monitoring plan that will support the project Adaptive Management Program.

The plan identifies performance measures along with desired outcomes (i.e., targets) in relation to specific project goals and objectives. A performance measure includes specific feature(s) to be monitored to determine project performance. In addition, if applicable, a risk endpoint was identified. Risk endpoints measure undesirable outcomes of a management or restoration action. A monitoring design was established to determine whether the desired outcome or risk endpoint is met.

Upon completion of the Medium Diversion at White Ditch project, monitoring for ecological success and adaptive management will be initiated and will continue until ecological success is achieved, as defined by the project-specific objectives. This monitoring plan includes the minimum monitoring actions to evaluate success and to determine adaptive management needs. Although the law allows for a 10-year cost-shared monitoring plan, ten years of monitoring may not be required. Once ecological success has been achieved, which may occur in less than ten years post-construction, no further monitoring will be performed. If success cannot be determined within that 10-year period of monitoring, any additional monitoring will be a non-Federal responsibility. This plan estimated monitoring costs for a period of ten years because that is the maximum allowed federal contribution to monitoring. As soon as ecological success is achieved, monitoring will cease.

The following discussion outlines key components of a monitoring plan that will support the LCA Medium Diversion at White Ditch project Adaptive Management Program. The plan identifies performance measures along with desired outcomes and monitoring designs in relation to specific project goals and objectives. Additional monitoring is identified as supporting information needs that will help further understand and corroborate project effects.

Objective 1: Maintain the current area of marsh habitat, of all types, that provide life-requisite habitat conditions for native coastal marsh fish and wildlife.

Performance Measure 1: Habitat and land:water classification

Desired Outcome: Reduce the rate of land loss (10-year post-construction trend) compared to the pre-project condition (1985–2012), excluding tropical storm events.

Desired Outcome: Maintain and/or increase acreage of marsh habitats from pre-construction estimates (41,206 acres).

Monitoring Design: Habitats will be classified using Landsat Thematic Mapper (TM) scenes collected in 3 pre- and 10 post-project years and Digital Orthophoto Quadrangles (DOQQs) for 1 pre- and 2 post-project years, as well as any available field data in the study area to assess land:water trends and habitat distribution.

Objective 2: Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish, and saline marsh are present and existing areas of marsh acres are maintained.

Performance Measure 2a: Plant diversity and cover

Desired Outcome: Enhance floristic quality of marsh vegetation communities.

Monitoring Design: Permanent vegetation monitoring stations will be established for assessing project area vegetation communities. These stations will be sampled annually beginning in PED for two years, during three years of construction, and ten years post construction.
Supporting Information Need: Salinity and hydroperiod (the period of time during which the wetland is covered by water, also known as frequency and duration of inundation) will be assessed by establishing 9 hydrologic monitoring sites in project and reference areas.

Risk Endpoint: Nutrification

Desired Outcome: Excessive nutrient introductions do not contribute to reduced biomass of belowground plant material when compared to pre-construction estimates.

Monitoring Design: Belowground biomass will be sampled quarterly at the 9 vegetation sites. These stations will be sampled for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction. Nutrients (total nitrogen [TN], ammonia, nitrate+nitrite, total phosphorous [TP]), metals, atrazine, and dissolved oxygen will be measured every two months in the immediate project outfall channel and at the 9 hydrologic monitoring sites for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

Desired Outcome: Mississippi River water introductions do not contribute to expansion of floating aquatic vegetation (water hyacinth) in project area when compared to pre-construction estimates along with not increasing the occurrences of water use impairments in the receiving waters.

Monitoring Design: The distribution of water hyacinth throughout the project area will be tracked by visual assessment of water hyacinth cover from overflights during summer.

Objective 3: Restore sediment inputs into the into the project area equivalent to an average of approximately 1,328,580 cubic yards of sediment per year.

Performance Measure 3a: Annual sediment discharge

Desired Outcome: Deliver 1.328M $yard^3$ (equivalent to 1.422M tons) of sediment through the White Ditch diversion each year.

Monitoring Design: Hourly turbidity recorders will be deployed in the outfall channel and at 9 hydrologic monitoring sites and correlated to total suspended solids (TSS) to investigate this measure. The sites will be measured for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

Performance Measure 3b: Accretion and elevation

Desired Outcome: Maintain marsh elevation within tidal frame (relative sea level rise = 0 cm yr^1).

Monitoring Design: Surface elevation tables (SET)/feldspar stations will be sampled at 9 hydrologic monitoring sites for assessing project area accretion and marsh elevation changes for 3 years prior to project completion to assess pre-project conditions and sampled for 10 years post-construction.

4.2.1 Monitoring Procedures

The following monitoring procedures will provide the information necessary to evaluate the previously identified project objectives for the Medium Diversion at White Ditch project:

Land:Water and Habitat Classification: Land/water and habitat summaries will be performed on classified Landsat TM scenes for 1985, 1987, 1990, 1998, 1999, 2001, 2002, 2004, 2005, 2006, 2008, 2009, 2010, 2011, and 2012 in the project area. Linear regression will be used to calculate land change trends based on those years, excluding anomalous data. Post-project trends calculated from Landsat TM scenes classified annually will be compared to the pre-project trends to determine whether conversion of land to open water is being reduced in the project area. DOQQs of the project area will need to be flown and habitat analyses completed to capture land cover for one pre-construction and two post-construction years.

Hydrology: Hourly turbidity, salinity, dissolved oxygen and water-level water monitoring will be initiated 3 years prior to anticipated project construction completion and conducted for 10 years post-construction at six locations within the project area and three reference locations with multi-parameter water quality sondes. Sondes will be surveyed to a vertical datum (NAVD 88), and marsh elevations in the immediate vicinity of each sonde will also be surveyed. Sondes will be serviced approximately 9 times per year. Hydroperiod metrics (depth, duration, and frequency of flooding) will be obtained from marsh elevations and recorded water levels. TSS will be predicted from turbidity measurements as described below.

Sediment Input and Distribution: Sediments introduced into the project area via riverine input are expected to contribute to soil building and thus a net elevation increase or stabilization.

Water discharge through the diversion structure will be monitored hourly with an acoustic Doppler current meter (ADCM). Hourly turbidity measurements will be measured with a logging optical backscatter nephlometric turbidity sensor, which will be field serviced and calibrated each month. During each field servicing event, a depth-integrated water sample will be taken from the outfall channel, and the sample will be analyzed for total suspended solids (TSS) by filtering 100–250 mL of each sample through pre-rinsed, pre-ashed, pre-weighed 47mm GF/F microfiber filters. Filters will be dried for 24 hours at 105° C, then combusted for 1 hour and 550° C and weighed. Thus, the inorganic fraction of TSS will be used as the metric for suspended solids in diverted river water. Linear regression will be used to estimate the relationship between turbidity and TSS, and hourly turbidity data will then be used to obtain hourly TSS values. Instantaneous sediment flux through the diversion structure $flux_{ed}$ will be calculated as

$$flux_{sed} = q_{div} \times tss$$

where q_{dv} and tss are the volume discharge and suspended sediment concentrations in the outfall channel, respectively. Total sediment delivery Q over the time interval $0 - T$ will be determined as

$$Q = \int_0^T flux_{sed}\, dt$$

where t is time.

Distribution of diverted sediments through the project area will be assessed by collection of hourly turbidity time series at each hydrologic monitoring site (above) by affixing an optical

backscatter nephlometric turbidity sensor to each water quality sonde. Water samples will be collected during monthly servicing of the sensors, and these samples will be analyzed for TSS and used to calibrate the turbidity sensors to TSS.

Water Quality: Measuring and monitoring various water quality parameters, including salinity, nutrients, turbidity, metals, atrazine, and total suspended solids (TSS) will dictate whether inputs from the Mississippi River are impacting water quality in the project area. Nutrients (TN, ammonia, nitrate+nitrite, TP) will be measured every two months in the immediate project outfall channel and at 9 hydrologic monitoring sites. Water samples will be collected in 500 mL acid-washed polyethylene bottles, stored on ice and taken to laboratory for processing. Within 24 hrs, 60 mL from each water sample will be filtered through pre-rinsed 25 mm 0.45 µm Millipore filters. Samples and filters will be frozen until analyzed within one month of collection. Nitrate and nitrite will be determined separately using automated cadmium reduction method, ammonium by automated phenate method and phosphate by automated ascorbic acid reduction method (Standard Methods 1992). Metals will be analyzed using the EPA SW-846 7000 series for analysis of metals is water. Atrazine will be analyzed using the EPA 600 series for the analysis of Atrazine in water.

Sediment Accretion and Elevation: Sediment accretion and elevation will be assessed at the nine hydrologic monitoring sites (above) semi-annually, beginning 3 years prior to anticipated project construction completion. Sediment elevation within the project area will be measured over time by using the rod-surface elevation table (RSET) technique which is described in Folse et al. (2008) and references therein. The RSET allows for precise, repeated measurements of the soil elevation. Marker horizons consisting of feldspar clay will be used to determine vertical accretion/loss within the project area (Folse et al. 2008).

Vegetation: Vegetation sampling will occur annually at the nine hydrologic monitoring sites (above), beginning in PED for two years, during three years of construction, and ten years post construction. Sampling will occur annually between August and October at each site, and will consist of sampling ten replicate 2 m x 2 m stations located along a transect within a 200 m x 200 m square. Vegetation stations will be located randomly on a 282.8-m transect that cuts diagonally through the square from one corner to the opposite corner. Each 2 m x 2 m vegetation station shall be spaced a minimum of 3 m apart giving a possible 94 establishment points along the diagonal transect.

Species composition and percent cover for each station will be determined using visual estimates of cover following the Braun-Blanquet cover scale (Mueller-Dombois and Ellenburg 1974). The 2 m x 2 m quadrat will be carefully placed on the vegetation and all vegetation within the quadrat, whether rooted within the station or hanging over the station, will be included in the sample. Species composition and percent cover data will be used to generate a Floristic Quality Index (FQI) score (Cretini et al. 2010) which will be tracked over time. Species composition data will be used to determine *in situ* marsh habitat classification, which will be used to ground-truth classifications from *Land:Water and Habitat Classification* above.

Belowground biomass will be sampled quarterly at the nine hydrologic monitoring sites via 10-cm diameter cores taken from each of three plots after the aboveground production has been removed. The cores will be taken to a maximum depth of 50 cm, or the entire mat thickness. Cores will be divided into 8 cm sections, and washed in a 0.5 mm sieve to remove soil particles. Live roots and rhizomes will be separated from the remaining matrix of dead roots and other organic material and dried at 65° C to a constant weight, and weighed.

4.2.2 Use of Monitoring Results and Analysis

Project monitoring is the responsibility of the OCPR and the USACE. However, because of the need to integrate monitoring for programmatic adaptive management, extensive agency coordination is required. A monitoring workgroup, led by the LCA S&T Program and the USGS, will be responsible for ensuring that project-specific monitoring plans are technically competent and appropriately integrated within a system-wide assessment and monitoring plan (SWAMP).

The results of the monitoring program will be communicated to an Assessment Team that will use the information to assess system responses to management, evaluate overall project performance, and construct project report cards. Recommended modifications (i.e., adaptation) of the Medium Diversion at White Ditch project will be provided as appropriate.

5.0 DATABASE MANAGEMENT

Database management is an important component of the monitoring plan and the overall adaptive management program. Data collected as part of the monitoring and adaptive management plans for the LCA projects will be archived as prescribed in the "LCA Data Management Strategic Plan" developed for the LCA S&T Office, and further developed by the LCA S&T Data Management Working Group.

Data standards, quality assurance and quality control procedures and metadata standards will be prescribed by the LCA S&T Data Management Working Group. Data collected for LCA with similar data types and collection frequencies as those data collected under the CRMS program will be managed by the Louisiana Strategic Online Natural Resources Information System (SONRIS). Pre-existing standard operating procedures built for SONRIS cover issues such as data upload process and format, quality assurance/quality control, and public data release. Storage of all other LCA collected data (spatial or non-spatial) will be handled by the LCA project-specific data libraries on LCA.GOV.

Where applicable, Open Geospatial Consortium standards will be used to facilitate data sharing among interested parties. Data analysis and reporting responsibilities will be shared between project assessment and adaptive management efforts in order to provide Medium Diversion at White Ditch project reports for the LCA Program Management Team.

5.1 Description and Location

The data management plan should identify the computing hardware and any specialized or custom software used in data management for an adaptive management program. Opportunities exist to develop either a centralized or distributed data management system. The data managers with input from the Adaptive Management Planning Team should determine which approach best suits the needs of the overall adaptive management program.

Individuals with responsibility for data management activities (data managers) in support of an adaptive management program should be identified. The data managers should collaborate with the Adaptive Management Planning Team in developing a data management plan to support the adaptive management program. The data management plan should be incorporated into the overall program adaptive management plan – either in the main body of the adaptive management plan or as an appendix.

5.2 Data Storage and Retrieval

Data standards, quality assurance and quality control procedures and metadata standards will be prescribed by the Data Management Working Group, and will be complementary with the CRMS-Wetlands program and SONRIS database. Data will be served using a map services tool, similar to that currently employed by the CRMS-Wetlands project.

5.3 Analysis, Summarizing, and Reporting

Data analysis and reporting responsibilities will be shared between project and programmatic adaptive management efforts in order to provide reports for the Medium Diversion at White Ditch project Assessment Team, project managers, and decision-makers.

6.0 ASSESSMENT

The assessment phase of the framework describes the process by which the results of the monitoring efforts will be compared to the desired project performance measures and/or acceptable risk endpoints (i.e., decision criteria) that reflect the goals and objectives of the management or restoration action. The assessment process addresses the frequency and timing for comparison of monitoring results to the selected measures and endpoints. The nature and format (e.g., qualitative, quantitative) of these comparisons are defined as part of this phase. The resulting methods for assessment should be documented as part of the overall adaptive management plan.

The results of the Medium Diversion at White Ditch project monitoring program will be regularly assessed in relation to the desired project outcomes as described by the previously specified project performance measures. This assessment process regularly measures the progress of the project in relation to the stated project goals and objectives, and is critical to the project adaptive management program. The assessments will continue through the life of the project or until it is decided that the project has successfully achieved its goals and objectives.

6.1 Assessment Process

The Assessment Team assigned to the Medium Diversion at White Ditch project will identify a combination of qualitative (i.e., professional judgment) and quantitative methods for comparing the values of the performance measures produced by monitoring with the selected values of these measures that define criteria for evaluating project effectiveness.

Appropriate statistical comparisons (e.g., hypothesis testing, ANOVA, multivariate methods, etc.) will be used to summarize monitoring data as they are obtained and compare these data summaries with the project decision criteria. These continued assessments will be documented as part of the project reporting and data management system.

6.2 Variances and Success

The project Assessment Team will collaborate with project managers and decision-makers to define magnitudes of difference (e.g., statistical differences, significance levels) between the values of monitored performance measures and the desired values (i.e., decision criteria) that will constitute variances. Meaningful comparisons between monitoring results and desired performance will require characterization of historical and current spatial-temporal variability that define baseline conditions. Variances (or their absence) will be used to recommend adaptive management actions, including (1) continuation of the project without modification, (2)

modification of the project within original design specifications, (3) development of new alternatives, or (4) termination of operation of the White Ditch diversion structure.

Conceptual models have been developed for each project describing the linkages between stressors and performance measures. The assessments will help determine whether the observed responses are linked to the project. Each project has been formulated to address as many system stressors as feasible. If the stressors targeted by the project have changed and the performance measure has not, the linkages in the conceptual model should be examined to determine what other factors may be influencing the performance measure response.

The assessments will also determine whether the responses are undesirable (e.g., are moving away from restoration goals) and if the responses have met the success criteria for the project. If performance measures are not responding as desired because the stressor has not changed enough in the desired direction, then recommendations should be made concerning modifications to the project. If the stressor has changed as expected/desired and the performance measure has not, additional research may be necessary to understand why.

From a system-wide perspective, scientific and technical information would be generated from the implementation of a system–wide monitoring effort. Information generated from this effort should be linked to evaluation LCA performance and system response. From a project-level perspective, monitoring plans should be designed to inform adaptive management decision making by providing monitoring data that are relevant to addressing uncertainty.

Similarly, for multiple performance measures and corresponding monitoring results, the Assessment Team will determine the number and magnitude of variances within a single assessment that will be required to recommend modifications to the project.

6.3 Frequency of Assessments

Ideally, the frequency of assessments for the Medium Diversion at White Ditch project would be determined by the relevant ecological scales of each performance measure. The project's technical support staff will identify for each performance measure the appropriate timescale for assessment. The project should have a combination of short-, medium-, and long-term performance measures. Assessments should be performed at a five year interval at a minimum; however, depending on the timescale of expected responses of the specific measure and frequency of data collection, it may be determined during PED that more frequent reporting may be necessary.

6.4 Documentation and Reporting

The Assessment Team will document each of the performed assessments and communicate the results of its deliberations to the managers and decision-makers designated for the Medium Diversion at White Ditch project. The Assessment Team will work with the project monitoring team and monitoring workgroup to produce periodic reports that will measure progress towards project goals and objectives as characterized by the selected performance measures. The results of the assessments will be communicated regularly to the project managers and decision-makers.

7.0 DECISION MAKING

Adaptive management is distinguished from more traditional monitoring in part through implementation of an organized, coherent, and documented decision process. For the Medium

Diversion at White Ditch project Adaptive Management Program, the decision process includes (1) anticipation of the kinds of management decisions that are possible within the original project design, (2) specification of values of performance measures that will be used as decision criteria, (3) establishment of a consensus approach to decision making, and (4) a mechanism to document, report, and archive decisions made during the timeframe of the Adaptive Management Program.

7.1 Decision Criteria

Decision criteria, also referred to as adaptive management triggers, are used to determine whether and when adaptive management opportunities should be implemented. These criteria are usually ranges of expected and/or desirable outcomes. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. Desired outcomes can be based on reference sites, predicted values, or comparison to historic conditions. Several potential decision criteria are identified below, based on the project objectives and performance measures. More specific decision criteria, possibly based on other parameters such as land:water relationship, hydrology, water quality, and sediment accretion and elevation; vegetation dynamics, will be developed during the pre-construction engineering and design phase of the project.

Sediment loading requirements:

- Desired sediment loading rates (1.422M tons yr^{-1}) are not achieved

To meaningfully manage this parameter, operations could be adjusted to increase the amount of sediment being discharged through the White Ditch structure, either by increasing the amount of river water discharged, or by timing diversions to better coincide with periods of high sediment concentrations in the Mississippi River.

Vegetation Community Dynamics

- Maintenance of all marsh habitats is not achieved

Operations may need to be adjusted to decrease the amount of river water discharged, or by timing diversions to better coincide with winter senescence of emergent vegetation. Additional modeling or experimental efforts might be required to understand and manage observed responses of belowground biomass.

To manage these outcomes, hydraulic models may need to be revisited and recalibrated based on field data and observations prior to change in management of a diversion and/or in diversion structures. Additional modeling or experimental efforts might be required to understand and manage observed biotic responses.

7.2 Potential Adaptive Management Measures

The project report card, drafted by the Assessment Team, will be used to evaluate project status and adaptive management needs. The Assessment Team may submit recommendations for adaptive management actions to the Adaptive Management Planning Team. The Adaptive Management Planning Team will investigate and further refine adaptive management recommendations and present them to the Program Management Team. Some potential adaptive management actions for this project may include modifying the operation of the existing diversion structure or modifying operation of existing outfall management features.

7.3 Project Close-Out

Close-out of the project would occur when it is determined that the project has been successful or when the maximum 10-year monitoring period has been reached. Success would be considered to have been achieved when the project objectives have been met, or when it is clear that they will be met based upon the trends for the site conditions and processes. Project success would be based on the following:

- Maintaining the pre-construction acreage and diversity of marsh types after 10 years.
- Meeting or exceeding 1,328,580 cubic yards of sediment per year into the project area.

There may be issues related to the sustainability of the project that would require some monitoring and management beyond achieving these objectives. Due to the variable nature of the Louisiana coastal zone, the monitoring baseline may change during the period of analysis. Consequently, it may be appropriate to consider extending project specific monitoring and adaptive management beyond 10 years.

8.0 COSTS FOR IMPLEMENTATION OF MONITORING AND ADAPTIVE MANAGEMENT PROGRAMS

The costs associated with implementing these monitoring and adaptive management plans were estimated based on currently available data and information developed during plan formulation as part of the feasibility study. Because uncertainties remain as to the exact project features, monitoring elements, and adaptive management opportunities, the costs estimated in Tables 1, 2, and 3 (below) will be need to be refined in PED during the development of the detailed monitoring and adaptive management plans.

8.1 Costs for Implementation of Monitoring Program

Costs to be incurred during the PED and construction phases include drafting of the detailed monitoring plan, monitoring site establishment and pre-construction and construction data acquisition to establish baseline conditions. Cost calculations for post-construction monitoring are displayed as a 10-year (maximum) total. If ecological success is determined earlier (prior to ten years post-construction), the monitoring program will cease and costs will decrease accordingly.

It is intended that monitoring conducted under the LCA program will utilize centralized data management, data analysis, and reporting functions. All data collection activities follow consistent and standardized processes regardless of the organization responsible for monitoring. Cost estimates include monitoring equipment, monitoring station establishment, data collection, quality assurance/quality control, data analysis, assessment, and reporting for the proposed monitoring elements (Table 1). These estimates account for a 2.6% annual inflation rate, adopted from the CWPPRA Program. The current total estimate for implementing the monitoring and assessment program is $9,363,400. Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs.

Table 1. Preliminary Cost Estimates for Implementation of the Monitoring Program for the LCA Medium Diversion at White Ditch Project.

Category	Activities	2 yr PED Set-up & Data Acquisition	3 yr Construction	10 yr Post-Construction	Total
Monitoring: planning and management	Monitoring workgroup, drafting detailed monitoring plan, working with PDTs on performance measures	$135,900	$53,200	$210,100	$399,200
Monitoring: data collection	Landrights, site construction, and surveying	$145,400			$145,400
	Land:water	$13,500	$21,600	$85,300	$120,400
	Habitat classification		$60,500	$145,000	$205,500
	Hydrology	$257,800	$412,400	$1,628,200	$2,298,400
	Sediment input & distribution	$37,400	$59,900	$236,300	$333,600
	Water Quality	$45,700	$73,200	$288,800	$407,700
	Sediment accretion and elevation	$29,200	$46,700	$184,300	$260,200
	Vegetation	$145,900	$233,400	$921,600	$1,300,900
	Fisheries	$374,200	$598,600	$2,363,200	$3,336,000
Database management	Database development, management, and maintenance, webpage development for communication of data to stakeholders	$62,400	$99,800	$393,900	$556,100
TOTAL		$1,247,400	$1,659,300	$6,456,700	$9,363,400

8.2 Costs for Implementation of Adaptive Management Program

Costs for the project adaptive management program were based on estimated level of effort. The current total estimate for implementing the adaptive management program is $1,780,000. Unless otherwise noted, costs will begin at the onset of the PED phase and will be budgeted as construction costs.

Table 2. Preliminary Cost Estimates for Set-up of Adaptive Management Program for the LCA Medium Diversion at White Ditch Project.

Category	Annual Cost	5 yr Total
Detailed AM Plan and Program Set-up (during PED and construction)	$100,000	$500,000
TOTAL	**$100,000**	**$500,000**

Table 3. Preliminary Cost Estimates for Implementation of Adaptive Management Program for the LCA Medium Diversion at White Ditch Project.

Category	Annual Cost	10 yr Total
Management of AM Program (post- construction)	$50,000	$500,000
Assessment	$47,000	$470,000
Decision making	$31,000	$310,000
TOTAL	**$128,000**	**$1,280,000**

9.0 LITERATURE CITED

Cretini, K.F., J.M. Visser, K.W. Krauss, and G.D. Steyer. 2010. CRMS Vegetation Analytical Team Framework: Methods for Collection, Development, and Use of Vegetation Response Variables. National Wetlands Research Center, Lafayette, LA, 64 p.

Folse, T.M., J.L. West, M.K. Hymel, J.P. Troutman, L. 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*. New York: John Wiley and Sons. 547 pp.

Standard Methods for the examination of water and wastewater. 18th edition, 1992. Greenberg, A.E., R.R. Trussell, L.S. Clesceri, M.A.H. Franson, eds. American Public Health Association. Washington D.C.

Steyer, G.D., and R.E. Stewart, Jr. 1992. Monitoring Program for Coastal Wetlands Planning, Protection, and Restoration Act projects. U.S. Fish and Wildlife Service, National Wetlands Research Center Open-File Report 93-01. 85 pp.

Steyer, G.D., R.C. Raynie, D.L. Steller, D. Fuller, and E. Swenson. 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open- File Report 95-01. Baton Rouge: Louisiana Department of Natural Resources, Coastal Restoration Division. 97 pp.

Steyer, G.D., C.E. Sasser, J.M. Visser, E.M. Swenson, J.A. Nyman, and R.C. Raynie. 2003. A Proposed Coast-wide Reference Monitoring System for Evaluating Wetland Restoration Trajectories in Louisiana. Environmental Monitoring and Assessment. 81:107–117.

ANNEX 1. LCA Medium Diversion at White Ditch Project

Conceptual Ecological Model

TABLE OF CONTENTS

Page

1.0 INTRODUCTION A-1
1.1 Conceptual Ecological Model Definition A-1
1.2 Purpose and Functions of Conceptual Ecological Models A-1
1.2.1 Ecosystem Simplification A-1
1.2.2 Communication A-1
1.2.3 Plan Formulation A-2
1.2.4 Science, Monitoring, and Adaptive Management A-3
1.2.5 Limitations of Conceptual Ecological Models A-3
1.3 Types of Conceptual Ecological Models A-4
1.3.1 Application of Conceptual Ecological Models to LCA Projects A-4
1.3.2 Model Components A-4
2.0 CONCEPTUAL ECOLOGICAL MODEL DEVELOPMENT A-5
2.1 Methodology A-5
2.2 Project Background A-6
2.2.1 Project Goals and Objectives A-6
2.2.2 Project Description A-7
3.0 CONCEPTUAL ECOLOGICAL MODEL DISCUSSION A-8
3.1 DriversA-8
3.1.1 Anthropogenic Alterations – Altered Hydrology A-8
3.1.2 Exotic and Invasive Species A-9
3.1.3 Relative Sea Level Rise A-11
3.2 Ecological Stressors A-11
3.2.1 Decreased Freshwater and Sediments A-11
3.2.2 Increased Saltwater Intrusion A-11
3.2.3 Increased Tidal Prism A-11
3.2.4 Habitat Conversion A-12
3.3 Ecological Effects A-12
3.3.1 Increased Submergence A-12
3.3.2 Decreased Wetland Health A-12
3.3.3 Increased Wetland Loss A-12
3.3.4 Loss of Navigation A-12
3.4 Attributes and Performance Measures A-12
3.4.1 Elevation and Accretion A-12
3.4.2 Land Cover A-13
3.4.3 Navigation A-13
3.4.4 Plant Diversity and Distribution A-14
3.4.5 Water Quality A-14
3.4.6 Soil Stability A-15
4.0 LITERATURE CITED A-16

LIST OF FIGURES

1. Conceptual Ecological Model Schematic Diagram A-5
2. Medium Diversion at White Ditch Project Study Area A-8
3. Conceptual Ecological Model, LCA Medium Diversion at White Ditch Project A-10

1.0 INTRODUCTION

1.1 Conceptual Ecological Model Definition

Although the term "conceptual ecological model" (CEM) may be applied to numerous disciplines, CEMs are generally simple, qualitative models, represented by a diagram, that describe general functional relationships among the essential components of an ecosystem. CEMs typically document and summarize current understanding of, and assumptions about, ecosystem function. When applied specifically to ecosystem restoration projects, CEMs also describe how restoration actions propose to alter ecosystem processes or components to improve system health (Fischenich 2008). To describe ecosystem function, a CEM usually diagrams relationships between major anthropogenic and natural stressors, biological indicators, and target ecosystem conditions.

1.2 Purpose and Functions of Conceptual Ecological Models

CEMs can be particularly helpful with the Louisiana Coastal Area (LCA) Program and its projects by providing assistance with four important tasks: ecosystem simplification, communication, plan formulation, and science, monitoring and adaptive management.

1.2.1 Ecosystem Simplification

Because natural systems are inherently complex, resource managers must utilize tools that simplify ecosystem relationships and functions within the target ecosystem. An understanding of the target ecosystem is paramount to planning and constructing effective ecosystem restoration projects. During CEM development, knowns and unknowns about the connections and causalities in the systems are identified and delineated (Fischenich 2008).

CEMs can promote ecosystem simplification through the following processes:

- Organization of existing scientific information;
- Clear depiction of system components and interactions;
- Promotion of understanding of the ecosystem;
- Diagnosis of underlying ecosystem problems;
- Isolation of cause and effect relationships; and
- Identification of species most likely to demonstrate an ecosystem response.

1.2.2 Communication

CEMs are an effective tool for the communication of complex ecosystem processes to a large diverse audience (Fischenich 2008). It is vitally important that project teams understand ecosystem function in order to realistically predict accomplishments to be achieved by restoration projects. CEMs can facilitate effective communication between project team members about ecosystem function, processes, and problems, and can assist in reaching consensus within the project team on project goals and objectives.

Because CEMs summarize relationships among the important attributes of complex ecosystems, they can serve as the basis for sound scientific debate. Stakeholder groups, agency functions (e.g., planning and operations), and technical disciplines typically relate to systems resource use and management independently, but CEMs can be used to link these perspectives.

The process of model development is at least as valuable as the model itself and affords an opportunity to draw fresh insight as well as address unique concerns or characteristics for a given project. Workshops to construct CEMs are brainstorming sessions that explore alternative ways to compress a complex system into a small set of variables and functions. This interactive process of system model construction facilitates communication between project team members and almost always identifies inadequately understood or controversial model components.

CEMs can promote communication by facilitating the following:

- Integrating input from multiple sources and informing groups of the ideas, interactions, and involvement of other groups (Fischenich 2008);
- Assembling project/study managers with the project team and stakeholders to discuss ecosystem condition, problems, and potential solutions;
- Synthesizing current understanding of ecosystem function;
- Developing consensus on a working set of hypotheses that explain habitat changes;
- Developing consensus on indicators that can reflect project-specific ecological conditions; and
- Establishing a shared vocabulary among project participants.

1.2.3 Plan Formulation

Formulating a plan for an effective ecosystem restoration project requires an understanding of the following elements:

- The underlying cause(s) of habitat degradation;
- The manner in which causal mechanisms influence ecosystem components and dynamics; and
- The manner in which intervening with a restoration project may reduce the effects of degradation.

These three elements should form the basis of any CEM applied to project formulation (Fischenich 2008).

CEMs can provide valuable assistance to the plan formulation process through the following:

- Supporting decision-making by assembling existing applicable science;
- Assisting with formulation of project goals and objectives, indicators, management strategies, and results;
- Providing a common framework among team members from which to develop alternatives;
- Supplementing numerical models to assess project benefits and impacts; and
- Identifying biological attributes or indicators that should be monitored to best interpret ecosystem conditions, changes, and trends.

1.2.4 Science, Monitoring, and Adaptive Management

Through the recognition of important physical, chemical, or biological processes in an ecosystem, CEMs identify aspects of the ecosystem that should be measured. Hypotheses about uncertain relationships or interactions between components may be tested and the model may be revised through research and/or an adaptive management process. Indicators for this process may occur at any level of organization, including the landscape, community, population, or genetic levels; and may be compositional (i.e., referring to the variety of elements in a system), structural (i.e., referring to the organization or pattern of the system), or functional (i.e., referring to ecological processes) in nature.

CEMs can be helpful in restoration science, monitoring, and adaptive management through the following:

- Making qualitative predictions of ecosystem response;
- Identifying possible system thresholds that can warn when ecological responses may diverge from the desired effect;
- Outlining further restoration and/or research and development needs;
- Identifying appropriate monitoring indicators and metrics;
- Providing a basis for implementing adaptive management strategies;
- Interpreting and tracking changes in project targets;
- Summarizing the most important ecosystem descriptors, spatial and temporal scales, and current and potential threats to the system;
- Facilitating open discussion and debate about the nature of the system and important management issues;
- Determining indicators for monitoring;
- Helping interpret monitoring results and explore alternative courses of management;
- Establishing institutional memory of the ideas that inspired the management and monitoring plan;
- Forecasting and evaluating effects on system integrity, stress, risks, and other changes;
- Identifying knowledge gaps and the prioritization of research;
- Interpreting and monitoring changes in target indicators; and
- Assisting in qualitative predictions and providing a key foundation for the development of benefits metrics, monitoring plans, and performance measures.

1.2.5 Limitations of Conceptual Ecological Models

CEMs cannot identify the most significant natural resources within the target ecosystem or prioritize project objectives. They do not directly contribute to the negotiations and trade-offs common to ecosystem restoration projects. CEMs are not *The truth*, but are simplified depictions of reality. They are not *Final*, but rather provide a flexible framework that evolves as understanding of the ecosystem increases. CEMs are not *Comprehensive* because they focus only

upon those components of an ecosystem deemed relevant while ignoring other important (but not immediately germane) elements. CEMs do not, in and of themselves, quantify restoration outcomes, but identify indicators that can be monitored to determine responses within the target ecosystem to restoration outputs.

Good conceptual models effectively communicate which aspects of the ecosystem are essential to the problem, and distinguish those outside the control of the implementing agency. The best conceptual models focus on key ecosystem attributes, are relevant, reliable, and practical for the problem considered, and communicate the message to a wide audience.

1.3 Types of Conceptual Ecological Models

CEMs can be classified according to both their composition and their presentation format. They can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. The most common types of CEMs are narrative, tabular, matrix, and various forms of schematic representations. A comprehensive discussion of these types of CEMs is provided in Fischenich (2008). Despite the variety in types of CEMs, "no single form will be useful in all circumstances" (Fischenich 2008). Therefore, it is of vital importance to establish the specific plan formulation needs to be addressed by the CEM, and develop the CEM accordingly because "[c]onceptual models . . . are most useful when they are adapted to solve specific problems" (Fischenich 2008).

1.3.1 Application of Conceptual Ecological Models to LCA Projects

CEMs have been widely used in other regions of North America when planning large-scale restoration projects (Barnes and Mazzotti 2005). The LCA team has decided to utilize the Ogden model (Ogden and Davis 1999). The LCA team recognizes that CEM development, like plan formulation, is likely to be an iterative process, and that CEMs developed for LCA projects during early plan formulation may be dramatically changed before project construction.

1.3.2 Model Components

The CEM utilized for LCA projects follows the top-down hierarchy of information using the components established by Ogden and Davis (1999). The schematic organization of the CEM is depicted in Figure 1 and includes the following components:

- *Drivers*- This component includes major external driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g., eustatic sea level rise) or anthropogenic (e.g., hydrologic alteration) in nature.
- *Ecological Stressors*- This component includes physical or chemical changes that occur within natural systems, which are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.
- *Ecological Effects*- This component includes biological, physical, or chemical responses within the natural system that are produced or affected by stressors. CEMs propose linkages between one or more ecological stressors and ecological effects and attributes to explain changes that have occurred in ecosystems.
- *Attributes*- This component (also known as indicators or end points) is a frugal subset of all potential elements or components of natural systems representative of overall

ecological conditions. Attributes may include populations, species, communities, or chemical processes. Performance measures and restoration objectives are established for each attribute. Post-project status and trends among attributes are measured by a system-wide monitoring and assessment program as a means of determining success of a program in reducing or eliminating adverse effects of stressors.

- *Performance measures*- This component includes specific features of each attribute to be monitored to determine the degree to which the attribute is responding to projects designed to correct adverse effects of stressors (i.e., to determine success of the project).

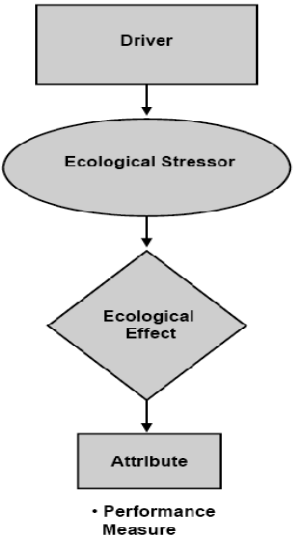


Figure 1. Conceptual Ecological Model Schematic Diagram.

This CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather, the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem monitoring goals.

2.0 CONCEPTUAL ECOLOGICAL MODEL DEVELOPMENT

2.1 Methodology

A CEM was developed for the Medium Diversion at White Ditch project by members of the interagency Project Delivery Team. The creation of this CEM was an interactive and iterative

process. Prior to model development, the project team reviewed existing information on the ecosystem within the study area. A small team meeting was then convened to identify and discuss causal hypotheses that best explain both natural and key anthropogenically driven alterations in the study area. A list of appropriate stressors and consequent ecological effects in the study area ecosystem was developed from these discussions. Additionally, a series of attributes was identified that exhibited characteristics that ideally suited them to serve as key indicators of project success through the measurement and analysis of performance measures associated with these attributes. The project team used these hypotheses and lists of components to develop an initial draft of the model and to prepare a supporting narrative document to explain the organization of the model and science supporting the hypotheses.

Additional information about the components of this CEM is presented below.

2.2 Project Background

The Medium Diversion at White Ditch project was identified as a near-term critical feature in the *Louisiana Coastal Area (LCA), Louisiana – Ecosystem Restoration Study* (2004 LCA Plan [USACE 2004]). The 2004 LCA Plan was recommended to Congress by a Chief of Engineers report dated January 31, 2005, which recommended a coordinated, feasible solution to the identified critical water resource problems and opportunities in coastal Louisiana. This project was included in that plan along with other near-term critical restoration features throughout coastal Louisiana. Including this project, 10 additional projects were recommended for further studies, in anticipation that such features would be subsequently recommended for future Congressional authorization. The 2004 LCA Plan was developed by the State of Louisiana and the United States Army Corps of Engineers (USACE) in order to implement some of the restoration strategies outlined in the 1998 report *Coast 2050: Toward a Sustainable Coastal Louisiana*.

The purpose of this study is to investigate the feasibility of restoring and maintaining ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges. This Feasibility Study was authorized by the 2004 LCA Plan and the 2007 Water Resources Development Act (WRDA 2007), which required the completion of a Feasibility Study and the incorporation of the study findings into a signed Chief of Engineers Report, which must be submitted to Congress by the Secretary of the Army by December 31, 2010.

Pursuant to the completion of this Feasibility Study, a CEM was developed to establish causal hypotheses that best explain the major alterations in the natural systems within the study area, to identify attributes of the natural system that are likely to exhibit a response to project features, and to identify performance measures that can be monitored to determine the degree of project success with respect to countering or correcting the natural system alterations.

2.2.1 Project Goals and Objectives

In consultation with the non-Federal sponsor and other interested parties, Goals and Objectives were developed in the first quarter of 2009. They are presented in Table 2.1.

Table 1: Goals and Objectives

Overarching System Goal	Objective
Restore and maintain ecological integrity, including habitats, communities, and populations of native species, and the processes that sustain them by reversing the trend of degradation and deterioration to the area between the Mississippi River and the River aux Chenes ridges, so as to contribute towards achieving and sustaining a larger coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus contribute to the economy and well-being of the Nation.	A. Maintain the current area of marsh habitat, of all types (41,206 acres) that provide life requisite habitat conditions for native coastal marsh fish and wildlife. B. Restore adequate freshwater and nutrient inputs into the project area such that sustainable areas of fresh, intermediate, brackish and saline marsh are present and existing areas of marsh acres are maintained. C. Restore sediment inputs into the project area equivalent to an average of approximately 1,328,580 cubic yards of sediment per year.

2.2.2 Project Description

The Medium Diversion at White Ditch project study area is located in LCA Subprovince 1 in the Breton Sound hydrologic basin in Plaquemines Parish, Louisiana (see figure 1.1). The boundary of the project encompasses over 98,000 acres of intermediate to brackish intertidal wetland habitats. The study area boundary follows distinct landscape features beginning in the north with the confluence of the non-Federal back levee and the Forty-Arpent Canal, extending along the non-Federal back levee, the Mississippi River levee, the Federal back levee and along the left descending natural bank of the Mississippi River to the west; past American Bay, California Bay, and through Breton Sound, near Bay Gardene to the south; into and along River aux Chenes to the east, and back to the point of beginning. The area has been significantly impacted by recent tropical storms and hurricanes and is currently isolated from the effects of the Caernarvon freshwater diversion, located at the northern end of the Breton Sound basin.

The area of interest where a diversion structure could be located occurs on the left descending bank of the Mississippi River, between White Ditch to the north (River Mile 64.5 above Head of Passes [AHP]) and the community of Phoenix to the south (River Mile 59.8 AHP). This 4.7-mile stretch is unique in that there is no hurricane protection levee (back levee) on the marsh side that protects existing homes and infrastructure from elevated water levels (tidal or storm surge). The Mississippi River levee is the only flood protection structure that keeps river water from entering the project study area. This situation minimizes the amount of infrastructure that could be affected by construction of a diversion structure and allows for a broader array of measures to be considered in addressing problems in the project area. The diversion influence area is approximately 98,000 acres encompassing an estuarine marsh system that has been heavily influenced by both man-made and natural processes. Channel construction, subsidence, erosion, saltwater intrusion, and storm-related damages have all significantly altered the natural environment, causing extensive losses of wetland habitats.

The location selected for the Tentatively Selected Plan is just north of Phoenix, LA. There are no known structures within the footprint of this area. It runs from the junction of the MR&T levee

and the Federal back levee to a point approximately 9,200 feet north on the MR&T levee. The White Ditch Value Engineering team identified this area as a good location to intake sediment because it is on a point bar. Point bars are locations where sediments drop out of the water column and settle. It is centrally located within the study area and could yield benefits to the north and south.

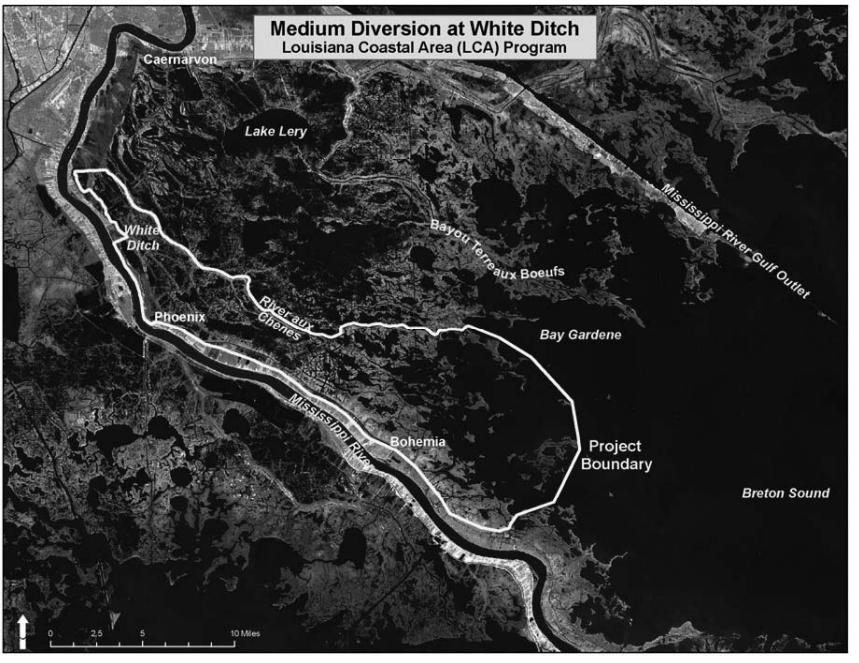


Figure 2. Medium Diversion at White Ditch Project Study Area.

3.0 CONCEPTUAL ECOLOGICAL MODEL DISCUSSION

The CEM developed for the Medium Diversion at White Ditch project is presented in Figure 3. Model components are identified and discussed in the following subsections.

3.1 Drivers

3.1.1 Anthropogenic Alterations – Altered Hydrology

The historic hydrology of the project area indicates that the current course of the Mississippi River has remained the same for the last 700 years and has directly influenced the development of the entire area. The project area is located on the east side of the Mississippi River and was formed between two natural levee ridge systems, River aux Chenes on the east and the

Mississippi River on the west. There are also two unnamed bayou ridges found within the project area. These ridges formed along the old natural bayous which were distributary channels for the Mississippi River. These natural bayous once carried sediments and nutrients into the project area during high river stages when the natural ridges were seasonally overtopped.

In the historical setting, floodwater from the river would recede and sediments and nutrients would be deposited in the inter-distributary basins located between ridges. During normal or low river stages the ridges along the distributary channels served like levees and buffered the basin areas from the daily tidal influence. This buffering effect created a low energy freshwater environment in the inter-distributary basins, forming deep organic soils. Drainage to the area was provided by a high water event breaching the River aux Chenes ridge in the southern part of the project area. This event caused the development of the Bayou Garelle tributary channel.

The present day hydrology of the project area has been altered and no longer functions in a historically natural pattern. Historically, water moved very slowly through the system. Freshwater slowly exited the system through meandering pathways in the marsh and saltwater was slow to intrude. Anthropogenic changes in the marsh allow water to rapidly pass through the system and saltwater is able to quickly intrude. The hydrologic balance within the marsh has been disturbed due to the following anthropogenic changes:

- The Mississippi River can no longer overflow its banks into the project area due to the Mississippi River protection levee. This has eliminated the introduction of freshwater from the river and disrupted natural sediment deposition patterns.
- Channels have been dredged through natural ridges, which has increased drainage and tidal exchange and exposed the soil to erosive forces.

3.1.2 Exotic and Invasive Species

Water hyacinth is a common invasive species in the Breton Sound Basin. It has already been demonstrated that areas supplied with freshwater from the river often becomes choked with dense floating mats of water hyacinth. Water hyacinth can eliminate the ability to utilize all propeller driven watercraft and can even restrict the mobility of airboats. During large storm events these floating mats can be picked up and dumped on native marsh vegetation. The result is that the native vegetation dies and the area is susceptible to erosive forces. Freshwater introduction by the Medium Diversion at White Ditch project has the potential to improve conditions for its growth. Opportunities exist to control this incursion through effective diversion, flexible management, prescribed burns of marsh grass, and chemical control.

Nutria is a common invasive species throughout the project area. Nutria is an introduced rodent that has proliferated throughout much of southern Louisiana. They are known to decimate marsh vegetation. Any marsh created by the project would be susceptible to damage by nutria. It may be necessary to deploy control measures if nutria become a problem in the project area.

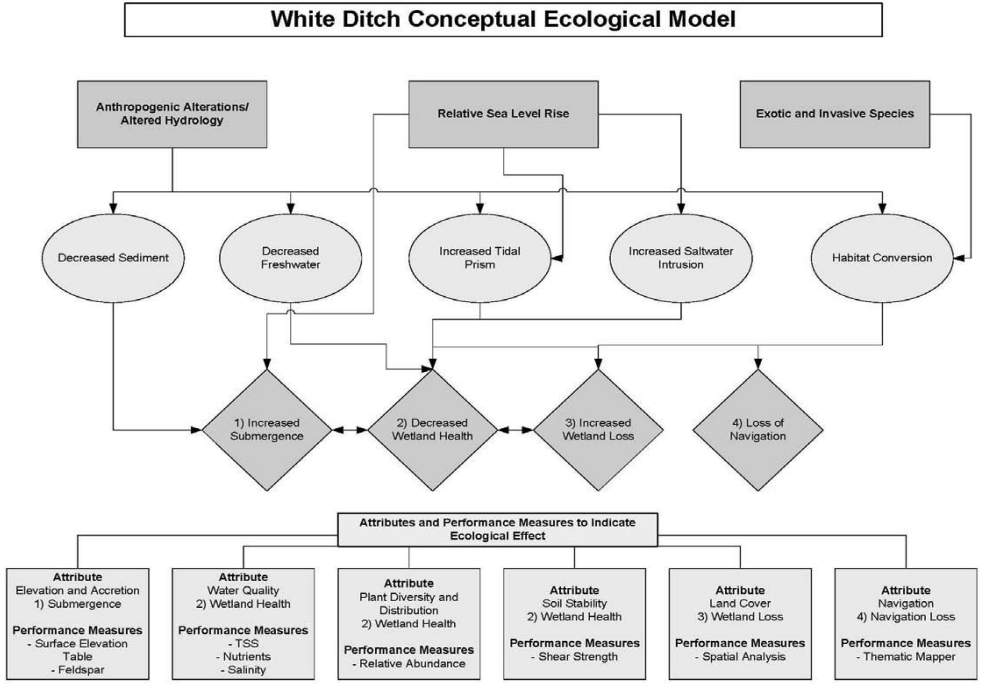


Figure 3: Conceptual Ecological Model, LCA Medium Diversion at White Ditch Project

3.1.3 Relative Sea Level Rise

Relative sea level rise consists of eustatic sea level rise combined with subsidence. Eustatic sea level rise is defined as the global increase in oceanic water levels primarily due to changes in the volume of major ice caps and glaciers, and expansion or contraction of seawater in response to temperature changes. Baseline (i.e., recent) eustatic sea level rise in the project area is approximately 0.75 foot/century. Subsidence is the decrease in land elevations, primarily due to consolidation of sediments, faulting, groundwater depletion, and possibly oil and gas withdrawal. Subsidence in the project area is approximately 2.35 feet/century. Relative sea level rise affects project area marshes by gradually inundating marsh plants. Marsh soil surfaces must vertically accrete to keep pace with the rate of relative sea level rise or marshes eventually convert to open water due to the depth of submergence.

3.2 Ecological Stressors

3.2.1 Decreased Freshwater and Sediments

The altered hydrology of the project area results in less freshwater and associated sediment and nutrients being delivered to marsh vegetation. Lack of freshwater facilitates increased saltwater intrusion and its associated effects on marsh vegetation. Vertical accumulation of wetland soils is achieved by accretion of mineral sediment inputs and/or organic accumulation resulting from above and below-ground plant productivity (DeLaune et al. 1983, DeLaune et al. 1990a). The survival and productivity of marshes is reliant on these soil-building processes to offset submergence and sea level rise (DeLaune et al. 1978, DeLaune et al. 1979, DeLaune et al. 1990b). As the natural hydrology of the project area marshes has become short-circuited by levees and canals, the residence time of the limited freshwater inputs has also decreased. Shorter residence times result in less settling of suspended sediments and less uptake of nutrients.

3.2.2 Increased Saltwater Intrusion

The altered hydrology of the project area facilitates increased saltwater intrusion and increased tidal exchange by providing efficient conduits for loss of freshwater and intrusion of saltwater. Wetland plant species have evolved different levels of tolerance to salinity and respond to salinity with different mechanisms. Numerous studies have demonstrated that elevated salinity can negatively affect all wetland species and can contribute to large-scale vegetation dieback (Chabreck and Linscombe 1982, McKee and Mendelssohn 1989). Storm surge can also be a mechanism for saltwater intrusion. This form of saltwater intrusion can be particularly detrimental to areas that have been hydraulically isolated, leading to extended durations of saltwater inundation.

3.2.3 Increased Tidal Prism

Degrading marsh and anthropogenic influences such as canals have resulted in an increased tidal prism. Healthy marsh acts like a sponge and slowly releases and absorbs tidal fluctuations. Impaired marsh cannot effectively slow water tidal movements and therefore there is increased erosion. Water flows in and out of the marsh at a much faster pace. Significant and immediate erosion of marsh vegetation and associated soils can occur as a result of tidal fluctuations. Losses may be more significant in areas that are already under stress from other ecological stressors but healthy marsh systems can be significantly impacted as well.

3.2.4 Habitat Conversion

Habitat conversion can be the result of several drivers acting independently or collectively. The conversion of habitat can make an area more susceptible to storms and erosion as well as altering the type of fauna expected to occur in the area. Freshwater marsh can be susceptible to saltwater intrusion. The effects of invasive species can damage or displace native vegetation.

3.3 Ecological Effects

3.3.1 Increased Submergence

Wetland plants employ different physical and/or metabolic mechanisms that enable them to tolerate and grow in flooded soils. However, in almost all cases plants are dependent on the maintenance of soil surface elevations to sustain the flooding regime to which they are adapted. Increases in flooding depth and duration cause stress to plants by altering metabolic function and negatively impacting productivity, survival, and regeneration. Relative sea level rise in the project area combined with insufficient accretion results in marsh systems with reduced productivity, survival, and regeneration due to submergence. Organic matter accumulation is also reduced, further exacerbating the impacts of submergence.

3.3.2 Decreased Wetland Health

Decreased freshwater, decreased nutrients, decreased residence time, increased saltwater intrusion, and increased submergence all act to decrease the overall health of the project area marshes. As marsh plants become stressed by inundation and saltwater intrusion, their productivity, survival, and regeneration are all negatively impacted. Over time, healthy marshes gradually decline to more interspersed marshes and eventually convert to open water.

3.3.3 Increased Wetland Loss

Wetland loss in the project area can be the result of gradual decline of marsh vegetation due to inundation and saltwater intrusion eventually leading to complete loss of marsh vegetation or the result of storm surge events. As marsh vegetation is lost, underlying soils are more susceptible to erosion and are typically lost as well, leading to deeper water and precluding marsh regeneration. Significant accretion of sediments is then required in order for marsh habitat to reestablish.

3.3.4 Loss of Navigation

Navigation can be significantly impaired by the presence of dense mats of water hyacinth. Water hyacinth can choke canals and open water areas to the point where propeller driven craft are completely incapable of utilizing once navigable waterways. In some cases the mats can become so thick that they are even impassable by airboat.

3.4 Attributes and Performance Measures

3.4.1 Elevation and Accretion

Ground surface elevation has been identified as a key indicator of project success with respect to increasing sediment and nutrient load within the study area. Comparison of pre-project elevations with post-project elevations would serve to determine whether sediment input and soil accretion is occurring within the study area in response to project features. A post-project decrease in the rate of elevation decline would implicitly indicate the introduction of sediment into the marshes as a result of the project. Two performance measures have been identified for

this attribute, including surface elevation table measurements and feldspar marker horizon measurements.

- *Surface Elevation Table (SET) measurements* provide a constant reference plane in space from which the distance to the sediment surface can be measured by means of pins lowered to the sediment surface. Repeated measurements of elevation can be made with high precision because the orientation of the table in space remains fixed for each sampling. Elevation change measured by the SET is influenced by both surface and subsurface processes occurring within the soil profile.
- *Feldspar marker horizon measurements* involve the placement of a cohesive layer of feldspar clay on the ground surface. Soil borings are extracted at the marker horizon location periodically to measure the amount of soil deposition and/or accretion that has occurred above the horizon since placement. Significant quantities of soil atop marker horizons are indicative of soil building within the area, which in turn indicates an increase in relative elevation.

A post-project stabilization of elevation as evidenced by SET measurements or documented soil accretion atop a marker horizon within the study area would be an indication of significant project success, while a post-project decrease in the rate of decline in elevation would be an indication of moderate project success. Conversely, no change in the rate of elevation decline post-project within the study area would indicate that the project did not succeed in offsetting subsidence and, by extension, habitat conversion, and future land loss.

3.4.2 Land Cover

Land cover has been identified as a key indicator of project success with respect to preventing, reducing, or reversing wetland loss in the study area. Comparison of pre-project land cover characteristics with post-project land cover characteristics would serve to determine whether the rate of conversion of marsh habitat to open water within the study area declines post-project.

- *Spatial analysis* has been identified as a performance measure for the determination of the response of land cover to the proposed project. Spatial analysis may involve comparative analysis of pre-project and post-project aerial or satellite imagery and may utilize thematic mapper analysis to determine relative changes in habitat composition within the study area.

A post-project stabilization in the total area of marsh habitat would be an indication of significant project success, while a post-project reduction in the rate of marsh loss within the study area would be an indication of moderate project success. Conversely, no change in the rate of marsh loss within the study area would indicate that the project did not succeed in preventing habitat conversion and, by extension, future habitat loss. Concurrently these tools would analyze navigable waterways in pre- and post -project conditions.

3.4.3 Navigation

Preservation of interior navigation by controlling invasive species would also be a key consideration. It would be beneficial to detect an increase in invasive species in navigable waterways.

- *Spatial analysis* has been identified as a performance measure for the determination of the increase of invasive species in the internal navigation systems within the proposed

project. Spatial analysis may involve comparative analysis of pre-project and post-project aerial or satellite imagery and may utilize thematic mapper analysis to determine relative changes within the study area.

3.4.4 Plant Diversity and Distribution

Plant diversity and distribution has been identified as a key indicator of project success with respect to preventing, reducing, or reversing wetland loss in the study area. Comparison of pre-project vegetation monitoring data with post-project vegetation monitoring data would serve to determine whether plant communities within the study area change in response to project features resulting in habitat changes. Relative abundance has been identified as the performance measure for this attribute.

- *Relative abundance* is a measure of the abundance or dominance of each species present in a sample. Relative abundance can be used to document the degree of impact in an area by measuring both species dominance and evenness. Relative abundance can be used to assess marsh health by comparing plant density before and after project implementation. The Braun-Blanquet method (Mueller-Dombois and Ellenberg 1974) as described in Steyer et al. (1995) will be utilized to measure relative abundance.

A post-project stabilization of relative abundance within the study area would be an indication of significant project success, while a post-project reduction in the rate of decline of relative abundance would be an indication of moderate project success. Conversely, no change in the rate of decline of relative abundance post-project would indicate that the project did not succeed in increasing vegetation productivity.

3.4.5 Water Quality

Water quality has been identified as a key indicator of project success with respect to reducing salinity levels and increasing sediment and nutrient loads within the study area. Comparison of pre-project water quality with post-project water quality would serve to determine whether freshwater throughput is introducing sediments and nutrients and flushing out saline waters within the study area in response to project features. Three performance measures have been identified for this attribute, including total suspended solids, nutrients, and salinity.

- *Total suspended solids* is a measurement of the total volume of sediment and other solids suspended in a given volume of water. Project features are designed to increase the amount of freshwater and consequently suspended sediments delivered to marshes in the study area.
- *Nutrients* are chemical compounds or minerals contained in surface waters that are extracted by organisms for nourishment. Common nutrients in surface waters include nitrates, phosphates, and ammonia. Project features are designed to increase the amount of freshwater and consequently nutrients delivered to marshes in the study area.
- *Salinity* is a measure of the concentration of dissolved salt in a given volume of water. Surface waters within the study area often exhibit elevated salinity levels with respect to their historic levels due to the altered hydrology of the area and periodically due to storm surge. Project features are designed to increase the amount of freshwater in the project area and consequently reduce salinity levels.

Post-project improvements in water quality within the study area, as evidenced by analyses of these measures, would be an indication of significant project success, while a post-project stabilization or decline in water quality within the study area would indicate that the project did not succeed in increasing riverine influence on the study area.

3.4.6 Soil Stability

Soil stability is a key indicator of the susceptibility of a marsh to erosive forces. The more stable a marsh is, the less vulnerable it is to erosion. The type of sediment that comprises a marsh as well as the vegetation present can influence stability. Shear strength would be used to measure soil stability throughout the marsh.

- *Shear strength* has been identified as a performance measure for the determination of the response of soil stability to the proposed project. Shear strength may involve comparative analysis of pre-project and post-project conditions along canals or waterbodies to determine whether the project is having positive effects on soil stability.

4.0 LITERATURE CITED

Barnes, T.K. and F.J. Mazzotti. 2005. Using Conceptual Models to Select Ecological Indicators for Monitoring. Restoration and Management of Estuarine Ecosystems. *In*: S.A. Bortone (ed.) *Estuarine Indicators*, CRC Press, Boca Raton, FL.

Chabreck, R.H. and G. Linscombe. 1982. Changes in vegetative types in Louisiana coastal marshes over a 10-year period. Louisiana Academy of Sciences 45:98–102.

DeLaune, R.D., W.H. Patrick, Jr. & R.J. Buresh. 1978. Sedimentation rates determined by 137 Cs dating in a rapidly accreting salt marsh. Nature 275:12. pp. 532–533.

DeLaune, R.D., R.J. Buresh, and W.H. Patrick, Jr. 1979. Relationship of soil properties to standing crop biomass of *Spartina alterniflora* in a Louisiana marsh. Estuarine Coastal Marine Science 8: 477–487.

DeLaune, R.D., C. J. Smith, and W. H. Patrick. 1983. Relationship of marsh elevation, redox potential, and sulfide to *Spartina alterniflora* productivity. Soil Sci. Soc. AM. J. 47:930–935.

DeLaune, R.D., S. R. Pezeshki, J. H. Pardue, J. H. Whitcomb, and W. H. Patrick, Jr. 1990a. Some influences of sediment addition to a deteriorating salt marsh in the Mississippi River deltaic plain: A pilot study. Journal of Coastal Research 6:1:181–188.

DeLaune, R.D., W.H. Patrick, and N. Van Breemen. 1990b. Processes governing marsh formation in a rapidly subsiding coastal environment. Catena 17:277–288. Cremlingen, Germany.

Fischenich, J.C. 2008. The Application of Conceptual Models to Ecosystem Restoration. Engineer Research and Development Center Publication TN-EMRRP-EBA-01. U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, MS.

McKee, K.L. and I.A. Mendelssohn. 1989. Response of a freshwater marsh plant community to increased salinity and increased water level. Aquatic Botany 34:301–316.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Ecology*. New York: John Wiley and Sons. 547 pp.

Ogden, J.C. and S.M. Davis. 1999. The Use of Conceptual Ecological Landscape Models as Planning Tools for the South Florida Ecosystem Restoration Programs. South Florida Water Management District, West Palm Beach, FL.

Steyer, G. D., R. C. Raynie, D. L. Steller, D. Fuller, and E. Swenson. 1995. Quality management plan for Coastal Wetlands Planning, Protection, and Restoration Act monitoring program. Open-file Series No. 95-01. Louisiana Department of Natural Resources, Coastal Restoration Division, Baton Rouge.

U.S. Army Corps of Engineers. 2004. Louisiana Coastal Area (LCA) Ecosystem Restoration Study. Volume I: Main Report. New Orleans District, New Orleans, LA.

Appendix J

Real Estate Plan

Real Estate Plan
Louisiana Coastal Area Near-Term Ecosystem Restoration Plan
Medium Diversion at White Ditch

1. PURPOSE

Title VII of the Water Resources Development Act of 2007 (Public Law 110-114) authorizes the Louisiana Coastal Area Program. The authority includes requirements for comprehensive planning, program governance, implementation, and other program components.

Coastal wetlands in Louisiana are a national significant environmental and economic resource. Erosion of these wetlands threatens the long-term stability of human populations in the area as well as important fish and wildlife resources.

This Real Estate Plan (REP) has been prepared to present the real estate requirements and support the Louisiana Coastal Area Near-Term Ecosystem Restoration Plan, Medium Diversion at White Ditch, Feasibility Report. Information contained within this report is based on preliminary data and is subject to change. **THE NON-STANDARD ESTATES PRESENTED IN THIS REP ARE NOT APPROVED AS PART OF THIS REAL ESTATE PLAN AND FURTHER REVIEW, REVISION, AND APPROVAL OF SUCH ESTATES ARE REQUIRED.**

2. DESCRIPTION OF LANDS, EASEMENTS, AND RIGHTS-OF-WAY (LER)

a. Description of Lands, Easements and Rights-of-Way (LER) required for the construction, operation and maintenance of the project

The White Ditch project area is located in the Breton Sound estuary and covers the area extending north and south from just south of Belair, Louisiana, to the coastline of Louisiana and extending east and west from the Mississippi River to the Oak River. This area extends about 50 km in the NW-SE directions and about 30 km in the SW-NE direction. Subsidence, erosion, channelization, saltwater intrusion, storm damage and the absence of fresh water, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area resulting in extensive wetland loss and ecosystem degradation. There is an existing siphon at the mouth of White Ditch that was built in 1963 and has not been in operation since 1991, except for two brief episodes.

The absence of a supply of fresh water, sediment, and nutrients has caused the marsh to degrade. This degradation coupled with the subsidence and sea level rise rate of approximately 1.04 cm per year has led to an increase in saltwater intrusion. The additional influx of saltwater from the Gulf of Mexico through the vast canal network in the project area has further damaged the marsh vegetation. In August and September 2005 Louisiana was hit by hurricanes Katrina and Rita. These hurricanes brought high winds and high tidal surges and destroyed thousands of acres of already weakened marsh. In September of 2008 hurricanes Ike and Gustav also hit the Gulf coast. While they did not make direct landfall in the project area, the tidal surges from these storms caused the loss of additional marsh acreage.

This restoration project would reverse the trend of habitat degradation between the Mississippi River and the River Aux Chenes Ridges through Mississippi River re-introduction. This will be accomplished by re-connecting the Mississippi River to the project area through the use of a river diversion. The material obtained through deepening/widening of the channel will be used to stabilize ridges on either side of the channel acting as containment. Dredge material will also be placed in strategic locations to build marsh. Any excess dredged material is to be used for beneficial marsh creation.

b. Total LER required for each project purpose and feature

There are thirteen (13) landowners of the twenty-two (22) parcels within the right-of-way needs for the project. All of the land needed for the project is privately owned. Landowners consist of three companies (Delacroix Corporation, Shayot Land Co, LLC, & Haspel & Davis), one church (St. John Baptist Church of Phoenix), and eight individuals in addition to State claimed water bottoms.

In the project area, lots/parcels are narrow and long extending back from the Mississippi River through the marsh. A typical parcel in the area is 40 arpents long. Because of the configuration of parcels, both the conveyance channel and the marsh creation/restoration features will affect 11 of the 13 landowners.

There is a total of 1,161.2 acres required for this project. The diversion structure will require approximately 7.2 acres, and is located within a single parcel, therefore affecting one landowner. Approximately 317.7 acres are necessary for the dredging of channels and improvement/enhancement of associated channel ridges needed to maximize the conveyance of fresh water and sediment. This feature affects 11 landowners on 15 parcels. This feature is also within NFS-owned water bottoms, and further addressed in section 3. below. Approximately 381 acres are required to accommodate marsh restoration efforts, affecting 18 parcels and 12 landowners. Approximately 3 acres are needed to install notched dike flow restrictors (canal plugs) to redirect and restrict a certain level of flow entering surrounding marshlands from the freshwater diversion. There are 6 of these features proposed for the project, two of which are located on State claimed water bottoms. Three of the plugs are proposed in canals owned by Delacroix Corporation (3 separate parcels) and one is located on property owned by a private individual. The additional 452.3 acres is required for temporary work area, which will affect all required tracts.

Construction of the project will also require the temporary relocation of State Highway 39 and a powerline adjacent to the highway. These relocations may cause temporary delays because of land records issues that are not uncommon since hurricane Katrina; right-of-way documentation no longer exists.

c. Estates to be acquired.

The Chief's Report that was approved in January 2005 for the 2004 LCA Ecosystem Restoration Study, contained several estates (both standard and non-standard) to be used for the LCA projects. The District acknowledges that it is Corps of Engineers policy to acquire fee simple title for ecosystem restoration projects in order to reduce the risk that incompatible uses on project land will occur after project construction and to ensure that ownership rights vested in the project are clear and enforceable (ER 1105-2-100, Appendix F, Amendment #2, F-20b(2)(a). However, regulations also

indicate that a lesser interest, such as, a specific type of permanent easement, may be appropriate depending upon the operational requirements of the project and other circumstances relevant to project implementation, including landowner preference (EP 1165-2-502, 17b). Circumstances wherein the acquisition of interests less than fee may be appropriate is where only select and easily identifiable and narrow affirmative rights are required for successful implementation of the project (ER 1105-2-100, Appendix F, Amendment # 2, F-20b(2)(b)i.).

Where project features exist, the proposed permanent estate acquisition is sufficient to accomplish construction, operation and maintenance of the features. The project has specific features in defined areas, and the necessary real estate rights are narrow, affirmative rights that can easily be defined. It is believed that a real estate interest is not necessary outside the project feature areas because the estates proposed herein provide sufficient rights to the Government to construct the project and also protect the interests of the Government by prohibiting use of the surface for mineral exploration or construction of improvements. In addition, because the project area is coastal wetlands, the project features are further protected through the police powers of the Federal Government through Section 404 of the Clean Water Act which require a permit from the Corps of Engineers for any activity that could negatively impact a wetland. Lastly, due to the topography of the project area, it is highly unlikely that the benefitted marshes could be developed. These three protections combined greatly reduce the risk that incompatible uses on project lands will occur after construction.

All documentation associated with the approval request of to deviate from fee simple title acquisition is included as Exhibit E.

Any activity that may have a detrimental effect to the benefits area of the project is regulated, therefore the risks over time would be minimal - aside from uncontrollable forces such as nature (hurricanes, etc.). The types of activities that could be considered risks (oil/gas surface exploration, excavation and fill activities, etc.) are currently regulated by the Louisiana Department of Natural Resources, Office of Coastal Management, under Title 43, Chapter 7 of the Louisiana Administrative Code. Specifically, Subchapter C, Section 723.A.2. requires permits for dredging or filling, urban developments, energy development activity(exploration and transmission of oil/gas), mining activities(surface & subsurface), surface water control, shoreline modification, recreational developments, industrial development, drainage projects and "any other activities or projects that would require a permit or other form of consent or authorization from the U.S. Army Corps of Engineers, the Environmental Protection Agency, or the Louisiana Department or Natural Resources." Additionally, activities in the marshes (wetlands) are regulated by Section 404 of the Clean Water Act under the purview of the USACE. Certain other activities are regulated by the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the EPA, and the Louisiana Department of Environmental Quality.

There are five (5) estates proposed for use for this project; three standard and two non-standard. The recommended estates to be acquired are explained below.

Temporary Work Area Easement (standard estate)

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A)(Tract No__); for a period not to exceed two (2) years, beginning with the date possession of the

land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a 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 the White Ditch 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.

Fee excluding minerals (with restriction on use of the surface) (standard estate)

The fee simple title to (the land described in Schedule A)(Tract No __), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding from the taking all oil and gas, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil and gas, but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said oil and gas.

Channel improvement easement (standard estate)

A perpetual and assignable right and easement to construct, operate, and maintain channel improvement works on, over and across (the land described in Schedule A)(Tract No) for the purposes as authorized by the Act of Congress approved _____, including the right to clear, cut, fell, remove and dispose of any and all timber, trees, underbrush, buildings, improvements and/or other obstructions therefrom; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, 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.

Canal alteration easement (non-standard estate)

A perpetual and assignable right and easement in (the land described in Schedule A)(Tract No__) to deposit materials within and around the canal, to place plugs or fully close the canal, to cut gaps in the canal, or make other alterations to the canal, in order to restore the hydrology and /or to stabilize the spoil banks along the canal; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form; provided however, that the rights, interests and privileges, associated with the original canal right-of-way, hereinabove excepted and reserved are hereby subordinated to the right of this canal alteration easement.

Wetland Creation and Restoration Easement (non-standard estate)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. -) to construct, operate, maintain, patrol, repair, renourish, and replace wetlands and associated coastal habitats, including the right to borrow and/or deposit fill; to accomplish any alterations of contours on said land; to plant vegetation on said land; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; to construct dikes and to install, alter, relocate, repair or plug cuts in the banks of dikes; to construct, operate and maintain pipelines for the purpose of dredge or spoil material transport and deposition; to move, store and remove equipment and supplies; to plug, fill or alter pipeline canals located within the limits of the easement; to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement (excepting the structures now existing on the land, described as _____), provided that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill, [that no vehicles shall be operated within the limits of the easement without such approval, except as may be required to operate and maintain the easement,] and that no trimming, cutting, felling or removal of trees, underbrush, and any other vegetation shall be conducted without such approval; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs,) successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form.

d. Breakdown of Acreage by Estate

Temporary Work Area Easement

Approximately 452.3 acres are required for the temporary work area associated with the construction of this project.

Fee excluding minerals

Approximately 7.2 acres of fee will be required for the structure location.

Channel Improvement Easement

Approximately 317.7 acres of permanent easement will be required to accommodate the conveyance channel features of this project. Channels will be dredged to allow for a greater volume of water to be conveyed. The dredged material will be used to restore the ridges along the conveyance channel in order to properly stabilize and contain the channel, thereby eliminating the need for dredge disposal areas.

Canal Alteration Easement

Approximately 3 acres of permanent easement will be required for placement of notched dike flow restrictors (plugs) to be placed in existing canals. These plugs will be utilized to redirect and restrict the amount of freshwater conveyed to certain locations with the project area.

Wetland Creation and Restoration Easement

Approximately 381 acres of permanent easement will be required for wetland creation and restoration. Dredged material obtained from deepening/widening the conveyance channel will be used for beneficial marsh creation.

3. LERRD OWNED BY THE NON-FEDERAL SPONSOR

The non-federal sponsor for this project is the Coastal Protection and Restoration Authority of Louisiana (CPRA), through the Office of Coastal Protection and Restoration. There are NFS-owned water bottoms required for this project.

A significant portion of the LERRD required for this project is located on NFS-owned water bottoms. Nearly the entire conveyance channel located east of the 40-arpent line is located within NFS-owned water bottoms, which equates to approximately half of the proposed channel improvement easement. In addition, two of the proposed channel plugs depicted in the attached Exhibit A are located on State water bottoms (the second northernmost plug, and the southernmost plug).

The above-referenced water bottoms are available for the project but not sufficient to cover the entire right-of-way necessary, therefore additional easements will be necessary. At this time, none of the right-of-way identified as NFS-owned water bottoms has been previously provided as an item of cooperation for another Federal project. Credit will be received for the required LERRD.

4. NON-STANDARD ESTATES DISCUSSION

The proposed non-standard estates, Wetland Creation and Restoration Easement and Canal Alteration Easement, are included herein, 2.c. above. Approval of these non-standard estates is requested as part of document approval. All documentation associated with the approval request of the non-standard estates is included as Exhibit E.

5. EXISTING FEDERAL PROJECTS WITHIN THE LERRD REQUIRED FOR THE PROJECT

There are no existing federal projects within the LERRD required for this project.

6. FEDERALLY OWNED LAND REQUIRED FOR PROJECT

There is no federally owned land within the project area. Therefore, no federally owned land is required for this project.

7. NAVIGATION SERVITUDE

Navigational Servitude allows acquisition of shore lands extending to the ordinary high-water mark thereof and may be exercised under statutory rights and powers without obligation for compensation to the riparian landowners. Navigational Servitude will not be exercised for this project.

8. MAPS

Exhibit A contains maps of the project area. Page 1 of Exhibit A is a Project Area map showing the geographic location of the project area. Page 2 of Exhibit A is a map depicting the proposed project features, and generally conveys the anticipated LER required to accommodate those features. Page 3 of Exhibit A is a map depicting the proposed projects features in a wider view so that all plug locations are also depicted.

9. INDUCED FLOODING

It is not anticipated that induced flooding will rise to the level of a taking for which just compensation will be owed. Induced flooding is largely dependent on the operation of the diversion. The proposed diversion structure is recommended to be operated by a "pulse" introduction of fresh water during seasonal high sediment loads being carried by the Mississippi River (March – May).

Although the White Ditch diversion will increase the frequency of inundation in the interior marshes during the March-April pulse, no substantial damage to private property is anticipated to occur. The benefited area consists of low-lying marsh and shallow open water accessible only by boat and vulnerable to tidal surges. The area was once subject to inundation by the Mississippi River during spring high water events, until levees were constructed along the river by the Mississippi River and Tributaries project. The White Ditch diversion is formulated to mimic these natural, land-building flood events by reintroducing freshwater, sediment and nutrients to the marshes in the project area. Over the 50-year period of analysis, the project is anticipated to prevent the loss of approximately 13,750 acres of emergent marsh in the project area and could potentially lead to a net gain in marsh acres. The current land uses are likely to be enhanced through operation of the diversion because it will improve fish and wildlife habitat in the benefited area.

Alligator egg harvesting is the only known current land use that has the potential to be impacted by a proposed freshwater diversion. However, due to the proposed operation of the diversion, alligator life cycle requirements (courtship, mating, nest building, egg laying, hatching, and rearing of young) within the project area are not expected to be altered.

The recommended "pulse" is anticipated to "freshen" (or dramatically reduce salinity in) the project area for a period of approximately four to five months, whereas currently, the area maintains a certain level of salinity during that time frame. After the seasonal "pulse", the diversion could be operated with a maintenance flow of 1,000 cfs. Salinity appears to be determined more by maintenance flows than by the approximate 2-month "pulse" activity. From the data evaluated up to this point, it appears that the overall salinity boundaries with the operation of the project are not drastically changed from the current salinity boundaries. However, the timing of the fresh waster introduction will drive the consequence to certain crops, specifically oysters.

There are no oyster leases within the LERRDs required for this project. There are oyster leases near the outer limits of the project boundary, as depicted in Exhibit B. The alteration of salinity during the spring months may affect the production of those oyster beds. However, Louisiana law does not require the State to ensure adequate salinity levels for the leased oyster beds.

There are no structures upon lands known to be impacted by the project. In addition, it is not likely or anticipated that any induced flooding that may occur will impact any structures.

All existing viable uses of the marshlands are not expected to be detrimentally affected by the periodic change in water elevation. Therefore, flowage easements are not necessary within the project area.

10. BASELINE COST ESTIMATE

A cost estimate of the real property interests required for this project is attached as Exhibit C and indicates the required interests for construction, operation and maintenance of this project. The Unit Value used to generate Total Real Estate Project Costs was derived from a Gross Appraisal that was performed in November 2009. Information used in the Gross Appraisal was obtained from the Parish Assessor's office, comparable sales, and interviews with local appraisers and landowners. The Sales Comparison Approach was used in the appraisal to derive current fair market value.

11. RELOCATION ASSISTANCE BENEFITS

It is not anticipated that there will be any residents eligible for relocation benefits. There are no structures in the vicinity of the proposed project alternative impacted area. Any required relocations will be performed in accordance with the provisions of Public Law 91-646, the Uniform Relocation Act, as amended.

12. MINERAL ACTIVITY/TIMBER HARVESTING IN PROJECT AREA

There is mineral activity (oil/gas wells and pipelines) within the vicinity of the proposed project area. There are two oil wells located within the proposed channel, and one oil well located within the proposed marsh creation/wetland restoration. All wells located within the right-of-way limits of the project are closed/abandoned and therefore, not productive or in use. Closed/abandoned wells within the project area are not anticipated to cause real estate issues or delays for the project.

There is also one line (believed to be formerly used for oil) that has a coastal permit. This permitted line lies across the proposed diversion channel. Although not documented within the State's system, after speaking with the Coastal Permits Section, it is believed that the line is no longer in use because the wells that previously served the line have been closed/abandoned. In fact, it is unknown whether the line has been removed because the use or abandonment of such lines is not a reporting requirement of the coastal permit. Although possible existence of the line is not anticipated to cause real estate issues, removal of the line, if necessary, may cause brief construction delays.

It is not anticipated that any merchantable timer will be impacted by the proposed project.

13. NON-FEDERAL SPONSOR ASSESSMENT

The Non-Federal sponsor for this project is the Coastal Protection and Restoration Authority of Louisiana (CPRA), through the Office of Coastal Protection and Restoration. As the non-federal sponsor, CPRA must provide all real estate interests required for the project, i.e., all lands, easements, rights-of-way, relocations, and any other interest, including suitable borrow and dredged or excavated material disposal areas (LERRDs).

The Non-Federal Sponsor is assessed to be fully capable to perform all acquisition activities associated with this project. The Sponsor has the capability to acquire and hold real estate as well as the ability to contract for real estate services to supplement its staff in order to meet project schedules. However, it must be recognized herein that CPRA is the non-federal sponsor for all New Orleans District coastal restoration projects and all hurricane risk reduction projects. Therefore, if all LCA projects and several hurricane risk reduction projects are authorized for construction under concurrent schedules, there is a possibility that CPRA may not be able to accomplish LER acquisition due to the massive amount of work required for such an undertaking. If that were the case, it is possible that CPRA may request that the Federal Government accomplish acquisition of LER on their behalf.

The Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capabilities is attached as Exhibit D.

14. ZONING IN LIEU OF ACQUISITION

There will be no zoning ordinances enacted to facilitate acquisition of land for the project.

15. SCHEDULE

A detailed schedule will be developed when the final ROW is determined. Normally, an estimate of one year is allowed to acquire ROW for a project.

16. FACILITY OR UTILITY RELOCATION

A brief survey was conducted of utilities/facilities that will be impacted by the proposed project. A determination of compensable interests has not been made as of the date of this report. However, an estimate of likely utility/facility relocation costs are included. The following facilities/utilities are anticipated to be impacted by the proposed project: State Highway 39, an Entergy power line along Highway 39, and a telephone cable that appears to be in the same right-of-way corridor and share the same poles as the power line. Estimated relocation costs for the State Highway and the Entergy powerline are $101,000 and $107,000 respectively.

17. HTRW AND OTHER ENVIRONMENTAL CONSIDERATIONS

Investigation for contaminants within the project boundaries was conducted in accordance with CERCLA, RCRA, and applicable State law, by the St. Louis District. Soil and water quality sampling is required prior to construction. It is not anticipated that any clean-up or response actions will be required.

However, if it is discovered that clean-up or response actions are necessary, in accordance with Article II. H. of the Feasibility Cost Sharing Agreement (FCSA), executed on 6 November 2008, "The non-federal sponsor shall be responsible for the total cost of developing a response plan for addressing any hazardous substances regulated under the Comprehensive Environmental Response, Compensation and Liability Act of 1980, Pub. L. No. 96-510, 94 Stat. 2767, (codified at 42 U.S.C. Sections 9601-9675), as amended, existing in, on, or under any lands, easements of rights-of-way that the Government determines to be required for the construction, operation, and maintenance of the project. Such costs shall not be included in total study costs."

18. LANDOWNER ATTITUDE

There is a great deal of landowner support for this project. That support is driven by the fact that the area in the vicinity of the proposed project is degrading at an alarming rate and that the potential exists to not only stop, but reverse the trend of degradation with the project area.

Even though there is a great deal of support for this project, there continues to be a great deal of concern from landowners regarding current land uses and harvesting activities that take place on the affected properties. Activities of concern include, but are not necessarily limited to oyster harvesting, alligator nesting and hunting activities. The concern is based on the fact that the afore-mentioned activities have the potential to adversely impact certain landowners financially.

19. NOTIFICATION TO THE NFS REGARDING THE RISKS ASSOCIATED WITH ACQUIRING LAND BEFORE EXECUTION OF THE PROJECT PARTNERSHIP AGREEMENT (PPA)

As project alternatives are clearly selected, the non-federal sponsor will be issued a risk letter explaining the risk of acquiring lands prior to the execution of the PCA and advised to wait on coordination of the acquisition plan and notice to proceed with acquisition.

20. OTHER REAL ESTATE ISSUES RELEVANT TO THE PROJECT

There are no other known real estate issues, other than those mentioned in this report.

ANNE L. KOSEL
Chief, Real Estate Division
USACE, St. Louis District

Prepared by:
Real Estate Plan – Lynn Hoerner, Realty Specialist
Cost Estimate – Timothy Nelson, Appraiser

EXHIBIT A
MAPS

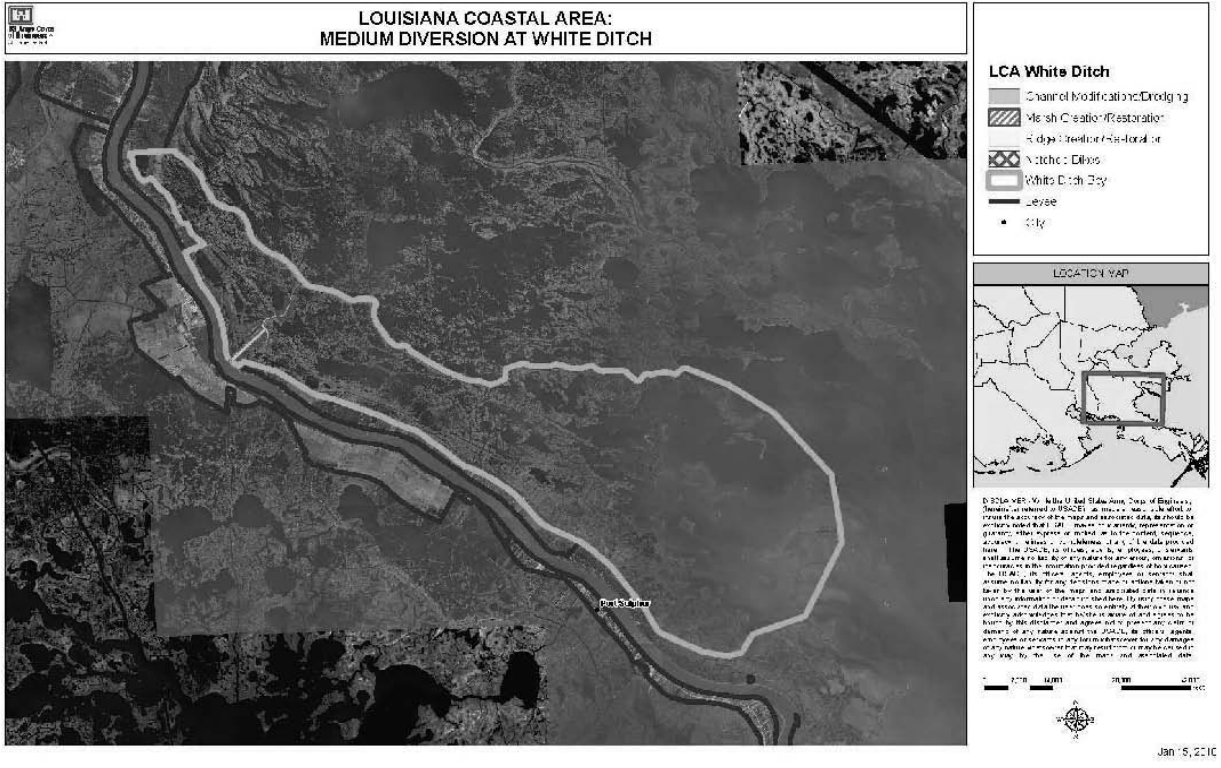

LOUISIANA COASTAL AREA:
MEDIUM DIVERSION AT WHITE DITCH
LCA White Ditch
Channel Modification/Dredging
Marsh Creation/Restoration
Ridge Creation/Restoration
Ditches
White Ditch Bay
Levee
City
LOCATION MAP
Port Sulphur
Jan 15, 2010

Exhibit A-1


LOUISIANA COASTAL AREA:
MEDIUM DIVERSION AT WHITE DITCH
BAYOU GARELLE
STATE CLAIMED WATER BOTTOMS
KIMBLE, ALBERTINE M
HARRAH'S RACING ST
HOOD, RIDER, LLC ET AL
HASPEL, DAVID ET AL
DELACROIX
HASPEL, S DAVIS
THOMAS, CORNELIUS ET AL
SCHAYOT LAND CO LLC
GRANGE, ET, GRACE A ET AL
CHAISSON, JOHN A ET AL
WHITE, GERALD, ET ET
MOSS, JOHN HO
RANDALL, ANDREW S VERA
THORNTON, CHARLES SR, ESTATE
CARTER, SEDONIA
SUMMERS, EMMETT S ET AL
ST JOHN BAPTIST CHURCH OF PHOENIX
COOK, SHERMAN EST
Lake Barre
LCA WHITE DITCH
Legend
Oil Gas Wells
Pipeline
Levee
Notched Dikes
Channel Modifications/Dredging
Marsh Creation/Restoration
Ridge Creation/Restoration
White Ditch Bdy
LOCATION MAP
DISCLAIMER - While the United States Army Corps of Engineers, (hereinafter referred to USACE) has made a reasonable effort to insure the accuracy of the maps and associated data, its should be explicitly noted that USACE makes no warranty, representation or guaranty, either express or implied, as to the content, sequence, accuracy, timeliness or completeness of any of the data provided herein. The USACE, its officers, agents, employees, or servants shall assume no liability of any nature for any errors, omissions, or inaccuracies in the information provided regardless of how caused. The USACE, its officers, agents, employees or servants shall assume no liability for any decisions made or actions taken or not taken by the user of the maps and associated data in reliance upon any information or data furnished here. By using these maps and associated data the user does so entirely at their own risk and explicitly acknowledges that he/she is aware of and agrees to be bound by this disclaimer and agrees not to present any claim or demand of any nature against the USACE, its officers, agents, employees or servants in any forum whatsoever for any damages of any nature whatsoever that may result from or may be caused in any way by the use of the maps and associated data.
0 1,000 2,000 4,000 6,000 Feet
N
W
E
S
3/17/2010

Exhibit A-2


LOUISIANA COASTAL AREA:
MEDIUM DIVERSION AT WHITE DITCH
BAYOU GARELLE
STATE CLAIMED WATER BOTTOMS
DELACROIX
THOMAS, CORNELIUS ET AL
SCHAYOT LAND CO LLC
LOPEZ ADDITION
LCA WHITE DITCH
Legend
Channel Modifications/Dredging
Marsh Creation/Restoration
Notched Dikes
Ridge Creation/Restoration
Oil Gas Wells
Pipeline
White Ditch Bdy
Levee
LOCATION MAP
DISCLAIMER - While the United States Army Corps of Engineers, (hereinafter referred to USACE) has made a reasonable effort to insure the accuracy of the maps and associated data, its should be explicitly noted that USACE makes no warranty, representation or guaranty, either express or implied, as to the content, sequence, accuracy, timeliness or completeness of any of the data provided herein. The USACE, its officers, agents, employees, or servants shall assume no liability of any nature for any errors, omissions, or inaccuracies in the information provided regardless of how caused. The USACE, its officers, agents, employees or servants shall assume no liability for any decisions made or actions taken or not taken by the user of the maps and associated data in reliance upon any information or data furnished here. By using these maps and associated data the user does so entirely at their own risk and explicitly acknowledges that he/she is aware of and agrees to be bound by this disclaimer and agrees not to present any claim or demand of any nature against the USACE, its officers, agents, employees or servants in any forum whatsoever for any damages of any nature whatsoever that may result from or may be caused in any way by the use of the maps and associated data.
0 1,000 2,000 4,000 6,000 Feet
3/17/2010

Exhibit A-3

EXHIBIT B
OYSTER LEASE LOCATION MAP

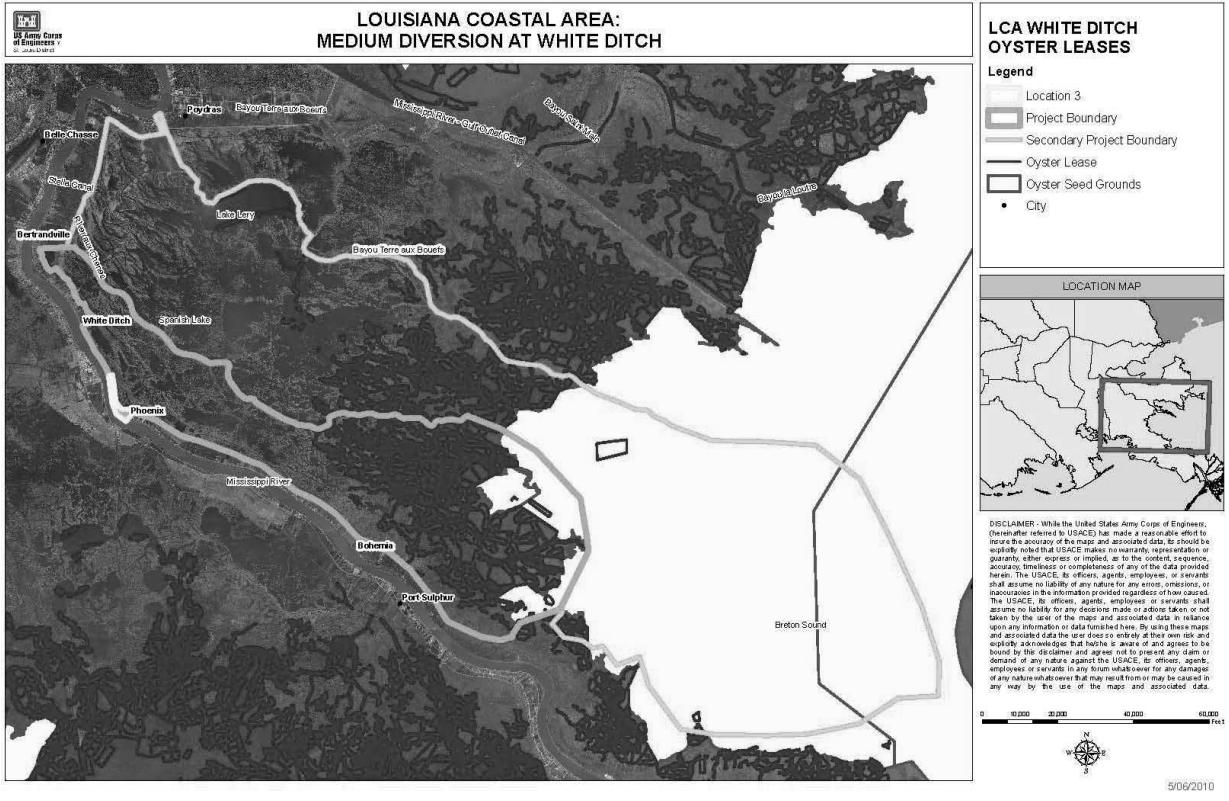

US Army Corps of Engineers
LOUISIANA COASTAL AREA:
MEDIUM DIVERSION AT WHITE DITCH
Poydras
Bayou Terre aux Boeufs
Mississippi River - Gulf Outlet
Bayou Terre Aux Boeufs
Belle Chasse
Bayou La Loutre
Lake Lery
Bertrandville
Bayou Terre aux Boeufs
White Ditch
Spanish Lake
Phoenix
Mississippi River
Bohemia
Port Sulphur
Breton Sound
LCA WHITE DITCH
OYSTER LEASES
Legend
Location 3
Project Boundary
Secondary Project Boundary
Oyster Lease
Oyster Seed Grounds
City
LOCATION MAP
DISCLAIMER - While the United States Army Corps of Engineers, (hereinafter referred to USACE) has made a reasonable effort to insure the accuracy of the maps and associated data, its should be explicitly noted that USACE makes no warranty, representation or guaranty, either express or implied, as to the content, sequence, accuracy, timeliness or completeness of any of the data provided herein. The USACE, its officers, agents, employees, or servants shall assume no liability of any nature for any errors, omissions, or inaccuracies in the information provided regardless of how caused. The USACE, its officers, agents, employees or servants shall assume no liability for any decisions made or actions taken or not taken by the user of the maps and associated data in reliance upon any information or data furnished here. By using these maps and associated data the user does so entirely at their own risk and explicitly acknowledges that he/she is aware of and agrees to be bound by this disclaimer and agrees not to present any claim or demand of any nature against the USACE, its officers, agents, employees or servants in any forum whatsoever for any damages of any nature whatsoever that may result from or may be caused in any way by the use of the maps and associated data.
0 10,000 20,000 40,000 60,000 Feet
N
W
E
S
5/06/2010

EXHIBIT C
REAL ESTATE COST ESTIMATE

White Ditch Bayou Restoration Project
Plaquemines Parish, Louisiana
Real Estate Cost Estimate
Alternate 3F

20-Jan-10

	Area (Acres)	Unit Value (per Acre)	Percent of Fee Value		Value
Fee Simple	7.2	$ 350	1	$	2,520
Canal Alternation Easement	3	$ 350	1	$	1,050
Channel Improvement Easement	317.7	$ 350	0.25	$	27,799
Wetland Creation and Restoration Easement	381	$ 350	0.25	$	33,338
Temporary Easement (Two year term)	440.3	$ 350	0.2	$	30,821
Temporary Easement (Two year term) (plugs)	12	$ 350	0.2	$	840
SUBTOTAL				$	96,367

Improvements	Number of Structures		
Single Family Residences	0		$ -
Commercial Improvements	0		$ -
SUBTOTAL			**$ -**
Severance Damages	(20 Percent of land cost, rounded)		$ 19,273
Contingencies	(25 Percent, rounded)		$ 28,910
Total Real Property Costs			$ 144,551
		CALL	**$ 145,000**
Acquisition Costs @ $15,000 per ownership (13 Owners)			$ 195,000
Relocation Assistance Cost (PL91-646)			
Supplement Replacement Housing			$ -
Business Moving Expenses			$ -
Title III expenses			$ 6,000
TOTAL PROJECT REAL ESTATE COST			**$ 346,000**

EXHIBIT D
NON FEDERAL SPONSOR ASSESSMENT

ASSESSMENT OF NON-FEDERAL SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY
Coastal Protection Restoration Authority (CPRA)
through the
Office of Coastal Protection and Restoration (OCPR)

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 of eminent domain for this project? **YES - But limited to expropriation.**

c. Does the sponsor have "quick-take" authority for this project? **NO - Although the sponsor does not have quick take authority, if this should be needed for the project, the sponsor may partner with a Levee District or Parish Government who has this authority (Act 225 RS38:301.1 and Act 320) if they agree.**

d. Are any of the lands/interests in land required for the 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? **Unknown**

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? **N/A**

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 workload, if any, and the project schedule?
The office of OCPR is staffed with 3 Land Specialists and one Manager. Given current and projected workload, the in-house staff is not sufficient to accomplish acquisition of realty interests for this project.

e. Can the sponsor obtain contractor support, if required in a timely fashion? **Unknown, no schedule has been drafted. Contracting typically takes 12 to 18 months.**

f. Will the sponsor likely request USACE assistance in acquiring real estate?
Yes it is likely, but ultimately depends on the responsibilities as agreed upon in the PPA yet to be developed.

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?

"A detailed schedule will be developed when the final ROW is determined. Normally, an estimate of one year is allowed to acquire ROW for a project." Once project designs are finalized, the sponsor will be requested to provide an acquisition schedule.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? **YES**

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable.
Fully capable

V. Coordination:

a. Has this assessment been coordinated with the sponsor?
YES

b. Does the sponsor concur with this assessment?
YES

Prepared By:

Judith Y. Gutierrez 3/25/10
Judith Y. Gutierrez
USACE
Chief, Appraisal. & Planning Branch

James L. Altman
James L. Altman
OCPR
Land Manager

Approved By:

Linda C. LaBure
Chief, Real Estate Division

EXHIBIT E
DEVIATION FROM FEE TAKING AND
NON-STANDARD ESTATES APPROVAL REQUEST

LCA: MEDIUM DIVERSION AT WHITE DITCH
REQUEST FOR APPROVAL TO DEVIATE FROM FEE TAKING AND
REQUEST FOR APPROVAL OF NON-STANDARD ESTATE

1. This is a request for approval to deviate from acquisition of the Fee estate for the LCA Medium Diversion at White Ditch project and request for approval to acquire a Channel Improvement Easement (standard estate), a Canal Alteration Easement (non-standard estate), and a Wetland Creation and Restoration Easement (non-standard estate) to accomplish the project.

2. The detailed project purpose and description is contained within the Real Estate Plan. The project entails re-connecting the Mississippi River to the project area through the use of a river diversion. The material obtained through deepening/widening of the channel will be used to stabilize ridges on either side of the channel acting as containment. Dredge material will also be placed in strategic locations to build marsh. Any excess dredge material is to be used for beneficial marsh creation.

3. Maps depicting the locations of project features are included in the Real Estate Plan as Exhibit A, pages 2 and 3.

4. The District acknowledges that it is Corps of Engineers policy to acquire fee simple title for ecosystem restoration projects in order to reduce the risk that incompatible uses on project land will occur after project construction and to ensure that ownership rights vested in the project are clear and enforceable (ER 1105-2-100, Appendix F, Amendment #2, F-20b(2)(a). However, regulations also indicate that a lesser interest, such as, a specific type of permanent easement, may be appropriate depending upon the operational requirements of the project and other circumstances relevant to project implementation, including landowner preference (EP 1165-2-502, 17b). Circumstances wherein the acquisition of interests less than fee may be appropriate is where only select and easily identifiable and narrow affirmative rights are required for successful implementation of the project (ER 1105-2-100, Appendix F, Amendment # 2, F-20b(2)(b)i.).

5. It is the opinion of the Non-Federal Sponsor, The Coastal Protection and Restoration Authority (CPRA), and the District that construction of this project can be accomplished through the acquisition of perpetual easements rather than fee. The project has specific features in defined areas, and the necessary real estate rights are narrow, affirmative rights that can easily be defined. The standard Channel Improvement Easement would allow the Government sufficient rights to construct the cuts necessary to form the conveyance channel. District Office of Counsel has prepared a non-standard Wetland Creation and Restoration Easement that would allow the Government necessary rights to place dredged material in the marsh to improve the habitat and would protect the environment by prohibiting construction of structures, excavation of the property or placement of fill without approval by the United States. The estate also prohibits use of the surface to explore for minerals. District Office of Counsel has also prepared a non-standard Canal Alteration Easement which would allow the placement of plugs in existing canals, to redirect and restrict freshwater flow, and specifically prohibits the use of the surface for mineral exploration in addition to prohibiting any activity that interferes with the rights of the easement.

6. It is the opinion of the District that the estates proposed herein provide sufficient rights to the Government to construct the project and also protect the interests of the Government by prohibiting use

of the surface for mineral exploration or construction of improvements. In addition, because the project area is coastal wetlands, the project features are further protected through the police powers of the Federal Government through Section 404 of the Clean Water Act which require a permit from the Corps of Engineers for any activity that could negatively impact a wetland. Lastly, due to the topography of the project area, it is highly unlikely that the benefitted marshes could be developed. These three protections combined greatly reduce the risk that incompatible uses on project lands will occur after construction.

7. The District proposes the acquisition of easements rather than fee considering that this project is one of 15 Louisiana Coastal Area (LCA) projects which collectively encompass thousands of acres. The decisions regarding which estates to acquire for ARTM will impact the other 14 LCA projects. The non-federal sponsor, The Coastal Protection Restoration Authority, is not in favor of owning fee interest over the project area for ARTM. The mission of the non-federal sponsor is to oversee all hurricane risk reduction projects and all coastal restoration projects in south Louisiana. The sponsor is willing to acquire a fee estate when it is absolutely necessary for the project. However, owning fee lands for public access is not within the authorized missions of the non-federal sponsor.

8. Approval of the non-standard Wetland Creation and Restoration Easement is requested because there is no standard easement that includes the real estate rights necessary for construction of certain project features. The project includes using dredged material for stabilization of ridges on either side of the conveyance channel and disposal of additional dredged material in designated areas to use it beneficially to enhance existing marsh and to propagate the growth of marsh in waterbottoms

    - The Wetland Creation and Restoration Easement provides all the necessary rights to protect the marsh as well as the marsh that will naturally propagate in the project areas. The only potential use of the property, given its location and physical characteristics, is for recreation (fishing and hunting) and mineral development. Recreational uses will not impact the viability of the project. The Wetland Creation and Restoration Easement prohibits the construction of structures, operation of vehicles, excavation of the land, disposal of material, cutting of trees, and the use of the surface for mineral exploration without prior approval by the United States

    - The cost of acquiring the Wetland Creation and Restoration Easement is less than the cost of acquiring Fee. For the purposes of this project the Wetland Creation and Restoration Easement is valued at 25% of Fee value

    - The Wetland Creation and Restoration Easement was written using language from several standard estates such as the Perpetual Beach Nourishment Easement, the Perpetual Beach Storm Damage Reduction Easement , the Fee Excluding Minerals (with restrictions on use of the surface), and the Flowage Easement (Permanent Flooding).

    - For ease of review, attached as Exhibit A is a highlighted version of the Wetland Creation and Restoration Easement indicating which language was taken from standard estates and which language is non-standard. Also attached as Exhibit B is a final version of the estate. Exhibit C is a written statement from Office of Counsel (MVN), indicating the legal sufficiency of the Non-Standard Estate.

9. Approval is also requested for a non-standard Canal Alteration Easement because there is no standard easement that includes the real estate rights necessary for the construction of certain project features. The project includes placing plugs in designated areas/canals to redirect freshwater within surrounding marshlands.

    - The Canal Alteration Easement provides all the necessary rights to construct, operate and maintain the plugs as well as adaptively manage the water restriction and conveyance associated with the project. The potential uses of the property given the location and physical characteristics are recreation (hunting and fishing) and mineral development. The Canal Alteration Easement specifically prohibits the use of the surface for mineral exploration in addition to prohibiting any activity that interferes with the rights of the easement.

    - For ease of review, attached as Exhibit D is a highlighted version of the Canal Alteration Easement which indicates which language was taken from standard estates and which language is non-standard. Also attached as Exhibit E is a final version of the estate. Exhibit F is a written statement from Office of Counsel (MVN), indicating the legal sufficiency of the Non-Standard Estate.

10. Similar non-standard Wetland Creation and Restoration Easement and Canal Alteration were previously included in the approved 2004 LCA Project Report.

11. Also enclosed as Exhibit G is a Quality Control Checklist, Request to Deviate from Guidance as to Appropriate Interest to Acquire and/or Request for Approval of Use of Non-Standard Estate.

12. Point of contact for this request is Ms. Lynn Hoerner, 314-331-8157.

Prepared by:

_____
Lynn Hoerner, Realty Specialist

Approved by:

_____
Anne Kosel
Chief, Real Estate Division
St. Louis District

WETLAND CREATION AND RESTORATION EASEMENT
(based on the standard Perpetual Beach Nourishment Easement and other standard estates)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. -) to construct, operate, maintain, patrol, repair, renourish, and replace wetlands and associated coastal habitats, including the right to borrow and/or deposit fill; to accomplish any alterations of contours on said land; to plant vegetation on said land; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; to construct dikes and to install, alter, relocate, repair or plug cuts in the banks of dikes; to construct, operate and maintain pipelines for the purpose of dredge or spoil material transport and deposition; to move, store and remove equipment and supplies; to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement (excepting the structures now existing on the land, described as _____); provided that no structures for permanent human habitation shall be constructed or maintained on the land; that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill, and that no trimming, cutting, felling or removal of trees, underbrush, and any other vegetation shall be conducted without such approval; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs,) successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form.

Exhibit A

WETLAND CREATION AND RESTORATION EASEMENT

(based on the standard Perpetual Beach Nourishment Easement and other standard estates)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. -) to construct, operate, maintain, patrol, repair, renourish, and replace wetlands and associated coastal habitats, including the right to borrow and/or deposit fill; to accomplish any alterations of contours on said land; to plant vegetation on said land; to excavate, dredge, cut away, and remove any or all of said land and to place thereon dredge or spoil material; to construct dikes and to install, alter, relocate, repair or plug cuts in the banks of dikes; to construct, operate and maintain pipelines for the purpose of dredge or spoil material transport and deposition; to move, store and remove equipment and supplies; to plug, fill or alter pipeline canals located within the limits of the easement; to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement (excepting the structures now existing on the land, described as _____), provided that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill, [that no vehicles shall be operated within the limits of the easement without such approval, except as may be required to operate and maintain the easement,] and that no trimming, cutting, felling or removal of trees, underbrush, and any other vegetation shall be conducted without such approval; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs,) successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form.

Exhibit B

STATEMENT OF REVIEW AND APPROVAL
LCA MEDIUM DIVERSION AT WHITE DITCH
WETLAND CREATION AND RESTORATION EASEMENT
NON-STANDARD ESTATE

This is to certify that the Wetland Creation and Restoration Easement, a non-standard estate, has been reviewed and is legally sufficient for the requirements of the above referenced project.

_____
Attorney Name, Title

_____
Date

Exhibit C

CANAL ALTERATION EASEMENT

A perpetual and assignable right and easement in (the land described in Schedule A)(Tract No__) to deposit materials within and around the canal, to place plugs or fully close the canal, to cut gaps in the canal, or make other alterations to the canal, in order to restore the hydrology and /or to stabilize the spoil banks along the canal; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form; provided however, that the rights, interests and privileges, associated with the original canal right-of-way, hereinabove excepted and reserved are hereby subordinated to the right of this canal alteration easement.

Exhibit D

CANAL ALTERATION EASEMENT

A perpetual and assignable right and easement in (the land described in Schedule A)(Tract No__) to deposit materials within and around the canal, to place plugs or fully close the canal, to cut gaps in the canal, or make other alterations to the canal, in order to restore the hydrology and /or to stabilize the spoil banks along the canal; and for such other purposes as may be required in connection with said work of improvement; reserving, however, to the owners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; and expressly excepting and excluding all oil, gas and other minerals occurring naturally in liquid or gaseous form, in and under said land and all appurtenant rights for the exploration, development, production and removal of said oil, gas and other minerals occurring naturally in liquid or gaseous form, but without the right to enter upon or over the surface of said land for the purpose of exploration, development, production and removal therefrom of said oil, gas and other minerals occurring naturally in liquid or gaseous form; provided however, that the rights, interests and privileges, associated with the original canal right-of-way, hereinabove excepted and reserved are hereby subordinated to the right of this canal alteration easement.

Exhibit E

STATEMENT OF REVIEW AND APPROVAL
LCA MEDIUM DIVERSION AT WHITE DITCH
CANAL ALTERATION EASEMENT
NON-STANDARD ESTATE

This is to certify that the Canal Alteration Easement, a non-standard estate, has been reviewed and is legally sufficient for the requirements of the above referenced project.

_____
Attorney Name, Title

_____
Date

Exhibit F

Quality Control Checklist

Request to Deviated from Guidance as to Appropriate Interest to Acquire
and/or
Request for Approval of Use of Non-standard Estate

ER 405-1-12, paragraphs 12-9 and 12-10

It is the policy of USACE to either acquire or to require a non-Federal sponsor to provide the minimum interest in real property necessary to support a project. The interests described in paragraph 12-9 of ER 405-1-12, have been determined to represent the minimum interest generally required to support the described purposes or features and must be utilized unless otherwise approved. Greater or lesser interests may be appropriate depending on the purposes of a project or a particular acquisition.

Standard estates approved for use in either full Federal or cost shared projects are contained in the RE Handbook. Once the appropriate interest needed is identified, the corresponding standard estate must be used as found in the regulations. Where there is no corresponding standard estate for the interest to be acquired or where changes to the corresponding standard estate are desired, a non-standard estate (NSE) must be drafted and approved. For all NSEs not within the scope of District's approval authority, or requests to deviate from guidance as to appropriate interest to acquire, approval may be obtained either by placing the language of the NSE, or request to deviate, in the Real Estate Plan (REP) of a feasibility report or other study decision document that is to be approved by HQUSACE or by request for approval by memorandum forwarded through MVD to HQ, Real Estate Community of Practice, for appropriate coordination, review, and final determination.

PROJECT: LCA – MEDIUM DIVERSION AT WHITE DITCH

Title and date of Decision Document which contains the REP requesting approval of estate deviation or NSE approval: LCA – Medium Diversion at White Ditch Feasibility Study

Subject line and date of memorandum requesting approval of estate deviation or NSE approval
N/A – requested as an exhibit in the Real Estate Plan

1. Does the proposed estate, whether standard or non-standard; provide sufficient interest for the construction, operation, and maintenance of the project? YES

2. Coordination has been made with the following and they concur with use of the proposed estate:

   Project Management X E&C X
   Operations N/A Office of Counsel X

   Coordination was made with the following other functional groups. Environmental

3. A statement of legal sufficiency from OC is attached to the REP or memo requesting approval by HQ ____Yes_____.

4. Is the cost to acquire the proposed estate more than the cost of acquiring a standard interest with a standard estate? ____NO____ Is this discussed in the request? ____Yes___

5. Did the Non-Federal Sponsor (NFS) propose the deviation from appropriate interest or use of a NSE? ___NO_____
If so, why? _____
If not, was the deviation or NSE coordinated with the NFS? _____YES_____

6. Can the non-standard estate be approved by the district Chief of RE? _____NO_____
If so, it must:
Serve the intended project purpose _____
Substantially conform with and not materially deviate from the corresponding standard estate _____
Does not increase the costs no potential liability of the Government? _____

7. Does the NSE conform to format of standard estate _____YES_____?

8. Does the request for approval which goes through MVD to HQ contain a detailed explanation of a justification for the deviation as to interest to be acquired? ___Yes_____

9. Does the request contain a detailed explanation of each non-standard clause in the estate? ___Yes_____. The request must detail the need for the language in relation to project requirements. Each non-standard right to be acquired, restriction/prohibition placed on fee owner's interest and/or reservation to the fee owner must be fully discussed. Is the acquisition or reservation of mineral rights held by the fee owner or outstanding 3rd party mineral rights fully discussed in relation to the estate language and project requirements? ___Yes___
If there are clauses found in the corresponding standard estate which have been deleted, is there an explanation of the deletion? ___N/A_____

10. Has the district deviated as to the appropriate interest on similar projects in the past? ____Yes____. If so, which project(s)? The Wetland Creation and Restoration Easement and Canal Alteration Easement is proposed for approval for other LCA projects.
11. Has the proposed NSE been previously approved by HQ for use for a project in your district? ___NO___. If so, which project(s)? _____
Provide a copy of the previous approval.

A copy of this Checklist is attached to the REP or memorandum requesting a deviation as to interest to be acquired or approval of a NSE. _____Yes_____

_____ _____
Realty Specialist or Appraiser Date

_____ _____
Branch or Section Chief Date

Louisiana Coastal Area (LCA) Program:
Medium Diversion at White Ditch Project

Appendix K
Cost Effectiveness & Incremental Cost Analysis

August 2010

DRAFT

TABLE OF CONTENTS

1.0 PURPOSE **1**
2.0 DESCRIPTION OF ALTERNATIVE PLANS **1**
2.1 Screening / Evaluation of Alternative Plans **2**
2.2 CE/IC Analysis **6**
2.3 Alternative Plans not Carried for Further Analysis **7**
3.0 FINAL ARRAY OF ALTERNATIVES **7**
3.1 No Action (Future without Project Conditions) **7**
3.1.1 Soils and Waterbottoms 9
3.1.2 Sedimentation and Erosion 10
3.1.3 Subsidence 10
3.1.4 Salinity 10
3.1.5 Vegetation Resources 11
3.1.6 Benthics 12
3.1.7 Essential Fish Habitat 12
3.2 Alternative 1 – 5,000 cfs diversion **13**
3.3 Alternative 2 – 10,000 cfs Max Diversion **14**
3.4 Alternative 3 – 15,000 cfs Max Diversion **15**
3.5 Alternative 4 – 35,000 cfs Max Diversion (TSP) **16**
4.0 COMPARISON OF ALTERNATIVE PLANS **16**
4.1 Incremental Cost/Cost Effectiveness Analysis Process **16**
4.2 Wetland Value Assessment (WVA) **17**
4.2.1 WVA Concept 18
4.2.2 Community Model Variable Selection 18
4.2.3 Suitability Index Graphs 19
4.2.4 Habitat Suitability Index Formula 19
4.2.5 Benefit Assessment 19
4.2.5 MDWD Summary 20
4.3 Cost Estimates for Habitat Improvement Measures. **22**
4.4 Results of the Incremental Cost/Cost Effectiveness Analysis **23**
4.5 Other Factors **25**
4.5.1 Recreational Benefits 26

4.5.2 Desired Future Condition 26
4.5.3 Relative Sea Level Rise 27
4.5.4 Breton Sound Benefits 29
4.5.5 Adaptive Management 29
4.5.6 Acceptability, Completeness, Effectiveness, and Efficiency. 30
4.5.7 Recommendation of the Tentatively Selected Plan 30

LIST OF TABLES

Table 1. LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1a 4
Table 2. LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1b 5
Table 3. Direct Footprint Acreage Impacts 20
Table 4a: WVA Benefits Summary 21
Table 4b. Acreage Summary 22
Table 5. LCA: White Ditch Cost Estimates 22
Table 6. White Ditch Incremental Cost/Cost Effectiveness Step 2 23
Table 7. White Ditch Incremental Cost/Cost Effectiveness Step 2 25
Table 8. Net Increase in Recreation Benefits 26
Table 9. ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under Historical Sea Level Rise Rates 28
Table 10. ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under the Intermediate and High Sea Level Rise Rates 29

LIST OF FIGURES

Figure 1. White Ditch CE/IC Analysis – Open Diversion 6
Figure 2. White Ditch CE/IC Analysis Step 1 – Mar/May Pulse 7
Figure 3. Louisiana Coastal Area: Medium Diversion at White Ditch – Future Without Project Condition 8
Figure 4. Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without Project Condition 9
Figure 5. Alternative 1 Location 3 13
Figure 6. Alternative 2 Location 3 14
Figure 7. Alternative 3 Location 3 15
Figure 8. Alternative 4 Location 3 16
Figure 9. CE/IC Analysis of Final Alternatives 24
Figure 10. CE/IC Best Buy Plans 25
Figure 11. FWP Acres at TY50 per Operational Plan 27
Figure 12. Comparison of Relative Sea Level Rise Effects 28

1.0 PURPOSE

The purpose of this appendix is to describe the process by which alternatives for the White Ditch were developed, and compared. A Cost Effectiveness & Incremental Cost Analysis (CE/IC) was utilized.

2.0 DESCRIPTION OF ALTERNATIVE PLANS

Conceptual alternatives were integrated with the suitable locations for diversion structures to yield an array of alternatives that meet the goals and objectives of the project and are likely to restore the impaired deltaic processes. The alternatives are:

1. **White Ditch (WD) 1: No Action.** Over a 50-year period of analysis, if nothing were done, we would see significant losses of all marsh types throughout the project area. More major storms could accelerate this loss. As a result open water habitats would continue to grow allowing for further intrusion of saltwater into the marsh.
2. **White Ditch (WD) 2: Location 2 – 5,000 cfs.** This alternative involves construction of a structure capable of diverting up to 5,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S), and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
3. **White Ditch (WD) 3: Location 2 – 10,000 cfs.** This alternative involves construction of a structure capable of diverting up to 10,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
4. **White Ditch (WD) 4: Location 2 – 15,000 cfs.** This alternative involves construction of a structure capable of diverting up to 15,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
5. **White Ditch (WD) 5: Location 2 – 35,000 cfs.** This alternative involves construction of a structure capable of diverting up to 35,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
6. **White Ditch (WD) 6: Location 3 – 5,000 cfs.** This alternative involves construction of a structure capable of diverting up to 5,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and

sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

7. **White Ditch (WD) 7: Location 3 – 10,000 cfs.** This alternative involves construction of a structure capable of diverting up to 10,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
8. **White Ditch (WD) 8: Location 3 – 15,000 cfs.** This alternative involves construction of a structure capable of diverting up to 15,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.
9. **White Ditch (WD) 9: Location 3 – 35,000 cfs.** This alternative involves construction of a structure capable of diverting up to 35,000 cfs. Additionally, once the preliminary freshwater and sediment supply benefits of the structure are determined, measures from the hydraulic distribution (H), sediment supply & distribution (S) and protection and sustainability (P) will be refined to improve beneficial distribution of freshwater and sediments to create and restore marsh habitat and improve its sustainability.

2.1 Screening / Evaluation of Alternative Plans

The ERDC-SAND2 model was originally known as the Boustany Model. The Boustany Model was developed for evaluating the marsh creation potential. ERDC modified and refined the Boustany model to specifically measure the marsh creation potential of diversion structures. The modified version became known as the SAND model. The SAND was refined further and became the SAND2. The ERDC-SAND2 Model was the tool used by the MDWD team to predict changes in marsh acreages for all alternatives over a 50 year planning horizon. It is an ecohydraulic engineering model specifically designed to assess the effectiveness of potential diversion projects on restoration of land in the coastal marsh. The ERDC- SAND2 model is fundamentally based on three processes impacting marsh accretion:

1. Historical land loss rates are applied to account for marsh loss due to all negatively impacting system processes (e.g. sea level rise, compaction, subsidence, etc.) along with background processes existing prior to the diversion operation (e.g. marsh nutrient cycling, net tidal and groundwater inputs, etc.).
2. Inorganic benefits of flow diversion from the addition of sediment.
3. Organic benefits of flow diversion due to plant growth, mortality, and burial stimulated by addition of the limiting nutrient (nitrogen).

The model applies these processes to assess Future With Project and Future Without Project conditions for alternative comparison. Since the FWOP condition is without diversion, FWOP marsh acreage is a function of land loss only. The model processes these categories and projects acres of marsh within a specified project area. With some slight modifications, the model can

also project acreages with accelerated sea level rise rates. Further information concerning the ERDC-SAND2 Model can be found in Appendix L.

The outputs (net and average annual acres) from the ERDC-SAND2 model become a key component of the WVA ecosystem model. Also, a defined operating plan had yet to be evaluated, so three such operating schemes were proposed to begin to characterize the potential range of benefits of various operating regimes for each diversion and the ability of each alternative to achieve the goals and objectives of the project. The Open Diversion reflects the upper threshold in terms of potential impacts. The other two regimes focus on maximizing sediment capture during the highest sediment load in the River based on available information. They are:

- Open Diversion Year Round
- A March 1–May 30 Maximum Pulse with no Maintenance Flow
- A March only pulse with a 1,000 cfs Monthly Maintenance Flow

Finally, the likelihood existed that these large diversion alternatives may have impacts beyond the immediate study area. Therefore the ERDC-SAND2 Model was run on the original study area as well as the entire Breton Sound Basin. The Institute for Water Resources (IWR) Planning Suite was used for the analysis.

Table 1 displays the costs and net acres of marsh created at the end of the 50-year period of analysis in order to compare alternatives that can achieve no net loss of marsh acres. The most cost effective alternatives and operating schemes that achieve a no net loss or desired future condition are highlighted in green. The desired future condition would be equivalent to the current marsh acres (2009) of 41,206. The Location 3 – 10,000 cfs alternative achieves this at the end of the period of analysis only for the year round open diversion operating regime. It does this more cost effectively than the same size diversion at Location 2. The Location 3 – 15,000 alternative achieves the desired future condition at the end of the period of analysis for the year round open diversion and the Mar/May Pulse. It does this more cost effectively than the same size diversion at Location 2. The Location 3 – 35,000 alternative achieves the desired future condition at the end of the period of analysis for all three operating regimes and more cost effectively than the same size diversion at Location 2. The 35,000 cfs diversion also achieves a no net loss of marsh within the expanded Breton Sound Basin if operated at full capacity year round.

It should be noted that the major difference in cost between Location 2 alternatives and Location 3 is the length of conveyance channels needed to move freshwater, nutrients and sediments. While Location 2 has an existing conveyance channel (White Ditch) Hydrologic and Hydraulic modeling indicated that it requires considerably more dredging and placement of material to make it effective at moving diversion flows to the majority of the study area. Location 3, while it does involve dredging of new conveyance channels, they are much shorter and more efficient at distributing diversion flows of freshwater, nutrients and sediments. A complete discussion of this can be found in the Engineering Appendix L.

Table 1. LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1a

Alternative	Total First Cost*	Annualized Cost**	Operating Regimes Gross/Net Acres (Original Study Area) Year 50			Operating Regimes Gross/Net Acres (Expanded Study Area) Year 50	
			Original Project Area - Open Diversion	Original Project Area - Mar/May Pulse	Original Project Area - March Pulse + 1,000 CFS	Expanded Project Area Open Diversion	Expanded Project Area Mar/May Pulse
Location 2 - 5,000 CFS Box	$181,800,000	$9,013,128	35,241/-5,965	32,676/-8,530	34,484/-6,722	69,251	64,481
Location 2 - 10,000 CFS Box	$230,000,000	$11,402,748	43,448/2,242	38,071/-3,135	36,318/-4,888	80,924	70,298
Location 2 - 15,000 CFS Box	$398,600,000	$19,761,458	51,445/10,239	43,327/2,121	38,111/-3,095	92,668	76,099
Location 2 - 35,000 CFS Box	$493,400,000	$24,461,373	76,174/34,968	59,670/18,464	44,364/3,155	139,965	98,909
Location 3 - 5,000 CFS Box	$140,600,000	$6,970,549	35,241/-5,965	32,676/-8,530	34,484/-6,722	69,251	64,481
Location 3 - 10,000 CFS Box	$165,000,000	$8,180,232	**43,448/ 2,242**	38,071/-3,135	36,318/-4,888	80,924	70,298
Location 3 - 15,000 CFS Box	$229,400,000	$11,373,001	**51,445/10,239**	**43,327/2,121**	38,111/-3,095	92,668	76,099
Location 3 - 35,000 CFS Box	$334,800,000	$16,598,435	**76,174/34,968**	**59,670/18,464**	**44,364/3,155**	**139,965**	98,909
*Excludes Real Estate and O&MRRR							
**FY 2010 Discount Rate 4 3/8%							

Table 2. LCA: White Ditch Incremental Cost/Cost Effectiveness Step 1b

	Incremental Cost/Cost Effectiveness Analysis - Open Operation				Incremental Cost/Cost Effectiveness Analysis Mar/May Pulse			
Alternative	Open Diversion (Average Annual Acres)	Incremental Cost	Incremental Acres	Incremental Cost per Acre	Mar/May Pulse (Average Annual Acres)	Incremental Cost	Incremental Acres	Incremental Cost per Acre
Location 2 - 5,000 CFS Box	5,276		Non Cost		2,715		Non Cost	
Location 2 - 10,000 CFS Box	11,553		Effective		5,853		Effective	
Location 2 - 15,000 CFS Box	17,860		Plans		8,984		Plans	
Location 2 - 35,000 CFS Box	42,731				21,282			
Location 3 - 5,000 CFS Box	5,276	$6,970,549	5,276	$1,321	2,715	$6,970,549	2,715	$2,567
Location 3 - 10,000 CFS Box	11,553	$1,209,683	6,277	$193	5,853	$1,209,683	3,138	$385
Location 3 - 15,000 CFS Box	17,860	$10,163,318	11,583	$877	8,984	$10,163,318	5,846	$1,739
Location 3 - 35,000 CFS Box	42,731	$6,435,117	31,148	$207	21,282	$6,435,117	15,436	$417
*Excludes Real Estate and O&MRRR								
**FY 2010 Discount Rate 4 3/8%								

2.2 CE/IC Analysis

In order to refine the preliminary alternatives further a two-step Cost Effectiveness & Incremental Cost (CE/IC) Analysis was utilized. The first step used preliminary cost estimates developed for each action alternative and outputs from the ERDC SAND2 Model. Table 2 displays the CE/IC analysis of the action alternatives. Average Annual Acres of Marsh is compared against the annualized first cost of the action alternatives. Average Annual Acres of Marsh produced by each size of diversion structure is the same for each location. All of the alternatives at location 2 were not cost effective while the 5, 10 and 15 thousand cfs diversions at location 3 were found to be cost effective. The 35,000 cfs diversion was considered a best buy.

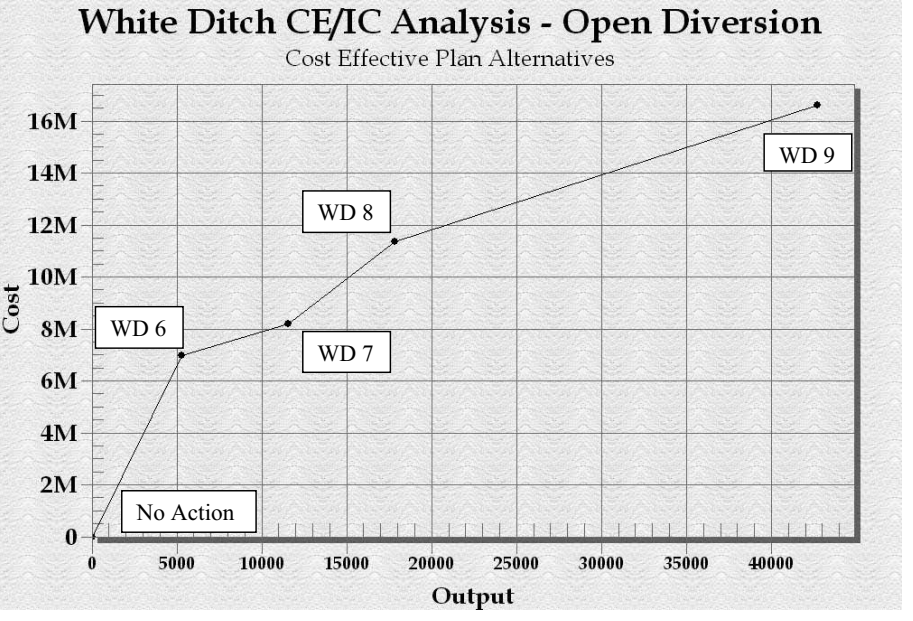


Figure 1. White Ditch CE/IC Analysis – Open Diversion

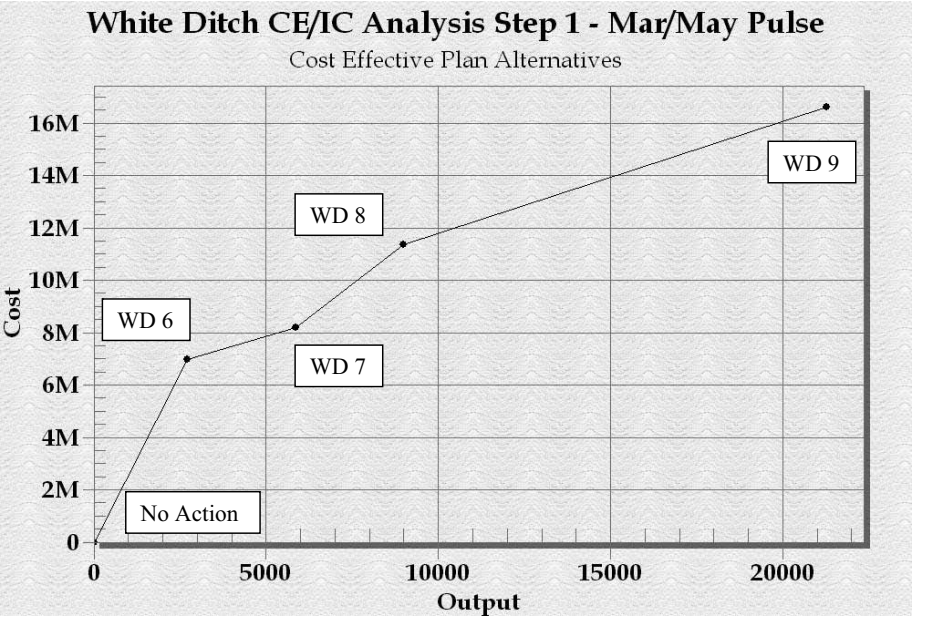


Figure 2. White Ditch CE/IC Analysis Step 1 – Mar/May Pulse

2.3 Alternative Plans not Carried for Further Analysis

Based on the above analysis it was determined that the following alternatives would not further evaluated:

- White Ditch (WD) 2: Location 2 – 5,000 cfs.
- White Ditch (WD) 3: Location 2 – 10,000 cfs.
- White Ditch (WD) 4: Location 2 – 15,000 cfs.
- White Ditch (WD) 5: Location 2 – 35,000 cfs.

3.0 FINAL ARRAY OF ALTERNATIVES

3.1 No Action (Future without Project Conditions)

No Action The future without project condition for White Ditch will continue to see declines in overall wetland acres of all types. The current altered deltaic process will result in the lack of freshwater, nutrients and sediments in the project are that are critical to sustain existing marsh and build additional areas. Overall the study area is expected to see an average loss of 274.5

acres of marsh per year. This land loss will, during the 50 year period of analysis, result in a further loss of 13,725 acres of marsh from the 2009 acreage of 41,206.

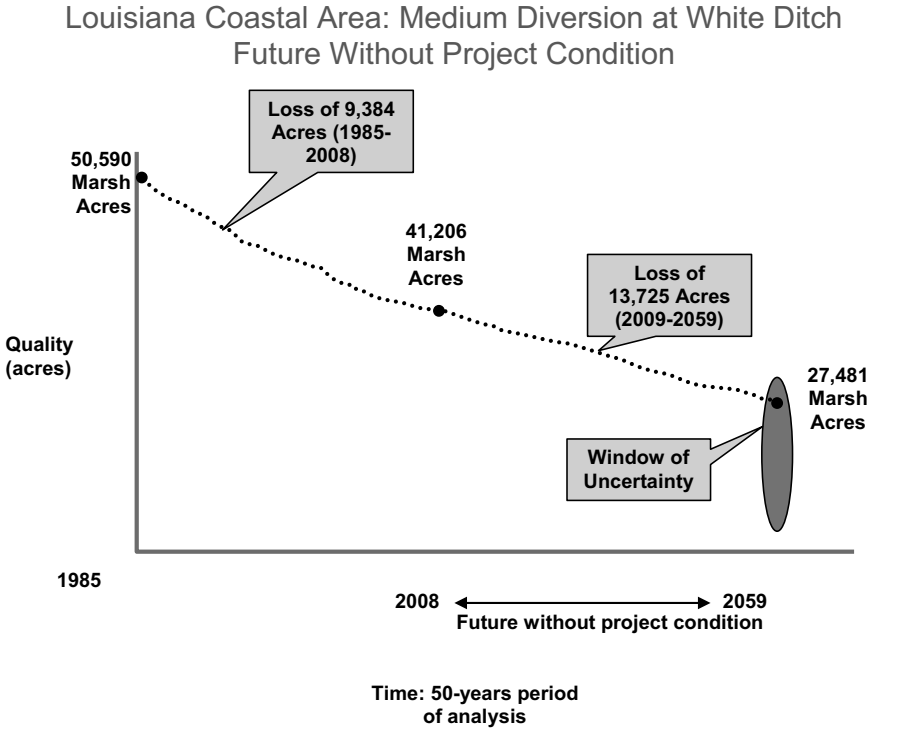


Figure 3. Louisiana Coastal Area: Medium Diversion at White Ditch – Future Without Project Condition

Waterbodies would grow larger and wave erosion would accelerate causing further land loss, making remaining marsh lands in the project area and the larger Breton Sound Basin more vulnerable to tropical storms. The Future Without Project Condition will likely see the existing marsh persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses. The Study Area will likely see additional salt water intrusion and conversion of the remaining intermediate and brackish marsh to saline marsh types with the associated salt-tolerant or marine fauna.

The remaining marsh acreage of 27,481 does not account for any losses that may be incurred by moderate or high rates of sea level rise. The figure below depicts the impacts of both the moderate and high rates of sea level rise on the project area.

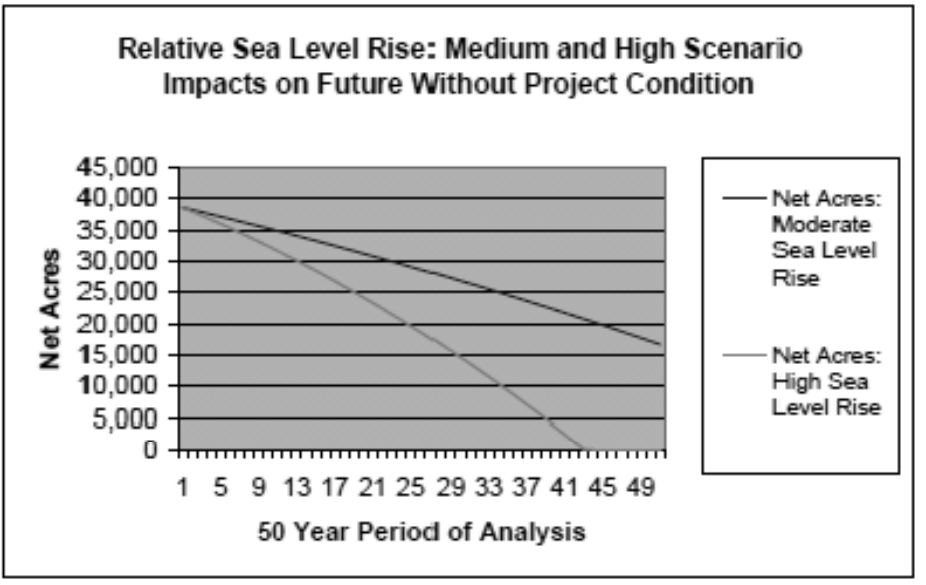


Figure 4. Relative Sea Level Rise: Medium and High Scenario Impacts on Future Without Project Condition

Marsh acres are the result of a variety of physical structure and functions within the larger ecosystem. Some of these components include soils and waterbottoms, sediment, subsidence, salinity, riparian vegetation, benthics and fishery resources. Summaries of the future without project condition for these resources are below with more details provided in Section 4.

3.1.1 Soils and Waterbottoms

No direct alteration of soils or substrate would occur under the No Action alternative and associated water management features. No conversion of prime or unique farmland would occur, and the No Action alternative would have no direct impact on these resources.

The indirect impacts of the No Action alternative, would be that the existing patterns of soil erosion and land loss would continue into the future. Organic soils in the project area would not be able to maintain their elevations due to subsidence, decreased plant productivity, wave erosion, and relative sea level rise. Net primary productivity within the project area would continue to decline and existing wetland vegetation would continue to diminish. The ongoing conversion of existing fragmented emergent wetlands to shallow open water would continue with associated indirect impacts on coastal vegetation, fish and wildlife resources, EFH, recreation, aesthetic, and socioeconomic resources. In the future, if no actions are taken to restore and protect marsh habitat within the project area, any prime and unique farmland that remains outside of the protection of existing Federal and non-Federal back levees would continue to be subject to further degradation and possible loss.

Cumulative impacts under the No Action alternative include continuing erosion and loss of marsh soils. Waterbodies would grow larger and wave erosion would accelerate causing further land loss, thus making remaining marsh lands in the project area and the larger Breton Sound Basin more vulnerable to tropical storms. In addition to land loss in coastal Louisiana, a large percentage of the Nation's wetlands would continue to disappear with accompanying impacts to wildlife, fisheries, coastal communities, and socioeconomic resources.

3.1.2 Sedimentation and Erosion

The No Action Alternative, i.e. not implementing a sediment and freshwater diversion in the White Ditch Study Area, would have a direct impact on sedimentation or erosion within the area between the Mississippi River and River aux Chenes through the continuation of existing degradation of marsh. The absence of a supply of fresh water, sediment, and nutrients combined with the ongoing pressures of wind and wave action, storm surges, and human activities has severely eroded marsh soils and reduced the ability of the project area to maintain a balance of emergent wetland and shallow water.

Indirect impacts of the No Action Alternative, not implementing the diversion, are the persistence of existing conditions. Consequences would include further degradation of the existing marsh from saltwater intrusion due to short circuited hydrologic processes present in the basin; as well as the continued lack of sediments, nutrients, and freshwater River aux Chenes and the Mississippi River. With the absences of these features, the marsh would not be able to sustain itself against subsidence and prolonged inundation from sea level rise. The No Action Alternative would cause the existing marsh to persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses.

Cumulative impacts would be the synergistic effect of the No Action Alternative on other sedimentation and erosive forces with the added combination of similar wetland degradation and wetland loss impacts to sedimentation and erosion throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal coastal restoration projects in the vicinity.

3.1.3 Subsidence

The Future Without Project Condition will likely see the existing marsh to persist with minimal circulation of water, nutrients, and sediment. The sediment deficit has and would continue to result in both subsidence and a disruption of natural processes that promote productivity and diversity in the marsh ecosystem. Increases in relative sea level due to continued subsidence and sea level rise would continue to inundate plant communities, which would ultimately lead to substantial losses.

3.1.4 Salinity

Under the No Action Alternative no direct impacts to salinity levels of the Mississippi River or the White Ditch project area would occur.

Indirect impacts of not implementing restoration features would result in the persistence of existing conditions for the Mississippi River and continued degradation of the White Ditch project area.

Cumulative impacts would be the synergistic effect of the No Action Alternative on salinity levels when considered in context with all past, present, and reasonably foreseeable acts of nature and/or the actions private entities, state government, and Federal government. The No Action Alternative would not contribute in a positive or negative manner to the cumulative effects on salinity.

3.1.5 Vegetation Resources

Direct impacts under the No Action Alternative, no construction of diversion structure or associated outfall management features would occur, and no BLH would be cleared or filled by construction activities. No opportunities for beneficial use of dredged material for construction features would occur. Existing BLH in the project footprint would continue to degrade and convert to intermediate marsh. No direct impacts to existing wetland vegetation resulting from construction of the proposed diversion and associated features would occur. No opportunities for beneficial reuse of marsh soil and substrate excavated for construction would be realized. No direct impacts to Submerged Aquatic Vegetation (SAV) would occur. Baseline SAV coverage was estimated at approximately 15% of open water areas in the vicinity of the proposed construction footprint (25% in the overall project area). Existing SAV in the project footprint would continue to degrade and die off as increased salinities enter the Study Area and marsh continues to decrease in acreage

Without implementation of the proposed diversion, no input of sediment, freshwater and nutrients to the project area would occur. This would result in indirect impacts including the continued erosion of marsh soils and continued fragmentation and conversion of BLH to intermediate and brackish marsh habitats. Both man-made and natural processes would contribute to the continued loss of vegetated habitats, including: continued erosion and subsidence, increased saltwater intrusion, and increased water velocities. Over the next 50 years, the remaining BLH species in the Study Area would experience continued subsidence, sea level rise, and salinity increases. The BLH would eventually diminish and convert to marsh. Over the next 50 years, approximately 13,750 acres of emergent marsh is projected to be lost, and it is likely that all remaining remnants of bottomland hardwood vegetation would disappear over the same period. Over the next 50 years, SAV is projected to be reduced from the estimated baseline of 25% of open water areas to approximately 15% as the area deteriorates.

Cumulative impacts would be the same effect of the No-Action alternative with land loss rates of approximately 274.5 acres per year throughout the 50-year project life. In addition, cumulative impacts would include the additive combination of coast wide BLH loss and degradation, as well as the benefits and impacts of other local, state, Federal, and private projects summarized in Section 1.5. The existing freshwater diversion at Caernarvon would freshen the surrounding waters, albeit to an unknown extent. In addition, the LCA Caernarvon Freshwater Diversion Modification (CFDM) project could potentially result in a selected plan having features that create and restore BLH ridges from the secondary use of channel dredging to redirect water flows. Some Section 10 and 404 permits have been issued by the CEMVN for maintenance

dredging canals northeast of the WDWD project. Some dredged material placement areas from this dredging would likely reforest with BLH species.

Cumulative impacts on wetland vegetation would be the synergistic effect of implementing the No-Action Alternative with the additive combination of coast wide wetland loss and degradation, as well as the benefits and impacts of other state and Federal projects in the vicinity. The existing freshwater diversion at Caernarvon would freshen the surrounding waters, albeit to an unknown extent. Modification of the operation of the Caernarvon structure could result in a conversion of some intermediate marsh to fresh marsh in areas adjacent to the MDWD project area. However, such wetland conversion would probably have little effect on the species composition of the wetlands in the project area other than a slight shift towards less salt-tolerant species. The introduction of nutrients would likely increase the productivity of the nearby marshes, but any potential effects on productivity within the MDWD project area are unknown at this time.

Cumulative impacts would be the same effect of the No-Action alternative with the additive combination of coast wide SAV loss, as well as the benefits and impacts of other state, Federal, or private projects summarized in the FS/EIS. The proposed projects have borrow areas, channel dredging, and marsh restoration sites in and adjacent to Lake Lery that would impact SAV from dredging and filling. CFDM could result in a conversion of some intermediate marsh to fresh marsh in areas adjacent to the MDWD project area. The Duffy (1997) study showed that SAV abundance (Eurasian watermilfoil and coontail) has increased in the Breton Sound Basin in response to diversions. The introduction of nutrients would likely increase the productivity of the nearby SAV, but any potential effects on productivity within the MDWD project area are unknown at this time.

3.1.6 Benthics

The Future Without Project Condition will likely see marine (saltwater) influences continue to take hold and convert freshwater wetlands into intermediate, brackish, and saline marsh. As freshwater inputs continue to decline and allow marine influences to predominate over riverine influence, salinity levels rise, resulting in the conversion of low-lying vegetated areas to open water and the redistribution of marine sediment. These actions eventually lead to conditions that expedite interior marsh loss and the benthic community and benthic processes would shift from that of an estuarine community to a more open water marine community. Over the long term, without renewed inputs of fresh water, sediment, and nutrients to restore and maintain emergent marsh habitat, the project area is likely to convert from a predominately estuarine habitat to a predominately marine habitat. The benthic community which support the estuarine system processes would be adversely affected by the reduction and eventual loss of this habitat.

3.1.7 Essential Fish Habitat

The No Action alternative (no construction of river diversion structure or associated outfall management features) would have no direct impact on EFH.

Indirect impacts of not implementing wetland creation/nourishment and shoreline protection features would result in the persistence of existing conditions resulting in the conversion of categories of EFH, such as estuarine marsh and SAV, to marine water column and mud, sand, or shell substrates is expected to continue. Over time, the No Action alternative would result in the

conversion of an estimated 13,724 acres of emergent marsh to open water. Substantial decreases in the quality of EFH in the project area would reduce the area's ability to support federally managed species.

Cumulative impacts would be the synergistic effect of the No-Action Alternative on EFH with the additive combination of similar EFH degradation and losses throughout coastal Louisiana, as well as the benefits and impacts of other state and Federal projects in the vicinity. Continued conversion of existing marsh to shallow open water habitats anticipated with the No Action alternative would contribute to declining quality of EFH, particularly nursery habitat for larval and juvenile fish and shrimp species.

3.2 Alternative 1 – 5,000 cfs diversion

Location 3 – 5,000 cfs. This alternative involves construction of a structure capable of diverting up to 5,000 cfs consisting of 3 15ft. x 15ft. box culverts. Additionally, 32 acres of ridge and terrace creation, 139 acres of marsh creation utilizing dredged material from an adjacent 153 acres of canal being reconfigured to convey freshwater, nutrient and sediments.



Figure 5. Alternative 1 Location 3

3.3 Alternative 2 – 10,000 cfs Max Diversion

Location 3 – 10,000 cfs. This alternative involves construction of a structure capable of diverting up to 10,000 cfs consisting of 3 15ft. x 15ft. box culverts. Additionally, 32 acres of ridge and terrace creation, 176 acres of marsh creation utilizing dredged material from an adjacent 167 acres of canal being reconfigured to convey freshwater, nutrient and sediments.



Figure 6. Alternative 2 Location 3

3.4 Alternative 3 – 15,000 cfs Max Diversion

Location 3 – 15,000 cfs. This alternative involves construction of a structure capable of diverting up to 15,000 cfs consisting of 10 15ft. x 15ft. box culverts. Additionally, 32 acres of ridge and terrace creation, 235 acres of marsh creation utilizing dredged material from an adjacent 182 acres of canal being reconfigured to convey freshwater, nutrient and sediments.



Figure 7. Alternative 3 Location 3

3.5 Alternative 4 – 35,000 cfs Max Diversion (TSP)

Location 3 – 35,000 cfs. This alternative involves construction of a structure capable of diverting up to 35,000 cfs consisting of 10 15ft. x 15ft. box culverts. Additionally, 31 acres of ridge and terrace creation, 385 acres of marsh creation utilizing dredged material from an adjacent 223 acres of canal being reconfigured to convey freshwater, nutrient and sediments.

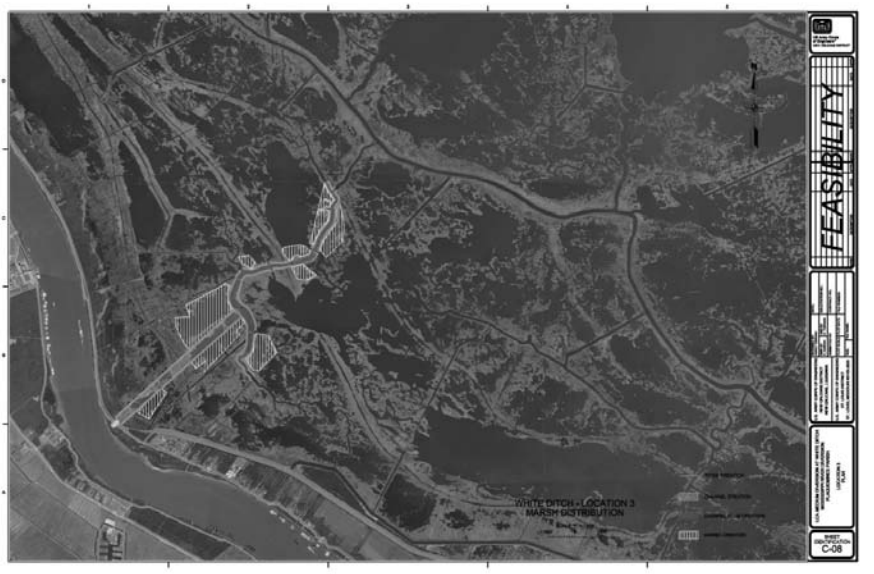


Figure 8. Alternative 4 Location 3

4.0 COMPARISON OF ALTERNATIVE PLANS

This section describes the alternative plans and the process used to determine the potential costs, habitat benefits, incremental cost/cost effectiveness, and other factors leading to a recommended plan.

4.1 Incremental Cost/Cost Effectiveness Analysis Process.

Cost effectiveness analysis was used to determine what project features should be built, based on habitat benefits (outputs) that meet the goals and objectives of the project and at the same time are the most cost effective. The Corps has incorporated cost effectiveness analysis into its planning process for all ecosystem restoration planning efforts. A cost effectiveness analysis is conducted to ensure that least cost alternatives are identified for various levels of output. After the cost effectiveness of the alternatives has been established, incremental cost analysis is conducted to reveal and evaluate changes in cost for increasing levels of environmental output.

Cost effectiveness and incremental analysis is a three step procedure: (1) calculate the environmental outputs of each alternative; (2) determine a cost estimate for each alternative; (3) combine the alternatives to evaluate the best overall project alternative based on habitat benefits and cost. While cost and environmental outputs are necessary factors, other factors such as the ability to construct, schedule, likelihood to achieve projected results, unmeasurable environmental benefits, ancillary benefits etc., are very important in deciding on the preferred alternative.

Environmental outputs were calculated as Average Annual Habitat Units (AAHUs). The annualized costs were calculated by applying a 4-3/8% annual interest rate to the construction costs over the 50-year period of analysis. What is described below is the second step of the process introduced in Section 1.1.1 above.

4.2 Wetland Value Assessment (WVA)

The Wetland Value Assessment (WVA) methodology is a quantitative habitat-based assessment methodology developed for use in determining wetland benefits of project proposals submitted for funding under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained. In addition, the WVA methodology provides an estimate of the number of acres benefited or enhanced by the project and the net acres of habitat protected/restored. See Appendix B for a complete description of the WVA and its application to this project.

The WVA was developed by the Environmental Work Group (EnvWG) assembled under the Planning and Evaluation Subcommittee of the CWPPRA Technical Committee; the EnvWG includes members from each agency represented on the CWPPRA Task Force and members of the Academic Assistance Subcommittee. The WVA was designed to be applied, to the greatest extent possible, using only existing or readily obtainable data.

The WVA has been developed strictly for use in determining the wetland benefits of proposed CWPPRA projects; it is not intended to provide a detailed, comprehensive methodology for establishing baseline conditions within a project area. Some aspects of the WVA have been defined by policy and/or functional considerations of the CWPPRA; therefore, user-specific modifications may be necessary if the WVA is used for other purposes.

The WVA is a modification of the Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1980). HEP is widely used by the Fish and Wildlife Service and other Federal and State agencies in evaluating the impacts of development projects on fish and wildlife resources. A notable difference exists between the two methodologies, however, in that HEP generally uses a species-oriented approach, whereas the WVA utilizes a community approach.

The WVA has been developed for application to several habitat types along the Louisiana coast and community models have been developed for fresh marsh, intermediate marsh, brackish marsh, saline marsh, fresh swamp, barrier islands, and barrier headlands (Attachments 1-4). A WVA Procedural Manual has also been prepared by the EnvWG to provide guidance to project

planners in the use of the various community models. Two other habitat assessment models for bottomland hardwoods and coastal chenier/ridge habitat were developed outside of the CWPPRA arena and are periodically used by the EnvWG.

Habitat types impacted by construction of the MDWD outfall management features (channel enlargement, marsh creation, and ridge creation) are intermediate marsh and open water in the intermediate salinity zone. Habitat types impacted by operation of the MDWD are intermediate, brackish, and saline marsh, and open water in the intermediate, brackish, and saline zones. Project implementation will create two habitat types found historically but not currently present in the impacted area – fresh marsh and ridge. Consequently, the WVA assessment for MDWD utilized community models for fresh/intermediate marsh, brackish marsh, saline marsh, and coastal chenier/ridge habitat.

4.2.1 WVA Concept

The WVA operates under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland habitat type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of community models developed specifically for each habitat type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values, and 3) a mathematical formula that combines the Suitability Index for each variable into a single value for habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI. The output of each model (the HSI) is assumed to have a linear relationship with the suitability of a coastal wetland system in providing fish and wildlife habitat.

The WVA models have been developed for determining the suitability of Louisiana coastal wetlands in providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. The models have been designed to function at a community level and therefore attempt to define an optimum combination of habitat conditions for common fish and wildlife species utilizing a given habitat type. Earlier attempts to capture other wetland functions and values such as storm-surge protection, flood water storage, water quality functions, and nutrient import/export were abandoned due to the difficulty in defining unified model relationships and meaningful model outputs for such a variety of wetland benefits. However, the ability of a Louisiana coastal wetland to provide those functions and values may be generally assumed to be positively correlated with fish and wildlife habitat quality as predicted through the WVA.

4.2.2 Community Model Variable Selection

Habitat variables considered appropriate for describing habitat quality in each wetland type were selected according to the following criteria:

- The condition described by the variable had to be important in characterizing fish and wildlife habitat quality in the wetland type under consideration;

- Values had to be easily estimated and predicted based on existing or readily obtainable data (e.g., aerial photography, habitat classification data, water quality monitoring stations, interviews with knowledgeable individuals, etc.); and
- The variable had to be sensitive to the types of changes expected to be brought about by typical wetland restoration projects proposed under the CWPPRA.
- The marsh community models used in the WVA assessment for the MDWD (fresh/intermediate, brackish, and saline) all utilize the same habitat variables. These are: 1) percent of wetland (marsh) covered by emergent vegetation; 2) percent of open water covered by submerged and floating-leaved aquatic vegetation; 3) Marsh edge and interspersion with open water; 4) percent of open water less than or equal to 1.5 feet deep in relation to marsh surface; 5) salinity; and 6) aquatic organism access.

4.2.3 Suitability Index Graphs

A suitability index graph is a graphical representation of how fish and wildlife habitat quality or "suitability" of a given habitat type is predicted to change as values of the given variable change, and allows the model user to numerically describe, through a Suitability Index, the habitat quality of a wetland area for any variable value. Each Suitability Index ranges from 0.1 to 1.0, with 1.0 representing the optimal condition for the variable in question. Suitability Index (SI) graphs were constructed for each variable. While the three marsh community models used for the MDWD utilize the same six variables, the suitability graphs for each variable differ according to the marsh community type (fresh/intermediate, brackish, or saline).

4.2.4 Habitat Suitability Index Formula

The final step in model development was to construct a mathematical formula that combines all Suitability Indices into a single Habitat Suitability Index value. Because the Suitability Indices range from 0.1 to 1.0, the HSI also ranges from 0.1 to 1.0, and is a numerical representation of the overall or "composite" habitat quality of the particular wetland area being evaluated. The HSI formula defines the aggregation of Suitability Indices in a manner unique to each wetland type depending on how the formula is constructed.

Within an HSI formula, any Suitability Index can be weighted by various means to increase the power or "importance" of that variable relative to the other variables in determining the HSI. Additionally, two or more variables can be grouped together into subgroups to further isolate variables for weighting.

4.2.5 Benefit Assessment

The net benefits of a proposed project are estimated by predicting future habitat conditions under two scenarios: future without-project and future with-project. Specifically, predictions are made as to how the model variables will change through time under the two scenarios. Through that process, HSIs are established for baseline (pre-project) conditions and for future without- and future with-project scenarios for selected "target years" throughout the expected life of the project. Those HSIs are then multiplied by the project area acreage at each target year to arrive at Habitat Units (HUs). Habitat Units represent a numerical combination of quality (HSI) and

quantity (acres) existing at any given point in time. The HUs resulting from the future without- and future with-project scenarios are annualized, averaged over the project life, to determine Average Annual Habitat Units (AAHUs). The "benefit" of a project can be quantified by comparing AAHUs between the future without- and future with-project scenarios. The difference in AAHUs between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity and quality. The starting point for the WVA 50 year period of analysis was assumed to be 2015 based upon the current schedule to complete Plans & Specifications and Construction. This 2015 date differs slightly from the 2009 used in the previous iterations of the planning process. While the starting point of the analysis has changes between steps (2015 compared to 2009) the entire final array of alternatives was evaluated on equal terms and therefore the comparison of alternatives and their respective benefits is valid.

The WVA assessment for the MDWD utilized habitat and land-water data generated by USGS for the project area, aerial photography, monitoring and hydrodynamic modeling data (for salinity) and also used field survey data collected for WVAs recently conducted for other, smaller CWPPRA projects within and adjacent to the MDWD project area. Separate WVA analyses were conducted for each marsh type and each diversion size alternative, and for each outfall management feature type. Target year 0 (TY0) was assumed to be 2015. The WVA analyses conducted for the future-without-project (FWOP) condition used two target years – 1 (TY1) and 50 (TY50) to assess changes in the project area over the 50-year planning horizon. Analyses of the future-with-project (FWP) condition also used TY1 and TY50, but added a target year 5 (TY5) within the 50-year planning horizon. TY5 was used in the FWP analyses because review of hydrodynamic modeling outputs projecting salinities indicated that a portion of the intermediate marsh area would transition to fresh marsh within a few years following the start of project operation. More detailed information concerning data sources, variable assumptions, anticipated habitat changes, and performance of the diversion alternatives over time is presented in an appendix to the USFWS Coordination Act Report at Appendix B.

4.2.5 MDWD Summary

Following the multiple operating regimes analyzed as part of Step 1 described previously, an optimal operating regime was established based on the best available supplies of freshwater, nutrients and sediments while avoiding the negative impacts of open diversions on the public, oyster and alligator resources. A March/April Open Pulse with a 1,000 cfs maintenance flow the rest of the year would achieve these ends. The WVA for the MDWD project is summarized below:

Table 3. Direct Footprint Acreage Impacts

	Ridge Creation	Marsh Creation	Channel Enlargement
Alternative 1: Location 3 – 5,000 cfs Diversion	32	139	153
Alternative 2: Location 3 – 10,000 cfs Diversion	32	176	167
Alternative 3: Location 3 – 15,000 cfs Diversion	32	235	182
Alternative 4: Location 3 – 35,000 cfs Diversion	31	385	223

Table 4a: WVA Benefits Summary

Benefits Summary				
Outfall Management Features				
Feature	**5,000 cfs**	**10,000 cfs**	**15,000 cfs**	**35,000 cfs**
Marsh Creation	54.59	72.52	92.19	155.20
Channel Enlargement	-15.99	-19.08	-21.89	-31.25
Ridge Footprint	-11.33	-11.33	-11.33	-11.37
Ridge Creation	28.24	28.24	28.24	27.36
Net AAHUs	**55.51**	**70.35**	**87.21**	**139.94**
Diversion Benefits				
Marsh Type	**5,000 cfs**	**10,000 cfs**	**15,000 cfs**	**35,000 cfs**
Fresh/Intermediate	3,505.05	3,862.13	5,650.28	8,802.11
Brackish	1,359.93	1,655.31	1,656.16	3,965.54
Saline	276.26	347.78	347.97	447.42
Net AAHUs	**5,141.24**	**5,86522**	**7,65441**	**13,215.07**
Total Net AAHUs	**5,196.75**	**5,935.57**	**7,741.62**	**13,355.01**

Table 5b. Acreage Summary

MDWD Final Array of Alternatives		
	WVA AAHU's March/Aprl Open + 1,000 cfs Maintenance Flow Year 0 = 2015	Gross/Net Acres March/Aprl Open + 1,000 cfs Maintenance Flow Year 0 = 2015 No Net Loss Acres = 39,587
Location 3 – 5,000 cfs	5,197	35,638 / -3,949
Location 3 – 10,000 cfs	5,936	40,419 / 562
Location 3 – 15,000 cfs	7,742	45,046 / 5,459
Location 3 – 35,000 cfs	13,555	59,902 /20,315

4.3 Cost Estimates for Habitat Improvement Measures.

Cost estimates were developed to conduct the cost effectiveness and incremental cost analysis of the various alternative plans. Items included in the first cost construction estimated are mobilization, dredging, placement, demobilization, contingency, Engineering and Design during Construction (EDC), Supervision & Administration (S&A), Real Estate and Operations and Maintenance. Table 3.12 summarizes the costs associated with each alternative plan. Following selection of the TSP, the design will be refined and a feasibility level cost estimate prepared in MCACES. Therefore, the cost of the recommended plan may differ from the numbers used during IC/CE analysis. Further details can be found in the Engineering and Cost Appendices.

Table 6. LCA: White Ditch Cost Estimates

Alternative	Total First Cost*	Annualized O&MRRR	Annualized First Cost**	**Total Annualized Cost**
Location 3 - 5,000 CFS Box	$152,900,000	$781,804	$7,580,348	$8,362,152
Location 3 - 10,000 CFS Box	$174,200,000	$871,463	$8,636,342	$9,507,805
Location 3 - 15,000 CFS Box	$241,700,000	$1,131,044	$11,982,801	$13,113,845
Location 3 - 35,000 CFS Box	$329,300,000	$1,467,836	$16,325,760	$17,793,596

*Includes Real Estate

**FY 2010 Discount Rate 4 3/8%

4.4 Results of the Incremental Cost/Cost Effectiveness Analysis

The analyses showed that alternative plans 1, 2, 3, and 4 are cost effective. Aside from the No Action alternative, Alternative 4 exhibited the lowest cost per Unit of all alternatives, $1,332 per AAHU. Alternative 3 exhibited the highest cost per Unit at $1,694 per AAHU.

Table 7. White Ditch Incremental Cost/Cost Effectiveness Step 2

Alternative	Total Annualized Cost	WVA AAHU	Average Cost per AAHU
Location 3 - 5,000 CFS Box	$8,362,152	5,197	$1,609
Location 3 - 10,000 CFS Box	$9,507,805	5,936	$1,602
Location 3 - 15,000 CFS Box	$13,113,845	7,742	$1,694
Location 3 - 35,000 CFS Box	$17,793,596	13,355	$1,332
*Includes Real Estate			
**FY 2010 Discount Rate 4 3/8%			

Overall, alternative 4 was considered a best buy plan. However, as the plans are linear in benefits and costs, a CE/IC analysis was conducted on all of the alternatives. These plans provide the greatest increase in benefits for the least increase in cost.

The No Action Alternative (FWOP) is cost effective, however provides no improvement in habitat quality resulting in steep declines in marsh. Alternative plan 1 provides 5,197 AAHUs over and above the No Action Alternative (FWOP) at an annualized incremental cost of $8,362,152 (tables 3.11 and 3.12). Alternative plan 2 provides 739 additional AAHUs, at an annualized incremental cost of $1,145,653. Alternative plan 3 provides 1,806 additional AAHUs, at an annualized incremental cost of $3,606,040. Alternative Plan 4 provides 5,613 additional AAHUs at an annualized incremental cost of $4,679,752. Alternative 4 has the lowest incremental cost per AAHU of $834.

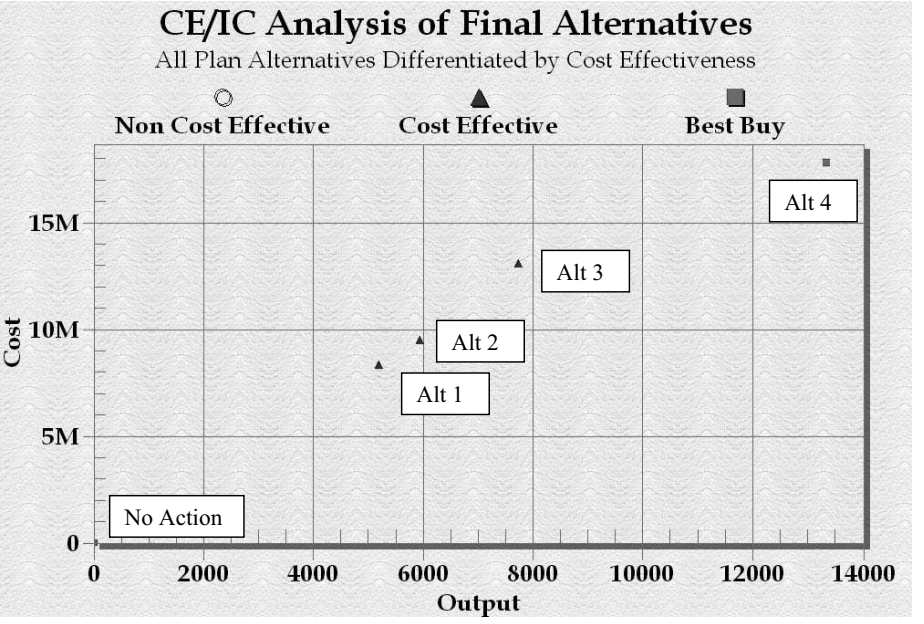


Figure 9. CE/IC Analysis of Final Alternatives

Table 8. White Ditch Incremental Cost/Cost Effectiveness Step 2

Alternative	Total Annualized Cost	WVA AAHU	Incremental Cost/Cost Effectiveness Analysis of Cost Effective Plans		
			Incremental Cost	Incremental AAHU	Incremental Cost per AAHU
Location 3 - 5,000 CFS Box	$8,362,152	5,197	$8,362,152	5,197	$1,609
Location 3 - 10,000 CFS Box	$9,507,805	5,936	$1,145,653	739	$1,550
Location 3 - 15,000 CFS Box	$13,113,845	7,742	$3,606,040	1,806	$1,997
Location 3 - 35,000 CFS Box	$17,793,596	13,355	$4,679,752	5,613	$834

*Includes Real Estate
**Discount Rate 4 3/8%

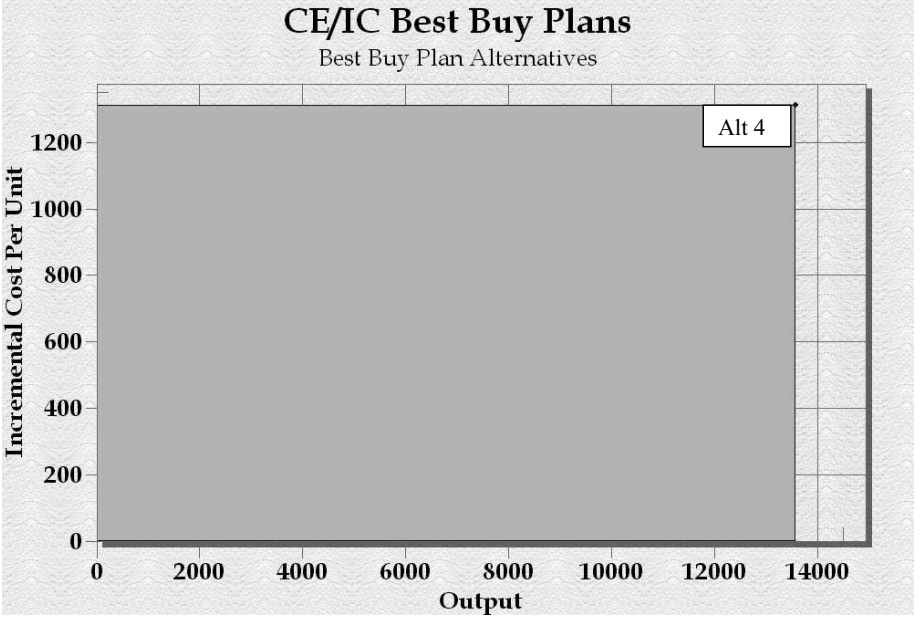


Figure 10. CE/IC Best Buy Plans

4.5 Other Factors

As part of the process to determine whether additional increments of ecosystem investment are worth the cost, other factors were considered.

4.5.1 Recreational Benefits

The primary purpose of the White Ditch Study is to determine a cost effective ecosystem restoration plan, however there are potential ancillary benefits to recreation. Recreation benefits are not being claimed to justify the project but are useful in discerning among the final alternatives. A complete analysis can be found in the Recreation Benefits Analysis Annex to Appendix K.

Given that the study area has 90,109 unit days per year and that each unit day is valued at $8.99, the total annual monetary value of the recreational resource that would be affected by the White Ditch project is $810,256. Given that the likelihood at success with fishing will increase and that environmental factors will improve over time if the proposed project is implemented, the total annual monetary value of the recreational resource will increase in the future compared to the annual monetary value of the recreational resource should the proposed project not be implemented.

To better understand the economic impact of the proposed project on recreation, the analysis considered effects over a 50-year period. The analysis uses the Federal discount rate for 2009 of 4 3/8%. The following table summarizes the potential net present value of recreational resources for each alternative.

Table 9. Net Increase in Recreation Benefits

	Without Project	**Alternative 1**	**Alternative 2**	**Alternative 3**	**Alternative 4**
Net Present Value of Benefits over 50 years	$0	$1,206,000	$1,278,000	$1,421,000	$853,000
Annualized Benefits	$0	$57,284	$60,704	$67,496	$40,517

4.5.2 Desired Future Condition

The desired future established early on in the study was to achieve a no net loss of marsh acres at the end of the 50-year period of analysis. While it was desirable to maximize the acres of marsh, it was uncertain if that was possible given the various physical and operational constraints. The outputs of the ERDC SAND model are one of the key components in the WVA. Based on the ERDC SAND results, Alternative 4 provided the most net acres at the end of period of analysis. In fact it is probable, based on the modeling, that the study area could see a return to historic marsh acreages. Finally, the IC/CE analysis of the final array of alternatives utilized WVA benefits based in part on an operation regime of Open Diversion during March-April with a 1,000 cfs maintenance flow the remainder of the year. As can be seen in the Figure below, under a variety of operating regimes, Alternative 4 is the most capable at achieving no net loss. Alternative 3 has the potential to achieve no net loss but there is no room for error. This uncertainty was viewed by the PDT and stakeholders as unacceptable.

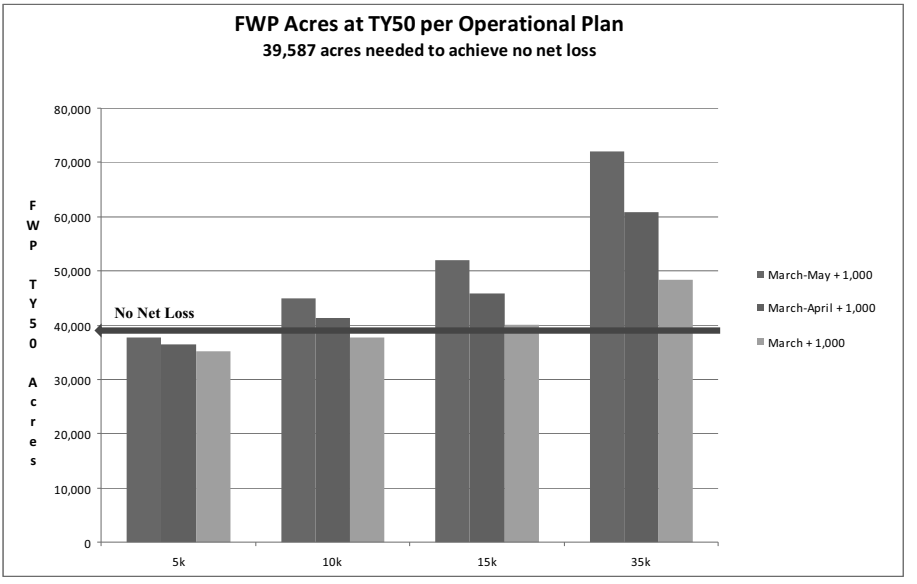


Figure 11. FWP Acres at TY50 per Operational Plan

4.5.3 Relative Sea Level Rise

An analysis of the high sea level rise scenario was conducted utilizing the ERDC-SAND2 model. The model was used to determine whether a net loss or gain of marsh acreage would occur assuming a high sea level rise scenario. Alternative 4 was the most effective at countering the effects of high sea level rise. Alternative 4 could maintain marsh acreage out to approximately year 20 of the analysis which was then quickly followed by a sharp decline and eventual collapse of the marsh and near total conversion to open water. This result was based on the March/April Pulse plus a 1,000 cfs maintenance flow the rest of the year. Table 9 and Table 10 display these details. It should be noted however, that in the event high sea level rise becomes a reality, Alternative 4 alone has the capability (assuming an open diversion) to divert large enough quantities of freshwater, nutrients and sediments to overcome high sea level rise. Longer term pulses of freshwater may result in large scale habitat switching to predominately freshwater types. Further, long term freshwater pulses can saturate marsh vegetation and soils such that they are less resilient to storm surge from seasonal events resulting in marsh displacement and conversion to open water. There is strong public feeling that the prolonged operation of Caernarvon prior to Katrina contributed to the severe loss of marsh. While not publicly acceptable at present (due to the anticipated negative consequences of over-freshening the basin), if the collapse of the marsh within the study areas was imminent, then having the ability to respond accordingly with a year round open diversion would be critical.

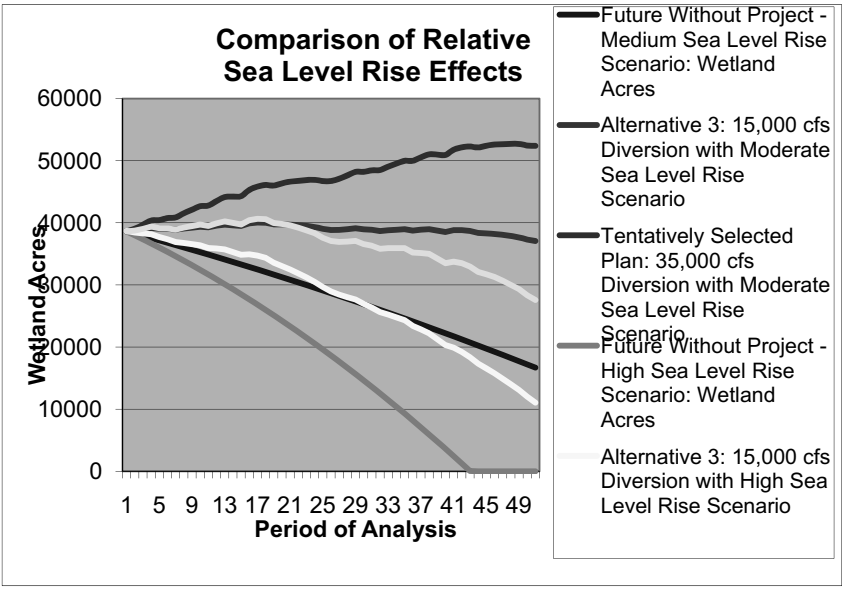


Figure 12. Comparison of Relative Sea Level Rise Effects

Table 10. ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under Historical Sea Level Rise Rates

Historic RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	36,000	33,300	30,500	27,800	25,000
5,000 cfs Diversion Alternative	38,700	38,300	37,800	37,000	36,600	35,600
10,000 cfs Diversion Alternative	38,700	39,300	39,900	39,900	40,700	40,400
15,000 cfs Diversion Alternative	38,700	40,300	41,900	42,700	44,600	45,000
35,000 cfs Diversion Alternative	38,700	43,800	48,800	52,200	57,300	59,900

*** The total project area for the Medium Diversion at White Ditch is 98,000 acres

Table 11. ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under the Intermediate and High Sea Level Rise Rates

Intermediate RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	34,900	30,900	26,500	21,800	16,900
35,000 cfs Diversion Alternative	38,700	42,800	46,600	48,500	51,800	52,400
High RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	31,500	23,700	14,000	2,900	0
35,000 cfs Diversion Alternative	38,700	39,500	39,600	36,300	33,800	27,600

*** The total project area for the Medium Diversion at White Ditch is 98,000 acres

4.5.4 Breton Sound Benefits

During the initial ERDC SAND evaluation of alternatives in Step 2, it was determined that Alternative 4 has the capability to create marsh in the larger Breton Sound basin through nutrient transfer. The modification of the Caernarvon Diversion is currently being evaluated in an effort to address the design deficiency in capturing sediment. It may be possible, with further analysis, to claim benefits to the Caernarvon project area as a result of implementing Alternative 4. This may lead to cost savings for the Caernarvon project.

4.5.5 Adaptive Management

Alternative 4 provides the most robust capability for adapting to future risk and uncertainty. As discussed above, Alternative 4 provides the most flexible management of operations to respond to sea level rise. The difference between alternatives 3 and 4 is the outfall canals, ridges and flow constrictions that are responsible for distributing flows at 15,000 and 35,000 cfs respectively. Just as sea level rise represents uncertainty at one end of the spectrum, it is also possible that the sea level rise will not be any more pronounced than historic levels. Also, as the science of operating large diversion structures is refined throughout the period of analysis, it is possible maximize environmental outputs with smaller diversions. Finally, it is expected that as the project is actually operated and benefits are achieved, it will be of value for the federal, state and local partnership to revisit the goals and objectives associated with the project area. If the project is proving to be very successful at creating marsh it may no longer necessary to maintain a 35,000 cfs diversion capability. To achieve this, O&M could be reduced resulting in outfall canals, ridges and flow constrictions necessary to support a decreased diversion flow.

4.5.6 Acceptability, Completeness, Effectiveness, and Efficiency.

Alternative 4 meets the four evaluation criteria of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. Special consideration is also given to these criteria within the larger context of the LCA Report (2004). The four criteria are acceptability, completeness, effectiveness, and efficiency.

Acceptability

The plan is acceptable to Federal, state, tribal, local entities, and the public. It is compatible with existing laws, regulations, and policies.

Completeness

The plan is complete. Realization of the plan does not depend on implementation of actions outside the plan.

Effectiveness

The plan is effective. It addresses all the project objectives. It improves marsh habitat by restoring deltaic process related to freshwater, nutrient and sediments. It does this by introducing the quantities of freshwater, nutrients and sediments required (objectives) to achieve no net loss of marsh during the period of analysis.

Efficiency

The plan is efficient. It is a cost-effective solution to the stated problems and objectives. No other plan produces the same level of output more cost effectively. The plan is cost effective and provides the greatest increase in benefits for the least increase in costs.

4.5.7 Recommendation of the Tentatively Selected Plan.

The interagency team recommends Alternative Plan 4 as the tentatively selected plan. This alternative best meets the study objectives. It would result in restoration of deltaic processes within the project area. In cooperation with the USFWS, NOAA, and the State of Louisiana the Corps has planned and would design a project that serves the needs of the nation.

ANNEX 1
Incidental Recreation Benefits

Introduction and Methodology

This report summarizes the potential incidental recreational benefits of the White Ditch Diversion project, which is the development of a freshwater diversion from the Mississippi River into marshland. The White Ditch Study Area is between the River aux Chenes and the Mississippi River in Plaquemines Parish, Louisiana.

The methodology for estimating the potential incidental recreational benefits of the White Ditch diversion is described by the USACE in publication number ER 1105-2-100, Planning - Planning Guidance Notebook. ER 1105-2-100 authorizes the use of three separate procedures to estimate recreation benefits. These are the travel cost method, the contingent valuation method, and the unit day value method. The first two require a variety of data that are not readily available for the White Ditch Project; therefore, the unit day value (UDV) method has been utilized. A model using the UDV method was developed to estimate the value of recreational benefits in the Study Area for the with- and without-project condition.

Annually, USACE publishes unit day values for both specialized recreation and general recreation. For this project, the general recreation unit day values for general recreation published in Economic Guidance Memorandum Number 10-03 (EGM 10-03) are used. The term "general recreation" refers to an area that provides access to a variety of recreational activities, is widely used, and provides supportive facilities, such as marinas.

Estimating Recreational Use Based Upon State of Louisiana Data

The Louisiana Statewide Comprehensive Outdoor Recreation Plan (SCORP) is published every five years by the Office of State Parks within the Louisiana Department of Culture, Recreation and Tourism. The SCORP is based upon in field and telephone surveys and is used to prioritize the funding of recreation facilities within the state and is prepared to comply with National Park Service guidelines. The 2003-2008 SCORP contains more detailed information, and more regional information than the 2009-2013 SCORP, so both were consulted for this analysis.

The 2003-2008 SCORP explains how facility use standards were developed. The 2003-2008 SCORP facility use standard is based upon a turnover of 20 boats per boat ramp daily, with three persons per boat. Hunting facility use is based upon a turnover of one hunter for every 25 acres per day. The 2009-2013 SCORP states that fishing and hunting are both declining recreational activities, with fishing declining 20% since the last SCORP.

The percentage of the population participating in saltwater fishing by boat based upon either SCORP differs significantly from that indicated by licensing, which is managed by the Louisiana Department of Wildlife and Fisheries (LADWF). The LADWF requires a saltwater endorsement to a fishing license when fishing south of Interstate 10. For this analysis, the midpoint between the two figures

(SCORP estimate and LADWF licensed population) is used to estimate the annual use of the study area for recreational fishing.

For each parish, the number of activity days for fishing in a boat was estimated based upon parish population in the latest Census estimate, the percentage of the population that participate in fishing from a boat provided in the SCORP, and the number of people in the parish with a fishing license and saltwater endorsement provided by LADWF. This number was multiplied by the average number of activity days for fishing in a boat per person in the region, which is provided in the SCORP, to estimate annual activity days by parish residents. The proportion of activity days for fishing from a boat was allocated to the study area for each parish. This figure was allocated 60% to weekends and 40% to weekdays. The result is that the number of weekday visitors annually in this area is estimated at 54,101; the number of weekend visitors annually is estimated at 36,063. The weekend visitation rate was compared with the study area capacity. The capacity of this study area is driven primarily by the availability of boat launches and parking for boat trailers. After reviewing the capacity of the two baot launches in the study area and the water access from outside the study area, a judgement was made that capacity constraints did not impact weekend visitation. Thus, the total number of visitors using this area for a day or the number of unit days is 90,164 annually.

A portion of the activity days for each parish were also allocated to the neighboring area to the northeast. This is the recreational area closest to the White Ditch Study Area and the area most likely to be used as an alternative, such as during the pulse period. The allocation of activity days to the two areas listed, Study Area and Adjacent Area, are less than 100%, because parish residents will spend some activity days in totally different regions. The White Ditch Study Area is in Plaquemines Parish, where the majority of the population lives on the west bank of the Mississippi River. A large portion of this population is unlikely to travel across the Mississippi River to the White Ditch Study Area or the adjacent area.

During the pulse period a portion of the activity days that would have been spent in the White Ditch Study Area might be spent in the adjacent area to the northeast, for the alternatives of 10,000 cfs (Alternative 2) or greater. The assumption is made that 10% of the activity days will be shifted from the Study Area to the adjacent area at Year 5 for Alternatives 2 and 3 and 20% for Alternative 4. At Year 10 the assumption is made that Alternatives 2 and 3 would have benefitted the study area enough to increase annual activity days to the original amount, despite the dislocation during the pulse period. Alternative 4 has a high diversion rate of 35,000 cfs during the pulse period, and this rate would significantly reduce visitation through the entire planning period. In comparison to the Caernarvon and Davis Pond Diversion Projects, the flow with Alternative 4 would be much higher, and, according to focus group members, recreational fishing would be greatly impacted for an extended period during and after the pulse period.

These shifts in user days, between the study area and the adjacent area are shown in the two tables below.

Recreation Resource Year 5

July 1, 2017	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
White Ditch Study Area					
Unit Day Value (2010 value)	$8.38	$8.73	$8.90	$9.08	$9.30
Number of Unit Days	90,164	90,164	81,148	81,148	72,131
Total Annual Monetary Value	$755,213	$786,951	$722,538	$736,820	$670,820
Total Benefit / Loss with Project	n/a	$31,738	-$32,675	-$18,393	-$84,393
Outside of Study Area					
Unit Day Value (2010 value)	$8.38	$8.38	$8.38	$8.38	$8.38
Number of Unit Days	167,106	167,106	176,122	176,122	185,138
Total Annual Monetary Value	$1,399,676	$1,399,676	$1,475,197	$1,475,197	$1,550,718
Total Benefit / Loss with Project	n/a	$0	$75,521	$75,521	$151,043
Net Monetary Benefit / Loss	n/a	$31,738	$42,846	$57,128	$66,649
Total Number of Unit Days - Both Areas	257,269	257,269	257,269	257,269	257,269

Recreation Resource Year 10

July 1, 2022	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
White Ditch Study Area					
Unit Day Value (2010 value)	$8.38	$8.82	$8.99	$9.12	$9.34
Number of Unit Days	90,164	90,164	90,164	90,164	81,148
Total Annual Monetary Value	$755,213	$794,885	$810,754	$822,656	$758,243
Total Benefit / Loss with Project	n/a	$39,672	$55,541	$67,443	$3,030
Outside of Study Area					
Unit Day Value (2010 value)	$8.38	$8.38	$8.38	$8.38	$8.38
Number of Unit Days	167,106	167,106	167,106	167,106	176,122
Total Annual Monetary Value	$1,399,676	$1,399,676	$1,399,676	$1,399,676	$1,475,197
Total Benefit / Loss with Project	n/a	$0	$0	$0	$75,521
Net Monetary Benefit / Loss	n/a	$39,672	$55,541	$67,443	$78,551
Total Number of Unit Days - Both Areas	257,269	257,269	257,269	257,269	257,269

There are three general activities in the study area. One activity, recreational fishing, is of high value. Recreational fishing is almost exclusively from boats, as there are no piers and bank fishing is difficult. The only other recreational activities are duck hunting, which has a short, 60 day season, and wildlife watching. The focus group attendees stated that most duck hunting was outside the White Ditch Study Area, in the Mississippi River Gulf Outlet area. The model was used to estimate the number of unit value days for duck hunting and wildlife watching. Based upon the estimates, as shown in the table below, the number of user days for these activities was approximately 6% of the number for recreational fishing. Therefore separate unit day values were not estimated for these activities and recreational benefits were not included for these activities.

White Ditch Study Area - Potential Visiting Population

	Parish of Residence				
Potential Recreational Users	**Plaquemines**	**St. Bernard**	**Orleans**	**Jefferson**	**Total**
Potential Visitors to Study Area Annually - Fishing	15,237	9,633	14,418	50,876	90,164
Potential Visitors to Adjacent Area Annually - Fishing	7,618	28,899	28,837	101,752	167,106
Potential Visitors to Study Area Annually - Duck Hunting	33	28	9	94	164
Potential Visitors to Adjacent Area Annually - Duck Hunting	66	56	17	188	327
Potential Visitors to Study Area Annually - Nature Study	1,155	1,024	1,693	2,368	6,241
Potential Visitors to Adjacent Area Annually - Nature Study	578	1,024	8,467	11,842	21,911
Potential Visitors to Study Area Annually - Total	16,425	10,685	16,121	53,338	96,569
Potential Visitors to Adjacent Area Annually - Total	8,262	29,979	37,321	113,781	189,343

The time in transit for the recreational fishers using the study area would change with the alternatives, based upon the species sought. During the pulse, saltwater species are expected to migrate away from the diversion towards open water. The drive time to boat launches would remain the same, but the time in transit by boat to fishing spots would increase for those seeking saltwater species. Within the White Ditch Study Area the additional transit time would not be significant. An additional 10 minutes of transit time by boat each way is not significant compared with the total preparation and transit time needed to spend the day fishing. Therefore the unit day value is not changed based upon transit time or "steaming time." However, some fishers will go to another area, outside the study area, rather than fish in more open water, which has more choppy conditions

Estimate of Unit Day Value

The study area is assumed to be stable in the without-project condition, meaning the unit day values for recreation remain constant.. The net changes in unit day values are determined by comparing the future condition with the current condition. The estimates of annual use are combined with unit day values to estimate annual recreation benefits. Unit day values were estimated using the most recent values available in EGM 10-03.

The Unit Day Value method involves assigning points in each of five categories or criteria. The five criteria are:

- Recreation Experience, the number of high quality recreational activities possible in the area;
- Availability of Opportunity, the availability of similar opportunities nearby;
- Carrying Capacity, the degree to which an area provides services to support recreation;
- Accessibility, the degree to which the area is readily accessible; and
- Environmental Quality, the aesthetic qualities of the area including water and vegetation, air and water quality, scenery, and climate.

Points were assigned for each of these five criteria. The determination of points for each criterion is described below. Two of the five criteria are impacted by the project.

Recreation Experience: A maximum of 30 points may be assigned for this criterion. Point values to be assigned are described in the table below.

Availability of Opportunity					
Description	Several similar opportunities within one hour and a few within 30 min travel time	Several similar opportunities within one hour but none within 30 min travel time	One or two within one hour travel time but none within 45 min	No similar opportunities within one hour travel time	No similar opportunities within two hour travel time
Range of Points	0–3	4–6	7–10	11–14	15–18

For this analysis, 16 points are assigned because there are three activities; wildlife watching, fishing and hunting, and because fishing in this area is, according to Focus Group participants, some of the best in the country. None of the alternatives affect the points assigned for this criterion.

Availability of Opportunity and Likelihood of Fishing Success: A maximum of 18 points may be assigned for this criterion. Point values to be assigned are described in the table below. Availability of Opportunity is equated with likelihood of success at fishing and hunting, as stated in Table 2 of EGM 10-03. During the annual pulse period and for a short period afterwards, likelihood of fishing success will diminish. During the other months, the likelihood of fishing success would not be

Recreation Experience					
Description	Two general activities available	Several general activities available	Several general activities available with one high quality	Several general activities available, more than one high quality	Numerous high quality activities available
Range of Points	0–4	5–10	11–16	17–23	24–30

impacted. The diversion is intended to improve the marsh and wildlife, so the long term impact on recreation should be beneficial. When the beneficial impacts to wildlife become apparent after ten years the likelihood of fishing and hunting success will increase.

For the White Ditch Study Area, the net increase in average annual habitat units and marsh acres are considered when estimating the improved likelihood of success at fishing and hunting. Other factors could be considered dependent upon data availability. The model does not use a direct correlation between these factors and the likelihood of fishing success but is dependent upon a subjective interpretation of the data.

Thus, 10 points are assigned for the without-project condition and additional points are assigned for each of the alternative's subsequent years based upon the environmental outputs of the project. The

outputs of the ecosystem restoration, Average Annual Habitat Units (AAHUs) and marsh acres, are used in assigning points for this criteria. Increasing AAHUs and marsh acres indicate increased likelihood of fishing success and increased esthetics. The correlation of these outputs to improvements in recreational fishing has been determined through previous research but the direct conversion of AAHUs and marsh acres to points is subjective. The model is consistent, in that more of these outputs result in more points. Within coastal Louisiana, different projects have different outputs, and sometimes these projects are adjacent to each other. For that reason the unit day values for the MRGO Ecosystem Restoration project are considered when determining the point assignment for the White Ditch Project.

The points assigned for Availability of Opportunity/Likelihood of Fishing Success are shown in the table below. Based upon increases in AAHUs and input from the focus group, each alternative is expected to increase the likelihood of fishing success significantly. Alternative 4 results in the highest number of points, 16 out of 18, compared to the other alternatives.

White Ditch Study Area General Recreation Points - Year 5

Criteria	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Recreation Experience (Number of Activities)	16	16	16	16	16
Availability of Opportunity *	10	11	12	13	16
Carrying Capacity	5	5	5	5	5
Accessibility	10	10	10	10	10
Environmental (Esthetic Quality) *	11	14	15	16	18
Total Points	**52**	**56**	**58**	**60**	**65**
Unit Day Value	**$8.38**	**$8.73**	**$8.90**	**$9.08**	**$9.30**
Variable - Availability of Opportunity					
Likelihood of Fishing Success (Net Change from Base)	0	1	2	3	6
Additional (Net Change) Marsh AAHUs	0	< 5457	< 6095	< 7921	< 13575
Marsh Creation (Acres)	0	< 55	< 70	< 91	< 163

Carrying Capacity: A maximum of 14 points may be assigned for this criterion. Point values to be assigned are described in the following table:

Carrying Capacity					
Description	Minimum facility development for public health and safety	Basic facilities to conduct activity	Adequate facilities to conduct activity	Optimum facilities to conduct activity	Ultimate facilities to conduct activity
Range of Points	0 - 2	3 - 5	6 - 8	9 - 11	12 - 14

For this analysis, 5 points are assigned because facilities to support recreation in this area are currently adequate. However, should the proposed White Ditch project and resulting changes in salinity levels reduce the amount of fishers utilizing existing marinas and causing them to go out of business, there may be negative impacts to recreational fishing because there will be fewer services available in the area. Since these closures are considered unlikely, the assumption is made that the marinas will remain in business and recreational users will be able to obtain the services they need.

Accessibility: A maximum of 18 points may be assigned for this criterion. Point values to be assigned are described in the following table:

Accessibility					
Description	Limited Access by any means to site	Fair access to site; limited access within site	Fair access to site; fair access within site	Good access to site; fair access within site	Good access to site; good access within site
Range of Points	0 - 3	4 - 6	7 - 10	11 - 14	15 - 18

For this analysis, 10 points are assigned because the study area has one highway providing access to the two boat launches within the site. None of the alternatives will affect this criterion.

Environmental: A maximum of 20 points may be assigned for this criterion. Point values to be assigned are described in the following table:

Environmental					
Description	Low aesthetic factors	Average aesthetic factors	Above average esthetic factors	High aesthetic factors	Outstanding aesthetic factors
Range of Points	0–2	3–6	7–10	11–15	16–20

For this analysis, 11 points are assigned because while the area is considered to be very beautiful, the

proposed project will affect some aesthetic factors during the pulse period and for several weeks afterward. In particular, increased turbidity may affect water quality and decreased salinity will kill some existing vegetation during the pulse period. However, because vegetation that can tolerate changing salinity levels will eventually be established in the area, the aesthetic quality of the area will recover. Thus over time, the number of points that can be assigned for this criterion will increase. The table below shows that increase at Year 10 of the project.

Study Area
General Recreation Points - Year 10

Criteria	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Recreation Experience (Number of Activities)	16	16	16	16	16
Availability of Opportunity *	10	12	13	14	17
Carrying Capacity	5	5	5	5	5
Accessibility	10	10	10	10	10
Environmental (Esthetic Quality) *	11	14	15	16	18
Total Points	**52**	**57**	**59**	**61**	**66**
Unit Day Value	**$8.38**	**$8.80**	**$8.99**	**$9.12**	**$9.34**
Variable - (Environmental - Esthetic Quality)					
Esthetic Quality (Net Change from Base)	0	3	4	5	7
Additional (Net Change) Marsh AAHUs	0	< 5457	< 6095	< 7921	< 13575
Marsh Creation (Acres)	0	< 55	< 70	< 91	< 163

Recreational Benefits

EGM 10-03 provides a table showing how to relate points assigned using the five criteria to dollar values. Since this project is evaluated to have a total of 52 points under the without-project condition, using linear interpolation and the values provided by EGM 10-03 for either 50 or 60 points, we assign a dollar value of $8.38 as the general recreation unit day value. Unit day value increases through year 50 for each alternative, based upon the evaluation points criteria discussed above to $8.90 for Alternative 1, $9.08 for Alternative 2, $9.17 for Alternative 3 and $9.34 for Alternative 4 (TSP).

The annualized benefits are based upon changes in both the number of unit days and the unit day value, occurring over a fifty period. Both of these figures were input into the model at the time of project completion, as well as five years, ten years, twenty years, and fifty years after project completion. The benefits for every year during the fifty year planning period were based on the outputs of the model for these years, with equal incremental changes between these years. The net present value (NPV) of the annual benefits is calculated and the NPV is annualized.

Given that the area has 90,164 unit days per year and that each unit day is valued at $8.38, the total annual monetary value of the recreational resource that would be affected by the White Ditch project is $755,213. Given that the likelihood at success with fishing will increase and that environmental factors will improve over time if the proposed project is implemented, the total annual monetary value of the recreational resource will increase in the future compared to the annual monetary value of the recreational resource should the proposed project not be implemented. A combination of an increase in unit day value and user-days for the with-project condition results in an increase in net benefits for each alternative. A combination of an increase in unit day value and total user-days for Alternatives 1-3 results in increased recreational benefits. Alternatives 1 through 3 are expected to increase user days by 9,000 in the study area by year 50, whereas annual visitation will not increase for Alternative 4 because of users shifting out of the study area during the pulse period. This annual decrease results from adverse conditions during the pulse period and for several weeks after. The number of unit value days and the value of those days at Year 50 are shown in the next table

The following table shows the net present value and total annualized benefits for each alternative, both inside the study are and outside the study area. There is a net positive benefit outside the study area from the displaced users during the pulse period.

Recreation Resource Year 50

July 1, 2062	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
White Ditch Study Area					
Unit Day Value (2010 value)	$8.38	$8.90	$9.08	$9.17	$9.34
Number of Unit Days	90,164	99,180	99,180	99,180	90,164
Total Annual Monetary Value	$755,213	$883,102	$900,557	$909,285	$842,492
Total Benefit / Loss with Project	n/a	$127,889	$145,344	$154,072	$87,279
Outside of Study Area					
Unit Day Value (2010 value)	$8.38	$8.38	$8.38	$8.38	$8.38
Number of Unit Days	167,106	167,106	167,106	167,106	167,106
Total Annual Monetary Value	$1,399,676	$1,399,676	$1,399,676	$1,399,676	$1,399,676
Total Benefit / Loss with Project	n/a	$0	$0	$0	$0
Net Monetary Benefit / Loss	n/a	$127,889	$145,344	$154,072	$87,279
Total Number of Unit Days - Both Areas	257,269	266,286	266,286	266,286	257,269

Total Recreation Resource Annualized Benefits

	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
White Ditch Study Area					
Total Net Present Value (NPV) all 50 years	15,345,000	16,815,000	16,795,000	16,983,000	15,831,000
Total Annualized Rec Benefits - 50 years	728,873	798,697	797,747	806,677	751,958
Net Present Value Increase / Decrease		1,470,000	1,450,000	1,638,000	486,000
Annualized Benefits Increase / Decrease		69,824	68,874	77,803	23,085
Outside of Study Area					
Total Net Present Value (NPV) all 50 years	28,344,000	28,344,000	28,637,000	28,637,000	29,262,000
Total Annualized Rec Benefits - 50 years	1,346,314	1,346,314	1,360,231	1,360,231	1,389,918
Net Present Value Increase / Decrease		0	293,000	293,000	918,000
Annualized Benefits Increase / Decrease		0	13,917	13,917	43,604

To better understand the economic impact of the proposed project on recreation, the analysis considered effects over a 50-year period. The analysis uses the Federal discount rate for 2009 of 0.04625. The following table summarizes the potential net present value of recreational resources for each alternative.

Net Increase in Recreation Benefits

	Without Project	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Net Present Value of Benefits over 50 years	$0	1,470,000	1,743,000	1,931,000	1,404,000
Annualized Benefits	$0	69,824	82,791	91,721	66,689

Alternative 3 has the highest benefits. Unit day values increase more for Alternative 3 than for Alternatives 1 and 2 and it has a higher number of unit days than Alternative 4. Alternative 4 has the highest unit day value for each year modeled because it has the highest level of environmental outputs . However, the high water flow for Alternative 4 is expected to cause the greatest reduction in visitation. To summarize, Alternative 3 has the highest benefits based upon the combination of both unit day values and annual visitation.

References

2006 National Survey of Fishing, Hunting, and Wildlife Related Recreation, U.S. Fish and Wildlife Service, Louisiana, issued March 2008.

Louisiana Statewide Comprehensive Outdoor Recreation Plan 2003-2008, Louisiana Department of Recreation and Tourism, December 2004.

Louisiana Statewide Comprehensive Outdoor Recreation Plan 2009-2013, Louisiana Department of Recreation and Tourism, July 2009.

Net Economic Values of Wildlife Related Recreation in 2006, U.S. Fish and Wildlife Service, Report 2006-05, July 2009.

Army Corps of Engineers, Economic Guidance Memorandum 10-03: Unit Day Values for Recreation, Fiscal Year 2010, November 2009.

Army Corps of Engineers, ER 1105-2-100, Chapter 3: Corps Civil Works Missions, April 2000.

This page intentionally left blank.

APPENDIX L:
Engineering Investigations

Volume VI
APPENDIX L:
Engineering

Medium Diversion at White Ditch Final Feasibility Report
Appendix L1 – Engineering Investigations and Cost Estimates
Table of Contents

L1. GENERAL 3

L2. HYDRAULICS AND HYDROLOGY 3

L2.1 CLIMATOLOGY 3
L2.2 SELECTION OF A HYDRODYNAMIC MODELING PROGRAM 4
L2.3 DATA COLLECTION FOR MODELING PURPOSES 5
L2.3.1 Bathymetry 6
L2.3.2 Tidal Stages 6
L2.3.3 Salinity 8
L2.3.4 Meteorological Data 8
L2.3.5 Caernarvon Flows 9
L2.3.6 URS Field Investigation 11
L2.4 HYDRODYNAMIC MODEL DOMAIN AND GRID GENERATION 14
L2.5 BOUNDARY CONDITIONS 26
L2.6 HYDRODYNAMIC MODEL CALIBRATION 26
L2.7 HYDRODYNAMIC ALTERNATIVES ANALYSIS 31
L2.7.1 Initial Screening Analysis 34
L2.8 ECOHYDRAULIC MODELING 45

L3. SURVEYING, MAPPING, AND GEOSPATIAL DATA REQUIREMENTS 48

L3.1 GEOSPATIAL DATA 48
L3.2 AERIAL PHOTOGRAPHY AND LIDAR 48
L3.2.1 2008 DOQQ Aerial Photography 48
L3.2.2 1992 Landsat Thermatic Satellite Image of Louisiana, UMT 15 NAD27 49
L3.2.3 2007 Mississippi River LIDAR 49
L3.3 GROUND TOPOGRAPHIC SURVEYS 50

L4. GEOLOGY 50

L5. GEOTECHNICAL INVESTIGATIONS AND DESIGN 54

L5.1 GENERAL 54
L5.2 GEOTECHNICAL DESIGN FOR DIVERSION FACILITY 54
L5.2.1 Stability Analyses 54
L5.2.2 Construction Excavation 58
L5.2.3 Pile Foundations 58
L5.2.4 Lateral Earth Pressures 61
L5.2.5 Hydrostatic Uplift 61
L5.2.6 Backfill 61
L5.3 GEOTECHNICAL DESIGN FOR TRANSMISSION SYSTEM 62
L5.4 LABORATORY TESTING PROGRAM AND EVALUATIONS 63

L6. ENVIRONMENTAL ENGINEERING 280

L7. CIVIL DESIGN CRITERIA 280

L7.1 SITE RECOMMENDATIONS 280
L7.2 CIVIL SITE DESIGN FOR DIVERSION FACILITY 281
L7.2.1 General 281
L7.2.2 Alternatives Array 282
L7.2.3 Description of Civil Site alternatives 282

C8. STRUCTURAL DESIGN CRITERIA 294

L8.1 FOUNDATION RECOMMENDATIONS 294
L8.1.1 General 294
L8.1.2 Description of Feature Foundations 294
L8.2 STRUCTURAL DESIGN FOR DIVERSION FACILITY 295
L8.2.1 General 295
L8.2.2 Description of Structural Features 296

L9. ELECTRICAL AND MECHANICAL REQUIREMENTS 301

L9.1 ELECTRICAL SOURCES AND SUPPLY REQUIREMENTS 301
L9.1.1 GENERAL 301
L9.1.2 Electrical Requirements Per Site 301
L9.2 SOLAR POWER SUPPLY SYSTEMS 302
L9.2.1 General 302
L9.3 ELECTRICAL AND MECHANICAL DESIGN FOR DIVERSION FACILITY 302
L9.3.1 General 303
L9.3.2 Electrical/Mechanical Requirements Per Site 303

L10. CONSTRUCTION PROCEDURES 304

L11. OPERATIONS AND MAINTENANCE 304

L11.1 OPERATIONS 304
L11.2 MAINTENANCE 307

L12. COST ESTIMATES 307

L12.1 BASIS OF COST ESTIMATE 307
L12.2 DETAILED ESTIMATE 308
L12.3 CONTINGENCIES 310
L12.4 RISK ANALYSIS 310

ANNEX 1: Quantifying Benefits of Freshwater Flow Diversions to Coastal Marshes
ANNEX 2: ERDC-SAND2 Model Verification
ANNEX 3: MCASES Cost Analysis
ANNEX 4: Hydrodynamic Modeling Analysis by URS Corporation

L1. General

The White Ditch project area is located in the Breton Sound estuary and covers the area extending north and south from just south of Belair, Louisiana to the coastline of Louisiana and extending east and west from the Mississippi River to the Oak River. This area extends about 50 km in the NW-SE directions and about 30 km in the SW-NE direction. Subsidence, erosion, channelization, saltwater intrusion, storm damage and the absence of fresh water, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area resulting in extensive wetland loss and ecosystem degradation. There is an existing siphon at the mouth of White Ditch that was built in 1963 and has not been in operation since 1991, except for two brief episodes.

The absence of a supply of fresh water, sediment, and nutrients has caused the marsh to degrade. This degradation coupled with the subsidence and sea level rise rate of approximately 1.04 cm per year has led to an increase in saltwater intrusion. The additional influx of saltwater from the Gulf of Mexico through the vast canal network in the project area has further damaged the marsh vegetation. In August and September of 2005 Louisiana was hit by hurricanes Katrina and Rita. These hurricanes brought high winds and high tidal surges and destroyed thousands of acres of already weakened marsh. In September of 2008 hurricanes Ike and Gustav also hit the Gulf coast. While they did not make direct landfall in the project area, the tidal surges from these storms caused the loss of additional marsh acreage.

The White Ditch area is part of the Breton Sound estuary system. Breton Sound estuary is located in southern Louisiana, between Breton Sound Bay and approximately the last 85 miles of the Mississippi River before it discharges into the Gulf of Mexico. The estuary consists of about 430 square miles (1,100 km2) of fresh and brackish coastal wetlands that are made up of shallow water ponds, lakes, bays, and a man-made canal system (Figure 1). The major rivers in the estuary are the Oak River (also known as River aux Chenes) and Bayou Terra aux Boeufs. The larger water bodies are Big Mar, Lake Leary, Spanish Lake, Grand Lake, and Little Lake.

The project is examining alternative designs for a fresh water diversion from the Mississippi River to the White Ditch Project area. Different alternative locations, channel depths and widths are considered for different peak diversion flow rates, ranging from 5,000 to 100,000 cfs.

L2. Hydraulics and Hydrology

L2.1 Climatology

The climate of the White Ditch study area is subtropical marine with long humid summers and short moderate winters. The climate is strongly influenced by the water surface of many sounds, bays, lakes and the Gulf of Mexico and seasonal changes in atmospheric circulation. During the fall and winter, the study area experiences cold continental air masses which produce frontal passages with temperature drops. During the spring and summer, the study area experiences tropical air masses which produce a warm, moist airflow conducive to thunderstorm development (USACE 2008a (MRGO LEIS)). The study area is also subject to periods of both

drought and flood, and the climate rarely seems to truly exhibit "average" conditions (MsCIP 2008).

The study area is susceptible to tropical waves, tropical depressions, tropical storms and hurricanes. These weather systems can cause considerable property and environmental damage and loss of human life. Historical data from 1899 to 2007 indicate that 30 hurricanes and 41 tropical storms have made landfall along the Louisiana coastline (NOAA 2009). The largest recent hurricanes were Katrina and Rita in 2005, which caused devastating damage in the study area. Hurricane Gustav, while much smaller and less intense, caused additional damage in the study area. Hurricane Ike, which made landfall in Galveston, Texas in 2008, caused flooding and wind damage in coastal areas as it passed the Louisiana Coast.

The total amount of marsh lost as a result of Hurricanes Katrina and Rita was over one third of the total predicted wetland losses predicted by the Coast 2050 Report (1999). Within the study area, about 40,910 acres of wetlands were converted to open water (Barras 2006). This loss rate exceeded the average background loss rate of about 2,160 acres per year for the period from 1956 to 2004 (Wicker 1980; Barras et al. 1994; Barras et al. 2003; Morton et al. 2005). New water bodies formed and existing water bodies expanded north and west of Lake Lery (USGS 2006). These changes occurred largely as a result of Hurricanes Katrina and Rita. The combined land-water changes caused by Hurricanes Katrina and Rita exceeded coastal land change from previous recent hurricanes combined, such as Hurricanes Andrew (1992), Lili (2002), and Tropical Storm Isidore (2002) (Barras 2006).

L2.2 Selection of a Hydrodynamic Modeling Program

A modeling program for a hydrologic study is primarily selected based on the following factors:

a. The configuration of water bodies, channels, and flow control structures in the study area;
b. The nature of water movement inside the system; and
c. The parameters to be studied (e.g., water level, velocity, sediment movement, and/or salinity etc.).

The project area is comprised of areas of marsh and open water with bounding channels and several intersecting interior channels. Since the project area is shallow, the vertical movement of water is insignificant relative to that in the longitudinal and transverse directions and can be ignored during hydrodynamic and salinity computations without loss of accuracy in the final results. The marsh system is assumed to be well mixed vertically. Sediment transportation is an important feature that the model must have; however, due to time constraints hydrodynamic sediment modeling will not be conducted as a part of this study. The project delivery team wants to ensure the opprotunity for this modeling to be done in the future to investigate likely sedimentation patterns within the project area. Therefore, a modeling program that can simulate 2D, vertically averaged movement of water and salinity is the most appropriate for the study. A number of hydraulic models meet the above criteria and were considered for use in simulating the White Ditch diversion alternatives. The candidate models are listed below and organized into finite element and finite volume categories. In general, the finite element models have unstructured meshing capabilities that allow for the efficient detailed resolution of small features,

However, they are difficult to implement in projects with large areas of wetting and drying, often requiring excessive bathymetric and topographic smoothing to achieve a stable solution.

Finite Element Models include:
ADCIRC – Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters: unstructured mesh, no salinity, poor wetting and drying.

FESWMS – Finite Element Surface Water Modeling System: unstructured mesh, no salinity, poor wetting and drying.

RMA2 – Resource Management Associates: unstructured mesh, salinity transport, poor wetting and drying

Finite Volume Models include:
CMS– Coastal Modeling System: salinity transport, good wetting and drying, rectilinear mesh

EFDC – Environmental Fluid Dynamics Code: salinity transport, good wetting and drying, curvilinear mesh

FVCOM – Finite Volume Community Ocean Model: unstructured mesh, good wetting and drying, commercial availability

POM– Princeton Ocean Model: salinity transport, good wetting and drying, curvilinear mesh

The finite difference models typically will not have any stability problems when considering wetting and drying, but often do not have the benefits of unstructured meshes since they typically use rectilinear or curvilinear structured meshes. The FVCOM model is unique in that it is a finite volume model that uses an unstructured mesh and therefore can realize the mesh generation benefits often associated with finite elements. However, the model is relatively new and limited to research applications. Non-research applications are occurring but model documentation and general industrial familiarity with the model are not mature. The remaining three finite volume models (CMS, EFDC and POM) all have similar capabilities and are suitable for the project.

OF those three, the CMS is supported by the USACE and therefore was selected for the project. CMS-Flow is a process-based 2D depth-averaged hydrodynamic, sediment transport and morphology model developed by the USACE for application in and around inlets and channels. It is accessible via the Surfacewater Modeling System (SMS) graphical user interface.

L2.3 Data Collection for Modeling Purposes

There were a number of existing data sets available to support the configuration, calibration and application of the hydrodynamic and salinity transport model. In addition to the existing data

sets, a bathymetric survey and a field measurement program were conducted prior to the modeling analysis in order to provide site-specific data. Each of these data sets is briefly described below.

L2.3.1 Bathymetry

There was sparse data within the coverage area, and the resolution of any available data was insufficient for model use. Digital Elevation Model (DEM) and contoured elevation coverages were available at http://atlas.lsu.edu/rasterdown.htm for portions of the modeled area, however the elevation values available in these datasets did not contain the precision necessary for use in the model.

The USACE conducted a bathymetric survey of the White Ditch area to both support of the modeling analysis and the alternative designs. The survey transects are shown in Figure C2.1. These data provide information on the channel depths and widths, the lake depths, ridges bounding the channels as well as the characteristics of the inter-tidal and land areas.



Figure L2.1: Surveys contract by the USACE to assist in Hydrodynamic modeling analysis of the White Ditch project area.

L2.3.2 Tidal Stages

Real-time tide data were downloaded from http://waterdata.usgs.gov/nwis for three U.S. Geological Survey (USGS) stations. Station locations include: Northeast Bay Gardene (Station

ID: 7374527), Black Bay near Snake Island (Station ID: 7374526) and Cow Bayou at American Bay (Station ID: 73745258). Tide data were also obtained from http://tidesonline.nos.noaa.gov/ for the National Atmospheric Oceanic and Atmospheric Administration (NOAA) Station Pilot East (Station ID: 8761305). Station locations are shown in Figure L2.2.

A review of the tide gages revealed that there were no suitable gage locations in the proximity of the White Ditch area. The closest gages were Cow Bayou at American Bay and Northeast Bay Gardene. Data from the Bay Gardene station was chosen for model use since it provided the most available data with the fewest data gaps.

Utilization of the Bay Gardene data was not without difficulty. A downward shift of 0.5 feet was done on the gage by the USGS in January 2010. They note that there is a level of uncertainty surrounding this gage considering its datum has been tied to a nearby telephone pole which has been through multiple hurricanes and is continually experiencing the effects of subsidence and erosion. In addition, although NOAA often publishes datum conversion between geodetic (i.e. NAV 88) and tidal datum for many gages along the US coast, its website Benchmark Page and does not contain the NAVD 88 and tidal datum conversion for the Bay Gardene station. This is likely due to accuracy and or data issues. NOAA does provide the VDATUM software for converting data to various datum along the US coastline and the coastal regions of the Great Lakes. It also provides estimates of the accuracy in the conversions. The published VDATUM accuracy information for the East Louisiana/Mississippi area is +/- 17.1 cm.

When the Bay Gardene data was averaged over a period multi-year period of time, it was discovered that the average was approximately 1.0 feet above sea level (0.0 feet NAVD88). Using standard modeling practices, all data was shifted downward by 1.0' for the average to coincide with approximate sea level. This 1.0 downward shift falls within the acceptable range established by coupling the USGS' 0.5 downward shift with the NOAA +/- 17.1 cm accuracy range. Most importantly, this adjustment reflects locally observed conditions and results in an accurately responding model.

It is important to note that the results of the model and its calibration are completely dependent on the accuracy of the tidal data that is used as input. Although it was the best available, there is a level of uncertainty surrounding the datum of the Bay Gardene gage which was used in the White Ditch Hydrodynamic Model. The USGS plans to re-survey the gage with state-of-the-art GPS in the near future, with possible publishing of the results in April 2010. It is recommended that the issue of calibration be revisited when this more accurate survey data is complete. It is also recommended that a sensitivity analysis be performed with different levels of tidal drivers (i.e. 0.5 feet above and below the level the model is currently calibrated at) to examine changes in salinity distribution. This sensitivity analysis should demonstrate that the tidal driver used in the model was indeed accurate. These efforts should be conducted before or as part PED phase.

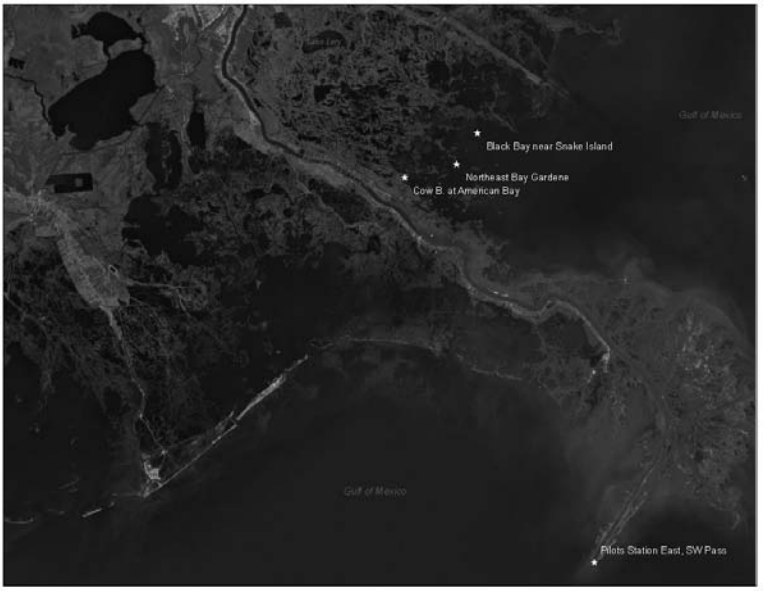


Figure L2.2: Salinity and Tidal gages used in the modeling process

L2.3.3 Salinity

Salinity data are available from the USGS. Data was accessed from http://waterdata.usgs.gov. Data originate from three Louisiana stations including: Northeast Bay Gardene (Station ID 7374527), Black Bay near Snake Island (Station ID 7374526), and Cow Bayou at American Bay (Station ID 73745258). Station locations are shown in Figure L2.2. Another salinity data set was available from Strategic Online Natural Resources Information System (SONRIS). This data set included hourly or monthly salinity measurements and stations were located throughout the Breton Sound with varying periods of record Figure L2.3. The average, max and minimum salinity values at stations with sufficient data are shown in the table in Figure 10. The data reflect the freshwater source of the Caernarvon Diversion.

L2.3.4 Meteorological Data

Wind data are available from various stations in the project area. The wind data were collected by NOAA from 1999 through 2009 (http://www.ncdc.noaa.gov/oa/ncdc.html). Louisiana wind station locations include: Grand Isle (Station Number 8762417), Pilot East (Station Number 8760922) and Shell Beach (Station Number 8761305). The location of these stations is shown in Figure 6. Hourly data was available from the Pilot East station and was downloaded for the time

period of 3/25/2004 through 7/23/2009. Acquired data is noncontiguous in content, containing a number of dates with no recorded data.

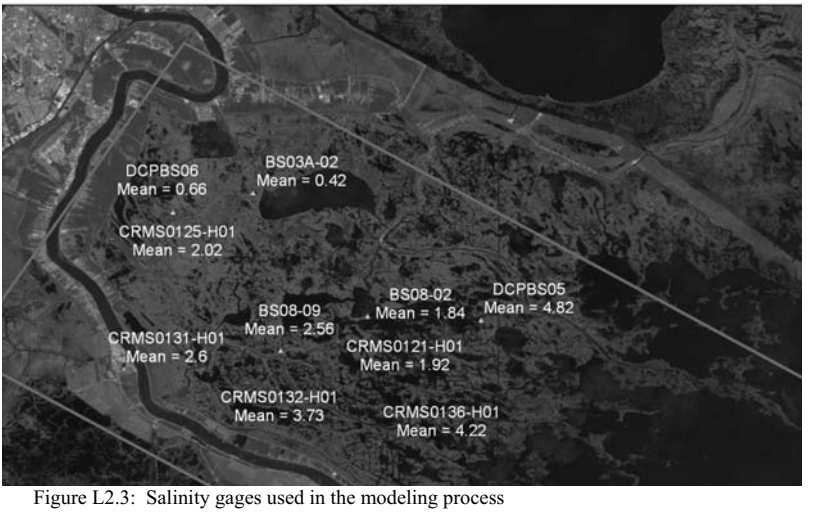


Figure L2.3: Salinity gages used in the modeling process

Rainfall data were obtained from the NOAA Port Sulfer Station (Station 167471) and from a Bell Chasse station. Station locations are shown in Figure L2.4.The data included a daily sum of rainfall in inches for 1/1/2004 through 8/27/2009 for Port Sulfur and 9/28/2006 through 8/20/2009 for Belle Chasse.

There were no daily evaporation data available from stations near the project area. In order to provide some information for evaporation rates, data in the literature was reviewed. A study conducted by Cooke et. al. (2008) provided measured data at a variety of stations in Louisiana. The nearest station was Houma for which summer evaporation rates were available. The data indicate some daily fluctuations do occur, ranging between 2 and 8 mm/day, with an average rate on the order of 5 mm/day.

L2.3.5 Caernarvon

On the northern edge of Breton Sound estuary is the Caernarvon freshwater diversion structure. It is located on the east bank of a Mississippi River oxbow at river mile 81.5. The diversion structure began operating in 1991 as a means for establishing optimal salinity conditions for oyster production, and can also be used to prevent saltwater intrusion during storms or droughts. The 23-meter-wide structure has the capacity to divert up to about 8,000cfs (226m^3/s) of Mississippi River water into the Breton Sound estuary, and has been managed at many different discharge rates since its commencement.

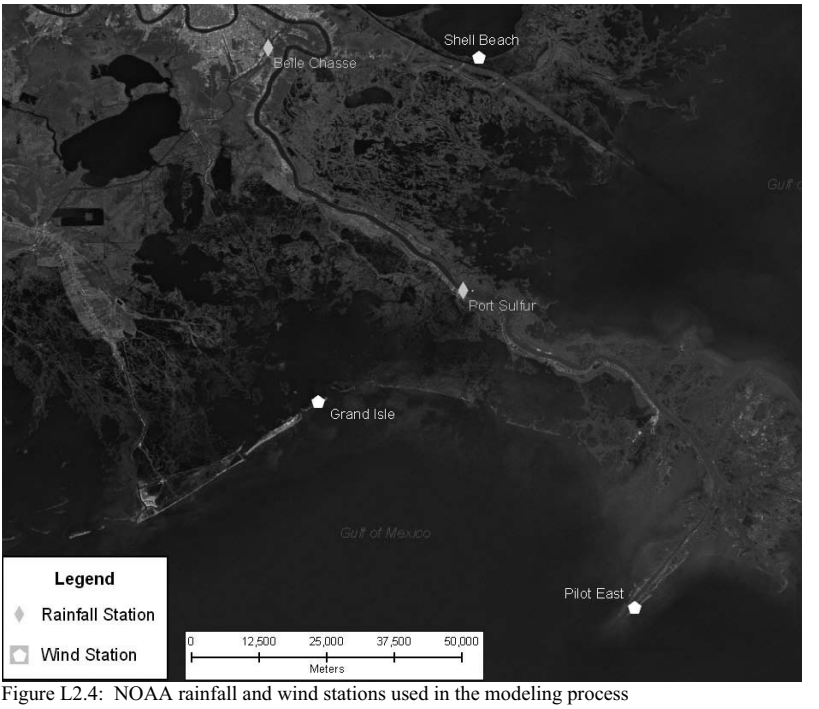


Figure L2.4: NOAA rainfall and wind stations used in the modeling process

The Louisiana Department of Natural Resources manages the Caernarvon Freshwater Diversion Project and provides daily flow data in cubic feet per second (cfs) from 1992 through 2009. Average monthly flows from the diversion are shown in Figure L2.5.

Based on discussions with local land managers, it is believed that the flow from the diversion followed two dominant paths from the diversion. The main one is to the south through the Bayou Mandeville area. The second one is directed to the west, through the Delacroix Canal, and ultimately merges with the Oaks River. It is believed that about 20 to 30 percent of the diversion flows went through the western path until Hurricane Katrina impacted the area. After Katrina, many of the smaller channels to the west were clogged with debris, and it is believed that only 5 to 10 percent of the diversion flow now flows westward.

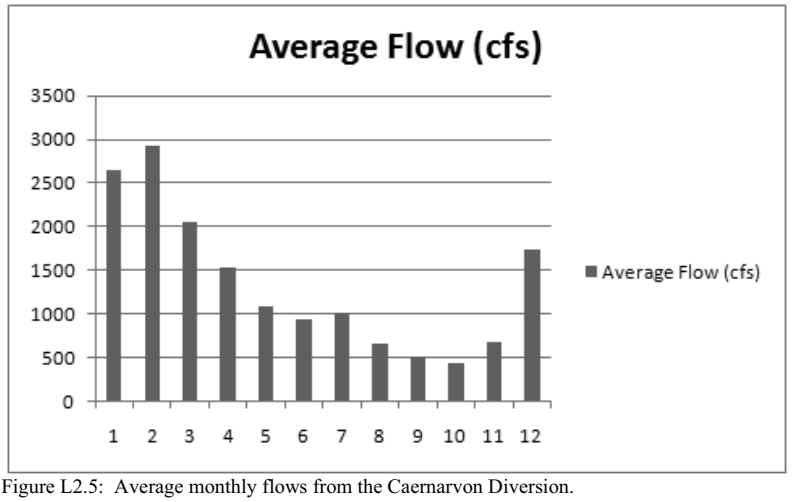


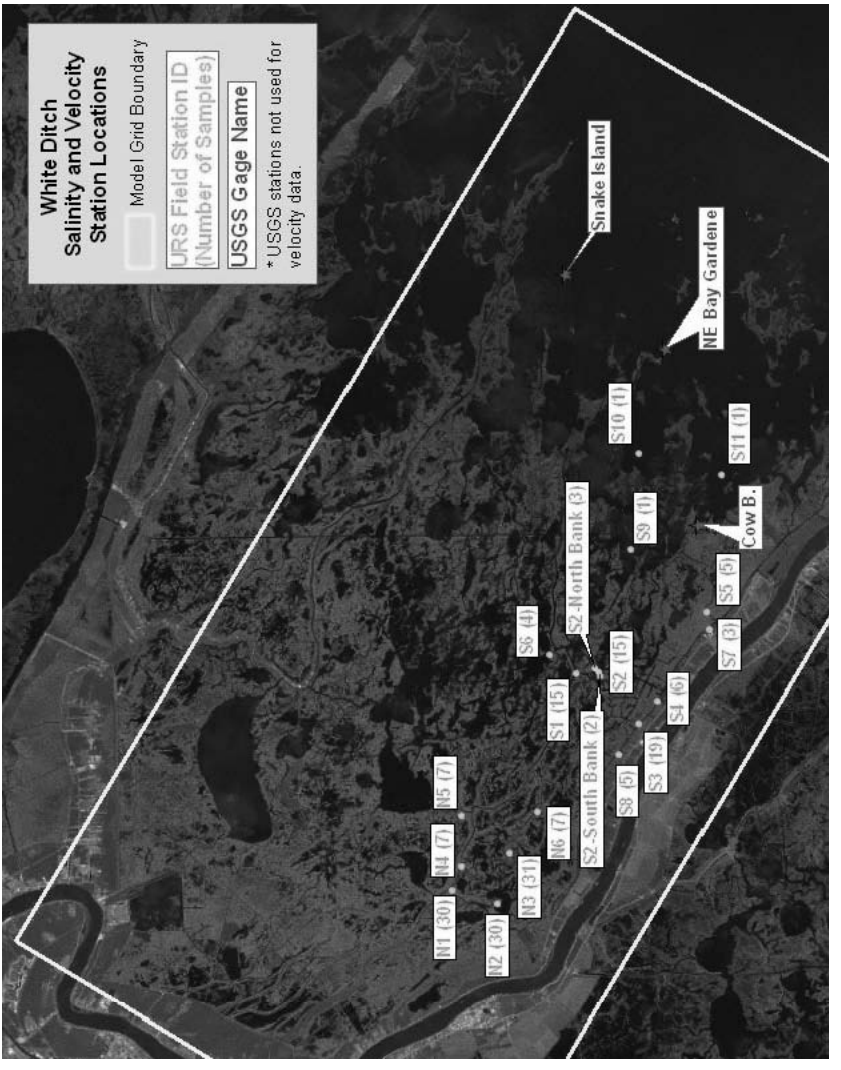
Figure L2.5: Average monthly flows from the Caernarvon Diversion.

L2.3.6 URS Field Investigation

The White Ditch field investigation was conducted from July 20, 2009 through July 23, 2009 to collect necessary calibration data for the CMS-Flow hydrodynamic model of the study area. The field investigation was conducted by two crews of URS field staff operating from airboats hired for the project. The field crews were accompanied by William Terry of the U.S. Army Corps of Engineers (USACE) St. Louis District Office for most of the field investigation. A summary of the two data sets explicitly used in the modeling analysis, the water elevations and the salinity data, are summarized here.

The study area and sampling stations are shown in Figure L2.6. Measurements of flow velocity, temperature, salinity and turbidity were collected periodically between July 21 and 23, 2009 at the primary stations (N1, N2, N3, S1, S2, and S3). Water level measurements were collected at stations N3 and S3 from July 20 to July 23, 2009 using temporary staff gauges and recording pressure transducers that were installed at these locations. Less frequent flow velocity, temperature and salinity measurements were collected at the secondary locations (Oak River Channel, N4, N5, N6, S4, S5, S6, S7, S8, S9, S10, and S11). Water depth measurements were collected at each of the primary and secondary locations, and at additional field locations (S12-S33) shown on Figure L2.7.

Figure L2.6: URS data collection stations for the modeling process.



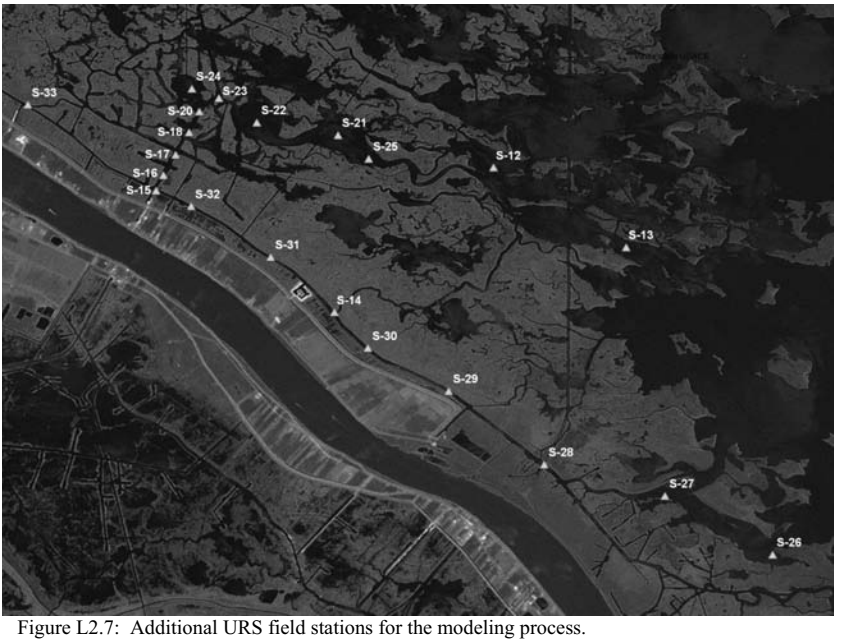


Figure L2.7: Additional URS field stations for the modeling process.

Staff gauges and recording pressure transducers were installed at locations S3 and N3 to measure water level fluctuations within the study area. The transducers used were Micro-Diver Dataloggers (Model DI601) manufactured by the Schlumberger Corporation. The data loggers were initially programmed to collect pressure measurements every five minutes in feet of water. The sample interval was changed to 30 seconds after approximately 24 hours.

Staff gauges constructed of 1-inch diameter PVC pipe was also installed at locations S3 and N3. Periodic measurements of the water level at each staff gauge were recorded. When compared to the tides at the Bay Gardene Station, it is evident that there is s significant loss of tidal amplitude as the tides propagate into the White Ditch area.

Salinity data (as well as temperature and turbidity measurements) were collected at each primary location and other select locations using a HydroLab Quanta system. The mean, maximum and minimum salinity at each station was also recorded. The SONRIS salinity data are also shown in Figure L2.3, and although the data represent different time periods, they show a general trends in the salinity patterns. The trends show a basic low to higher salinity gradient from offshore to the NW as well as a high to low gradient from the east bank of the Mississippi River to the NE. The

general gradients, even those in the White Ditch area, point towards the Caernarvon Diversion, indicating that it is a significant source of freshwater in the area.
Salinity measurements were also made at surface and bottom. The data indicates a very minor difference between the two; less than 0.5 ppt.

L2.4 Hydrodynamic Model Domain and Grid Generation

The model domain is shown in Figure L2.8. The domain includes all of the white ditch area as well as an extensive portion of Breton Sound. A primary reason for including the larger portion of Breton Sound was the potential influence of the diversion peak flows on the east of the Oaks River. Also, the channels providing flow pathways from the Caernarvon Diversion to the White Ditch area required inclusion since the Caernarvon Diversion flows provided a significant portion of the freshwater to the White Ditch area (the other being rainfall).

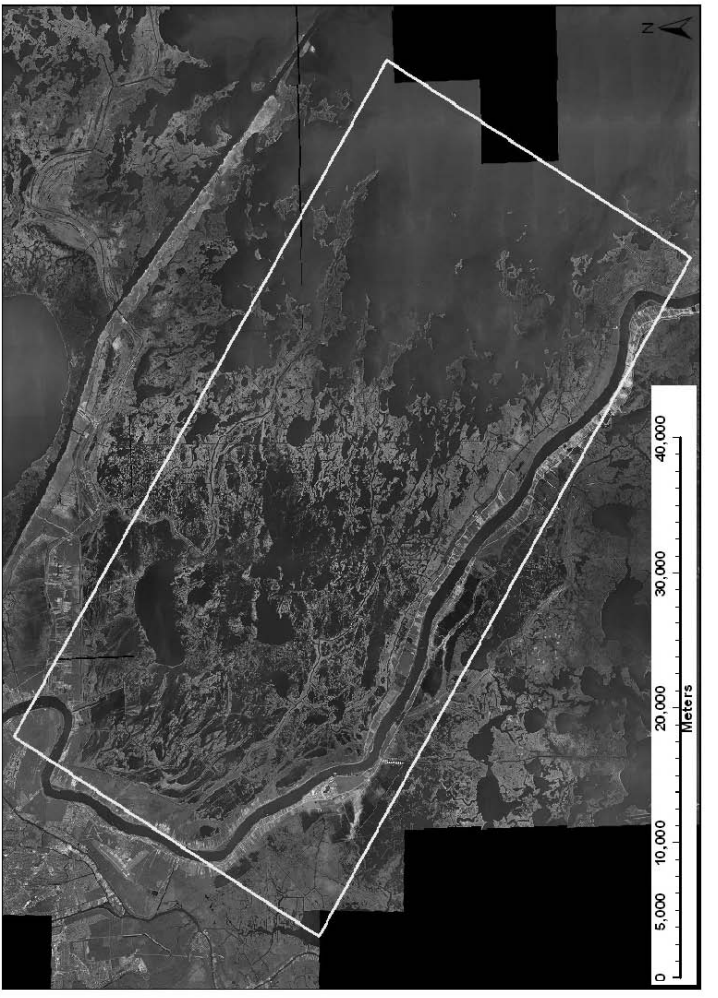
To provide bathymetric data for the model grid, a project-specific bathymetric and topographic data set was developed. This data was used to set the bottom elevation of the cells in the model grid. Initial experiments with the model indicated that the grid resolution in the White

Ditch area would need to be on the order of 10 to 30 meters. This level of resolution would provide sufficient resolution of the channel features but allow for reasonable simulation times on high-end workstations. Therefore, the bathymetric and topographic data should have a minimum resolution of 10 meters in the White Ditch area.

The area bathymetry and topography were developed from existing bathymetric data, land/water boundary data and results from the project field survey. It was determined early in the bathymetric data development that existing bathymetric data were limited to areas above MSL and sets did not provide sufficient resolution for direct use in the grid generation. Therefore the following approach was used to develop the bathymetric and topographic data set:

- Acquire the most recent land/water boundary data
- Update the land/water boundary data for Post Katrina conditions
- Divide the land/water boundaries into small polygons representing channels, lakes, land segments and other features
- Assign depths to each polygon
- Convert the polygons to a 10 meter grid and export
- Import the 10 meter grid into SMS and use to populate the CMS

Figure L2.8: Grid/Model extents.



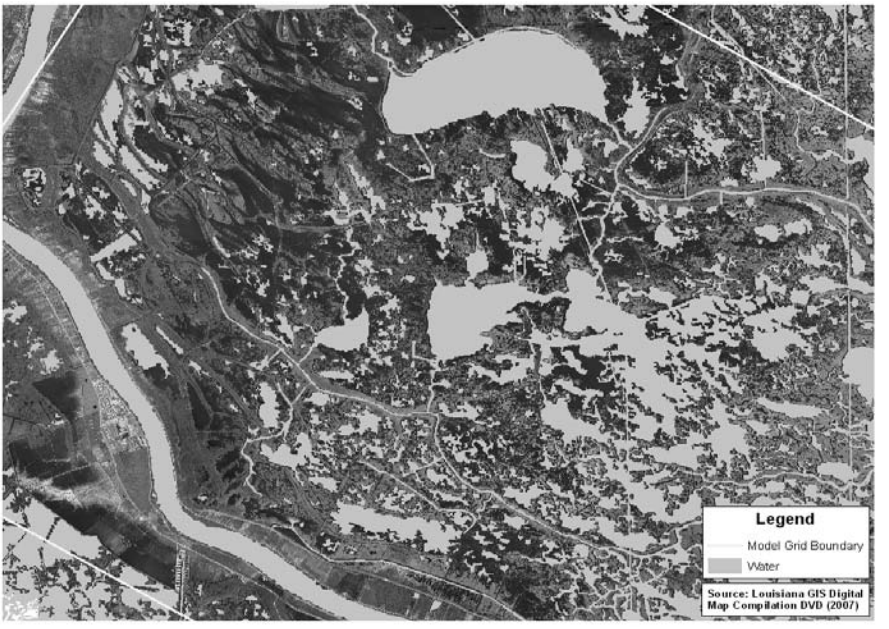


Figure L2.9: Marsh loss attributed to Hurricanes Katrina and Rita

Several datasets of land and water polygons were obtained for use in developing the bathymetric dataset; one from the Louisiana GIS Digital Map Compilation DVD (2007) and one from the ESRI Streetmap dataset. The land/water polygon data from the LA GIS Digital Map Compilation DVD was used to start the bathymetric data processing. This polygon data represents pre-Katrina conditions and is shown in Figure L2.9 overlaying post-Katrina aerial images. It is clear that there were some significant changes in the land mass in the White Ditch area, especially in the NW region. These changes were confirmed in a USGS study, the results of which are shown in Figure L2.10. Therefore In order to update the land/water polygons to reflect post-Katrina conditions, polygons from the ESRI dataset were used in compliment and this set was further modified. Additional digitizing was conducted so that the final set of polygons reflected the land and water boundaries as depicted in the most current aerial photography available for the area. Additional reviews of the polygon data set indicated that not all of the canals in the study area were completely represented in the processing. Canals not represented were digitized and canal water body connections that were inaccurate were modified. The final set of polygons is shown in Figure L2.11a and L2.11b.

Figure L2.10: USGS Water Area Change in Southeastern Louisiana

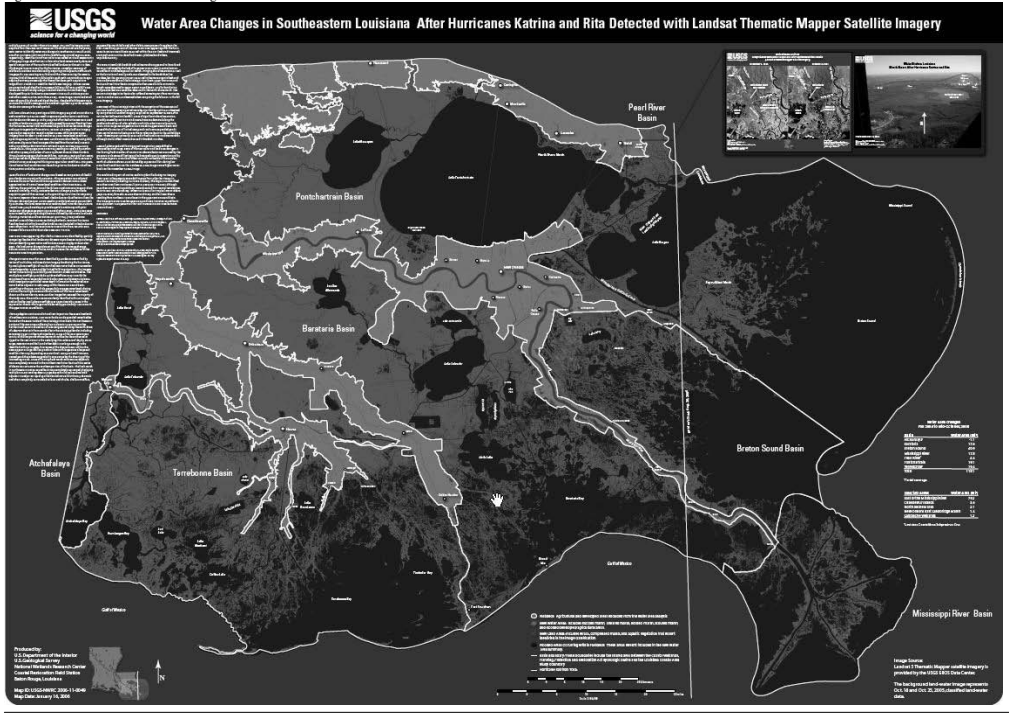


Figure L2.11a: Land analysis polygons

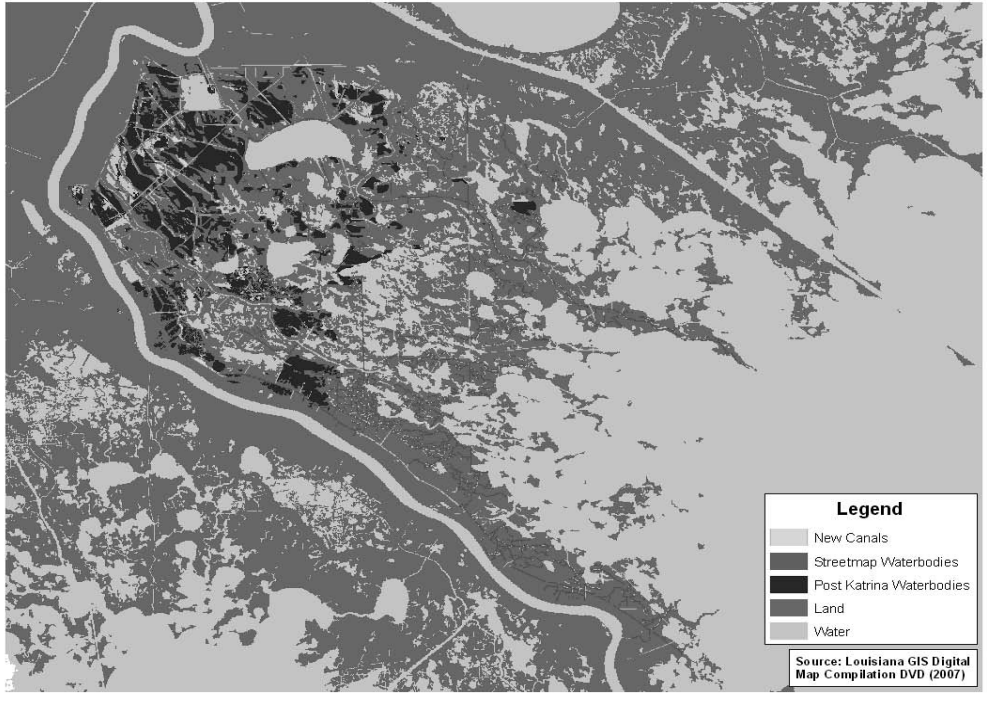


Figure L2.11b: Land analysis polygons

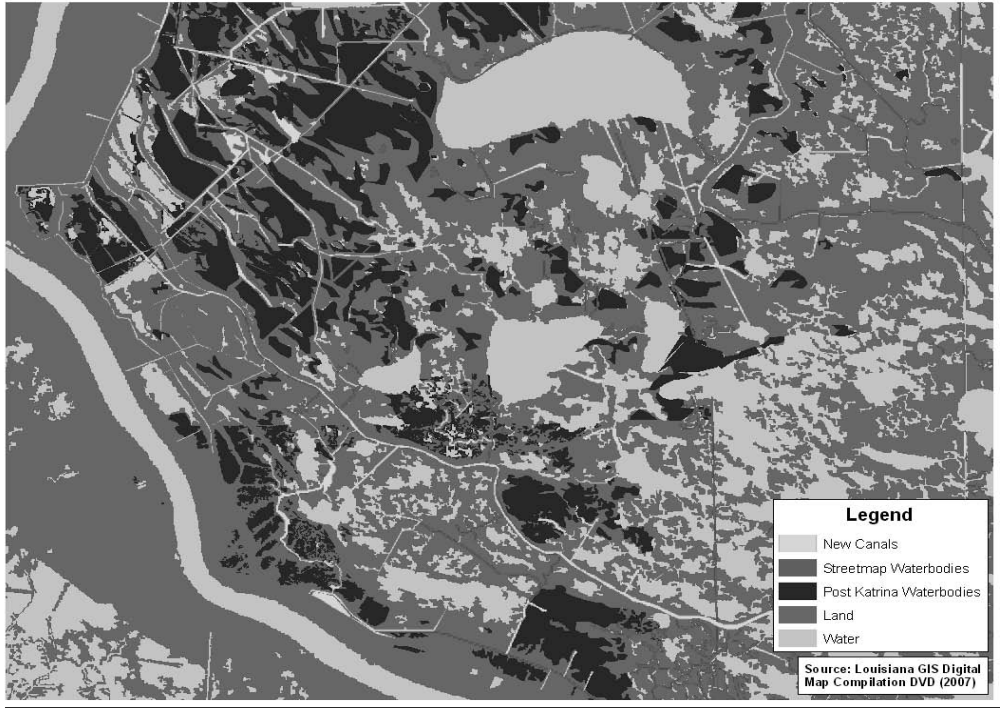
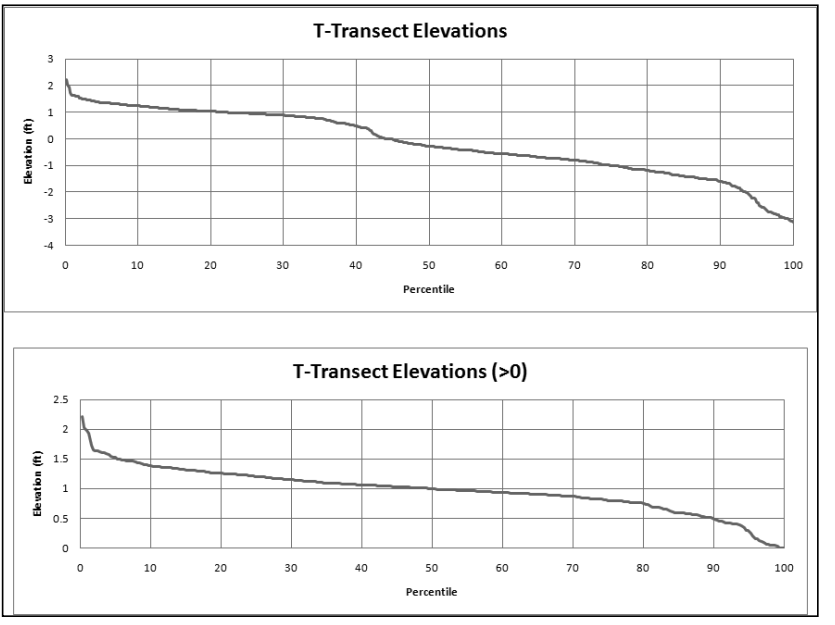


Figure L2.12: Distributed survey data developed by URS Corp.



The next step was to assign depth values to each of the polygons in the data set. As pointed out in Section 2, there was no comprehensive bathymetric data set available. In order to assign depths, information from the project bathymetric survey and NOAA nautical chart data were used. The first step was to set the land elevation. For this purpose, all of the survey data was pooled and sorted to identify the distribution and range. The distribution of the data is shown in Figure L2.12. There is a distinctive break in the distribution at elevation 0 ft (NAVD 88) that is likely representative of MSL, where the channel and lake banks are steepest. Assuming that most of the inter-tidal zones and land segments lie at or above 0 ft elevation, the data was filtered to eliminate values below 0 feet, and then resorted. The results are also shown in Figure L2.12, and indicate that the median land elevation is 1 foot NAVD 88. This value was adopted as the land elevation and all land polygons were assigned a depth of -1 ft.

In order to assign depth values to the canals and lakes, the survey data transects were processed and used to develop a suitable average depth for each cross-section. Each transect cross-section was clipped so that the only the portion below MSL remained. Then the hydraulic radius of the cross-section was calculated. Then the cross-section effective depth was calculated so that it would yield the same hydraulic radius as the original cross-section. This value was then assigned to the center point of the cross-section transect and used to assign depth values in the

canal and lake polygons. The effective depths and their locations, as obtained by this procedure, are shown in Figure L2.13. The effective depth data did not provide sufficient information to assign depths to all canal and lake polygons. Therefore a generalized template for canal and lake depths was developed and used to assign the depths to the remaining polygons. A review of Figure L2.13 indicates that there is a general increase in the canal and lake depths from the NW to the SE. A template, shown in Figure L2.14, was developed using this trend.

After completing the depth assignments to each polygon, the depth data were interpolated from the polygons to a point grid. The point grid consisted of 10 m spacing in the White Ditch area and expanded to 50 m spacing to the east of the Oaks River and to the SE. The 50 m resolution was necessary to keep the file size manageable and still provide sufficient resolution of key features. A view of the bathymetric data as reflected by the point grid is shown in Figure L2.15. An enlarged portion of the point grid data is shown in Figure L2.16, where the points are color coded by the assigned depths.

The point grid bathymetry dataset was imported into SMS, triangulated, and the depths were interpolated on to the CMS grid. Based on trials in the focus area near White Ditch, a 20 meter resolution was determined to be optimal for areas in the vicinity of the proposed diversion.

The grid was designed with 20 meter spacing in the White Ditch area with the cell spacing expanding to the SE and SW. In these regions of grid expansion, the grid was allowed to increase to a maximum grid cell size of 500 meters in order to keep the number of cells as low as possible and help manage simulation run time while still providing detailed resolution in the White Ditch study area. Certain cells are 'inactive' and represent areas protected by levees or that are above 4 feet elevation. These cells are not used in the model simulations and are a by-product of the inherent CMS rectangular grid structure. A QAQC process was performed in order to ensure canal connections and other components necessary for accurate flow simulation, and cell properties were adjusted manually where appropriate. The final grid contains 866,791 active cells in 992 Columns and 569 Rows. After some initial testing, a time step of 1.5 seconds was found to provide numerically stable solutions, and the model simulations (including salinity transport) were determined to take about two days (48 hours) in order to simulate a one month period on an HP Workstation Z400 with an Intel 2.93 Ghz Xeon Quad processor and 8gb DD3 SDRam.

Figure L2.13: Measured water depths within the White Ditch project area

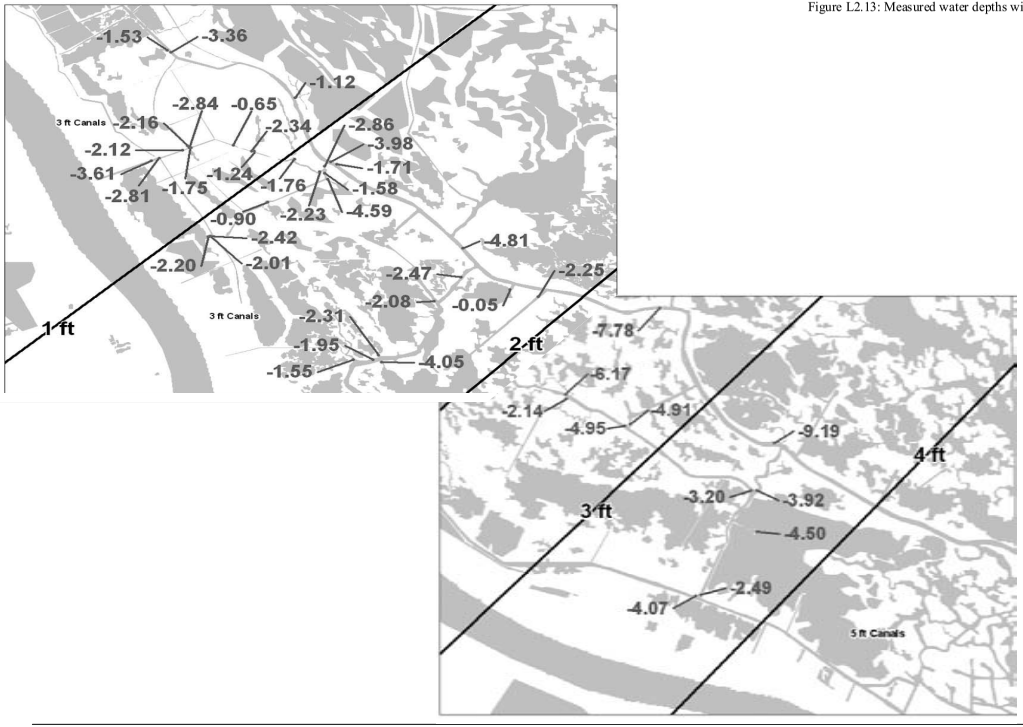
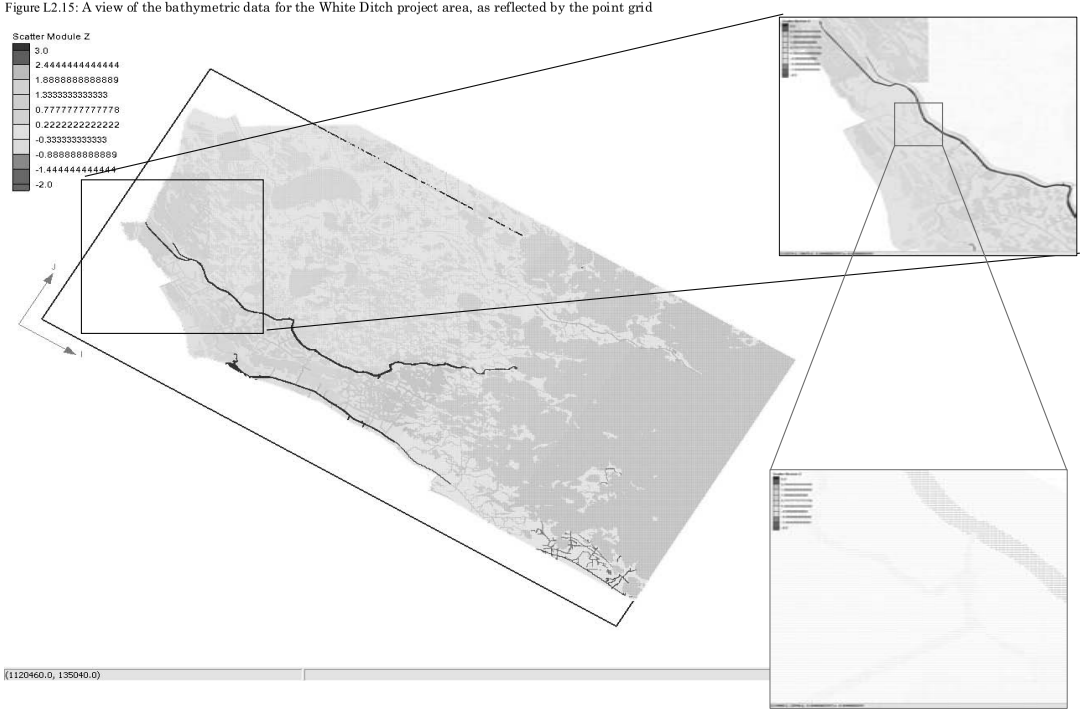


Figure L2.14: Water depth trend used for modeling purposes

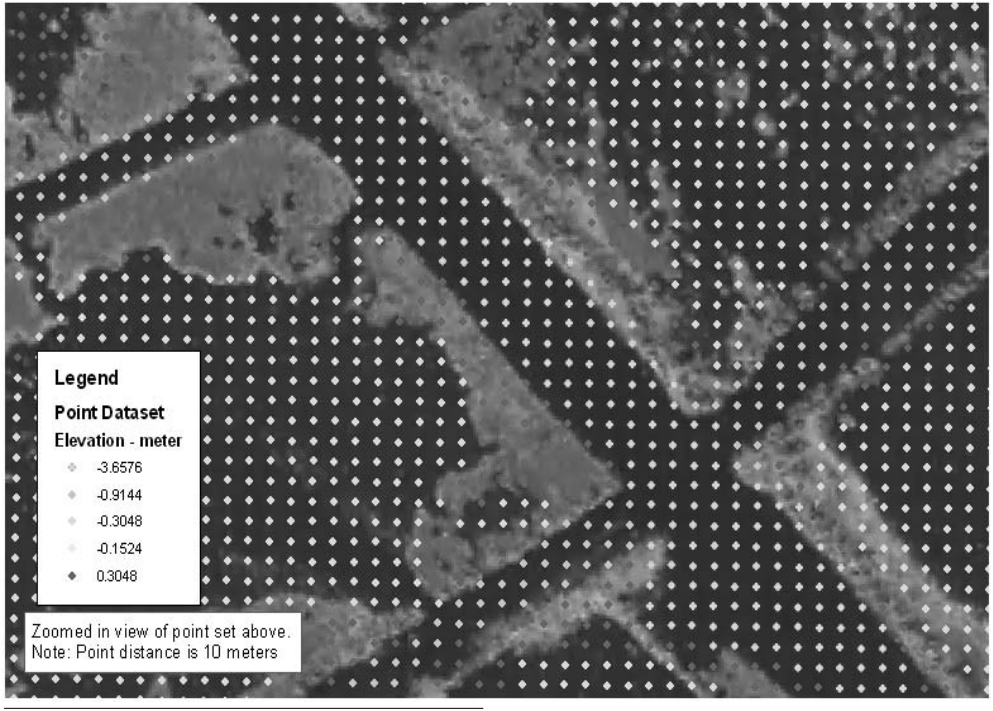


Figure L2.15: A view of the bathymetric data for the White Ditch project area, as reflected by the point grid



912

Figure L2.16: An enlarged portion of the point grid data for the White Ditch hydrodynamic model



913

L2.5 Boundary Conditions

The boundary conditions required for the White Ditch model simulations included:

- Offshore tide elevation
- Offshore salinity values
- Flow boundaries (flow rate and salinity)
- Rainfall and Evaporation
- Wind Forcing

As discussed in the Section L2.3, it was not possible to obtain a tidal calibration to measured data in the White Ditch area without shifting the reported elevation of the tide data. The Bay Gardene tide data is reported as NAVD 88 and the mean tide elevation for one or more year period is approximately one foot above sea level; therefore, a shift of 1.0 feet down was made to set the average at approximately sea level.

Local survey data in the White Ditch area indicates that the median land elevation (based on numerous survey points on transects across the area) is about 1 foot. During the rising tide, it would be expected that land would become inundated and during a falling tide the inundated areas would become dry. When this was reproduced in the model simulations it caused a severe attenuation of the tide range in the White Ditch area. The effect was so severe that there was no possibility of matching the measured tide range in the White Ditch area. Local knowledge of the area, based on discussion with airboat operators who spend a sufficient amount of time in the White Ditch area, indicates that during normal tides the land areas do not become submerged, even at high tides. These two factors further supported the decision to shift the Bay Gardene data downward by 1.0 feet.

Note that during the model calibration, it was found that the salinity calibration was sensitive to both the total flow rate from the Caernarvon Diversion as well as the split between the amounts assumed to flow through the Delacroix Canal to the west and the through Bayou Mandeville to the south. Therefore, the grid was modified slightly in the region of the Caernarvon Diversion so that the flow splits could be assigned directly.

The actual values assigned to each boundary condition varied for the model calibrations and the alternatives and the specific values used are discussed in the subsequent sections.

L2.6 Hydrodynamic Model Calibration

A model calibration was conducted for both hydrodynamics and salinity transport, with the hydrodynamic calibration completed first. The hydrodynamic and salinity calibration were conducted simultaneously. This was necessary because it was learned in the preliminary salinity calibration simulations that the salinity calibration was sensitive to the total flow and flow split assumed for the Caernarvon Diversion. Since these flow rates may influence the tidal response in the project area, it was necessary to conduct the hydrodynamic and salinity calibration simultaneously.

The hydrodynamic calibration period was selected to coincide with the period for which the stage data was available from the project field program, namely the four day period July 20 through July 24th. Preliminary testing with the model indicated that the tidal flows required a relatively short spin-up period, on the order of one-week, but it was found that the salinity simulations required a much longer spin-up period.

The salinity calibration focused on the same period for data comparison, July 20th through July 24th, for which salinity data was available from the project field program. After some preliminary testing with the model, it was found that a two-month spin-up was required to eliminate the effects of the initial conditions on the solution.

For the calibration simulation, the model was configured with measured wind, tide, rainfall, evaporation, salinity and Caernarvon flow data corresponding to the calibration period. For the evaporation, the average value of 5 mm/day adopted from the Cooke et al. (2008) study was used. For the Caernarvon diversion flows, freshwater was assumed, and the corresponding salinity was assigned a value of zero.

The key calibration parameters are:

- Bottom Fiction (Manning's n)
- Lateral Dispersion
- Fresh Water flow and flow split from Caernarvon
- Fresh Water from Caernarvon reaching River Aux Chenes

The calibration simulations indicated that the hydrodynamic calibration was most sensitive to the bottom friction, with a minor sensitivity to the Caernarvon flow splits. The salinity calibration was most sensitive to the Caernarvon Diversion flow rate and flow split, with a lower level of sensitivity to the lateral dispersion.

An initial range for the lateral dispersion was obtained by considering the length scales of the water bodies in the White Ditch area and the length-scale dependent dispersion values from a study by URS. For this analysis, a length scale was developed by taking the square-root of the area of each of the polygons used to represent each water body and then selecting the median value. The median value is approximately 300 meters, for which the associated dispersion coefficient is $10 m^2/s$.

The rational for adjusting the total Caernarvon flow is that the model grid domain does not contain the entire area influenced by the diversion flow. Therefore, only a portion of the flow actually drains through the region covered by the model grid. The remaining portion of the flow drains towards the MRGO channel that is not represented in the model grid. Thus it is appropriate to reduce the Caernarvon flow rates so that they better represent the flow entering the area covered by the model gird. The 'best' reduction level was determined via the salinity calibration.

It was found the salinity calibration was sensitive, albeit to a smaller degree, to the assumed split in Caernarvon flows that go off to the west and south. Historically the portion flowing to the west, directly towards the White Ditch area, was about 20 to 30 percent. However, it is believed

by local land managers that after Hurricane Katrina, the percentage flowing directly to the west is lower, due to blockage of many of the smaller canals, and is currently about 5 to 10 percent.

After assigning the dispersion value, a sequence of final calibration simulations were completed in which the bottom friction and the total flow and flow split for the Caernarvon were systematically altered. The final calibration was obtained with the following parameter values:

- Manning's n: 0.012
- Dispersion Coefficient: 10 m2/s
- Amount of Measured Caernarvon Flow applied: 58%
- Amount of Applied Caernarvon Flow directed to the west: 5%

The final stage calibration is shown in Figure L2.17 and the final salinity calibration is shown in Figure L2.18. The simulated stage calibration indicates that the model represents the measured tide amplitude reduction and phase shifts at stations S3 and N3. The salinity calibration results shown in Figure L2.18 represent the time-averaged salinity values over the last four days of the simulation, which correspond to the time period of the measured values obtained during the project field program. The spatial gradients and the actual salinity levels are well represented in the simulated results. The largest discrepancy occurs in the southern station (Simulated Salinity Point 37) where the model results slightly under-predict the salinity levels.

Figure L2.17: Final Stage Calibration

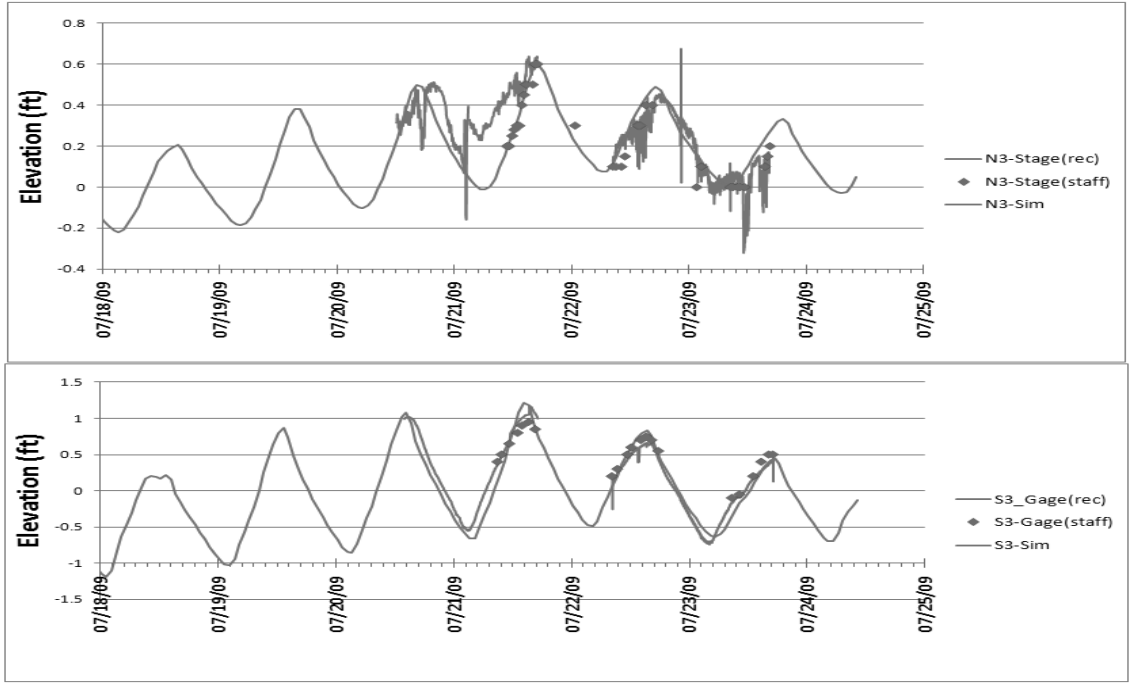
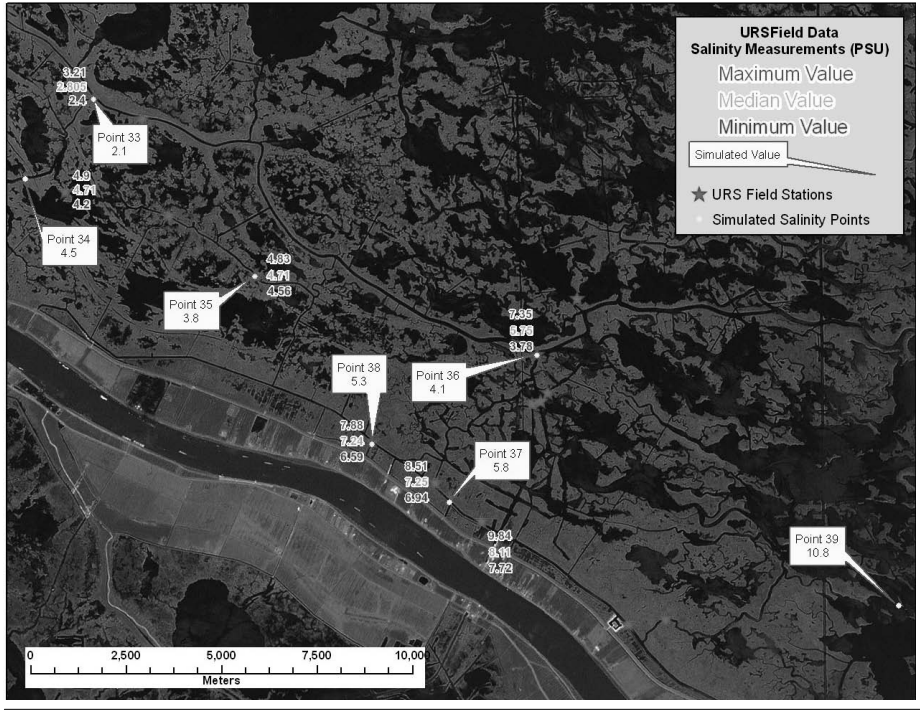


Figure L2.18: Final Salinity calibration results



L2.7 Hydrodynamic Alternatives Analysis

The hydrodynamic model's primary purpose is to compare the different alternatives developed by the project delivery team and support the quantification of environmental benefits. Each series of simulations were established with the same background, or boundary conditions, to allow for a direct comparison of benefits between each diversion alternative. There were thirteen total alternatives being modeled as shown in Figure L2.19. Alternatives at each location consist of a similar layout with expanded channels for the larger flow diversions. Layouts for Location 2 at the existing White Ditch are shown in Figure L2.20. Layouts for Location 3 at the existing White Ditch are shown in Figure L2.21. Specifics showing channel cross-sections and dimensions of the features involved please see section L7 - Civil Design Criteria.

	Location 2 White Ditch, LA	Location 3 Phoenix, LA
5,000 cfs	**X**	**X**
10,000 cfs	**X**	**X**
15,000 cfs	**X**	**X**
35,000 cfs	**X**	**X**
70,000 cfs	**X**	**X**
100,000 cfs	**X**	**X**
NO ACTION	**X**	

Figure L2.19

Figure L2.20: General Layout of Outfall Features for Location 2



Figure L2.21: General Layout of Outfall Features for Location 3



L2.7.1 Initial Screening Analysis

The initial screening of alternatives was conducted to narrow down the number of alternatives to be run for the WVA Analysis based on time constraints. These simulations were setup to examine a hypothetical spring pulse period and allow for the comparison of results between all runs. Each simulation was to run for a one month duration with "maximum" flows from the proposed new diversion as well as from the existing Caernarvon diversion (8,000cfs). Other parameters are as follows:

- Average spring (March-May) tidal conditions.
- Average spring (March-May) wind forcing conditions for Plaquemines Parish, LA.
- Average spring (March-May) rainfall inputs.
- An average evaporation constant of 5mm/day.
- Starting salinity over the entire grid of 7ppt.

Images of the salinity results can be seen on Figure L2.21 thru Figure L2.28. It is very apparent that any diversion alternative will greatly freshen the project area, particularly if the diversion is operated in conjunction with Caernarvon. Other conclusions that were drawn from this initial modeling are that the larger diversions, 70,000cfs and 100,000cfs, will overtop the River Aux Chene ridge which violates our project scope.

675 Figure L2.21: Initial screening analysis at Location 2 with a 5,000cfs outfall



Figure L2.22: Initial screening analysis at Location 2 with a 10,000cfs outfall



680

924

Figure L2.23: Initial screening analysis at Location 2 with a 15,000cfs outfall

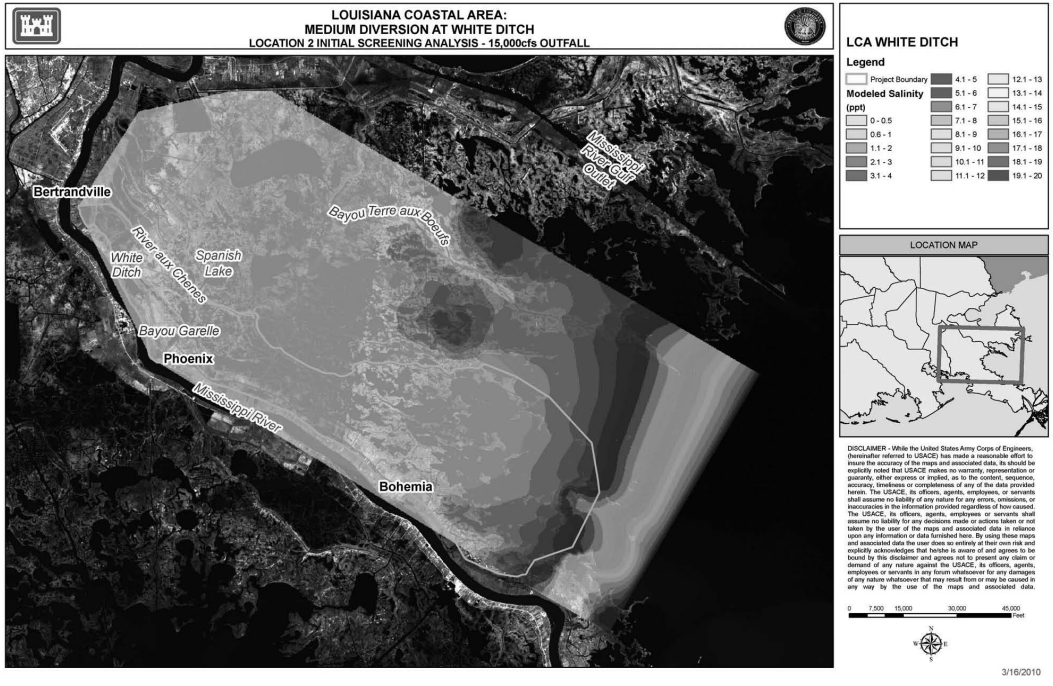


Figure L2.24: Initial screening analysis at Location 2 with a 35,000cfs outfall

685

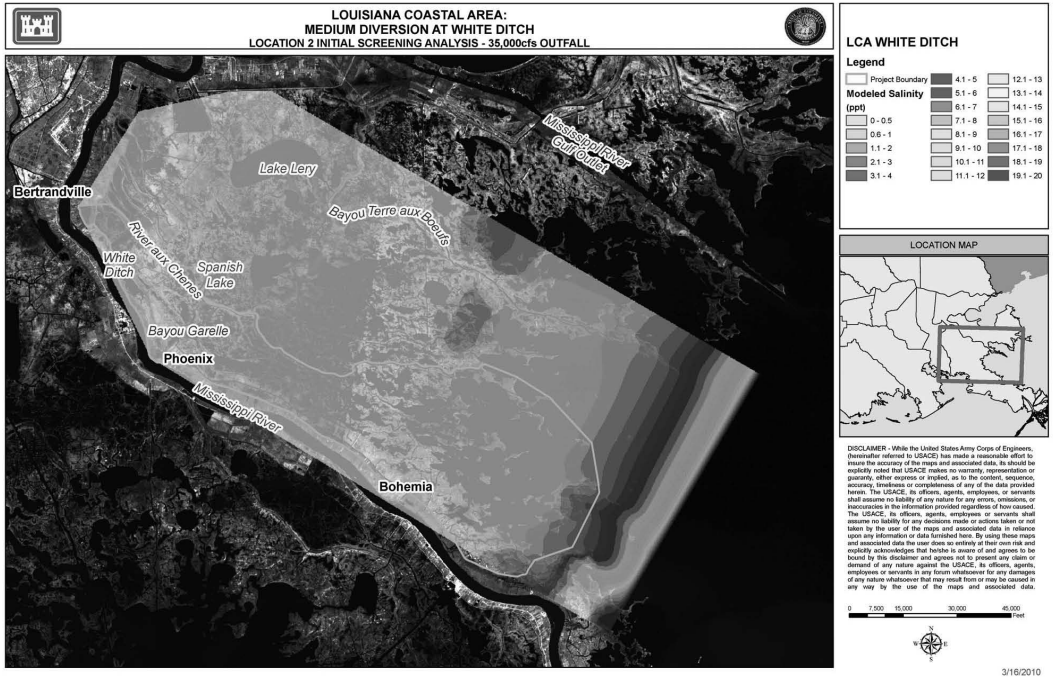


Figure L2.25: Initial screening analysis at Location 3 with a 5,000cfs outfall



690 Figure L2.26: Initial screening analysis at Location 3 with a 10,000cfs outfall



Figure L2.27: Initial screening analysis at Location 3 with a 15,000cfs outfall



695

929

Figure L2.28: Initial screening analysis at Location 3 with a 35,000cfs outfall



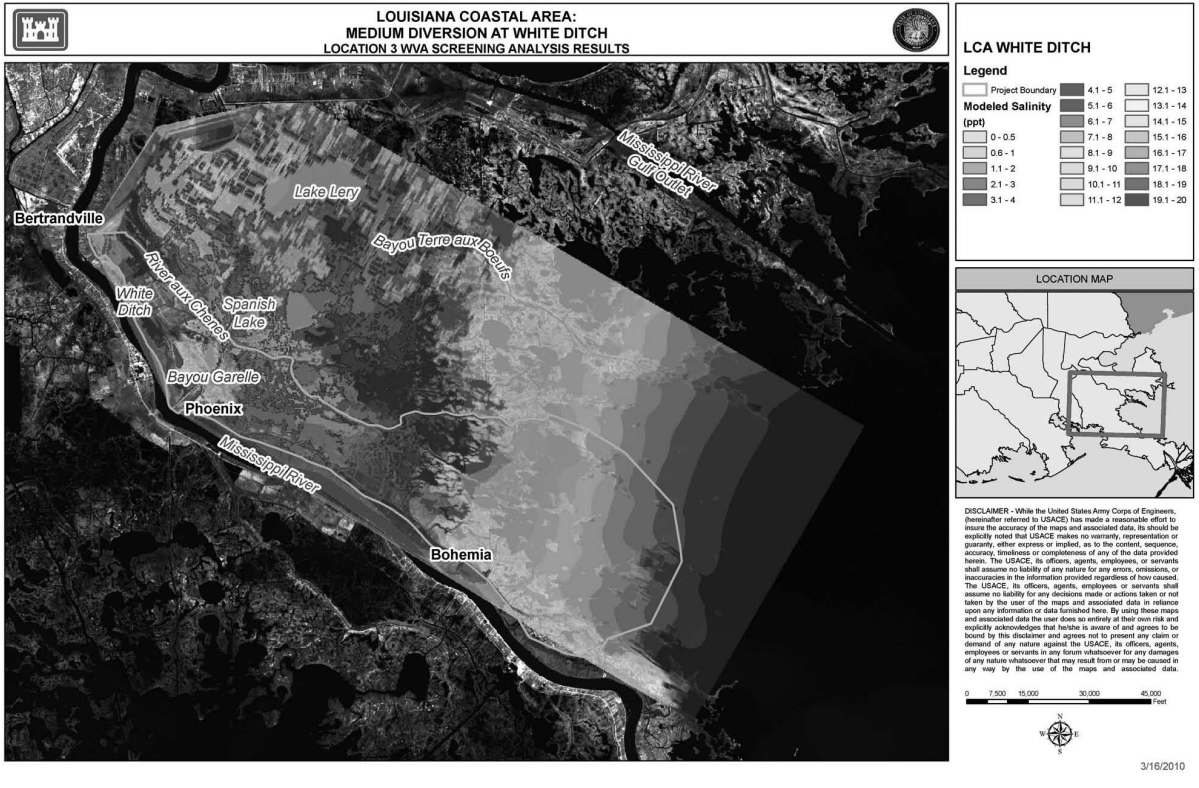
L2.7.2 WVA Screening Analysis

Based off of a preliminary screening involving costs and benefits for each alternative by the project delivery team, it was assessed that only the diversions at Phoenix, LA of 35,000cfs and less would have further analysis conducted on them. These runs are conducted to analyze how salinities would encroach back into the Breton Sound with "maintenance" flows coming from the proposed diversion (1000cfs) and Caernarvon (800cfs). For these runs, simulations would start following the final results of their particular runs from the initial screening of alternatives using the salinities that were estimated there. These simulations would continue for a 3 month period with the following parameters:

- Average summer (June-August) tidal conditions.
- Average summer (June-August) wind forcing conditions for Plaquemines Parish, LA.
- Average summer (June-August) rainfall inputs.
- An average evaporation constant of 5mm/day.

Images of the salinity result show the models progression back to a natural salinity state can be seen in Figure L2.29. It appears that no matter the maximum diversion capacity, salinities will still re-regulate themselves in the sound with the maintenance flows.

Figure L2.29: Results from the WVA Analysis of Location 3 Alternatives



720

932

L2.8 Ecohydraulic Modeling

The ERDC-SAND2 Model is the tool used to project marsh acreages throughout the life of the project. It is an ecohydraulic model specifically designed to estimate impacts from flow diversions on the land loss rates of coastal marsh. The ERDC-SAND2 Model is fundamentally based on three processes impacting marsh accretion due to flow diversion:

1) Historical land loss rates are applied to account for marsh loss due to all negatively impacting system processes (e.g. sea level rise, compaction, subsidence, etc.) along with background processes existing prior to the diversion operation (e.g. marsh nutrient cycling, net tidal and groundwater inputs, etc.).

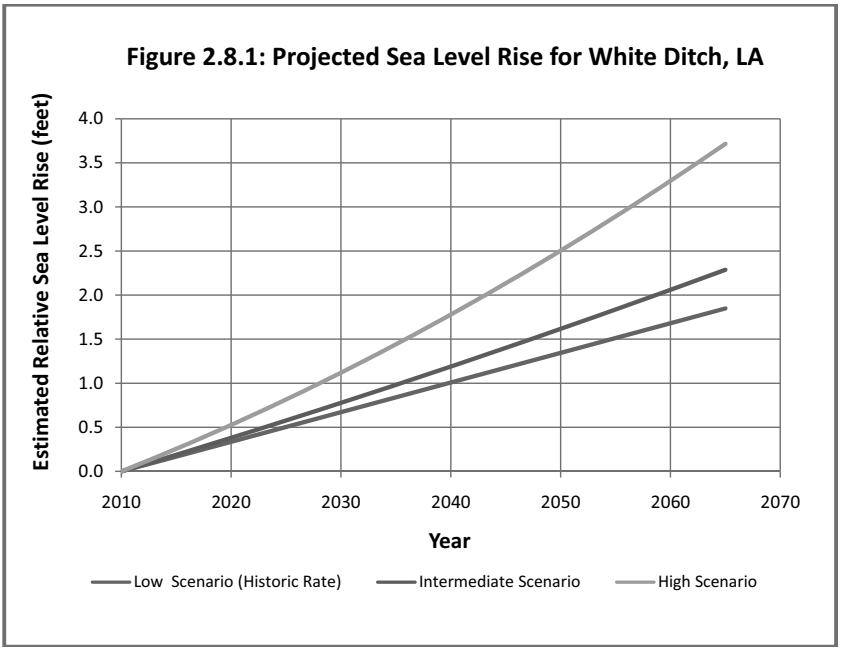
2) Inorganic benefits of flow diversion from the addition of sediment.

3) Organic benefits of flow diversion due to plant growth, mortality, and burial stimulated by addition of the limiting nutrient (nitrogen).

The model applies these processes to assess Future With Project (FWP) and Future WithOut Project (FWOP) conditions for alternative comparison. Since the FWOP condition is without diversion, FWOP marsh acreage is a function of land loss only. The model processes these categories and projects acres of marsh within a specified project area.

For the Medium Diversion at White Ditch (MDWD) there were three different land loss rates that were examined. These land loss rates were developed for the three relative sea level rise rates that were specified by the by USACE New Orleans District (MVN). The projected sea level rise rates that were used for analysis are shown in Figure 2.8.1 and are:

- Low Scenario (Historic Rate) – 0.40 inches per year
- Intermediate Scenario – 0.50 inches per year
- High Scenario – 0.81 inches per year



Benefits from sediment introduction, or inorganic benefits, come from calculations within the model. The model has 25 years of flow and suspended sediment load data from the Mississippi River built in. This data set is rolled forward to allow for a 50 year project life. With the MDWD, project maximum operations of the diversion are only proposed for March and April; throughout the remainder of the year there is a 1,000cfs maintenance flow. During March and April, the modeler assumed that 3% of the total flow in the Mississippi River would be diverted (The flow through the diversion will be driven by the head difference between the river and marsh; however, there is no good correlation between stage and flow built into the model) up to the maximum capacity of the diversion. The modeler also assumed that the diversion would be shut down at any time the Mississippi River went below 300,000cfs to protect navigational interests. Calculations within the model distribute the sediment over open water areas.

Benefits from increased plant productivity are derived from higher nutrient rates entering into the marsh. Nutrient levels are pulled from existing Mississippi River flow data and correspond to diverted flows into the project area. Benefits from increased plant productivity result in vertical accretion for areas of existing marsh.

For land building to occur in the ERDC-SAND2 Model, you must simply have more accretion than sea level rise. With the MDWD, the majority of the benefits come from sediment

deposition. Greater diversion capacities allow for more sediment deposition and more benefits. Results from the model for the MDWD can be seen in Table 2.8.1 and Table 2.8.2.

Table 2.8.1: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under Historical Sea Level Rise Rates

Historic RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	36,000	33,300	30,500	27,800	25,000
5,000 cfs Diversion Alternative	38,700	38,300	37,800	37,000	36,600	35,600
10,000 cfs Diversion Alternative	38,700	39,300	39,900	39,900	40,700	40,400
15,000 cfs Diversion Alternative	38,700	40,300	41,900	42,700	44,600	45,000
35,000 cfs Diversion Alternative	38,700	43,800	48,800	52,200	57,300	59,900

*** The total project area for the Medium Diversion at White Ditch is 98,000 acres

Table 2.8.2: ERDC-SAND2 Model Calculations of Acreages for the MDWD Project Area under the Intermediate and High Sea Level Rise Rates

Intermediate RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	34,900	30,900	26,500	21,800	16,900
35,000 cfs Diversion Alternative	38,700	42,800	46,600	48,500	51,800	52,400
High RSLR	Gross Acres of Marsh					
Project Life Years	0	10	20	30	40	50
No Action Alternative (FWOP)	38,700	31,500	23,700	14,000	2,900	0
35,000 cfs Diversion Alternative	38,700	39,500	39,600	36,300	33,800	27,600

*** The total project area for the Medium Diversion at White Ditch is 98,000 acres

780

Further information on the ERDC-SAND2 Model concerning data from the runs used in the MDWD Analysis, model verification, and the equations behind the model can be found in Annexes of Appendix L.

785

L3. Surveying, Mapping, and Geospatial Data Requirements

L3.1 Geospatial Data

The data which represents the potential features in the project were created using ArcGIS 9.3. The horizontal coordinate system used for the features is NAD 1983 StatePlane Louisiana South FIPS 1702 Feet. The data that were created during this project references the 2008 Digital Orthophoto Quarter Quadrangles, for further information on that data set see C.3.2.

Plaquemine Parish provided oil gas well data, and landowner data. The horizontal coordinate system for both sets of data is NAD 1983 StatePlane Louisiana South FIPS 1702 Feet. Additional landowner data were provided by Ralph Gipson of Fenstermaker & Associates, Inc. The horizontal coordinate system for the Fenstermaker data is NAD 1927 StatePlane Louisiana South FIPS 1702 Feet. General base data is licensed for use from Tele Atlas North America. The horizontal coordinate system for the Tele Atlas data is GCS WGS 1984. The Mississippi Valley- New Orleans District provided pipeline data. This data set was produced by the Coastal Management Division (CMD) of the Louisiana Department of Natural Resources in a cooperative agreement with the U.S. Minerals Management Service (MMS). The data set is a map and database of all of the pipelines that could be identified in the data available to the CMD. The data sets used included the Coastal Use Permit files, State Land Office Right Of Way files, the DNR Office of Conservation files, and MMS records. Also used were wall maps produced by the Louisiana Geological Survey and maps and information from individual companies. The horizontal coordinate system for the pipeline data is NAD 1983 UTM Zone 15N.

ArcGIS software provided the capabilities of transforming the data and aerial photography into one uniform coordinate system for analysis of features and map production. The uniform coordinate system used for these tasks was NAD 1983 StatePlane Louisiana South FIPS 1702 Feet.

L3.2 Aerial Photography and LIDAR

L3.2.1 2008 DOQQ Aerial Photography

The 2008 Digital Orthophoto Quarter Quadrangles (DOQQs) were provided by the Mississippi Valley- New Orleans District. The following information is provided in the metadata of the DOQQ data set. This data set was produced in accordance with USGS Standards for Digital Orthophotos, 1996. Review was provided by the USGS National Geospatial Technical Operations Center (NGTOC). The data set was created by Photo Science, Inc. in 2009 for the USGS National Wetlands Research Center and CWPPRA Task Force.

The horizontal coordinate system is projected coordinate system NAD 1983 UTM Zone 15N. The DOQQ horizontal positional accuracy and the assurance of that accuracy depend, in part, on the accuracy of the data inputs to the rectification process. These inputs consist of the digital elevation model (DEM), aero triangulation control and methods, sensor calibration, and aerial imagery that meet National Aerial Photography Program (NAPP) standards. The vertical accuracy of the verified USGS format DEM is equivalent to or better than a USGS level 1 or 2

DEM, with a root mean square error (RMSE) of no greater than 7.0 meters. Field control is acquired by third-order class 1 or better survey methods sufficiently spaced to meet National Map Accuracy Standards (NMAS) for 1:12,000-scale products. Photo-identifiable ground test points are identified in the orthorectified image and measured. The image coordinates are compared to the known positions of these points and the radial differences for each point computed. A radial RMSE value is then calculated for the DOQQ. Note: Adjacent DOQQ's, when displayed together in a common planimetric coordinate system, and may exhibit positional discrepancies across common DOQQ boundaries. Linear features, such as streets, may be offset between images. However, these edge mismatches still conform to NMAS positional horizontal accuracy requirements. The estimated accuracy is 3.34 meters which was determined by the Federal Geographic Data Committee, 1998, Geospatial Positioning Accuracy Standard, Part 3, National Standard for Spatial Data Accuracy, FGDC-STD-007.3-1998.

L3.2.2 1992 Landsat Thermatic Satellite Image of Louisiana, UMT 15 NAD27

The 1992 Landsat Imagery was provided by the Mississippi Valley- New Orleans District. The following information is provided in the metadata of the Landsat data set. The originator of the data is Louisiana Oil Spill Coordinator's Office (LOSCO) and the publication date is 1996.

The horizontal coordinate system is projected coordinate system NAD 1983 UTM Zone 15N. This data set is comprised of a pair of satellite images of Louisiana that were produced from ten scenes of 30-meter resolution TM imagery. The original image data were geo-rectified and re-sampled to 25-meter cells by the Earth observation Satellite Corporation, EOSAT. These data were obtained by LSU from the Baton Rouge office of the USGS National Wetlands Research Center through a cooperative agreement. The processing to make a seamless enhanced image was performed by LSU and funded by the Louisiana Oil Spill Coordinator's Office. The locational accuracy of the satellite imagery is approximately 98 feet (30 meters). The image was constructed from a red, green, blue (RGB) composite of bands 7,5 & 3 which has the relative appearance of a normal color image, unlike typical false color composites using infrared light in which vegetation is red instead of green. The image is a simulation of the natural environment and is not an accurate representation of "true-color" as perceived by humans. Band 7 is mid-infrared, band 5 is near-infrared, and band 3 is red-visible light. The 3-band, 24-bit composite images were contrast stretched, histogram corrected, and color-matched, and then reduced to a single band, 8-bit image resembling the original composites. They were mosaicked and clipped to fit the 'state boundary'. That data set, which was in UTM zone 15, NAD27 coordinates, was published on the Louisiana Oil Spill Contingency Plan Map CD in 1996. This pair of images in UTM zone 15, NAD83 coordinates was derived by projecting and clipping splitting that UTM zone 15 NAD27 image. The images are in GeoTIFF format, but are accompanied by world files (.tfw) so they can be used in GIS that support TIFF but do not read georeferencing information from GeoTIFF format files.

L3.2.3 2007 Mississippi River LIDAR

The LIDAR was provided by the Mississippi Valley- New Orleans District. The following information is provided in the metadata of the LIDAR data set. The originator of the data is NGS and the date is 2006.

This data set was created to evaluate the condition of the Mississippi River Levee System and river banks as a part of a larger levee assessment process to determine encroachments and calculate slope stability. Data were collected through John Chance and Associates FLI-MAP system, in which a helicopter flies over a given corridor at a low altitude, collecting GPS coordinates and laser rangings. These coordinates and elevations are validated against a video simultaneously recorded by the helicopter. The horizontal controls are "B" order or better and the absolute accuracy is on the order of 15cm. The vertical control references the revised 2003 Geoid (revised in 2005 for South Louisiana) and the absolute accuracy is on the order of 10cm.

L3.3 Ground Topographic Surveys

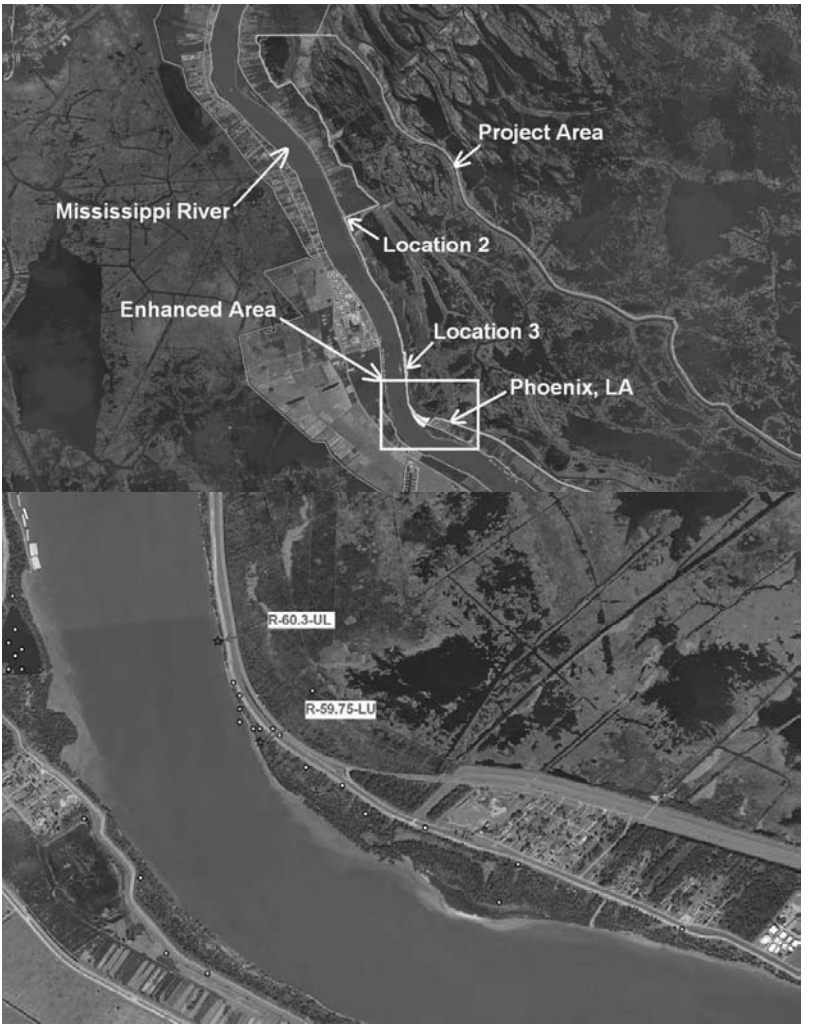
No surveying was conducted during the feasibility stage of this project.

L4. Geology

The study area is from the Mississippi River, at approximately Mississippi River Mile 60, near the Plaquemines Parish town of Phoenix and extending into the marsh towards Oak River. This is an area of low relief ranging from below sea level to approximately +7 NGVD in elevation on the area adjacent to the river.

Fine grained material make up the majority of the stratigraphy with deposits in the area consisting of a silt to sandy silt layer with clay seams extending from ground surface to approximately -80 and -40 NGVD in elevation for borings R-59.75-LU and R-60.3-UL, respectively, shown in Figure L4.1. The silt to sandy silt layers are underlain by a clay layer with silt seams. After an average depth of -108 NGVD for the previously two mentioned borings, various silt and clay seams layers alternate until the end of the two borings. Borings R-59.75-LU and R-60.3-UL can be seen in Figures L4.2 and L4.3, respectively.

Ground water is at or near the surface in the study area and is directly connected to the Mississippi River.



910

Figure L4.1 Overview of the project area with the boring locations used for the subsurface evaluation.

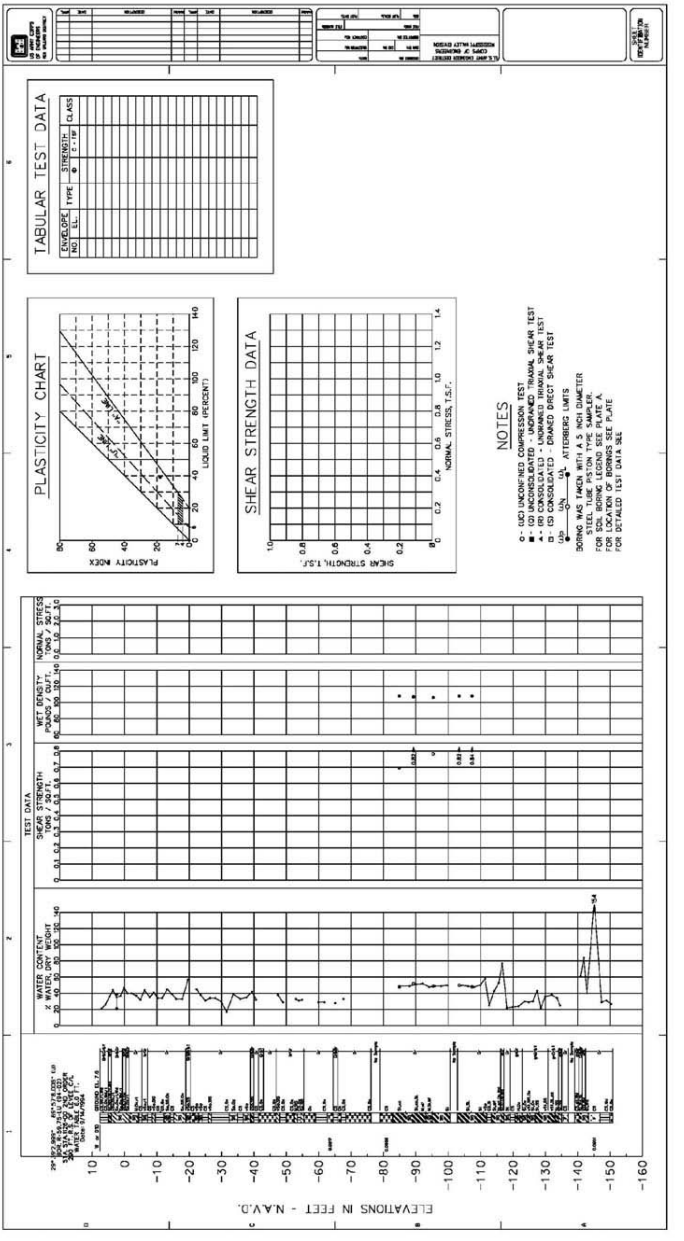


Figure L4.2 Subsurface exploration details for Borings R-59.75-LU.

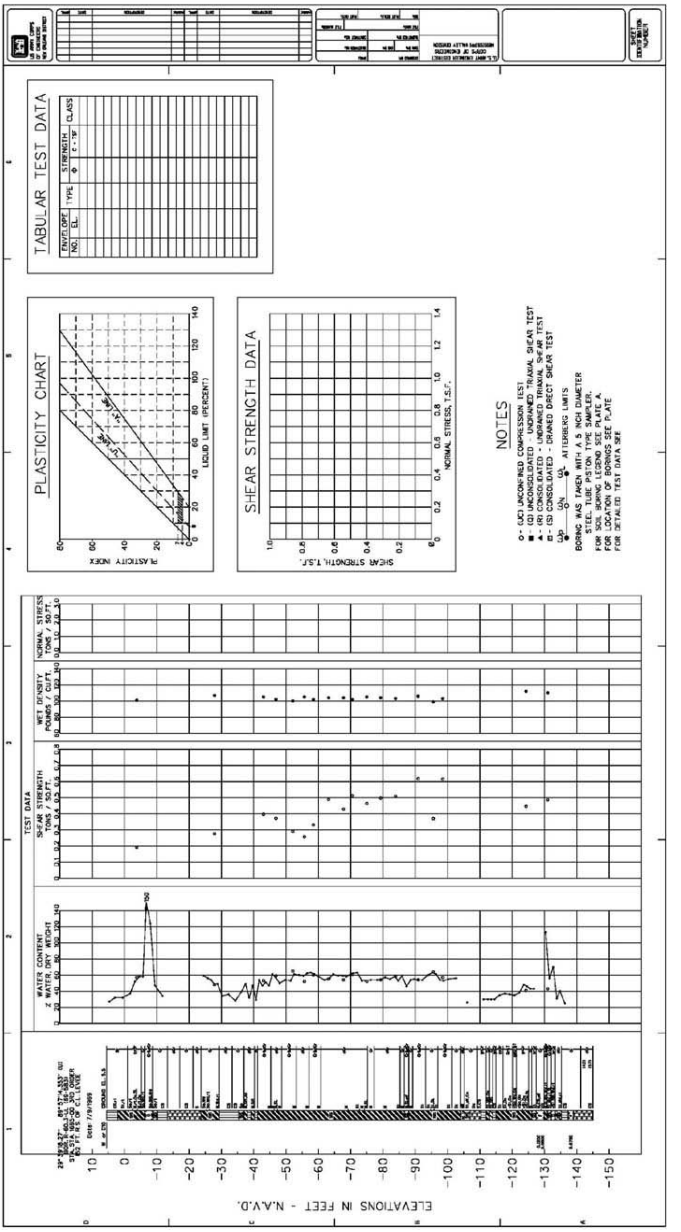


Figure L4.3 Subsurface exploration details for Borings R-60.3-UL.

L5. Geotechnical Investigations and Design

L5.1 General

The project area is located on the east bank of the Mississippi River near the town of Phoenix and the unincorporated area of Plaquemines Parish, Louisiana. See the vicinity map on Figure L4.1 and Section L4 for the regional geology of the area. (This report was written after Location 3 was selected for the area of construction, and substantially, this geotechnical investigation and design only refers to Location 3.) This section describes the results of geotechnical investigation and designs performed for the diversion facility (box culvert) and transmission system (dredged canals), discussed in Sections L5.2 and L5.3, respectively. The subsurface information available for the design of the diversion facility and transmission system is for a general design and cost estimate purposes only. A significant subsurface exploration will be needed in the future to accurately determine the geology of the construction area. The analyses shall be revised using the newly collected data including slope stability analyses, settlement analyses, pile foundation design, etc. Construction considerations shall include all aspects of construction including backfilling, dewatering, pile installation, culvert construction, and dredging. The subsequent geotechnical design on the detail features will be presented in a Design Report (DR) in an appropriate time prior to the preparation of the Plans and Specifications of the project.

L5.2 Geotechnical Design for Diversion Facility

L5.2.1 Stability Analyses

The results of the soil borings and laboratory test data were evaluated and the shear strength and density parameters were selected for design. In general, design shear strengths were based on the results of unconfined compression tests (UCT) and recommendation from the Hurricane and Storm Damage Reduction System Design Guidelines (HSDRSDG). The boring locations used for design are located in Location 3 and are shown in Figure L4.1. In addition, the available soil design shear strengths and stratification from the borings are shown on Figures L5.1 and L5.2.

Global stability of the diversion facility was analyzed using the Spencer Method in GeoStudio 2007 (Version 7.14, Build 4606) for the slope stability analysis. Design requirements are such that a minimum factor of safety of 1.4 evaluated by unconsolidated-undrained (Q) shear strength parameters is required for low water conditions, where the Q-tests are supplemented by UCT tests. Due to time constraints, no new borings were drilled and design was based on existing borings with UCT test results. The analyses are shown on Plate L5.1. The results for the global stability analysis showed that there were no unbalanced loads and the required factors or safety were met. A summary of the results are presented in Table L5.1.

960 Table L5.1 Global stability summary for the diversion facility

Case	Boring Number	Factor of Safety	
		Required	Obtained
Water at Project Grade (levees)	R-59.75-LU	1.4	7.38
	R-60.3-UL	1.4	7.08
Low Water (non-hurricane condition) S-Case	R-59.75-LU	1.4	10.23*
	R-60.3-UL	1.4	5.11*

Note: * indicates that analysis was performed using an infinitely strong and weightless material to prevent the failure surface from cutting into the diversion facility

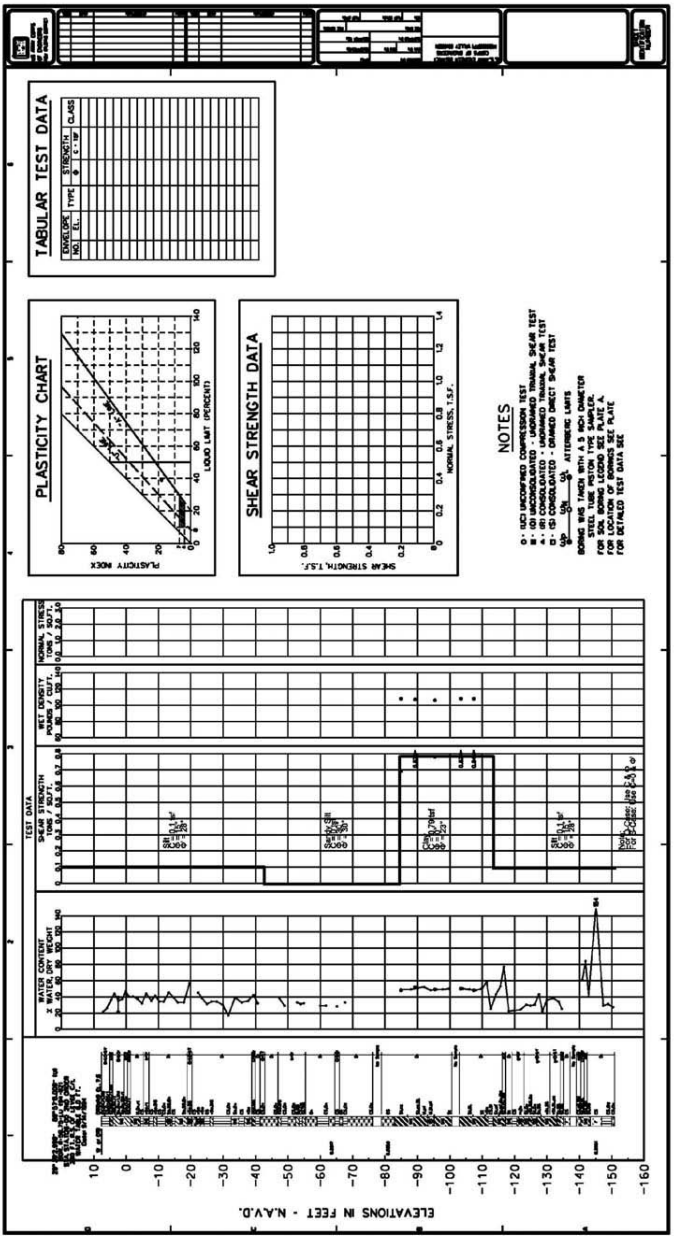


Figure L5.1 Strength lines shown for Borings R-59.75-LU.

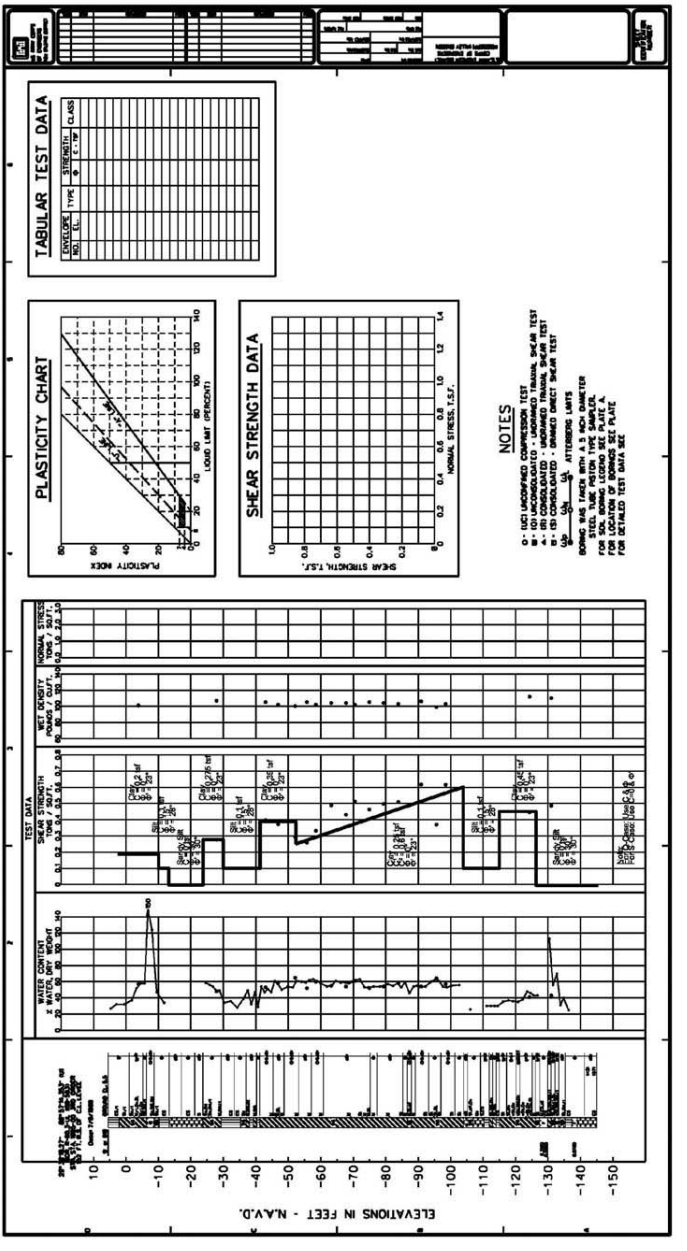


Figure L5.2 Subsurface exploration details for Borings R-60.3-UL.

L5.2.2 Construction Excavation

There was determined to be sufficient land both riverside and landside of the Mississippi River Levee (MRL) for construction of temporary flood protection, which consists of natural ground. Excavated material from the degrading of the MRL will be used to construct this temporary earthen barrier. The diversion facility will be constructed using an engineered staged design. A carefully planned construction excavation should consider the following:

a. Risk of flooding.

b. Historical river elevations in the area of construction.

c. Excavation will be to Elevation –20 NGVD.

d. The approximate prevailing ground surface elevation is 6.5 NGVD.

e. Ground water outside the excavation is dependent on the river level of the Mississippi River (Approximate Elevation is 4 NGVD).

Following completion of the diversion facility construction, the temporary earthen barrier can be recycled into the MRL.

L5.2.3 Pile Foundations

A deep pile foundation is recommended for the diversion facility. The type of pile to be used and the estimated ultimate pile load capacity versus tip elevation curves for cost estimate purposes is presented. The final design should be verified in the forthcoming DR after site specific subsurface exploration and testing is completed. The overburden pressure will be limited to approximately 3500 psf in accordance with the HSDRSDG.

Analyses have been made to determine the estimated allowable single pile load capacities in compression and tension for square, prestressed, precast concrete piles (12”x12” and 14”x14”) and steel H-piles (HP14x73) for support of the proposed structures, as indicated by the Structural Design Section. The results of the estimated pile load capacities are given on Figures L5.3 and L.5.4 and consider the two design borings (R-59.75-LU and R-60.3-UL). The allowable load capacities assume the piles are installed vertically and neglect skin friction along the top 2 feet to allow for embedment in the concrete and seal slab. These allowable load capacities contain an estimated factor of safety shown in the table below against failure of a single pile through the soil. The output for the pile design spreadsheet for both borings is shown in Plate L5.2. The pile capacities, which accounted for the factor of safety, for the two borings were combined and the lower, more conservative strength was chosen for design.

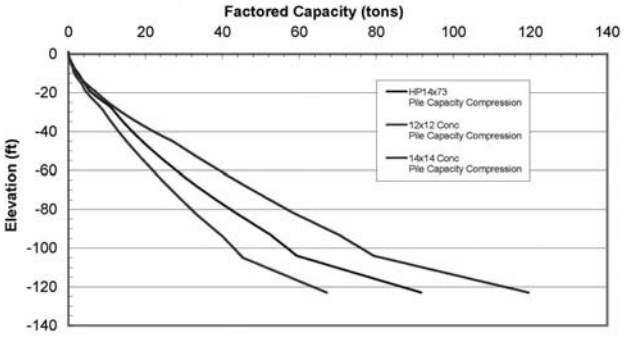
The Structural Design Section determined from the pile capacity charts that all piles tips would terminate at EL. -90.0’ (a total pile length of ≈ 70’, excluding the 2’ placed in the pile cap). Due to lack of boring information, negative skin friction was not accounted for. Negative skin friction from dragdown should be considered in subsequent design reports.

Recommended factors-of-safety for compression and tension design loads are:

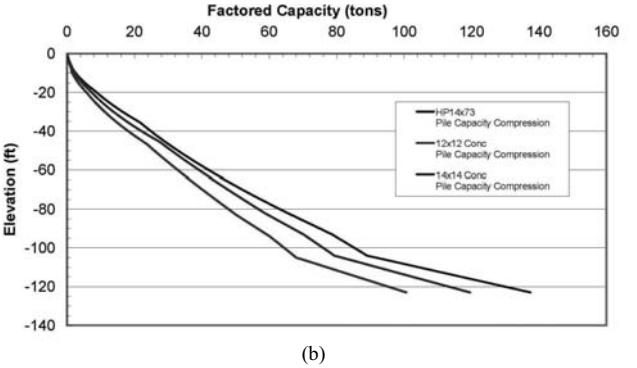
1010

Design Case	With Pile Load Test	Without Pile Load Test
Q-Case	2.0	3.0
S-Case	1.5	1.5

Note: Q-Case is characterized as a short term undrained case relative to the soil. S-Case is characterized as a long term consolidated drained case relative to the soil.

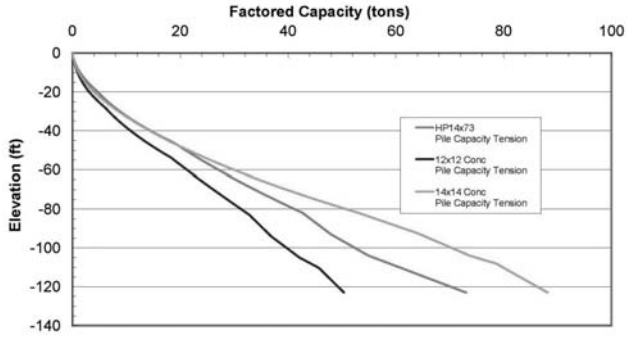


(a)

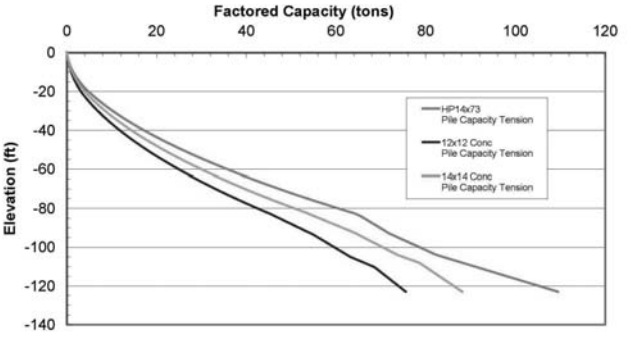


(b)

Figure L5.3 Pile design charts for piles in compression without load tests (a) and with load tests (b).



(a)



(b)

Figure L5.3 Pile design charts for piles in tension without load tests (a) and with load tests (b).

Precast concrete piles should meet the requirements outlined in Section 805.14 of the LSSRB. The design of the pile should consider allowable driving stresses.

Analyses for pile capacities are based only on a soil-pile relationship. Therefore, the structural capacity of the piles and their connections to transmit these loads should be determined by a structural engineer.

The piles will derive the majority of their supporting capacity from skin friction. Therefore, it is necessary to consider the effect of group action. In this regard, the supporting value of friction

piles installed in groups should be investigated on the basis of group perimeter. All piles should be installed to the same tip embedment in order to minimize differential foundation settlements.

All pile driving operations should be supervised by experienced personnel to ensure proper procedures are followed and accurate records are kept during all pile driving operations. The driving records should include the date, type of pile, pile size, hammer model, driving energy, and number of blows per foot of penetration for the embedment of the pile. An accurate driving record is especially important to verify piles are installed to the required tip embedment and to give an indication of any unusual driving characteristics which may include pile breakage.

L5.2.4 Lateral Earth Pressures

Lateral earth pressures and lateral fluid pressures from ground water should be calculated prior to design of the diversion facility.

L5.2.5 Hydrostatic Uplift

Hydrostatic uplift during construction should be controlled by dewatering using sumps and pumps, piezometers, positive cutoff, well points and/or deep wells if required. A passive trench collection system (French drain) with gravel fill is recommended; however the contractor is responsible for designing the necessary dewatering system. A registered professional engineer having qualifications and experience in similar dewatering and pressure relief systems shall design this system. If a trench collection system is chosen, the trenches should not be continuous from the riverside to the landside as to allow for uncontrollable seepage during a flood event after construction. For cost estimating purposes, the trapezoidal trench was 3 feet deep with an 8 foot width on top and a 2 foot width on the bottom. The design along with assumptions, computations, figures and detail plans, shall be submitted for review. Piezometric levels in the foundation strata should be reduced to no higher than the excavation surface. Adequate temporary piezometers shall be required to monitor the performance of the dewatering system. Because dewatering and pressure relief operations will lower the ground water level in the vicinity of the excavations and thus result in settlement of the adjacent ground surface, measures such as cutoff walls, recharge wells, and/or some other method may be necessary design of the dewatering system and excavation cofferdam to minimize these effects. Minimizing the duration of dewatering and pressure relief will also minimize these effects. The pressure relief system should be designed, installed and operated by a contractor experienced and qualified in the field of pressure relief

Hydrostatic uplift will act upon the box culvert after construction due to the return of normal ground water levels. The total weight of the culvert plus overlying overburden must counteract this hydrostatic uplift. A minimum factor of safety against flotation, found in the HSDRSDG and based on total weights, should be provided at all times.

L5.2.6 Backfill

Placement of approved materials as backfill should be completed according to current recommended guidelines.

L5.3 Geotechnical Design for Transmission System

Due to the time constraints and limited existing borings away from the Mississippi River levee, limited soil data is known for the marsh wetlands. The previously mentioned two borings (R-60.3-UL and R-59.75-LU) were assumed to be representative of the entire marsh. It is recommended that additional subsurface exploration and testing be completed to verify these assumptions.

The results of the soil borings and laboratory test data were evaluated and the shear strength and density parameters were selected for design. In general, design shear strengths were based on the results of UCT. The available soil design shear strengths and stratification are located on the previously mentioned Figures L5.1 and L5.2.

Stability of earth cuts were analyzed using the Spencer Method in GeoStudio 2007 (Version 7.14, Build 4606) for the slope stability analysis. Design requirements are such that a minimum factor of safety of 1.4 evaluated by unconsolidated-undrained (Q) shear strength parameters is required for low water conditions, where the Q-tests are supplemented by UCT tests. Due to time constraints, no new borings were drilled and design was based off of existing borings with UCT test results. This analysis is shown on Plate L.5.3.

The main channel leading away from the diversion facility was analyzed for slope stability. For the 35,000 cfs outflow option, the slope for the main channel extends from +6 to -16 NGVD with a 10 foot wide access berm above the slope. Using this cross-section with the boring information, the maximum slope, meeting the required factors of safety, was determined to be 1 on 4.5 (Vertical on Horizontal). The results are summarized in Table L5.2.

For cost estimating purposes, a 50% reduction factor was assumed for the consolidation of dredged material. In subsequent design reports, additional borings need to be taken along the transmission system in order to determine accurate material information. This additional information will be used for determining the transmission system's slope stability and for the settlement of the foundation and placement of the ridges lining the canals.

Table L5.2 Slope stability summary of the transmission system

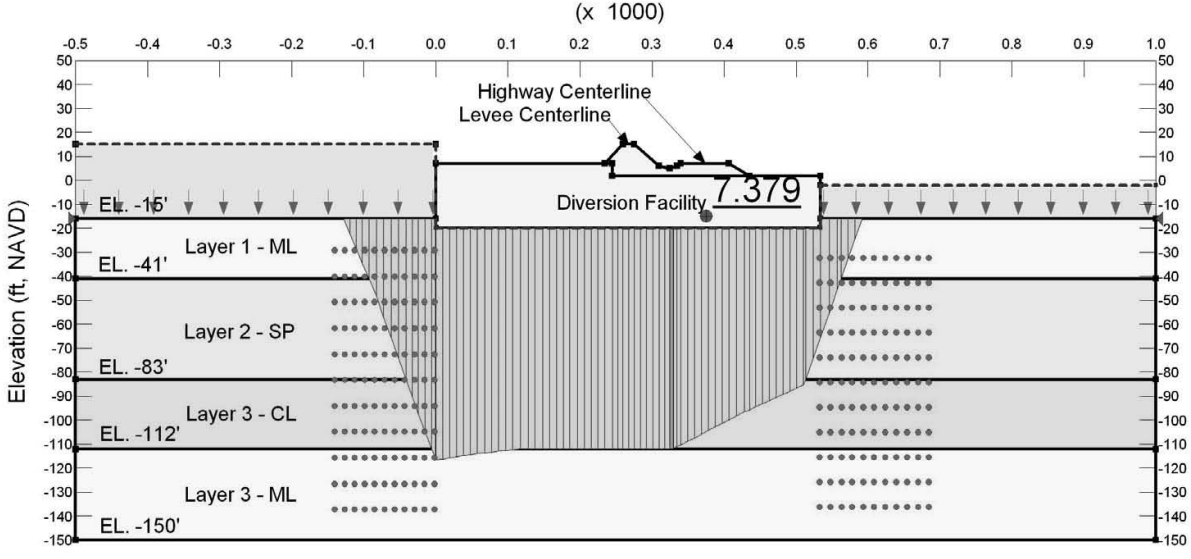
Boring/Slope	Case	Factor of Safety	
		Required	Obtained
R-59.75-LU 1 on 3.5	Low Water (hurricane condition)	1.4	1.84
	Low Water(non-hurricane condition)	1.4	1.81
	Water at Project Grade (levees)	1.4	3.48
R-60.3-UL 1 on 4.5	Low Water (hurricane condition)	1.4	2.64
	Low Water(non-hurricane condition)	1.4	1.48
	Water at Project Grade (levees)	1.4	5.15

L5.4 Laboratory Testing Program and Evaluations

Soil mechanics laboratory tests consisting of natural water content, unit weight, Atterberg liquid and plastic limits, and unconfined compression shear were performed on undisturbed samples obtained from the borings. There were two 5 inch diameter borings used in this evaluation. The borings are both in the vicinity of Location 3 and are shown on Figure L4.1. Boring R-59.75-LU is located 290 FT. R.S. from STA.1126+00 of MRL and Boring R-60.3-UL is located 152 FT. R.S. from STA. 1695+00 of the MRL. The results of these laboratory tests are presented on the boring logs in Figures L4.2 and L4.3. It is recommended that additional site specific subsurface exploration and testing be completed to verify the results of these two borings.

Plate L5.1

LCA MVN - WHITE DITCH
Location 3 - Diversion Facility
Spencer's Block Search
Boring: R-59.75-LU
TOW EL. 15.0'
Optimization



Name: Layer 1-ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1
Name: Layer 2-SP	Model: Mohr-Coulomb	Unit Weight: 122 pcf	Cohesion: 0 psf	Phi: 33 °	Piezometric Line: 1
Name: Layer 3-CL	Model: Mohr-Coulomb	Unit Weight: 105 pcf	Cohesion: 1580 psf	Phi: 0 °	Piezometric Line: 1
Name: Layer 4-ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1

Top of Levee

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

1.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 90
Last Edited By: Goetz, Ryan MVS
Date: 3/3/2010
Time: 3:29:48 PM
File Name: Location 3 - 35k cfs - Global Stability_R-59.75-LU.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/3/2010
Last Solved Time: 3:31:00 PM

2.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

3.0 ANALYSIS SETTINGS

3.1 Top of Levee

Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1

Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

4.0 MATERIALS

4.1 Layer 1-ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

4.2 Layer 2-SP

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

4.3 Layer 3-CL

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 1580 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

4.4 Layer 4-ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

5.0 SLIP SURFACE LIMITS

Left Coordinate: (-500, -16) ft
Right Coordinate: (1000, -16) ft

6.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-140.5428, -29.3568) ft
Lower Left: (-140.5428, -137.335) ft
Lower Right: (-1.358, -137.335) ft
X Increments: 10
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (532.9439, -32.40831) ft
Lower Left: (532.9439, -136.39582) ft
Lower Right: (684.9054, -136.39582) ft
X Increments: 10
Y Increments: 10

Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

7.0 PIEZOMETRIC LINES

260 ### 7.1 Piezometric Line 1

7.1.1 Coordinates

	X (ft)	Y (ft)
	-500	15
	0	15
	0	-20
	534	-20
	534	-16
	534	-2
	1000	-2

8.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 1-ML	1,2,3,4,5,6,11,7	35364
Region 2	Layer 2-SP	7,11,12,8	63000
Region 3	Layer 3-CL	9,8,12,13	43500
Region 4	Layer 4-ML	10,9,13,14	57000
Region 5		17,15,16,19,20,21,22,23,24,25,26	1182.5
Region 6		3,2,18,17,26,25,24,27,28,5,4	12973

9.0 POINTS

	X (ft)	Y (ft)
Point 1	-500	-16
Point 2	0	-16

Point 3	0	-20
Point 4	534	-20
Point 5	534	-16
Point 6	1000	-16
Point 7	-500	-41
Point 8	-500	-83
Point 9	-500	-112
Point 10	-500	-150
Point 11	1000	-41
Point 12	1000	-83
Point 13	1000	-112
Point 14	1000	-150
Point 15	260	15
Point 16	275	15
Point 17	235	7
Point 18	0	7
Point 19	310	6
Point 20	325	5
Point 21	335	6
Point 22	340	7
Point 23	407	7
Point 24	435	2
Point 25	245	2
Point 26	245	7

Point 27	534	2
Point 28	534	-2
Point 29	0	15
Point 30	-500	15

10.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	7.379	(273.321, -16)	272.7444	(-128.336, -16)	(591.648, -16)
2	17388	14.640	(273.321, -16)	282.839	(-101.097, -16)	(647.738, -16)

10.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-123.90385	-19.125	2129.4231	2263.9411	36.043996	200
2	Optimized	-115.03955	-25.375	2519.424	2982.4463	124.06645	200
3	Optimized	-106.17525	-31.625	2909.4248	3701.0436	212.11361	200
4	Optimized	-97.31094	-37.875	3299.4257	4419.5487	300.13606	200
5	Optimized	-87.70344	-44.649	3722.1245	5183.4177	948.97486	0
6	Optimized	-77.38865	-52.63575	4220.4652	6096.5083	1218.3167	0
7	Optimized	-67.10975	-61.31125	4761.8517	7112.6674	1526.6376	0
8	Optimized	-56.83085	-69.98675	5303.1638	8128.9752	1835.1034	0
9	Optimized	-46.55195	-78.66225	5844.5503	9144.5395	2143.0381	0
10	Optimized	-37.090075	-86.648175	6342.8683	10113.69	0	1580
11	Optimized	-28.445225	-93.94452	6798.1214	10873.918	0	1580
12	Optimized	-19.56274	-101.1945	7250.5169	11646.947	0	1580
13	Optimized	-10.442624	-108.39815	7700.012	12398.113	0	1580
14	Optimized	-3.3970835	-113.9632	8047.2428	13007.31	1329.0459	200

15	Optimized	-0.4558	-116.2457	8189.6958	13297.755	1368.7004	200
16	Optimized	0.0404	-116.5933	6027.4621	10954.322	1320.1483	200
17	Optimized	4.8526085	-116.3976	6015.201	11156.434	1377.5893	200
18	Optimized	14.396224	-115.94955	5987.2549	11104.101	1371.0547	200
19	Optimized	23.93984	-115.5015	5959.3089	11051.767	1364.5201	200
20	Optimized	33.48346	-115.0535	5931.3629	10999.434	1357.9856	200
21	Optimized	43.027075	-114.60545	5903.4168	10947.101	1351.451	200
22	Optimized	52.57069	-114.1574	5875.4708	10894.767	1344.9164	200
23	Optimized	62.2438	-113.7759	5851.6512	10845.605	1338.126	200
24	Optimized	72.0464	-113.4609	5831.9727	10808.899	1333.5635	200
25	Optimized	81.849	-113.1459	5812.2942	10771.174	1328.7278	200
26	Optimized	91.6516	-112.8309	5792.6158	10734.468	1324.1653	200
27	Optimized	101.4542	-112.5159	5773.0392	10697.762	1319.5754	200
28	Optimized	111.8586	-112.2709	5757.6636	10664.46	1314.7721	200
29	Optimized	122.8648	-112.09585	5746.762	10643.565	1312.0944	200
30	Optimized	133.2148	-112.00845	5741.2826	10628.413	1309.5027	200
31	Optimized	142.90865	-112.0088	5741.3857	10628.413	1309.4751	200
32	Optimized	152.6025	-112.00915	5741.3857	10628.413	1309.4751	200
33	Optimized	162.2963	-112.0095	5741.3857	10628.413	1309.4751	200
34	Optimized	171.9901	-112.00985	5741.3857	10628.413	1309.4751	200
35	Optimized	181.68395	-112.0102	5741.3857	10629.445	1309.7515	200
36	Optimized	191.3778	-112.01055	5741.4889	10629.445	1309.7239	200
37	Optimized	201.0716	-112.0109	5741.4889	10629.445	1309.7239	200
38	Optimized	210.7654	-112.01125	5741.4889	10629.445	1309.7239	200

39	Optimized	220.45925	-112.0116	5741.4889	10629.445	1309.7239	200
40	Optimized	230.1531	-112.01195	5741.592	10629.445	1309.6962	200
41	Optimized	240	-112.0123	5741.6	10629	1309.5749	200
42	Optimized	248.75	-112.0126	5741.6	10629.2	1309.6285	200
43	Optimized	256.25	-112.01285	5741.6	10629.333	1309.6642	200
44	Optimized	263.75	-112.01315	5741.6	10629.333	1309.6642	200
45	Optimized	271.25	-112.01345	5741.6	10629.333	1309.6642	200
46	Optimized	279.375	-112.01375	5741.6	10629.371	1309.6744	200
47	Optimized	288.125	-112.01405	5741.7143	10629.371	1309.6438	200
48	Optimized	296.875	-112.01435	5741.7143	10629.486	1309.6744	200
49	Optimized	305.625	-112.01465	5741.7143	10629.486	1309.6744	200
50	Optimized	314.02885	-112.01495	5741.7129	10629.46	1309.6679	200
51	Optimized	321.5351	-112.06035	5744.6104	10631.037	1309.3141	200
52	Optimized	325.71125	-112.1178	5748.1717	10636.654	1309.8649	200
53	Optimized	327.78545	-112.065	5744.8768	10649.5	1314.1899	200
54	Optimized	329.28115	-111.9943	5740.2673	10641.691	0	1580
55	Optimized	332.2007	-111.55325	5712.9393	10628.478	0	1580
56	Optimized	337.5	-110.72905	5661.5325	10541.857	0	1580
57	Optimized	344.7857	-109.5959	5590.7689	10422.75	0	1580
58	Optimized	354.35715	-108.10725	5497.8561	10266.244	0	1580
59	Optimized	363.9286	-106.61855	5405.0466	10109.737	0	1580
60	Optimized	373.5	-105.1299	5312.1338	9953.2308	0	1580
61	Optimized	383.0714	-103.64125	5219.221	9796.7244	0	1580
62	Optimized	392.64285	-102.1526	5126.3082	9640.1147	0	1580

63	Optimized	402.2143	-100.66396	5033.3954	9483.6083	0	1580
64	Optimized	412.3263	-99.09121	4935.3148	9318.5303	0	1580
65	Optimized	422.9789	-97.434395	4831.8889	9144.0513	0	1580
66	Optimized	431.6526	-96.1431	4751.3452	9003.3198	0	1580
67	Optimized	439.69645	-95.03077	4681.8775	8886.3396	0	1580
68	Optimized	449.08935	-93.731885	4600.8846	8749.7694	0	1580
69	Optimized	458.4823	-92.433	4519.7862	8613.1993	0	1580
70	Optimized	467.87525	-91.134115	4438.7932	8476.7346	0	1580
71	Optimized	477.26815	-89.83523	4357.6948	8340.1645	0	1580
72	Optimized	486.6611	-88.536345	4276.7019	8203.5943	0	1580
73	Optimized	496.05405	-87.23746	4195.6035	8067.0242	0	1580
74	Optimized	505.44695	-85.938575	4114.6105	7930.4541	0	1580
75	Optimized	511.5134	-84.144565	4002.6619	7939.2243	0	1580
76	Optimized	518.16255	-78.58949	3655.9989	7372.3253	2413.4106	0
77	Optimized	528.72085	-69.76847	3105.5639	6244.9984	2038.7726	0
78	Optimized	539.9296	-60.404015	3644.436	6418.2556	1801.3395	0
79	Optimized	551.78885	-50.49612	3026.1263	5152.2576	1380.7258	0
80	Optimized	560.32685	-43.271085	2575.3772	4236.0574	1078.4584	0
81	Optimized	567.72065	-36.833335	2173.6081	3399.7299	328.53833	200
82	Optimized	577.29155	-28.5	1653.6096	2401.8906	200.50129	200
83	Optimized	586.8625	-20.166665	1133.611	1404.13	72.485353	200

10.2 Slices of Slip Surface: 17388

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	17388	-96.930715	-20.166665	2194.3792	2386.7406	51.543076	200

962

2	17388	-88.59736	-28.5	2714.4422	3346.511	169.36232	200
3	17388	-80.264025	-36.833335	3234.4204	4306.2814	287.20429	200
4	17388	-70.84736	-46.25	3822.0138	5390.0402	1018.2882	0
5	17388	-60.34736	-56.75	4477.1988	6635.6258	1401.6989	0
6	17388	-49.84736	-67.25	5132.3839	7881.2114	1785.1095	0
7	17388	-39.34736	-77.75	5787.5689	9127.0664	2168.695	0
8	17388	-29.264025	-87.833335	6416.7751	10305.96	0	1580
9	17388	-19.59736	-97.499985	7020.0348	11313.222	0	1580
10	17388	-9.930695	-107.16665	7622.8555	12320.483	0	1580
11	17388	-3.22768	-113.8697	8041.4065	13044.003	1340.4416	200
12	17388	-0.679	-115.7392	8158.3211	13466.863	1422.4195	200
13	17388	4.8958335	-115.73775	5974.0594	11064.51	1363.9822	200
14	17388	14.687499	-115.73525	5973.8551	11063.489	1363.7633	200
15	17388	24.479165	-115.73275	5973.753	11063.489	1363.7907	200
16	17388	34.270835	-115.73025	5973.5487	11063.489	1363.8454	200
17	17388	44.0625	-115.7277	5973.4466	11063.489	1363.8727	200
18	17388	53.854165	-115.72515	5973.2423	11062.468	1363.6538	200
19	17388	63.645835	-115.72265	5973.1402	11062.468	1363.6812	200
20	17388	73.4375	-115.72015	5972.936	11062.468	1363.7359	200
21	17388	83.229165	-115.71765	5972.7317	11061.446	1363.517	200
22	17388	93.020835	-115.71515	5972.6296	11061.446	1363.5444	200
23	17388	102.81249	-115.71265	5972.4253	11061.446	1363.5991	200
24	17388	112.60415	-115.71015	5972.3232	11061.446	1363.6265	200
25	17388	122.39585	-115.7076	5972.1189	11060.425	1363.4075	200

26	17388	132.1875	-115.70505	5972.0168	11060.425	1363.4349	200
27	17388	141.97915	-115.70255	5971.8126	11060.425	1363.4896	200
28	17388	151.77085	-115.70005	5971.7104	11059.404	1363.2433	200
29	17388	161.5625	-115.69755	5971.5062	11059.404	1363.2981	200
30	17388	171.35415	-115.69505	5971.4041	11059.404	1363.3254	200
31	17388	181.14585	-115.69255	5971.1998	11058.383	1363.1065	200
32	17388	190.9375	-115.69	5971.0977	11058.383	1363.1339	200
33	17388	200.72915	-115.68745	5970.8934	11058.383	1363.1886	200
34	17388	210.52085	-115.68495	5970.7913	11058.383	1363.216	200
35	17388	220.3125	-115.68245	5970.587	11057.361	1362.9971	200
36	17388	230.10415	-115.67995	5970.3828	11057.361	1363.0518	200
37	17388	240	-115.6774	5970.3	11057	1362.9772	200
38	17388	248.75	-115.67515	5970.1333	11056.8	1362.9682	200
39	17388	256.25	-115.67325	5970	11056.667	1362.9682	200
40	17388	263.75	-115.67135	5969.8667	11056.4	1362.9325	200
41	17388	271.25	-115.6694	5969.7333	11056.133	1362.8968	200
42	17388	279.375	-115.6673	5969.6	11055.886	1362.8661	200
43	17388	288.125	-115.66505	5969.4857	11055.657	1362.8355	200
44	17388	296.875	-115.6628	5969.3714	11055.429	1362.8049	200
45	17388	305.625	-115.66055	5969.2571	11055.2	1362.7743	200
46	17388	313.75	-115.65845	5969.0667	11054.933	1362.7539	200
47	17388	321.25	-115.65655	5968.9333	11054.667	1362.7181	200
48	17388	330	-115.6543	5968.8	11054	1362.5752	200
49	17388	337.5	-115.65235	5968.8	11054.2	1362.6288	200

50	17388	344.7857	-115.6505	5968.5967	11053.731	1362.5576	200
51	17388	354.35715	-115.64805	5968.3878	11053.731	1362.6136	200
52	17388	363.9286	-115.6456	5968.2833	11053.731	1362.6416	200
53	17388	373.5	-115.64315	5968.1788	11052.686	1362.3896	200
54	17388	383.0714	-115.6407	5967.9699	11052.686	1362.4456	200
55	17388	392.64285	-115.63825	5967.8654	11052.686	1362.4736	200
56	17388	402.2143	-115.63575	5967.6564	11052.686	1362.5296	200
57	17388	411.66665	-115.6333	5967.5353	11051.785	1362.3206	200
58	17388	421	-115.63095	5967.321	11051.785	1362.378	200
59	17388	430.33335	-115.6286	5967.2139	11051.785	1362.4067	200
60	17388	439.95	-115.6261	5967.0707	11051.515	1362.3728	200
61	17388	449.85	-115.62355	5966.8687	11050.505	1362.1563	200
62	17388	459.75	-115.621	5966.7677	11050.505	1362.1833	200
63	17388	469.65	-115.61845	5966.5657	11050.505	1362.2375	200
64	17388	479.55	-115.61595	5966.4646	11049.495	1361.9939	200
65	17388	489.45	-115.6134	5966.2626	11049.495	1362.048	200
66	17388	499.35	-115.61085	5966.1616	11049.495	1362.0751	200
67	17388	509.25	-115.6083	5965.9596	11049.495	1362.1292	200
68	17388	519.15	-115.60575	5965.7576	11048.485	1361.9127	200
69	17388	529.05	-115.6032	5965.6566	11048.485	1361.9397	200
70	17388	541.07	-115.6001	7088.3766	12389.631	1420.4668	200
71	17388	549.9392	-113.79915	6976.3146	12385.459	1449.3759	200
72	17388	556.5717	-107.16665	6562.4147	11657.022	0	1580
73	17388	566.23835	-97.499985	5959.2282	10634.399	0	1580

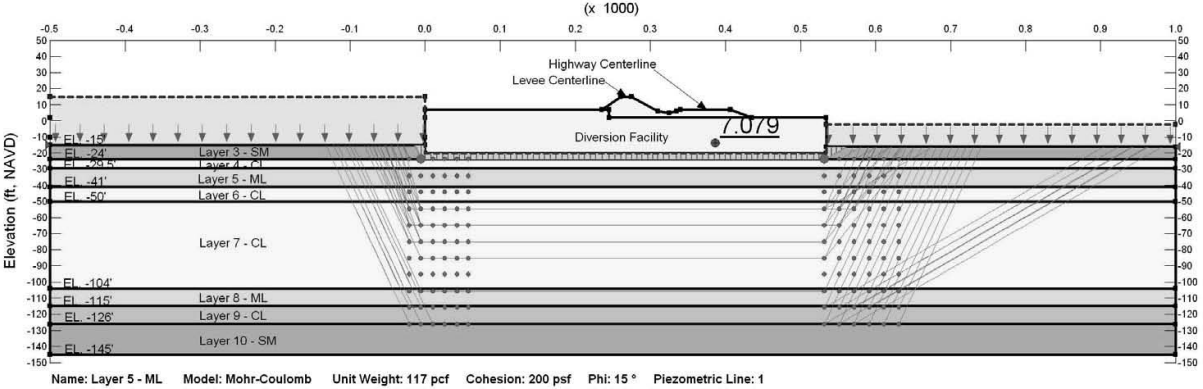
74	17388	575.90505	-87.833335	5355.9686	9611.7764	0	1580
75	17388	585.9884	-77.75	4726.7739	8515.5873	2460.4842	0
76	17388	596.4884	-67.25	4071.5888	7194.981	2028.3546	0
77	17388	606.9884	-56.75	3416.4038	5874.4421	1596.2687	0
78	17388	617.4884	-46.25	2761.2188	4553.7011	1164.0516	0
79	17388	626.90505	-36.833335	2173.5902	3372.4759	321.24046	200
80	17388	635.23835	-28.5	1653.6121	2381.31	194.98607	200
81	17388	643.5717	-20.166665	1133.6339	1390.144	68.73168	200

270

966

LCA MVN - WHITE DITCH
Location 3 - Diversion Facility
Spencer's Block Search
Boring: R-60.3-LU

TOW EL. 15.0'
Optimization



Name: Layer 5 - ML Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 200 psf Phi: 15 ° Piezometric Line: 1
Name: Layer 4 - CL Model: Mohr-Coulomb Unit Weight: 107 pcf Cohesion: 550 psf Phi: 0 ° Piezometric Line: 1
Name: Layer 6 - CL Model: Mohr-Coulomb Unit Weight: 101 pcf Cohesion: 780 psf Phi: 0 ° Piezometric Line: 1
Name: Layer 7 - CL Model: S=f(depth) Unit Weight: 101 pcf C-Top of Layer: 500 psf C-Rate of Change: 14 psf/ft Limiting C: 1200 psf Piezometric Line: 1
Name: Layer 3 - SM Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 30 ° Piezometric Line: 1
Name: Layer 9 - CL Model: Mohr-Coulomb Unit Weight: 115 pcf Cohesion: 900 psf Phi: 0 ° Piezometric Line: 1
Name: Layer 10 - SM Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 30 ° Piezometric Line: 1
Name: Layer 8 - ML Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 200 psf Phi: 15 ° Piezometric Line: 1

Water at Project Grade (levee)

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

11.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 96
Last Edited By: Goetz, Ryan MVS
Date: 3/7/2010
Time: 11:30:30 AM
File Name: Location 3 - 35k cfs - Global Stability_R-60.3-LU.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/7/2010
Last Solved Time: 11:30:55 AM

12.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

13.0 ANALYSIS SETTINGS

13.1 Low Water (hurricane condition)

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No

Slip Surface Option: Block
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

14.0 MATERIALS

14.1 Layer 5 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

14.2 Layer 4 - CL

Model: Mohr-Coulomb
Unit Weight: 107 pcf
Cohesion: 550 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

14.3 Layer 6 - CL

Model: Mohr-Coulomb
Unit Weight: 101 pcf
Cohesion: 780 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

14.4 Layer 7 - CL

Model: S=f(depth)
Unit Weight: 101 pcf
C-Top of Layer: 500 psf
C-Rate of Change: 14 psf/ft
Limiting C: 1200 psf
Pore Water Pressure
Piezometric Line: 1

14.5 Layer 3 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

14.6 Layer 9 - CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 900 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

14.7 Layer 10 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

14.8 Layer 8 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

15.0 SLIP SURFACE LIMITS

Left Coordinate: (-500, -15) ft
Right Coordinate: (1000, -16) ft

16.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-21.2598, -24) ft
Lower Left: (-21.2598, -126) ft
Lower Right: (57.7899, -126) ft
X Increments: 5
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (531.875, -24) ft
Lower Left: (531.875, -126) ft
Lower Right: (631.067, -126) ft
X Increments: 5
Y Increments: 10
Starting Angle: 0 °

Ending Angle: 45 °
Angle Increments: 3

17.0 PIEZOMETRIC LINES

17.1 Piezometric Line 1

17.1.1 Coordinates

	X (ft)	Y (ft)
	-500	15
	0	15
	0	-20
	534	-20
	534	-2
	1000	-2

18.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM	17,18,12,8	28500
Region 2	Layer 9 - CL	17,7,11,18	16500
Region 3	Layer 8 - ML	7,6,10,11	16500
Region 4	Layer 5 - ML	15,16,9,21	17250
Region 5	Layer 4 - CL	5,15,21,20	8250
Region 6	Layer 3 - SM	14,23,3,4,24,19,20,5	10364
Region 7	Layer 6 - CL	16,25,26,9	13500
Region 8	Layer 7 - CL	25,6,10,26	81000
Region 9		29,27,28,31,32,33,34,35,36,37,38	1182.5
Region 10		3,23,22,2,30,29,38,37,36,39,40,24,4	12973

19.0 POINTS

	X (ft)	Y (ft)

Point 1	-500	2
Point 2	0	2
Point 3	0	-20
Point 4	534	-20
Point 5	-500	-24
Point 6	-500	-104
Point 7	-500	-115
Point 8	-500	-145
Point 9	1000	-41
Point 10	1000	-104
Point 11	1000	-115
Point 12	1000	-145
Point 13	-500	-10
Point 14	-500	-15
Point 15	-500	-29.5
Point 16	-500	-41
Point 17	-500	-126
Point 18	1000	-126
Point 19	1000	-16
Point 20	1000	-24
Point 21	1000	-29.5
Point 22	0	-10
Point 23	0	-15
Point 24	534	-16

Point 25	-500	-50
Point 26	1000	-50
Point 27	260	15
Point 28	275	15
Point 29	235	7
Point 30	0	7
Point 31	310	6
Point 32	325	5
Point 33	335	6
Point 34	340	7
Point 35	407	7
Point 36	435	2
Point 37	245	2
Point 38	245	7
Point 39	534	2
Point 40	534	-2
Point 41	1000	-2
Point 42	-500	15
Point 43	0	15

20.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	7.079	(273.642, -14.75)	198.0375	(-14.4499, -15)	(561.731, -16)
2	170	7.079	(273.642, -14.75)	198.038	(-14.4499, -15)	(561.731, -16)

20.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-9.94986	-19.5	2152.8262	2386.9572	135.17557	0
2	Optimized	-2.72493	-24	2433.6405	2970.3515	309.87026	0
3	Optimized	3.7903225	-24	249.59618	488.12469	137.7145	0
4	Optimized	11.370967	-24	249.59618	488.12469	137.7145	0
5	Optimized	18.951615	-24	249.59618	488.12469	137.7145	0
6	Optimized	26.53226	-24	249.59618	488.12469	137.7145	0
7	Optimized	34.112905	-24	249.59618	488.12469	137.7145	0
8	Optimized	41.69355	-24	249.59618	488.12469	137.7145	0
9	Optimized	49.274195	-24	249.59618	488.12469	137.7145	0
10	Optimized	56.85484	-24	249.59618	488.12469	137.7145	0
11	Optimized	64.435485	-24	249.59618	488.12469	137.7145	0
12	Optimized	72.01613	-24	249.59618	488.12469	137.7145	0
13	Optimized	79.596775	-24	249.59618	488.12469	137.7145	0
14	Optimized	87.17742	-24	249.59618	488.12469	137.7145	0
15	Optimized	94.758065	-24	249.59618	488.12469	137.7145	0
16	Optimized	102.3387	-24	249.59618	488.12469	137.7145	0
17	Optimized	109.91935	-24	249.59618	488.12469	137.7145	0
18	Optimized	117.5	-24	249.59618	488.12469	137.7145	0
19	Optimized	125.08065	-24	249.59618	488.12469	137.7145	0
20	Optimized	132.6613	-24	249.59618	488.12469	137.7145	0
21	Optimized	140.24195	-24	249.59618	488.12469	137.7145	0
22	Optimized	147.8226	-24	249.59618	488.12469	137.7145	0
23	Optimized	155.4032	-24	249.59618	488.12469	137.7145	0

24	Optimized	162.98385	-24	249.59618	488.12469	137.7145	0
25	Optimized	170.5645	-24	249.59618	488.12469	137.7145	0
26	Optimized	178.14515	-24	249.59618	488.12469	137.7145	0
27	Optimized	185.7258	-24	249.59618	488.12469	137.7145	0
28	Optimized	193.30645	-24	249.59618	488.12469	137.7145	0
29	Optimized	200.8871	-24	249.59618	488.12469	137.7145	0
30	Optimized	208.46775	-24	249.59618	488.12469	137.7145	0
31	Optimized	216.0484	-24	249.59618	488.12469	137.7145	0
32	Optimized	223.62905	-24	249.59618	488.12469	137.7145	0
33	Optimized	231.2097	-24	249.59618	488.12469	137.7145	0
34	Optimized	240	-24	249.6	488.12	137.70959	0
35	Optimized	248.75	-24	249.6	488.12	137.70959	0
36	Optimized	256.25	-24	249.6	488.12	137.70959	0
37	Optimized	263.75	-24	249.6	488.12	137.70959	0
38	Optimized	271.25	-24	249.6	488.12	137.70959	0
39	Optimized	278.5	-24	249.6	488.12857	137.71453	0
40	Optimized	285.5	-24	249.6	488.12857	137.71453	0
41	Optimized	292.5	-24	249.6	488.12857	137.71453	0
42	Optimized	299.5	-24	249.6	488.12857	137.71453	0
43	Optimized	306.5	-24	249.6	488.12857	137.71453	0
44	Optimized	313.75	-24	249.6	488.12	137.70959	0
45	Optimized	321.25	-24	249.6	488.12	137.70959	0
46	Optimized	330	-24	249.6	488.12	137.70959	0
47	Optimized	337.5	-24	249.6	488.12	137.70959	0

48	Optimized	343.7222	-24	249.59554	488.12242	137.71356	0
49	Optimized	351.16665	-24	249.59554	488.12242	137.71356	0
50	Optimized	358.6111	-24	249.59554	488.12242	137.71356	0
51	Optimized	366.05555	-24	249.59554	488.12242	137.71356	0
52	Optimized	373.5	-24	249.59554	488.12242	137.71356	0
53	Optimized	380.94445	-24	249.59554	488.12242	137.71356	0
54	Optimized	388.3889	-24	249.59554	488.12242	137.71356	0
55	Optimized	395.83335	-24	249.59554	488.12242	137.71356	0
56	Optimized	403.2778	-24	249.59554	488.12242	137.71356	0
57	Optimized	410.5	-24	249.6	488.12857	137.71453	0
58	Optimized	417.5	-24	249.6	488.12857	137.71453	0
59	Optimized	424.5	-24	249.6	488.12857	137.71453	0
60	Optimized	431.5	-24	249.6	488.12857	137.71453	0
61	Optimized	438.72595	-24	249.6	488.12904	137.7148	0
62	Optimized	446.17785	-24	249.6	488.12904	137.7148	0
63	Optimized	453.6298	-24	249.6	488.12904	137.7148	0
64	Optimized	461.08175	-24	249.6	488.12904	137.7148	0
65	Optimized	468.53365	-24	249.6	488.12904	137.7148	0
66	Optimized	475.98555	-24	249.6	488.12904	137.7148	0
67	Optimized	483.4375	-24	249.6	488.12904	137.7148	0
68	Optimized	490.88945	-24	249.6	488.12904	137.7148	0
69	Optimized	498.34135	-24	249.6	488.12904	137.7148	0
70	Optimized	505.79325	-24	249.6	488.12904	137.7148	0
71	Optimized	513.2452	-24	249.6	488.12904	137.7148	0

72	Optimized	520.69715	-24	249.6	488.12904	137.7148	0
73	Optimized	528.14905	-24	249.6	488.12904	137.7148	0
74	Optimized	532.9375	-23.715305	231.83582	459.14429	131.23661	0
75	Optimized	537.46645	-22.501785	1279.3044	1678.5985	230.53257	0
76	Optimized	544.3993	-20.64413	1163.3992	1448.9894	164.88561	0
77	Optimized	551.33215	-18.786475	1047.48	1219.4639	99.294951	0
78	Optimized	558.265	-16.928825	931.56088	989.89664	33.680165	0

20.2 Slices of Slip Surface: 170

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	170	-9.94986	-19.5	2152.8262	2386.9572	135.17557	0
2	170	-2.72493	-24	2433.6405	2970.3515	309.87026	0
3	170	3.7903225	-24	249.59618	488.12469	137.7145	0
4	170	11.370967	-24	249.59618	488.12469	137.7145	0
5	170	18.951615	-24	249.59618	488.12469	137.7145	0
6	170	26.53226	-24	249.59618	488.12469	137.7145	0
7	170	34.112905	-24	249.59618	488.12469	137.7145	0
8	170	41.69355	-24	249.59618	488.12469	137.7145	0
9	170	49.274195	-24	249.59618	488.12469	137.7145	0
10	170	56.85484	-24	249.59618	488.12469	137.7145	0
11	170	64.435485	-24	249.59618	488.12469	137.7145	0
12	170	72.01613	-24	249.59618	488.12469	137.7145	0
13	170	79.596775	-24	249.59618	488.12469	137.7145	0
14	170	87.17742	-24	249.59618	488.12469	137.7145	0
15	170	94.758065	-24	249.59618	488.12469	137.7145	0

16	170	102.3387	-24	249.59618	488.12469	137.7145	0
17	170	109.91935	-24	249.59618	488.12469	137.7145	0
18	170	117.5	-24	249.59618	488.12469	137.7145	0
19	170	125.08065	-24	249.59618	488.12469	137.7145	0
20	170	132.6613	-24	249.59618	488.12469	137.7145	0
21	170	140.24195	-24	249.59618	488.12469	137.7145	0
22	170	147.8226	-24	249.59618	488.12469	137.7145	0
23	170	155.4032	-24	249.59618	488.12469	137.7145	0
24	170	162.98385	-24	249.59618	488.12469	137.7145	0
25	170	170.5645	-24	249.59618	488.12469	137.7145	0
26	170	178.14515	-24	249.59618	488.12469	137.7145	0
27	170	185.7258	-24	249.59618	488.12469	137.7145	0
28	170	193.30645	-24	249.59618	488.12469	137.7145	0
29	170	200.8871	-24	249.59618	488.12469	137.7145	0
30	170	208.46775	-24	249.59618	488.12469	137.7145	0
31	170	216.0484	-24	249.59618	488.12469	137.7145	0
32	170	223.62905	-24	249.59618	488.12469	137.7145	0
33	170	231.2097	-24	249.59618	488.12469	137.7145	0
34	170	240	-24	249.6	488.12	137.70959	0
35	170	248.75	-24	249.6	488.12	137.70959	0
36	170	256.25	-24	249.6	488.12	137.70959	0
37	170	263.75	-24	249.6	488.12	137.70959	0
38	170	271.25	-24	249.6	488.12	137.70959	0
39	170	278.5	-24	249.6	488.12857	137.71453	0

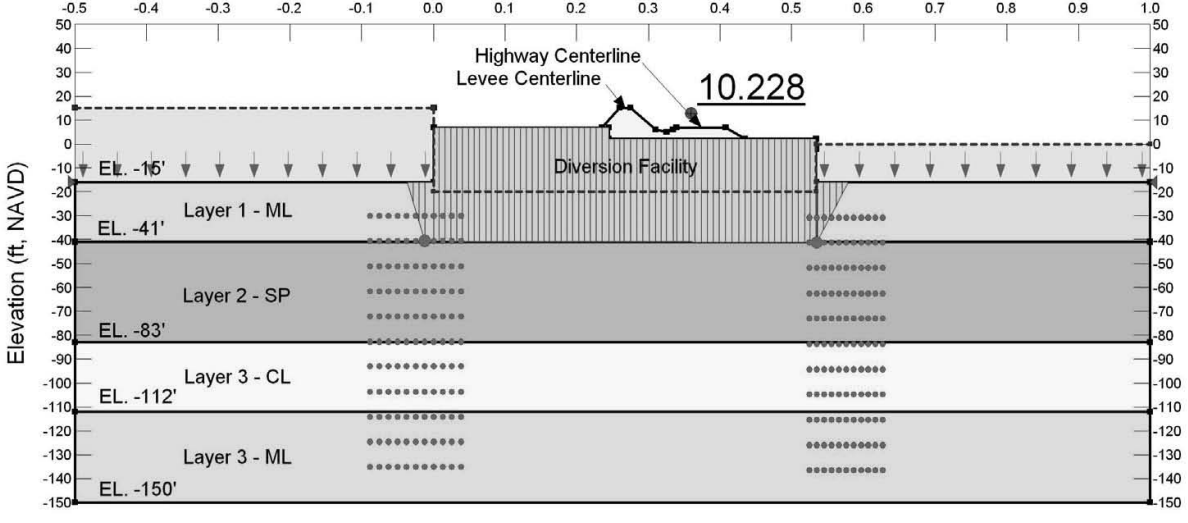
40	170	285.5	-24	249.6	488.12857	137.71453	0
41	170	292.5	-24	249.6	488.12857	137.71453	0
42	170	299.5	-24	249.6	488.12857	137.71453	0
43	170	306.5	-24	249.6	488.12857	137.71453	0
44	170	313.75	-24	249.6	488.12	137.70959	0
45	170	321.25	-24	249.6	488.12	137.70959	0
46	170	330	-24	249.6	488.12	137.70959	0
47	170	337.5	-24	249.6	488.12	137.70959	0
48	170	343.7222	-24	249.59554	488.12242	137.71356	0
49	170	351.16665	-24	249.59554	488.12242	137.71356	0
50	170	358.6111	-24	249.59554	488.12242	137.71356	0
51	170	366.05555	-24	249.59554	488.12242	137.71356	0
52	170	373.5	-24	249.59554	488.12242	137.71356	0
53	170	380.94445	-24	249.59554	488.12242	137.71356	0
54	170	388.3889	-24	249.59554	488.12242	137.71356	0
55	170	395.83335	-24	249.59554	488.12242	137.71356	0
56	170	403.2778	-24	249.59554	488.12242	137.71356	0
57	170	410.5	-24	249.6	488.12857	137.71453	0
58	170	417.5	-24	249.6	488.12857	137.71453	0
59	170	424.5	-24	249.6	488.12857	137.71453	0
60	170	431.5	-24	249.6	488.12857	137.71453	0
61	170	438.72595	-24	249.6	488.12904	137.7148	0
62	170	446.17785	-24	249.6	488.12904	137.7148	0
63	170	453.6298	-24	249.6	488.12904	137.7148	0

64	170	461.08175	-24	249.6	488.12904	137.7148	0
65	170	468.53365	-24	249.6	488.12904	137.7148	0
66	170	475.98555	-24	249.6	488.12904	137.7148	0
67	170	483.4375	-24	249.6	488.12904	137.7148	0
68	170	490.88945	-24	249.6	488.12904	137.7148	0
69	170	498.34135	-24	249.6	488.12904	137.7148	0
70	170	505.79325	-24	249.6	488.12904	137.7148	0
71	170	513.2452	-24	249.6	488.12904	137.7148	0
72	170	520.69715	-24	249.6	488.12904	137.7148	0
73	170	528.14905	-24	249.6	488.12904	137.7148	0
74	170	532.9375	-23.715305	231.83582	459.14429	131.23661	0
75	170	537.46645	-22.501785	1279.3044	1678.5985	230.53257	0
76	170	544.3993	-20.64413	1163.3992	1448.9894	164.88561	0
77	170	551.33215	-18.786475	1047.48	1219.4639	99.294951	0
78	170	558.265	-16.928825	931.56088	989.89664	33.680165	0

981

LCA MVN - WHITE DITCH
Location 3 - Diversion Facility
Spencer's Block Search
Boring: R-59.75-LU

Low Water (non-hurricane condition) S-Case
Optimization
(x 1000)



Name: Concrete Model: Mohr-Coulomb Unit Weight: 0.001 pcf Cohesion: 2e+005 psf Phi: 0 ° Piezometric Line: 1
Name: Layer 1 -ML - S Case Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Layer 2-SP - S Case Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Layer 3 - CL - S Case Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 23 ° Piezometric Line: 1
Name: Layer 4 -ML - S Case Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

Top of Levee - S-Case

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

21.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 100
Last Edited By: Goetz, Ryan MVS
Date: 3/8/2010
Time: 4:40:55 PM
File Name: Location 3 - 35k cfs - Global Stability_R-59.75-LU.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/8/2010
Last Solved Time: 4:42:13 PM

22.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

23.0 ANALYSIS SETTINGS

23.1 Top of Levee - S-Case (2)

Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1

983

Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

24.0 MATERIALS

24.1 Concrete

Model: Mohr-Coulomb
Unit Weight: 0.001 pcf
Cohesion: 2e+005 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

24.2 Layer 1 -ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

24.3 Layer 2-SP - S Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

24.4 Layer 3 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

24.5 Layer 4 -ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

25.0 SLIP SURFACE LIMITS

Left Coordinate: (-500, -16) ft
Right Coordinate: (1000, -16) ft

26.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-87.8848, -30.20441) ft
Lower Left: (-87.8848, -135.18302) ft
Lower Right: (38.9764, -135.18302) ft
X Increments: 10
Y Increments: 10

Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (524.8026, -30.69344) ft
Lower Left: (524.8026, -136.65011) ft
Lower Right: (627.3109, -136.65011) ft
X Increments: 10
Y Increments: 10
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

27.0 PIEZOMETRIC LINES

27.1 Piezometric Line 1

27.1.1 Coordinates

	X (ft)	Y (ft)
	-500	15
	0	15
	0	-20
	534	-20
	534	-16
	534	0
	1000	0

28.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 1 -ML - S Case	1,2,3,4,5,6,11,7	35364
Region 2	Layer 2-SP - S Case	7,11,12,8	63000
Region 3	Layer 3 - CL - S Case	9,8,12,13	43500
Region 4	Layer 4 -ML - S Case	10,9,13,14	57000

Region 5		17,15,16,19,20,21,22,23,24,25,26	1182.5
Region 6	Concrete	3,2,18,17,26,25,24,27,28,5,4	12973

555 **29.0 POINTS**

	X (ft)	Y (ft)
Point 1	-500	-16
Point 2	0	-16
Point 3	0	-20
Point 4	534	-20
Point 5	534	-16
Point 6	1000	-16
Point 7	-500	-41
Point 8	-500	-83
Point 9	-500	-112
Point 10	-500	-150
Point 11	1000	-41
Point 12	1000	-83
Point 13	1000	-112
Point 14	1000	-150
Point 15	260	15
Point 16	275	15
Point 17	235	7
Point 18	0	7
Point 19	310	6
Point 20	325	5

Point 21	335	6
Point 22	340	7
Point 23	407	7
Point 24	435	2
Point 25	245	2
Point 26	245	7
Point 27	534	2
Point 28	534	-2
Point 29	0	15
Point 30	-500	15

30.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	10.228	(271.193, -16)	214.4399	(-36.4704, -16)	(578.855, -16)
2	3131	10.228	(271.193, -16)	214.44	(-36.4704, -16)	(578.855, -16)

30.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-32.353305	-20.117045	2191.286	2363.3806	91.504308	0
2	Optimized	-24.119215	-28.351135	2705.0794	3288.6036	310.26535	0
3	Optimized	-15.885125	-36.585225	3218.9586	4213.8266	528.98074	0
4	Optimized	-5.88404	-40.708585	3476.1801	4826.4417	717.94683	0
5	Optimized	4.051724	-40.71925	1292.9056	2360.9688	567.89928	0
6	Optimized	12.155174	-40.727945	1293.3992	2426.1262	602.28163	0
7	Optimized	20.25862	-40.73664	1294.0163	2427.2369	602.54409	0
8	Optimized	28.362065	-40.74534	1294.5099	2428.2241	602.80655	0

9	Optimized	36.465515	-40.754035	1295.0035	2429.2113	603.06901	0
10	Optimized	44.568965	-40.76273	1295.6205	2430.1986	603.26586	0
11	Optimized	52.672415	-40.77143	1296.1141	2431.3092	603.59393	0
12	Optimized	60.775865	-40.780125	1296.7312	2432.2965	603.79078	0
13	Optimized	68.87931	-40.78882	1297.2248	2433.2837	604.05324	0
14	Optimized	76.982755	-40.797515	1297.7184	2434.2709	604.3157	0
15	Optimized	85.086205	-40.80621	1298.3354	2435.3816	604.57816	0
16	Optimized	93.189655	-40.81491	1298.829	2436.3688	604.84062	0
17	Optimized	101.29309	-40.823605	1299.4461	2437.356	605.03747	0
18	Optimized	109.39655	-40.8323	1299.9397	2438.3433	605.29993	0
19	Optimized	117.5	-40.841	1300.4333	2439.4539	605.628	0
20	Optimized	125.60345	-40.849695	1301.0503	2440.4411	605.82485	0
21	Optimized	133.7069	-40.85839	1301.5439	2441.4284	606.08731	0
22	Optimized	141.81035	-40.86709	1302.1609	2442.4156	606.28415	0
23	Optimized	149.9138	-40.875785	1302.6546	2443.5262	606.61223	0
24	Optimized	158.01725	-40.88448	1303.1482	2444.5135	606.87469	0
25	Optimized	166.1207	-40.89318	1303.7652	2445.5007	607.07154	0
26	Optimized	174.22415	-40.901875	1304.2588	2446.4879	607.334	0
27	Optimized	182.3276	-40.91057	1304.8758	2447.5986	607.59646	0
28	Optimized	190.43105	-40.919265	1305.3695	2448.5858	607.85892	0
29	Optimized	198.5345	-40.92796	1305.8631	2449.573	608.12138	0
30	Optimized	206.63795	-40.93666	1306.4801	2450.5603	608.31822	0
31	Optimized	214.7414	-40.945355	1306.9737	2451.6709	608.6463	0
32	Optimized	222.84485	-40.95405	1307.5907	2452.6581	608.84315	0

33	Optimized	230.9483	-40.96275	1308.0843	2453.6454	609.10561	0
34	Optimized	240	-40.972465	1308.6987	2454.7975	609.39157	0
35	Optimized	248.75	-40.981855	1309.266	2455.8654	609.65771	0
36	Optimized	256.25	-40.989905	1309.7726	2456.7987	609.88457	0
37	Optimized	262.82985	-40.996965	1310.205	2457.7166	610.14273	0
38	Optimized	270.32985	-41.00501	1310.6668	2458.8117	745.61406	0
39	Optimized	279.375	-41.014715	1311.3135	2459.9986	745.9648	0
40	Optimized	288.125	-41.024105	1311.885	2461.1415	746.33589	0
41	Optimized	296.875	-41.033495	1312.4564	2462.2843	746.70698	0
42	Optimized	305.625	-41.042885	1313.0278	2463.4272	747.07807	0
43	Optimized	313.75	-41.051605	1313.626	2464.532	747.40713	0
44	Optimized	321.25	-41.059655	1314.1193	2465.4654	747.69287	0
45	Optimized	330	-41.069045	1314.6987	2466.6975	748.1168	0
46	Optimized	337.5	-41.077095	1315.2192	2467.5985	748.36387	0
47	Optimized	344.1875	-41.084275	1315.7007	2468.5358	748.65989	0
48	Optimized	352.5625	-41.093265	1316.1783	2469.6105	749.04759	0
49	Optimized	360.9375	-41.10225	1316.7753	2470.6851	749.35776	0
50	Optimized	369.3125	-41.111235	1317.3723	2471.8791	749.74547	0
51	Optimized	377.6875	-41.120225	1317.85	2472.9537	750.13317	0
52	Optimized	386.0625	-41.129215	1318.447	2474.0284	750.44334	0
53	Optimized	394.4375	-41.138205	1319.044	2475.103	750.7535	0
54	Optimized	402.8125	-41.14719	1319.641	2476.1776	751.06366	0
55	Optimized	411.66665	-41.15669	1320.2135	2477.3556	751.4569	0
56	Optimized	421	-41.16671	1320.7492	2478.6414	751.94396	0

57	Optimized	430.33335	-41.176725	1321.3921	2479.8199	752.29185	0
58	Optimized	439.125	-41.18616	1322.0598	2480.9682	752.60391	0
59	Optimized	447.375	-41.195015	1322.5447	2482.0591	752.99749	0
60	Optimized	455.625	-41.203865	1323.1507	2483.15	753.31235	0
61	Optimized	463.875	-41.21272	1323.6356	2484.2409	753.70593	0
62	Optimized	472.125	-41.221575	1324.2416	2485.3318	754.0208	0
63	Optimized	480.375	-41.230425	1324.7265	2486.4227	754.41438	0
64	Optimized	488.625	-41.23928	1325.3325	2487.5136	754.72924	0
65	Optimized	496.875	-41.248135	1325.9386	2488.4833	754.96539	0
66	Optimized	505.125	-41.25699	1326.4234	2489.5742	755.35897	0
67	Optimized	513.375	-41.265845	1327.0295	2490.6652	755.67383	0
68	Optimized	521.625	-41.274695	1327.5143	2491.7561	756.06741	0
69	Optimized	529.875	-41.28355	1328.1204	2510.9076	768.11096	0
70	Optimized	534.5267	-41.288545	2576.4383	3960.0126	898.50362	0
71	Optimized	535.3038	-41.144555	2567.3885	4040.1996	956.45471	0
72	Optimized	539.8843	-38.5	2402.4	3711.3	695.95448	0
73	Optimized	548.54455	-33.5	2090.4	3110.9	542.60948	0
74	Optimized	557.2048	-28.5	1778.4	2510.5	389.26447	0
75	Optimized	565.86505	-23.5	1466.4	1910.1	235.91947	0
76	Optimized	574.5253	-18.5	1154.4	1309.8	82.627646	0

30.2 Slices of Slip Surface: 3131

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	3131	-32.353305	-20.117045	2191.286	2363.3806	91.504308	0
2	3131	-24.119215	-28.351135	2705.0794	3288.6036	310.26535	0

3	3131	-15.885125	-36.585225	3218.9586	4213.8266	528.98074	0
4	3131	-5.88404	-40.708585	3476.1801	4826.4417	717.94683	0
5	3131	4.051724	-40.71925	1292.9056	2360.9688	567.89928	0
6	3131	12.155174	-40.727945	1293.3992	2426.1262	602.28163	0
7	3131	20.25862	-40.73664	1294.0163	2427.2369	602.54409	0
8	3131	28.362065	-40.74534	1294.5099	2428.2241	602.80655	0
9	3131	36.465515	-40.754035	1295.0035	2429.2113	603.06901	0
10	3131	44.568965	-40.76273	1295.6205	2430.1986	603.26586	0
11	3131	52.672415	-40.77143	1296.1141	2431.3092	603.59393	0
12	3131	60.775865	-40.780125	1296.7312	2432.2965	603.79078	0
13	3131	68.87931	-40.78882	1297.2248	2433.2837	604.05324	0
14	3131	76.982755	-40.797515	1297.7184	2434.2709	604.3157	0
15	3131	85.086205	-40.80621	1298.3354	2435.3816	604.57816	0
16	3131	93.189655	-40.81491	1298.829	2436.3688	604.84062	0
17	3131	101.29309	-40.823605	1299.4461	2437.356	605.03747	0
18	3131	109.39655	-40.8323	1299.9397	2438.3433	605.29993	0
19	3131	117.5	-40.841	1300.4333	2439.4539	605.628	0
20	3131	125.60345	-40.849695	1301.0503	2440.4411	605.82485	0
21	3131	133.7069	-40.85839	1301.5439	2441.4284	606.08731	0
22	3131	141.81035	-40.86709	1302.1609	2442.4156	606.28415	0
23	3131	149.9138	-40.875785	1302.6546	2443.5262	606.61223	0
24	3131	158.01725	-40.88448	1303.1482	2444.5135	606.87469	0
25	3131	166.1207	-40.89318	1303.7652	2445.5007	607.07154	0
26	3131	174.22415	-40.901875	1304.2588	2446.4879	607.334	0

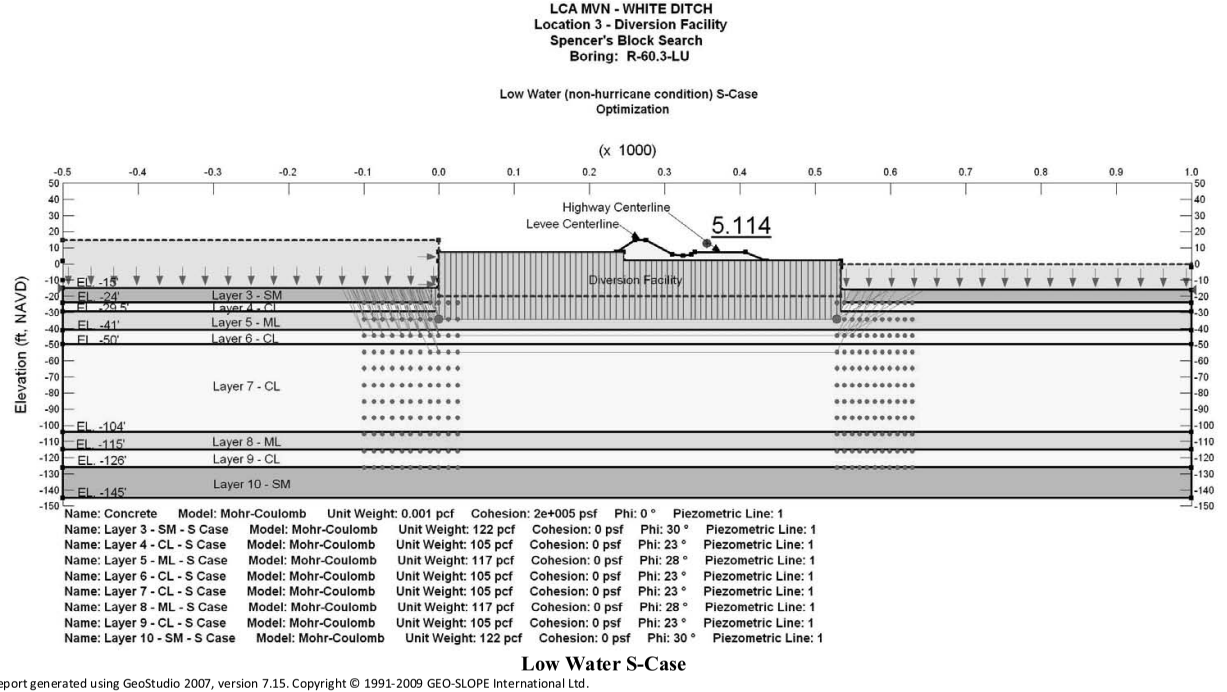
27	3131	182.3276	-40.91057	1304.8758	2447.5986	607.59646	0
28	3131	190.43105	-40.919265	1305.3695	2448.5858	607.85892	0
29	3131	198.5345	-40.92796	1305.8631	2449.573	608.12138	0
30	3131	206.63795	-40.93666	1306.4801	2450.5603	608.31822	0
31	3131	214.7414	-40.945355	1306.9737	2451.6709	608.6463	0
32	3131	222.84485	-40.95405	1307.5907	2452.6581	608.84315	0
33	3131	230.9483	-40.96275	1308.0843	2453.6454	609.10561	0
34	3131	240	-40.972465	1308.6987	2454.7975	609.39157	0
35	3131	248.75	-40.981855	1309.266	2455.8654	609.65771	0
36	3131	256.25	-40.989905	1309.7726	2456.7987	609.88457	0
37	3131	262.82985	-40.996965	1310.205	2457.7166	610.14273	0
38	3131	270.32985	-41.00501	1310.6668	2458.8117	745.61406	0
39	3131	279.375	-41.014715	1311.3135	2459.9986	745.9648	0
40	3131	288.125	-41.024105	1311.885	2461.1415	746.33589	0
41	3131	296.875	-41.033495	1312.4564	2462.2843	746.70698	0
42	3131	305.625	-41.042885	1313.0278	2463.4272	747.07807	0
43	3131	313.75	-41.051605	1313.626	2464.532	747.40713	0
44	3131	321.25	-41.059655	1314.1193	2465.4654	747.69287	0
45	3131	330	-41.069045	1314.6987	2466.6975	748.1168	0
46	3131	337.5	-41.077095	1315.2192	2467.5985	748.36387	0
47	3131	344.1875	-41.084275	1315.7007	2468.5358	748.65989	0
48	3131	352.5625	-41.093265	1316.1783	2469.6105	749.04759	0
49	3131	360.9375	-41.10225	1316.7753	2470.6851	749.35776	0
50	3131	369.3125	-41.111235	1317.3723	2471.8791	749.74547	0

51	3131	377.6875	-41.120225	1317.85	2472.9537	750.13317	0
52	3131	386.0625	-41.129215	1318.447	2474.0284	750.44334	0
53	3131	394.4375	-41.138205	1319.044	2475.103	750.7535	0
54	3131	402.8125	-41.14719	1319.641	2476.1776	751.06366	0
55	3131	411.66665	-41.15669	1320.2135	2477.3556	751.4569	0
56	3131	421	-41.16671	1320.7492	2478.6414	751.94396	0
57	3131	430.33335	-41.176725	1321.3921	2479.8199	752.29185	0
58	3131	439.125	-41.18616	1322.0598	2480.9682	752.60391	0
59	3131	447.375	-41.195015	1322.5447	2482.0591	752.99749	0
60	3131	455.625	-41.203865	1323.1507	2483.15	753.31235	0
61	3131	463.875	-41.21272	1323.6356	2484.2409	753.70593	0
62	3131	472.125	-41.221575	1324.2416	2485.3318	754.0208	0
63	3131	480.375	-41.230425	1324.7265	2486.4227	754.41438	0
64	3131	488.625	-41.23928	1325.3325	2487.5136	754.72924	0
65	3131	496.875	-41.248135	1325.9386	2488.4833	754.96539	0
66	3131	505.125	-41.25699	1326.4234	2489.5742	755.35897	0
67	3131	513.375	-41.265845	1327.0295	2490.6652	755.67383	0
68	3131	521.625	-41.274695	1327.5143	2491.7561	756.06741	0
69	3131	529.875	-41.28355	1328.1204	2510.9076	768.11096	0
70	3131	534.5267	-41.288545	2576.4383	3960.0126	898.50362	0
71	3131	535.3038	-41.144555	2567.3885	4040.1996	956.45471	0
72	3131	539.8843	-38.5	2402.4	3711.3	695.95448	0
73	3131	548.54455	-33.5	2090.4	3110.9	542.60948	0
74	3131	557.2048	-28.5	1778.4	2510.5	389.26447	0

75	3131	565.86505	-23.5	1466.4	1910.1	235.91947	0
76	3131	574.5253	-18.5	1154.4	1309.8	82.627646	0

560

995



Low Water S-Case

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

31.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 98
Last Edited By: Goetz, Ryan MVS

Date: 3/8/2010
Time: 4:56:57 PM
File Name: Location 3 - 35k cfs - Global Stability_R-60.3-LU.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/8/2010
Last Solved Time: 4:58:20 PM

32.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

33.0 ANALYSIS SETTINGS

33.1 Low Water S-Case

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: Yes
    Tension Crack
        Tension Crack Option: (none)
FOS Distribution
    FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced

Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

34.0 MATERIALS

34.1 Concrete

Model: Mohr-Coulomb
Unit Weight: 0.001 pcf
Cohesion: 2e+005 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.2 Layer 3 - SM - S Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.3 Layer 4 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

34.4 Layer 5 - ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.5 Layer 6 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.6 Layer 7 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.7 Layer 8 - ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.8 Layer 9 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

34.9 Layer 10 - SM - S Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

35.0 SLIP SURFACE LIMITS

Left Coordinate: (-500, -15) ft
Right Coordinate: (1000, -16) ft

36.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-99.2758, -24) ft
Lower Left: (-99.2758, -126) ft
Lower Right: (24.6802, -126) ft
X Increments: 10
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (528.863, -24) ft
Lower Left: (528.863, -126) ft
Lower Right: (629.013, -126) ft
X Increments: 10
Y Increments: 10
Starting Angle: 0 °

1000

Ending Angle: 45 °
Angle Increments: 3

37.0PIEZOMETRIC LINES

710 **37.1 Piezometric Line 1**

37.1.1 Coordinates

	X (ft)	Y (ft)
	-500	15
	0	15
	0	-20
	534	-20
	534	0
	1000	0

38.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM - S Case	17,18,12,8	28500
Region 2	Layer 9 - CL - S Case	17,7,11,18	16500
Region 3	Layer 8 - ML - S Case	7,6,10,11	16500
Region 4	Layer 5 - ML - S Case	15,16,9,21	17250
Region 5	Layer 4 - CL - S Case	5,15,21,20	8250
Region 6	Layer 3 - SM - S Case	14,23,3,4,24,19,20,5	10364
Region 7	Layer 6 - CL - S Case	16,25,26,9	13500
Region 8	Layer 7 - CL - S Case	25,6,10,26	81000
Region 9		29,27,28,31,32,33,34,35,36,37,38	1182.5
Region 10	Concrete	3,23,22,2,30,29,38,37,36,39,40,24,4	12973

39.0 POINTS

	X (ft)	Y (ft)

1001

Point 1	-500	2
Point 2	0	2
Point 3	0	-20
Point 4	534	-20
Point 5	-500	-24
Point 6	-500	-104
Point 7	-500	-115
Point 8	-500	-145
Point 9	1000	-41
Point 10	1000	-104
Point 11	1000	-115
Point 12	1000	-145
Point 13	-500	-10
Point 14	-500	-15
Point 15	-500	-29.5
Point 16	-500	-41
Point 17	-500	-126
Point 18	1000	-126
Point 19	1000	-16
Point 20	1000	-24
Point 21	1000	-29.5
Point 22	0	-10
Point 23	0	-15
Point 24	534	-16

Point 25	-500	-50
Point 26	1000	-50
Point 27	260	15
Point 28	275	15
Point 29	235	7
Point 30	0	7
Point 31	310	6
Point 32	325	5
Point 33	335	6
Point 34	340	7
Point 35	407	7
Point 36	435	2
Point 37	245	2
Point 38	245	7
Point 39	534	2
Point 40	534	-2
Point 41	1000	-2
Point 42	-500	15
Point 43	0	15

40.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	5.114	(263.877, -14.75)	196.2609	(-19.311, -15)	(547.063, -16)
2	3480	5.114	(263.877, -14.75)	196.261	(-19.311, -15)	(547.063, -16)

715 **40.1 Slices of Slip Surface: Optimized**

1003

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-14.811	-19.5	2152.8262	2347.8306	112.58582	0
2	Optimized	-7.561	-26.75	2605.2384	3145.7251	229.42299	0
3	Optimized	-2.4055	-31.85	2923.391	3669.6274	396.78092	0
4	Optimized	3.7903225	-34.2	886.08555	1541.1617	348.31019	0
5	Optimized	11.370967	-34.2	886.08555	1617.1447	388.71105	0
6	Optimized	18.951615	-34.2	886.08555	1617.1447	388.71105	0
7	Optimized	26.53226	-34.2	886.08555	1617.1447	388.71105	0
8	Optimized	34.112905	-34.2	886.08555	1617.1447	388.71105	0
9	Optimized	41.69355	-34.2	886.08555	1617.1447	388.71105	0
10	Optimized	49.274195	-34.2	886.08555	1617.1447	388.71105	0
11	Optimized	56.85484	-34.2	886.08555	1617.1447	388.71105	0
12	Optimized	64.435485	-34.2	886.08555	1617.1447	388.71105	0
13	Optimized	72.01613	-34.2	886.08555	1617.1447	388.71105	0
14	Optimized	79.596775	-34.2	886.08555	1617.1447	388.71105	0
15	Optimized	87.17742	-34.2	886.08555	1617.1447	388.71105	0
16	Optimized	94.758065	-34.2	886.08555	1617.1447	388.71105	0
17	Optimized	102.3387	-34.2	886.08555	1617.1447	388.71105	0
18	Optimized	109.91935	-34.2	886.08555	1617.1447	388.71105	0
19	Optimized	117.5	-34.2	886.08555	1617.1447	388.71105	0
20	Optimized	125.08065	-34.2	886.08555	1617.1447	388.71105	0
21	Optimized	132.6613	-34.2	886.08555	1617.1447	388.71105	0
22	Optimized	140.24195	-34.2	886.08555	1617.1447	388.71105	0
23	Optimized	147.8226	-34.2	886.08555	1617.1447	388.71105	0

24	Optimized	155.4032	-34.2	886.08555	1617.1447	388.71105	0
25	Optimized	162.98385	-34.2	886.08555	1617.1447	388.71105	0
26	Optimized	170.5645	-34.2	886.08555	1617.1447	388.71105	0
27	Optimized	178.14515	-34.2	886.08555	1617.1447	388.71105	0
28	Optimized	185.7258	-34.2	886.08555	1617.1447	388.71105	0
29	Optimized	193.30645	-34.2	886.08555	1617.1447	388.71105	0
30	Optimized	200.8871	-34.2	886.08555	1617.1447	388.71105	0
31	Optimized	208.46775	-34.2	886.08555	1617.1447	388.71105	0
32	Optimized	216.0484	-34.2	886.08555	1617.1447	388.71105	0
33	Optimized	223.62905	-34.2	886.08555	1617.1447	388.71105	0
34	Optimized	231.2097	-34.2	886.08555	1617.1447	388.71105	0
35	Optimized	240	-34.2	886.08	1617.1	388.69023	0
36	Optimized	248.75	-34.2	886.08	1617.0667	388.67251	0
37	Optimized	256.25	-34.2	886.08	1617.0667	388.67251	0
38	Optimized	263.75	-34.2	886.08	1617.0667	388.67251	0
39	Optimized	271.25	-34.2	886.08	1617.0667	388.67251	0
40	Optimized	278.5	-34.2	886.08571	1617.1429	388.70998	0
41	Optimized	285.5	-34.2	886.08571	1617.1429	388.70998	0
42	Optimized	292.5	-34.2	886.08571	1617.1429	388.70998	0
43	Optimized	299.5	-34.2	886.08571	1617.1429	388.70998	0
44	Optimized	306.5	-34.2	886.08571	1617.1429	388.70998	0
45	Optimized	313.75	-34.2	886.08	1617.0667	388.67251	0
46	Optimized	321.25	-34.2	886.08	1617.0667	388.67251	0
47	Optimized	330	-34.2	886.08	1617.1	388.69023	0

1005

48	Optimized	337.5	-34.2	886.08	1617.1	388.69023	0
49	Optimized	343.7222	-34.2	886.08363	1617.0449	388.65898	0
50	Optimized	351.16665	-34.2	886.08363	1617.0449	388.65898	0
51	Optimized	358.6111	-34.2	886.08363	1617.0449	388.65898	0
52	Optimized	366.05555	-34.2	886.08363	1617.0449	388.65898	0
53	Optimized	373.5	-34.2	886.08363	1617.0449	388.65898	0
54	Optimized	380.94445	-34.2	886.08363	1617.0449	388.65898	0
55	Optimized	388.3889	-34.2	886.08363	1617.0449	388.65898	0
56	Optimized	395.83335	-34.2	886.08363	1617.0449	388.65898	0
57	Optimized	403.2778	-34.2	886.08363	1617.0449	388.65898	0
58	Optimized	410.5	-34.2	886.08571	1617.1429	388.70998	0
59	Optimized	417.5	-34.2	886.08571	1617.1429	388.70998	0
60	Optimized	424.5	-34.2	886.08571	1617.1429	388.70998	0
61	Optimized	431.5	-34.2	886.08571	1617.1429	388.70998	0
62	Optimized	438.91095	-34.2	886.07435	1617.1228	388.70534	0
63	Optimized	446.73285	-34.2	886.07435	1617.1228	388.70534	0
64	Optimized	454.5548	-34.2	886.07435	1617.1228	388.70534	0
65	Optimized	462.37675	-34.2	886.07435	1617.1228	388.70534	0
66	Optimized	470.19865	-34.2	886.07435	1617.1228	388.70534	0
67	Optimized	478.02055	-34.2	886.07435	1617.1228	388.70534	0
68	Optimized	485.84245	-34.2	886.07435	1617.1228	388.70534	0
69	Optimized	493.66435	-34.2	886.07435	1617.1228	388.70534	0
70	Optimized	501.4863	-34.2	886.07435	1617.1228	388.70534	0
71	Optimized	509.30825	-34.2	886.07435	1617.1228	388.70534	0

72	Optimized	517.13015	-34.2	886.07435	1617.1228	388.70534	0
73	Optimized	524.95205	-34.2	886.07435	1617.1228	388.70534	0
74	Optimized	531.213	-31.85	739.43808	1447.4776	376.4713	0
75	Optimized	533.7815	-29.2815	579.16417	1562.3501	417.33766	0
76	Optimized	536.5315	-26.5315	1655.5489	2350.7845	295.10999	0
77	Optimized	543.063	-20	1248.0433	1556.165	177.89417	0

40.2 Slices of Slip Surface: 3480

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	3480	-14.811	-19.5	2152.8262	2347.8306	112.58582	0
2	3480	-7.561	-26.75	2605.2384	3145.7251	229.42299	0
3	3480	-2.4055	-31.85	2923.391	3669.6274	396.78092	0
4	3480	3.7903225	-34.2	886.08555	1541.1617	348.31019	0
5	3480	11.370967	-34.2	886.08555	1617.1447	388.71105	0
6	3480	18.951615	-34.2	886.08555	1617.1447	388.71105	0
7	3480	26.53226	-34.2	886.08555	1617.1447	388.71105	0
8	3480	34.112905	-34.2	886.08555	1617.1447	388.71105	0
9	3480	41.69355	-34.2	886.08555	1617.1447	388.71105	0
10	3480	49.274195	-34.2	886.08555	1617.1447	388.71105	0
11	3480	56.85484	-34.2	886.08555	1617.1447	388.71105	0
12	3480	64.435485	-34.2	886.08555	1617.1447	388.71105	0
13	3480	72.01613	-34.2	886.08555	1617.1447	388.71105	0
14	3480	79.596775	-34.2	886.08555	1617.1447	388.71105	0
15	3480	87.17742	-34.2	886.08555	1617.1447	388.71105	0
16	3480	94.758065	-34.2	886.08555	1617.1447	388.71105	0

17	3480	102.3387	-34.2	886.08555	1617.1447	388.71105	0
18	3480	109.91935	-34.2	886.08555	1617.1447	388.71105	0
19	3480	117.5	-34.2	886.08555	1617.1447	388.71105	0
20	3480	125.08065	-34.2	886.08555	1617.1447	388.71105	0
21	3480	132.6613	-34.2	886.08555	1617.1447	388.71105	0
22	3480	140.24195	-34.2	886.08555	1617.1447	388.71105	0
23	3480	147.8226	-34.2	886.08555	1617.1447	388.71105	0
24	3480	155.4032	-34.2	886.08555	1617.1447	388.71105	0
25	3480	162.98385	-34.2	886.08555	1617.1447	388.71105	0
26	3480	170.5645	-34.2	886.08555	1617.1447	388.71105	0
27	3480	178.14515	-34.2	886.08555	1617.1447	388.71105	0
28	3480	185.7258	-34.2	886.08555	1617.1447	388.71105	0
29	3480	193.30645	-34.2	886.08555	1617.1447	388.71105	0
30	3480	200.8871	-34.2	886.08555	1617.1447	388.71105	0
31	3480	208.46775	-34.2	886.08555	1617.1447	388.71105	0
32	3480	216.0484	-34.2	886.08555	1617.1447	388.71105	0
33	3480	223.62905	-34.2	886.08555	1617.1447	388.71105	0
34	3480	231.2097	-34.2	886.08555	1617.1447	388.71105	0
35	3480	240	-34.2	886.08	1617.1	388.69023	0
36	3480	248.75	-34.2	886.08	1617.0667	388.67251	0
37	3480	256.25	-34.2	886.08	1617.0667	388.67251	0
38	3480	263.75	-34.2	886.08	1617.0667	388.67251	0
39	3480	271.25	-34.2	886.08	1617.0667	388.67251	0
40	3480	278.5	-34.2	886.08571	1617.1429	388.70998	0

41	3480	285.5	-34.2	886.08571	1617.1429	388.70998	0
42	3480	292.5	-34.2	886.08571	1617.1429	388.70998	0
43	3480	299.5	-34.2	886.08571	1617.1429	388.70998	0
44	3480	306.5	-34.2	886.08571	1617.1429	388.70998	0
45	3480	313.75	-34.2	886.08	1617.0667	388.67251	0
46	3480	321.25	-34.2	886.08	1617.0667	388.67251	0
47	3480	330	-34.2	886.08	1617.1	388.69023	0
48	3480	337.5	-34.2	886.08	1617.1	388.69023	0
49	3480	343.7222	-34.2	886.08363	1617.0449	388.65898	0
50	3480	351.16665	-34.2	886.08363	1617.0449	388.65898	0
51	3480	358.6111	-34.2	886.08363	1617.0449	388.65898	0
52	3480	366.05555	-34.2	886.08363	1617.0449	388.65898	0
53	3480	373.5	-34.2	886.08363	1617.0449	388.65898	0
54	3480	380.94445	-34.2	886.08363	1617.0449	388.65898	0
55	3480	388.3889	-34.2	886.08363	1617.0449	388.65898	0
56	3480	395.83335	-34.2	886.08363	1617.0449	388.65898	0
57	3480	403.2778	-34.2	886.08363	1617.0449	388.65898	0
58	3480	410.5	-34.2	886.08571	1617.1429	388.70998	0
59	3480	417.5	-34.2	886.08571	1617.1429	388.70998	0
60	3480	424.5	-34.2	886.08571	1617.1429	388.70998	0
61	3480	431.5	-34.2	886.08571	1617.1429	388.70998	0
62	3480	438.91095	-34.2	886.07435	1617.1228	388.70534	0
63	3480	446.73285	-34.2	886.07435	1617.1228	388.70534	0
64	3480	454.5548	-34.2	886.07435	1617.1228	388.70534	0

1009

65	3480	462.37675	-34.2	886.07435	1617.1228	388.70534	0
66	3480	470.19865	-34.2	886.07435	1617.1228	388.70534	0
67	3480	478.02055	-34.2	886.07435	1617.1228	388.70534	0
68	3480	485.84245	-34.2	886.07435	1617.1228	388.70534	0
69	3480	493.66435	-34.2	886.07435	1617.1228	388.70534	0
70	3480	501.4863	-34.2	886.07435	1617.1228	388.70534	0
71	3480	509.30825	-34.2	886.07435	1617.1228	388.70534	0
72	3480	517.13015	-34.2	886.07435	1617.1228	388.70534	0
73	3480	524.95205	-34.2	886.07435	1617.1228	388.70534	0
74	3480	531.213	-31.85	739.43808	1447.4776	376.4713	0
75	3480	533.7815	-29.2815	579.16417	1562.3501	417.33766	0
76	3480	536.5315	-26.5315	1655.5489	2350.7845	295.10999	0
77	3480	543.063	-20	1248.0433	1556.165	177.89417	0

1010

720

725

730

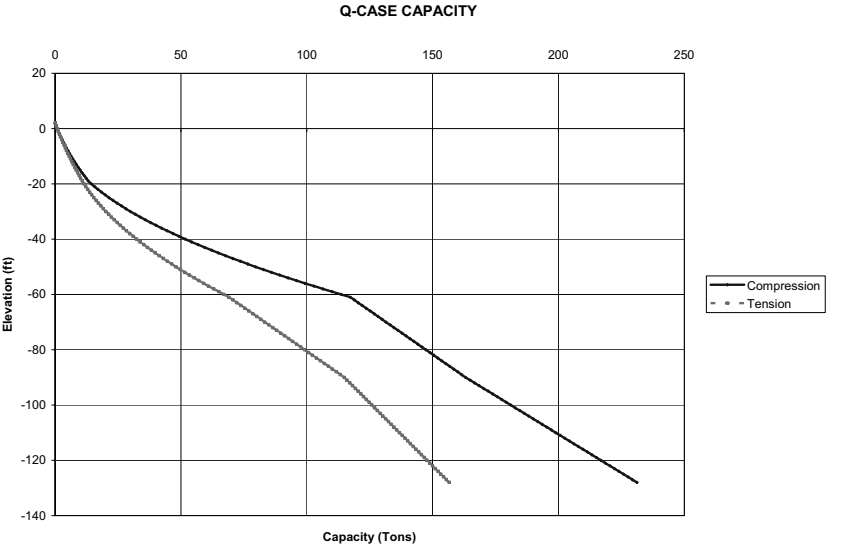
735 **Plate L5.2**

740

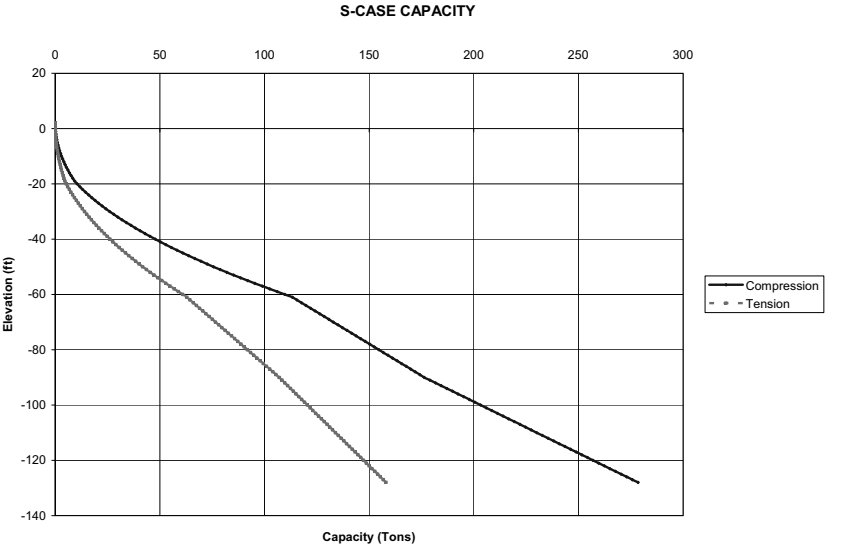
745

750

Boring
R-59.75-LU
12x12 Concrete Pile Capacities


Q-CASE CAPACITY
0
50
100
150
200
250
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

755


S-CASE CAPACITY
0
50
100
150
200
250
300
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

1015

Boring R-59.75-LU_12x12 Concrete Pile_Q-Case

Stratum	Tip	Increment	$\gamma_{(moist)}$	$\gamma_{(sub)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Q-CASE Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.400	0.011	0.005	0.000	0.411	0.405
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.800	0.043	0.022	0.000	0.843	0.822
1	-1	1	117	54.5999985	136.5	136.5	163.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.200	0.098	0.049	0.000	1.298	1.249
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.600	0.174	0.087	0.000	1.774	1.687
1	-3	1	117	54.5999985	245.699997	245.699997	273	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.000	0.272	0.136	0.000	2.272	2.136
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.400	0.391	0.195	0.000	2.791	2.595
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.800	0.532	0.266	0.000	3.332	3.066
1	-6	1	117	54.5999985	409.5	409.5	436.800018	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.200	0.695	0.348	0.000	3.895	3.548
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.600	0.880	0.440	0.000	4.480	4.040
1	-8	1	117	54.5999985	518.700012	518.700012	546	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.000	1.086	0.543	0.000	5.086	4.543
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.400	1.314	0.657	0.000	5.714	5.057
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.800	1.564	0.782	0.000	6.364	5.582
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.200	1.835	0.918	0.000	7.035	6.118
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.600	2.129	1.064	0.000	7.729	6.664
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.000	2.444	1.222	0.000	8.444	7.222
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.400	2.780	1.390	0.000	9.180	7.790
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.800	3.139	1.569	0.000	9.939	8.369
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.200	3.519	1.759	0.000	10.719	8.959
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.600	3.921	1.960	0.000	11.521	9.560
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.000	4.344	2.172	0.000	12.344	10.172
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.400	4.790	2.395	0.000	13.190	10.795
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	6.008	3.077	0.000	14.408	11.477
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	7.288	3.794	0.000	15.688	12.194
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	8.629	4.545	0.000	17.029	12.945
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	10.033	5.331	0.000	18.433	13.731
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	11.498	6.151	0.000	19.898	14.551
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	13.025	7.006	0.000	21.425	15.406
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	14.613	7.896	0.000	23.013	16.296
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	16.263	8.820	0.000	24.663	17.220
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	17.975	9.779	0.000	26.375	18.179
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	19.749	10.772	0.000	28.149	19.172
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	21.584	11.800	0.000	29.984	20.200
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	23.481	12.862	0.000	31.881	21.262
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	25.440	13.959	0.000	33.840	22.359
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	27.461	15.091	0.000	35.861	23.491
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	29.543	16.257	0.000	37.943	24.657
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	31.687	17.457	0.000	40.087	25.857
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	33.893	18.692	0.000	42.293	27.092
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	36.160	19.962	0.000	44.560	28.362
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	38.489	21.267	0.000	46.889	29.667
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	40.880	22.605	0.000	49.280	31.005
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	43.333	23.979	0.000	51.733	32.379
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	45.847	25.387	0.000	54.247	33.787
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	48.423	26.829	0.000	56.823	35.229
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	51.060	28.307	0.000	59.460	36.707
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	53.760	29.818	0.000	62.160	38.218
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	56.521	31.364	0.000	64.921	39.764
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	59.344	32.945	0.000	67.744	41.345

1016

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	62.229	34.561	0.000	70.629	42.961
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	65.175	36.211	0.000	73.575	44.611
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	68.183	37.895	0.000	76.583	46.295
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	71.253	39.614	0.000	79.653	48.014
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	74.384	41.368	0.000	82.784	49.768
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	77.577	43.156	0.000	85.977	51.556
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	80.832	44.979	0.000	89.232	53.379
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	84.149	46.836	0.000	92.549	55.236
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	87.527	48.728	0.000	95.927	57.128
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	90.967	50.654	0.000	99.367	59.054
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	94.469	52.615	0.000	102.869	61.015
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	98.032	54.611	0.000	106.432	63.011
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	101.657	56.640	0.000	110.057	65.040
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	105.281	58.670	0.000	113.681	67.070
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	8.400	108.905	60.700	0.000	117.305	69.100
3	-62	1	105	42.5999985	3671.10205	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	9.980	108.905	60.700	0.000	118.885	70.680
3	-63	1	105	42.5999985	3713.70215	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	11.560	108.905	60.700	0.000	120.465	72.260
3	-64	1	105	42.5999985	3756.30225	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	13.140	108.905	60.700	0.000	122.045	73.840
3	-65	1	105	42.5999985	3798.90234	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	14.720	108.905	60.700	0.000	123.625	75.420
3	-66	1	105	42.5999985	3841.50244	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	16.300	108.905	60.700	0.000	125.205	77.000
3	-67	1	105	42.5999985	3884.10254	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	17.880	108.905	60.700	0.000	126.785	78.580
3	-68	1	105	42.5999985	3926.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	19.460	108.905	60.700	0.000	128.365	80.160
3	-69	1	105	42.5999985	3969.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	21.040	108.905	60.700	0.000	129.945	81.740
3	-70	1	105	42.5999985	4011.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	22.820	108.905	60.700	0.000	131.525	83.320
3	-71	1	105	42.5999985	4054.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	24.200	108.905	60.700	0.000	133.105	84.900
3	-72	1	105	42.5999985	4097.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	25.780	108.905	60.700	0.000	134.685	86.480
3	-73	1	105	42.5999985	4139.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	27.360	108.905	60.700	0.000	136.265	88.060
3	-74	1	105	42.5999985	4182.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	28.940	108.905	60.700	0.000	137.845	89.640
3	-75	1	105	42.5999985	4224.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	30.520	108.905	60.700	0.000	139.425	91.220
3	-76	1	105	42.5999985	4267.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	32.100	108.905	60.700	0.000	141.005	92.800
3	-77	1	105	42.5999985	4310.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	33.680	108.905	60.700	0.000	142.585	94.380
3	-78	1	105	42.5999985	4352.70313	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	35.280	108.905	60.700	0.000	144.185	95.980
3	-79	1	105	42.5999985	4395.30322	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	36.840	108.905	60.700	0.000	145.745	97.540
3	-80	1	105	42.5999985	4437.90332	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	38.420	108.905	60.700	0.000	147.325	99.120
3	-81	1	105	42.5999985	4480.50342	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	40.000	108.905	60.700	0.000	148.905	100.700
3	-82	1	105	42.5999985	4523.10352	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	41.580	108.905	60.700	0.000	150.485	102.280
3	-83	1	105	42.5999985	4565.70361	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	43.160	108.905	60.700	0.000	152.065	103.860
3	-84	1	105	42.5999985	4608.30371	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	44.740	108.905	60.700	0.000	153.645	105.440
3	-85	1	105	42.5999985	4650.90381	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	46.320	108.905	60.700	0.000	155.225	107.020
3	-86	1	105	42.5999985	4693.50391	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	47.900	108.905	60.700	0.000	156.805	108.600
3	-87	1	105	42.5999985	4736.104	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	49.480	108.905	60.700	0.000	158.385	110.180
3	-88	1	105	42.5999985	4778.7041	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	51.060	108.905	60.700	0.000	159.965	111.760
3	-89	1	105	42.5999985	4821.3042	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	52.640	108.905	60.700	0.000	161.545	113.340
3	-90	1	105	42.5999985	4863.9043	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	54.220	108.905	60.700	0.000	163.125	114.920
4	-91	1	117	54.5999985	4912.50439	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	54.620	110.298	61.396	0.000	164.918	116.016
4	-92	1	117	54.5999985	4967.10449	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	55.020	111.690	62.092	0.000	166.710	117.112
4	-93	1	117	54.5999985	5021.70459	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	55.420	113.083	62.788	0.000	168.503	118.208
4	-94	1	117	54.5999985	5076.30469	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	55.820	114.475	63.484	0.000	170.295	119.304
4	-95	1	117	54.5999985	5130.90479	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	56.220	115.867	64.181	0.000	172.087	120.401
4	-96	1	117	54.5999985	5185.50488	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	56.620	117.260	64.877	0.000	173.880	121.497
4	-97	1	117	54.5999985	5240.10498	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	57.020	118.652	65.573	0.000	175.672	122.593
4	-98	1	117	54.5999985	5294.70508	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	57.420	120.045	66.269	0.000	177.465	123.689
4	-99	1	117	54.5999985	5349.30518	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	57.820	121.437	66.965	0.000	179.257	124.785
4	-100	1	117	54.5999985	5403.90527	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	58.220	122.829	67.662	0.000	181.049	125.882
4	-101	1	117	54.5999985	5458.50537	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	58.620	124.222	68.358	0.000	182.842	126.978

1017

4	-102	1	117	54.5999685	5513.10547	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	59.020	125.614	69.054	0.000	184.634	128.074
4	-103	1	117	54.5999685	5567.70557	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	59.420	127.006	69.750	0.000	186.427	129.170
4	-104	1	117	54.5999685	5622.30566	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	59.820	128.399	70.446	0.000	188.219	130.266
4	-105	1	117	54.5999685	5676.90576	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	60.220	129.791	71.143	0.000	190.011	131.363
4	-106	1	117	54.5999685	5731.50586	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	60.620	131.184	71.839	0.000	191.804	132.459
4	-107	1	117	54.5999685	5786.10596	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	61.020	132.576	72.535	0.000	193.596	133.555
4	-108	1	117	54.5999685	5840.70605	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	61.420	133.968	73.231	0.000	195.388	134.651
4	-109	1	117	54.5999685	5895.30615	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	61.820	135.361	73.927	0.000	197.181	135.747
4	-110	1	117	54.5999685	5949.90625	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	62.220	136.753	74.623	0.000	198.973	136.844
4	-111	1	117	54.5999685	6004.50635	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	62.620	138.146	75.320	0.000	200.766	137.940
4	-112	1	117	54.5999685	6059.10645	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	63.020	139.538	76.016	0.000	202.558	139.036
4	-113	1	117	54.5999685	6113.70654	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	63.420	140.930	76.712	0.000	204.350	140.132
4	-114	1	117	54.5999685	6168.30664	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	63.820	142.323	77.408	0.000	206.143	141.228
4	-115	1	117	54.5999685	6222.90674	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	64.220	143.715	78.104	0.000	207.935	142.325
4	-116	1	117	54.5999685	6277.50684	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	64.620	145.107	78.801	0.000	209.728	143.421
4	-117	1	117	54.5999685	6332.10693	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	65.020	146.500	79.497	0.000	211.520	144.517
4	-118	1	117	54.5999685	6386.70703	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	65.420	147.892	80.193	0.000	213.312	145.613
4	-119	1	117	54.5999685	6441.30713	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	65.820	149.285	80.889	0.000	215.105	146.709
4	-120	1	117	54.5999685	6495.90723	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	66.220	150.677	81.585	0.000	216.897	147.805
4	-121	1	117	54.5999685	6550.50732	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	66.620	152.069	82.282	0.000	218.690	148.902
4	-122	1	117	54.5999685	6605.10742	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.020	153.462	82.978	0.000	220.482	149.998
4	-123	1	117	54.5999685	6659.70752	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.420	154.854	83.674	0.000	222.274	151.094
4	-124	1	117	54.5999685	6714.30762	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.820	156.246	84.370	0.000	224.067	152.190
4	-125	1	117	54.5999685	6768.90771	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.220	157.639	85.066	0.000	225.859	153.286
4	-126	1	117	54.5999685	6823.50781	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.620	159.031	85.763	0.000	227.651	154.383
4	-127	1	117	54.5999685	6878.10791	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.020	160.424	86.459	0.000	229.444	155.479
4	-128	1	117	54.5999685	6932.70801	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.420	161.816	87.155	0.000	231.236	156.575

1018

760

Boring R-59.75-LU_12x12 Concrete Pile_S-Case

								S-CASE														
Stratum	Tip	Increment	$\gamma_{(weak)}$	$\gamma_{(soft)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.021	0.010	0.000	0.021	0.010
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.084	0.042	0.000	0.084	0.042
1	-1	1	117	54.5999985	136.5	136.5	163.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.189	0.094	0.000	0.189	0.094
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.335	0.168	0.000	0.335	0.168
1	-3	1	117	54.5999985	245.699997	245.699997	273	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.524	0.262	0.000	0.524	0.262
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.755	0.377	0.000	0.755	0.377
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.027	0.513	0.000	1.027	0.513
1	-6	1	117	54.5999985	409.5	409.5	436.800018	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.341	0.671	0.000	1.341	0.671
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.698	0.849	0.000	1.698	0.849
1	-8	1	117	54.5999985	518.700012	518.700012	546	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.096	1.048	0.000	2.096	1.048
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.536	1.268	0.000	2.536	1.268
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.018	1.509	0.000	3.018	1.509
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.542	1.771	0.000	3.542	1.771
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.108	2.054	0.000	4.108	2.054
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.716	2.358	0.000	4.716	2.358
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.365	2.683	0.000	5.365	2.683
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.057	3.029	0.000	6.057	3.029
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.791	3.395	0.000	6.791	3.395
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.566	3.783	0.000	7.566	3.783
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.384	4.192	0.000	8.384	4.192
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	9.243	4.621	0.000	9.243	4.621
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	10.461	5.304	0.000	10.461	5.304
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	11.741	6.020	0.000	11.741	6.020
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	13.083	6.772	0.000	13.083	6.772
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	14.486	7.558	0.000	14.486	7.558
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	15.951	8.378	0.000	15.951	8.378
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	17.478	9.233	0.000	17.478	9.233
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	19.066	10.123	0.000	19.066	10.123
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	20.717	11.047	0.000	20.717	11.047
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	22.429	12.005	0.000	22.429	12.005
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	24.202	12.999	0.000	24.202	12.999
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	26.038	14.026	0.000	26.038	14.026
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	27.935	15.089	0.000	27.935	15.089
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	29.884	16.186	0.000	29.884	16.186
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	31.914	17.317	0.000	31.914	17.317
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	33.996	18.483	0.000	33.996	18.483
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	36.140	19.684	0.000	36.140	19.684
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	38.348	20.919	0.000	38.348	20.919
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	40.613	22.189	0.000	40.613	22.189
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	42.942	23.493	0.000	42.942	23.493
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	45.333	24.832	0.000	45.333	24.832
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	47.786	26.206	0.000	47.786	26.206
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	50.300	27.614	0.000	50.300	27.614
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	52.876	29.056	0.000	52.876	29.056
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	55.514	30.533	0.000	55.514	30.533
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	58.213	32.045	0.000	58.213	32.045
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	60.974	33.591	0.000	60.974	33.591
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	63.797	35.172	0.000	63.797	35.172

1020

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	66.682	36.787	0.000	66.682	36.787
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	69.628	38.437	0.000	69.628	38.437
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	72.636	40.122	0.000	72.636	40.122
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	75.706	41.841	0.000	75.706	41.841
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	78.837	43.594	0.000	78.837	43.594
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	82.031	45.383	0.000	82.031	45.383
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	85.285	47.205	0.000	85.285	47.205
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	88.602	49.063	0.000	88.602	49.063
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	91.980	50.954	0.000	91.980	50.954
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	95.420	52.881	0.000	95.420	52.881
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	98.922	54.842	0.000	98.922	54.842
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	102.486	56.837	0.000	102.486	56.837
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	106.110	58.867	0.000	106.110	58.867
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	109.734	60.897	0.000	109.734	60.897
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	113.359	62.926	0.000	113.359	62.926
3	-62	1	105	42.5999985	3671.10205	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	115.532	64.448	0.000	115.532	64.448
3	-63	1	105	42.5999985	3713.70215	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	117.706	65.969	0.000	117.706	65.969
3	-64	1	105	42.5999985	3756.30225	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	119.880	67.491	0.000	119.880	67.491
3	-65	1	105	42.5999985	3798.90234	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	122.053	69.012	0.000	122.053	69.012
3	-66	1	105	42.5999985	3841.50244	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	124.227	70.534	0.000	124.227	70.534
3	-67	1	105	42.5999985	3884.10254	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	126.400	72.055	0.000	126.400	72.055
3	-68	1	105	42.5999985	3926.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	128.574	73.577	0.000	128.574	73.577
3	-69	1	105	42.5999985	3969.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	130.747	75.098	0.000	130.747	75.098
3	-70	1	105	42.5999985	4011.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	132.921	76.620	0.000	132.921	76.620
3	-71	1	105	42.5999985	4054.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	135.094	78.141	0.000	135.094	78.141
3	-72	1	105	42.5999985	4097.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	137.268	79.663	0.000	137.268	79.663
3	-73	1	105	42.5999985	4139.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	139.442	81.184	0.000	139.442	81.184
3	-74	1	105	42.5999985	4182.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	141.615	82.706	0.000	141.615	82.706
3	-75	1	105	42.5999985	4224.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	143.789	84.227	0.000	143.789	84.227
3	-76	1	105	42.5999985	4267.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	145.962	85.749	0.000	145.962	85.749
3	-77	1	105	42.5999985	4310.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	148.136	87.270	0.000	148.136	87.270
3	-78	1	105	42.5999985	4352.70313	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	150.309	88.792	0.000	150.309	88.792
3	-79	1	105	42.5999985	4395.30322	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	152.483	90.313	0.000	152.483	90.313
3	-80	1	105	42.5999985	4437.90332	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	154.656	91.835	0.000	154.656	91.835
3	-81	1	105	42.5999985	4480.50342	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	156.830	93.356	0.000	156.830	93.356
3	-82	1	105	42.5999985	4523.10352	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	159.003	94.878	0.000	159.003	94.878
3	-83	1	105	42.5999985	4565.70361	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	161.177	96.399	0.000	161.177	96.399
3	-84	1	105	42.5999985	4608.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	163.351	97.921	0.000	163.351	97.921
3	-85	1	105	42.5999985	4650.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	165.524	99.442	0.000	165.524	99.442
3	-86	1	105	42.5999985	4693.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	167.698	100.964	0.000	167.698	100.964
3	-87	1	105	42.5999985	4736.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	169.871	102.485	0.000	169.871	102.485
3	-88	1	105	42.5999985	4778.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	172.045	104.007	0.000	172.045	104.007
3	-89	1	105	42.5999985	4821.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	174.218	105.528	0.000	174.218	105.528
3	-90	1	105	42.5999985	4863.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	176.392	107.050	0.000	176.392	107.050
4	-91	1	117	54.5999985	4912.50439	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	179.079	108.393	0.000	179.079	108.393
4	-92	1	117	54.5999985	4967.10449	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	181.766	109.737	0.000	181.766	109.737
4	-93	1	117	54.5999985	5021.70459	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	184.453	111.080	0.000	184.453	111.080
4	-94	1	117	54.5999985	5076.30469	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	187.140	112.424	0.000	187.140	112.424
4	-95	1	117	54.5999985	5130.90479	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	189.827	113.767	0.000	189.827	113.767
4	-96	1	117	54.5999985	5185.50488	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	192.514	115.111	0.000	192.514	115.111
4	-97	1	117	54.5999985	5240.10498	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	195.201	116.454	0.000	195.201	116.454
4	-98	1	117	54.5999985	5294.70508	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	197.888	117.798	0.000	197.888	117.798
4	-99	1	117	54.5999985	5349.30518	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	200.575	119.141	0.000	200.575	119.141
4	-100	1	117	54.5999985	5403.90527	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	203.262	120.485	0.000	203.262	120.485
4	-101	1	117	54.5999985	5458.50537	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	205.949	121.828	0.000	205.949	121.828

1021

4	-102	1	117	54.5999685	5513.10547	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	208.636	123.172	0.000	208.636	123.172
4	-103	1	117	54.5999685	5567.70557	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	211.323	124.515	0.000	211.323	124.515
4	-104	1	117	54.5999685	5622.30566	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	214.011	125.859	0.000	214.011	125.859
4	-105	1	117	54.5999685	5676.90576	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	216.698	127.202	0.000	216.698	127.202
4	-106	1	117	54.5999685	5731.50586	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	219.385	128.546	0.000	219.385	128.546
4	-107	1	117	54.5999685	5786.10596	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	222.072	129.889	0.000	222.072	129.889
4	-108	1	117	54.5999685	5840.70605	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	224.759	131.233	0.000	224.759	131.233
4	-109	1	117	54.5999685	5895.30615	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	227.446	132.577	0.000	227.446	132.577
4	-110	1	117	54.5999685	5949.90625	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	230.133	133.920	0.000	230.133	133.920
4	-111	1	117	54.5999685	6004.50635	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	232.820	135.264	0.000	232.820	135.264
4	-112	1	117	54.5999685	6059.10645	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	235.507	136.607	0.000	235.507	136.607
4	-113	1	117	54.5999685	6113.70654	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	238.194	137.951	0.000	238.194	137.951
4	-114	1	117	54.5999685	6168.30664	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	240.881	139.294	0.000	240.881	139.294
4	-115	1	117	54.5999685	6222.90674	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	243.568	140.638	0.000	243.568	140.638
4	-116	1	117	54.5999685	6277.50684	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	246.255	141.981	0.000	246.255	141.981
4	-117	1	117	54.5999685	6332.10693	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	248.942	143.325	0.000	248.942	143.325
4	-118	1	117	54.5999685	6386.70703	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	251.629	144.668	0.000	251.629	144.668
4	-119	1	117	54.5999685	6441.30713	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	254.316	146.012	0.000	254.316	146.012
4	-120	1	117	54.5999685	6495.90723	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	257.003	147.355	0.000	257.003	147.355
4	-121	1	117	54.5999685	6550.50732	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	259.690	148.699	0.000	259.690	148.699
4	-122	1	117	54.5999685	6605.10742	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	262.377	150.042	0.000	262.377	150.042
4	-123	1	117	54.5999685	6659.70752	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	265.064	151.386	0.000	265.064	151.386
4	-124	1	117	54.5999685	6714.30762	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	267.751	152.729	0.000	267.751	152.729
4	-125	1	117	54.5999685	6768.90771	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	270.438	154.073	0.000	270.438	154.073
4	-126	1	117	54.5999685	6823.50781	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	273.125	155.416	0.000	273.125	155.416
4	-127	1	117	54.5999685	6878.10791	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	275.813	156.760	0.000	275.813	156.760
4	-128	1	117	54.5999685	6932.70801	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	278.500	158.103	0.000	278.500	158.103

1022

765

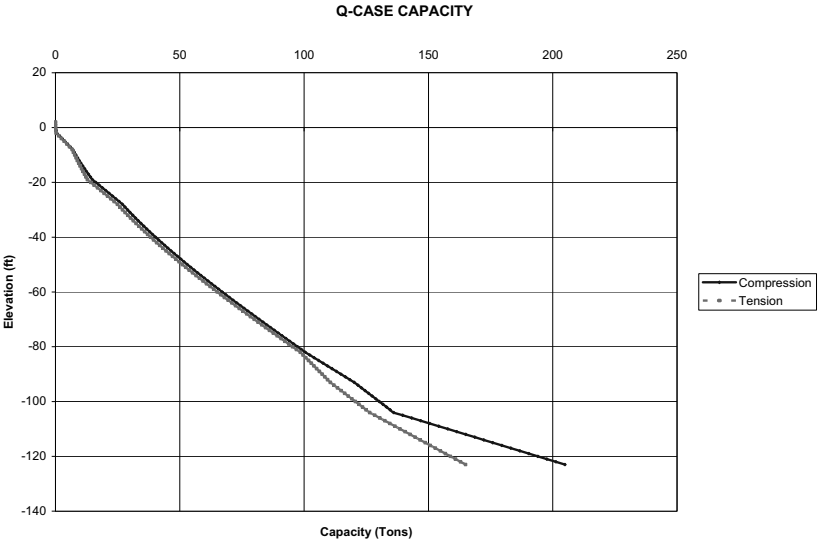
770

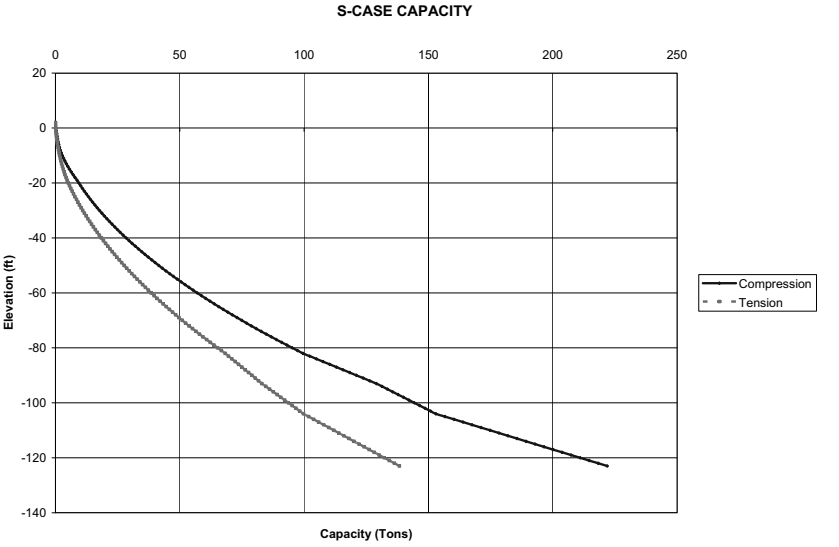
775

780

Boring
R-60.3-UL
12x12 Concrete Pile Capacities

785


Q-CASE CAPACITY
0
50
100
150
200
250
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension


S-CASE CAPACITY
0
50
100
150
200
250
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

Boring R-60.3-UL_12x12 Concrete Pile_Q-Case

								Q-CASE														
Stratum	Tip	Increment	$\gamma_{(moist)}$	$\gamma_{(sub)}$	ΔH	Mid-layer ΔH (used)	Bottom ΔH (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.031	0.017	0.000	0.031	0.017
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.123	0.069	0.000	0.123	0.069
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.278	0.156	0.000	0.278	0.156
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.494	0.276	0.000	0.494	0.276
2	-3	1	107	44.5999985	260.699982	260.699982	283	550	536.25	0	0	1.00	1.00	1.00	9.00	No	1.072	0.494	0.276	0.000	1.566	1.349
2	-4	1	107	44.5999985	305.299988	305.299988	327.800006	550	536.25	0	0	1.00	1.00	1.00	9.00	No	2.145	0.494	0.276	0.000	2.639	2.421
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	550	536.25	0	0	1.00	1.00	1.00	9.00	No	3.217	0.494	0.276	0.000	3.711	3.494
2	-6	1	107	44.5999985	394.5	394.5	416.800018	550	536.25	0	0	1.00	1.00	1.00	9.00	No	4.290	0.494	0.276	0.000	4.784	4.566
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	550	536.25	0	0	1.00	1.00	1.00	9.00	No	5.363	0.494	0.276	0.000	5.856	5.639
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	550	536.25	0	0	1.00	1.00	1.00	9.00	No	6.435	0.494	0.276	0.000	6.929	6.711
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.835	0.706	0.383	0.000	7.541	7.218
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.235	0.940	0.500	0.000	8.175	7.735
3	-11	1	117	54.5999985	642.5	642.5	669.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.635	1.195	0.627	0.000	8.830	8.262
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.035	1.473	0.766	0.000	9.508	8.801
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.435	1.772	0.916	0.000	10.207	9.351
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.835	2.093	1.076	0.000	10.928	9.911
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.235	2.435	1.247	0.000	11.670	10.482
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.635	2.799	1.429	0.000	12.434	11.084
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.035	3.185	1.622	0.000	13.220	11.657
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99968	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.435	3.593	1.826	0.000	14.028	12.261
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.835	4.022	2.041	0.000	14.857	12.876
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	12.177	4.022	2.041	0.000	16.199	14.217
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	13.518	4.022	2.041	0.000	17.540	15.559
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	14.860	4.022	2.041	0.000	18.882	16.901
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	16.201	4.022	2.041	0.000	20.224	18.242
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	17.543	4.022	2.041	0.000	21.565	19.584
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	18.885	4.022	2.041	0.000	22.907	20.925
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	20.226	4.022	2.041	0.000	24.248	22.267
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	21.568	4.022	2.041	0.000	25.590	23.609
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	22.909	4.022	2.041	0.000	26.932	24.950
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59981	512.962952	504.819092	0	0	1.00	1.00	1.00	9.00	No	23.919	4.022	2.041	0.000	27.941	25.960
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	525.925903	514.373291	0	0	1.00	1.00	1.00	9.00	No	24.948	4.022	2.041	0.000	28.970	26.988
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	538.888916	523.756399	0	0	1.00	1.00	1.00	9.00	No	25.995	4.022	2.041	0.000	30.017	28.036
5	-32	1	101	38.5999985	1589.09961	1589.09961	1608.39954	551.851868	532.977539	0	0	1.00	1.00	1.00	9.00	No	27.061	4.022	2.041	0.000	31.083	29.102
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	564.814819	542.027588	0	0	1.00	1.00	1.00	9.00	No	28.145	4.022	2.041	0.000	32.167	30.186
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	577.777771	550.909668	0	0	1.00	1.00	1.00	9.00	No	29.247	4.022	2.041	0.000	33.269	31.288
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	590.740723	559.623657	0	0	1.00	1.00	1.00	9.00	No	30.366	4.022	2.041	0.000	34.389	32.407
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	603.703674	568.169556	0	0	1.00	1.00	1.00	9.00	No	31.503	4.022	2.041	0.000	35.525	33.543
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	616.666687	576.547485	0	0	1.00	1.00	1.00	9.00	No	32.656	4.022	2.041	0.000	36.678	34.697
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	629.629639	584.757385	0	0	1.00	1.00	1.00	9.00	No	33.825	4.022	2.041	0.000	37.847	35.866
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	642.59259	592.799194	0	0	1.00	1.00	1.00	9.00	No	35.011	4.022	2.041	0.000	39.033	37.052
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	655.555542	600.672974	0	0	1.00	1.00	1.00	9.00	No	36.212	4.022	2.041	0.000	40.234	38.253
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	668.518494	608.378784	0	0	1.00	1.00	1.00	9.00	No	37.429	4.022	2.041	0.000	41.451	39.470
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	681.481506	615.916504	0	0	1.00	1.00	1.00	9.00	No	38.661	4.022	2.041	0.000	42.683	40.702
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	694.444458	623.286194	0	0	1.00	1.00	1.00	9.00	No	39.907	4.022	2.041	0.000	43.930	41.948
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	707.40741	630.487793	0	0	1.00	1.00	1.00	9.00	No	41.168	4.022	2.041	0.000	45.191	43.209
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	720.370361	637.521423	0	0	1.00	1.00	1.00	9.00	No	42.443	4.022	2.041	0.000	46.466	44.484
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	733.333313	644.386963	0	0	1.00	1.00	1.00	9.00	No	43.732	4.022	2.041	0.000	47.754	45.773

1026

5	-47	1	101	38.5999985	2168.09961	2168.09961	2187.39966	746.296326	651.084534	0	0	1.00	1.00	1.00	9.00	No	45.034	4.022	2.041	0.000	49.057	47.075
5	-48	1	101	38.5999985	2206.69971	2206.69971	2225.99976	759.259277	657.614014	0	0	1.00	1.00	1.00	9.00	No	46.350	4.022	2.041	0.000	50.372	48.390
5	-49	1	101	38.5999985	2245.2998	2245.2998	2264.59985	772.222229	663.975464	0	0	1.00	1.00	1.00	9.00	No	47.678	4.022	2.041	0.000	51.700	49.718
5	-50	1	101	38.5999985	2283.8999	2283.8999	2303.19995	785.185181	670.168884	0	0	1.00	1.00	1.00	9.00	No	49.018	4.022	2.041	0.000	53.040	51.059
5	-51	1	101	38.5999985	2322.5	2322.5	2341.80005	798.148132	676.194214	0	0	1.00	1.00	1.00	9.00	No	50.370	4.022	2.041	0.000	54.392	52.411
5	-52	1	101	38.5999985	2361.1001	2361.1001	2380.40015	811.111084	682.051575	0	0	1.00	1.00	1.00	9.00	No	51.734	4.022	2.041	0.000	55.757	53.775
5	-53	1	101	38.5999985	2399.7002	2399.7002	2419.00024	824.074097	687.740906	0	0	1.00	1.00	1.00	9.00	No	53.110	4.022	2.041	0.000	57.132	55.151
5	-54	1	101	38.5999985	2438.30029	2438.30029	2457.60034	837.037048	693.262207	0	0	1.00	1.00	1.00	9.00	No	54.496	4.022	2.041	0.000	58.519	56.537
5	-55	1	101	38.5999985	2476.90039	2476.90039	2496.20044	850	698.615356	0	0	1.00	1.00	1.00	9.00	No	55.894	4.022	2.041	0.000	59.916	57.934
5	-56	1	101	38.5999985	2515.50049	2515.50049	2534.80054	862.962952	703.800537	0	0	1.00	1.00	1.00	9.00	No	57.301	4.022	2.041	0.000	61.323	59.342
5	-57	1	101	38.5999985	2554.10059	2554.10059	2573.40063	875.925903	708.817749	0	0	1.00	1.00	1.00	9.00	No	58.719	4.022	2.041	0.000	62.741	60.760
5	-58	1	101	38.5999985	2592.70068	2592.70068	2612.00073	888.888916	713.66687	0	0	1.00	1.00	1.00	9.00	No	60.146	4.022	2.041	0.000	64.168	62.187
5	-59	1	101	38.5999985	2631.30078	2631.30078	2650.60083	901.851868	718.3479	0	0	1.00	1.00	1.00	9.00	No	61.583	4.022	2.041	0.000	65.605	63.624
5	-60	1	101	38.5999985	2669.90088	2669.90088	2689.20093	914.814819	722.880962	0	0	1.00	1.00	1.00	9.00	No	63.029	4.022	2.041	0.000	67.051	65.069
5	-61	1	101	38.5999985	2708.50098	2708.50098	2727.80103	927.777771	727.205933	0	0	1.00	1.00	1.00	9.00	No	64.483	4.022	2.041	0.000	68.505	66.524
5	-62	1	101	38.5999985	2747.10107	2747.10107	2766.40112	940.740723	731.382874	0	0	1.00	1.00	1.00	9.00	No	65.946	4.022	2.041	0.000	69.968	67.987
5	-63	1	101	38.5999985	2785.70117	2785.70117	2805.00122	953.703674	735.391785	0	0	1.00	1.00	1.00	9.00	No	67.417	4.022	2.041	0.000	71.439	69.457
5	-64	1	101	38.5999985	2824.30127	2824.30127	2843.60132	966.666687	739.232666	0	0	1.00	1.00	1.00	9.00	No	68.895	4.022	2.041	0.000	72.917	70.936
5	-65	1	101	38.5999985	2862.90137	2862.90137	2882.20142	979.629639	742.905518	0	0	1.00	1.00	1.00	9.00	No	70.381	4.022	2.041	0.000	74.403	72.422
5	-66	1	101	38.5999985	2901.50146	2901.50146	2920.80151	992.59259	746.410339	0	0	1.00	1.00	1.00	9.00	No	71.874	4.022	2.041	0.000	75.896	73.914
5	-67	1	101	38.5999985	2940.10156	2940.10156	2959.40161	1005.55554	749.74707	0	0	1.00	1.00	1.00	9.00	No	73.373	4.022	2.041	0.000	77.395	75.414
5	-68	1	101	38.5999985	2978.70166	2978.70166	2998.00171	1018.51849	752.915771	0	0	1.00	1.00	1.00	9.00	No	74.879	4.022	2.041	0.000	78.901	76.920
5	-69	1	101	38.5999985	3017.30176	3017.30176	3036.60181	1031.48145	755.916504	0	0	1.00	1.00	1.00	9.00	No	76.391	4.022	2.041	0.000	80.413	78.432
5	-70	1	101	38.5999985	3055.90186	3055.90186	3075.2019	1044.44448	758.749146	0	0	1.00	1.00	1.00	9.00	No	77.908	4.022	2.041	0.000	81.931	79.949
5	-71	1	101	38.5999985	3094.50195	3094.50195	3113.802	1057.40735	761.413757	0	0	1.00	1.00	1.00	9.00	No	79.431	4.022	2.041	0.000	83.453	81.472
5	-72	1	101	38.5999985	3133.10205	3133.10205	3152.4021	1070.37036	763.910278	0	0	1.00	1.00	1.00	9.00	No	80.959	4.022	2.041	0.000	84.981	83.000
5	-73	1	101	38.5999985	3171.70215	3171.70215	3191.0022	1083.33337	766.238892	0	0	1.00	1.00	1.00	9.00	No	82.491	4.022	2.041	0.000	86.514	84.532
5	-74	1	101	38.5999985	3210.30225	3210.30225	3229.60229	1096.29626	768.396353	0	0	1.00	1.00	1.00	9.00	No	84.028	4.022	2.041	0.000	88.050	86.069
5	-75	1	101	38.5999985	3248.90234	3248.90234	3268.20239	1109.25928	770.391785	0	0	1.00	1.00	1.00	9.00	No	85.569	4.022	2.041	0.000	89.591	87.610
5	-76	1	101	38.5999985	3287.50244	3287.50244	3306.80249	1122.22217	772.216187	0	0	1.00	1.00	1.00	9.00	No	87.113	4.022	2.041	0.000	91.136	89.154
5	-77	1	101	38.5999985	3326.10254	3326.10254	3345.40259	1135.18518	773.872559	0	0	1.00	1.00	1.00	9.00	No	88.661	4.022	2.041	0.000	92.683	90.702
5	-78	1	101	38.5999985	3364.70264	3364.70264	3384.00269	1148.14819	775.360962	0	0	1.00	1.00	1.00	9.00	No	90.212	4.022	2.041	0.000	94.234	92.253
5	-79	1	101	38.5999985	3403.30273	3403.30273	3422.60278	1161.11108	776.681274	0	0	1.00	1.00	1.00	9.00	No	91.765	4.022	2.041	0.000	95.787	93.806
5	-80	1	101	38.5999985	3441.90283	3441.90283	3461.20288	1174.0741	777.833496	0	0	1.00	1.00	1.00	9.00	No	93.321	4.022	2.041	0.000	97.343	95.362
5	-81	1	101	38.5999985	3480.50293	3480.50293	3499.80298	1187.03699	778.817749	0	0	1.00	1.00	1.00	9.00	No	94.879	4.022	2.041	0.000	98.901	96.919
5	-82	1	101	38.5999985	3519.10303	3500	3500	1200	779.633911	0	0	1.00	1.00	1.00	9.00	No	96.438	4.022	2.041	0.000	100.460	98.479
6	-83	1	117	54.5999985	3585.70313	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	96.838	5.415	2.737	0.000	102.252	99.575
6	-84	1	117	54.5999985	3620.30322	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	97.238	6.807	3.433	0.000	104.045	100.671
6	-85	1	117	54.5999985	3674.90332	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	97.838	8.199	4.129	0.000	105.837	101.767
6	-86	1	117	54.5999985	3729.50342	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	98.038	9.592	4.825	0.000	107.630	102.863
6	-87	1	117	54.5999985	3784.10352	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	98.438	10.984	5.522	0.000	109.422	103.960
6	-88	1	117	54.5999985	3838.70361	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	98.838	12.376	6.218	0.000	111.214	105.056
6	-89	1	117	54.5999985	3893.30371	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	99.238	13.769	6.914	0.000	113.007	106.152
6	-90	1	117	54.5999985	3947.90381	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	99.638	15.161	7.610	0.000	114.799	107.248
6	-91	1	117	54.5999985	4002.50391	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.038	16.554	8.306	0.000	116.592	108.344
6	-92	1	117	54.5999985	4057.104	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.438	17.946	9.003	0.000	118.384	109.441
6	-93	1	117	54.5999985	4111.7041	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.838	19.338	9.699	0.000	120.176	110.537
7	-94	1	115	52.5999985	4165.30371	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	102.278	19.338	9.699	0.000	121.616	111.977
7	-95	1	115	52.5999985	4217.90381	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	103.718	19.338	9.699	0.000	123.056	113.417
7	-96	1	115	52.5999985	4270.50391	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	105.158	19.338	9.699	0.000	124.496	114.857
7	-97	1	115	52.5999985	4323.104	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	106.598	19.338	9.699	0.000	125.936	116.297
7	-98	1	115	52.5999985	4375.7041	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	108.038	19.338	9.699	0.000	127.376	117.737
7	-99	1	115	52.5999985	4428.3042	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	109.478	19.338	9.699	0.000	128.816	119.177
7	-100	1	115	52.5999985	4480.9043	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	110.918	19.338	9.699	0.000	130.256	120.617
7	-101	1	115	52.5999985	4533.50439	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	112.358	19.338	9.699	0.000	131.696	122.057

1027

7	-102	1	115	52.5999985	4586.10449	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	113.798	19.338	9.699	0.000	133.136	123.497
7	-103	1	115	52.5999985	4838.70459	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	115.238	19.338	9.699	0.000	134.576	124.937
7	-104	1	115	52.5999985	4691.30469	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	116.678	19.338	9.699	0.000	136.016	126.377
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	22.963	11.728	0.000	139.641	128.406
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	26.587	13.758	0.000	143.265	130.436
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	30.212	15.788	0.000	146.889	132.466
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	33.836	17.817	0.000	150.514	134.495
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	37.460	19.847	0.000	154.138	136.525
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	41.085	21.877	0.000	157.763	138.555
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	44.709	23.906	0.000	161.387	140.584
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	48.333	25.936	0.000	165.011	142.614
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	51.958	27.966	0.000	168.636	144.644
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	55.582	29.995	0.000	172.260	146.673
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	59.206	32.025	0.000	175.884	148.703
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	62.831	34.055	0.000	179.509	150.732
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	66.455	36.084	0.000	183.133	152.762
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	70.080	38.114	0.000	186.758	154.792
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	73.704	40.144	0.000	190.382	156.821
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	77.328	42.173	0.000	194.006	158.851
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	80.953	44.203	0.000	197.631	160.881
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	84.577	46.232	0.000	201.255	162.910
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	116.678	88.201	48.262	0.000	204.879	164.940
4	-124	1	117	54.5999985	6714.30762	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.820	156.246	84.370	0.000	224.067	152.190
4	-125	1	117	54.5999985	6768.90771	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.220	157.639	85.066	0.000	225.859	153.286
4	-126	1	117	54.5999985	6823.50781	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.620	159.031	85.763	0.000	227.651	154.383
4	-127	1	117	54.5999985	6878.10791	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.020	160.424	86.459	0.000	229.444	155.479
4	-128	1	117	54.5999985	6932.70801	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.420	161.816	87.155	0.000	231.236	156.575

1028

790

Boring R-60.3-UL_12x12 Concrete Pile_S-Case

S-CASE

Stratum	Tip	Increment	$\gamma_{(saat)}$	$\gamma_{(sat)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.031	0.017	0.000	0.031	0.017
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.123	0.069	0.000	0.123	0.069
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.278	0.156	0.000	0.278	0.156
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.494	0.276	0.000	0.494	0.276
2	-3	1	107	44.5999985	260.699982	260.699982	283	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	0.656	0.390	0.000	0.656	0.390
2	-4	1	107	44.5999985	305.299988	305.299988	327.600006	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	0.845	0.523	0.000	0.845	0.523
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.063	0.675	0.000	1.063	0.675
2	-6	1	107	44.5999985	394.5	394.5	416.800018	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.308	0.846	0.000	1.308	0.846
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.580	1.037	0.000	1.580	1.037
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.881	1.247	0.000	1.881	1.247
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.290	1.452	0.000	2.290	1.452
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.741	1.678	0.000	2.741	1.678
3	-11	1	117	54.5999985	642.5	642.5	669.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.235	1.924	0.000	3.235	1.924
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.770	2.192	0.000	3.770	2.192
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.347	2.480	0.000	4.347	2.480
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.966	2.790	0.000	4.966	2.790
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.627	3.120	0.000	5.627	3.120
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.330	3.472	0.000	6.330	3.472
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.075	3.844	0.000	7.075	3.844
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.861	4.238	0.000	7.861	4.238
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.690	4.652	0.000	8.690	4.652
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	9.389	5.141	0.000	9.389	5.141
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	10.112	5.648	0.000	10.112	5.648
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	10.859	6.171	0.000	10.859	6.171
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	11.630	6.710	0.000	11.630	6.710
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	12.426	7.267	0.000	12.426	7.267
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	13.245	7.840	0.000	13.245	7.840
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	14.088	8.430	0.000	14.088	8.430
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	14.955	9.037	0.000	14.955	9.037
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	15.846	9.661	0.000	15.846	9.661
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59961	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	16.761	10.301	0.000	16.761	10.301
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	17.699	10.959	0.000	17.699	10.959
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	18.662	11.633	0.000	18.662	11.633
5	-32	1	101	38.5999985	1589.09961	1589.09961	1608.39954	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	19.649	12.323	0.000	19.649	12.323
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	20.660	13.031	0.000	20.660	13.031
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	21.695	13.755	0.000	21.695	13.755
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	22.754	14.497	0.000	22.754	14.497
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	23.836	15.254	0.000	23.836	15.254
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	24.943	16.029	0.000	24.943	16.029
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	26.074	16.821	0.000	26.074	16.821
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	27.228	17.629	0.000	27.228	17.629
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	28.407	18.454	0.000	28.407	18.454
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	29.610	19.296	0.000	29.610	19.296
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	30.836	20.154	0.000	30.836	20.154
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	32.087	21.030	0.000	32.087	21.030
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	33.361	21.922	0.000	33.361	21.922
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	34.660	22.831	0.000	34.660	22.831
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	35.982	23.757	0.000	35.982	23.757

1029

5	-47	1	101	38.5999985	2168.09961	2168.09961	2187.39996	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	37.329	24.699	0.000	37.329	24.699
5	-48	1	101	38.5999985	2206.69971	2206.69971	2225.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	38.699	25.658	0.000	38.699	25.658
5	-49	1	101	38.5999985	2245.2998	2245.2998	2264.59985	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	40.093	26.634	0.000	40.093	26.634
5	-50	1	101	38.5999985	2283.8999	2283.8999	2303.19995	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	41.512	27.627	0.000	41.512	27.627
5	-51	1	101	38.5999985	2322.5	2322.5	2341.80005	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	42.954	28.637	0.000	42.954	28.637
5	-52	1	101	38.5999985	2361.1001	2361.1001	2380.40015	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	44.420	29.663	0.000	44.420	29.663
5	-53	1	101	38.5999985	2399.7002	2399.7002	2419.00024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	45.911	30.706	0.000	45.911	30.706
5	-54	1	101	38.5999985	2438.30029	2438.30029	2457.60034	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	47.425	31.766	0.000	47.425	31.766
5	-55	1	101	38.5999985	2476.90039	2476.90039	2496.20044	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	48.963	32.843	0.000	48.963	32.843
5	-56	1	101	38.5999985	2515.50049	2515.50049	2534.80054	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	50.525	33.937	0.000	50.525	33.937
5	-57	1	101	38.5999985	2554.10059	2554.10059	2573.40063	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	52.111	35.047	0.000	52.111	35.047
5	-58	1	101	38.5999985	2592.70068	2592.70068	2612.00073	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	53.721	36.174	0.000	53.721	36.174
5	-59	1	101	38.5999985	2631.30078	2631.30078	2650.60083	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	55.355	37.318	0.000	55.355	37.318
5	-60	1	101	38.5999985	2669.90088	2669.90088	2689.20093	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	57.014	38.478	0.000	57.014	38.478
5	-61	1	101	38.5999985	2708.50098	2708.50098	2727.80103	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	58.696	39.656	0.000	58.696	39.656
5	-62	1	101	38.5999985	2747.10107	2747.10107	2766.40112	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	60.402	40.850	0.000	60.402	40.850
5	-63	1	101	38.5999985	2785.70117	2785.70117	2805.00122	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	62.132	42.061	0.000	62.132	42.061
5	-64	1	101	38.5999985	2824.30127	2824.30127	2843.60132	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	63.885	43.289	0.000	63.885	43.289
5	-65	1	101	38.5999985	2862.90137	2862.90137	2882.20142	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	65.663	44.533	0.000	65.663	44.533
5	-66	1	101	38.5999985	2901.50146	2901.50146	2920.80151	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	67.465	45.795	0.000	67.465	45.795
5	-67	1	101	38.5999985	2940.10156	2940.10156	2959.40161	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	69.291	47.073	0.000	69.291	47.073
5	-68	1	101	38.5999985	2978.70166	2978.70166	2998.00171	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	71.141	48.368	0.000	71.141	48.368
5	-69	1	101	38.5999985	3017.30176	3017.30176	3036.60181	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	73.015	49.679	0.000	73.015	49.679
5	-70	1	101	38.5999985	3055.90186	3055.90186	3075.2019	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	74.912	51.008	0.000	74.912	51.008
5	-71	1	101	38.5999985	3094.50195	3094.50195	3113.802	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	76.834	52.353	0.000	76.834	52.353
5	-72	1	101	38.5999985	3133.10205	3133.10205	3152.4021	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	78.780	53.715	0.000	78.780	53.715
5	-73	1	101	38.5999985	3171.70215	3171.70215	3191.0022	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	80.750	55.094	0.000	80.750	55.094
5	-74	1	101	38.5999985	3210.30225	3210.30225	3229.60229	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	82.743	56.489	0.000	82.743	56.489
5	-75	1	101	38.5999985	3248.90234	3248.90234	3268.20239	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	84.761	57.902	0.000	84.761	57.902
5	-76	1	101	38.5999985	3287.50244	3287.50244	3306.80249	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	86.802	59.331	0.000	86.802	59.331
5	-77	1	101	38.5999985	3326.10254	3326.10254	3345.40259	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	88.868	60.777	0.000	88.868	60.777
5	-78	1	101	38.5999985	3364.70264	3364.70264	3384.00269	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	90.958	62.239	0.000	90.958	62.239
5	-79	1	101	38.5999985	3403.30273	3403.30273	3422.60278	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	93.071	63.719	0.000	93.071	63.719
5	-80	1	101	38.5999985	3441.90283	3441.90283	3461.20288	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	95.209	65.215	0.000	95.209	65.215
5	-81	1	101	38.5999985	3480.50293	3480.50293	3499.80298	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	97.370	66.728	0.000	97.370	66.728
5	-82	1	101	38.5999985	3519.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	99.544	68.250	0.000	99.544	68.250
6	-83	1	117	54.5999985	3565.70313	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	102.231	69.593	0.000	102.231	69.593
6	-84	1	117	54.5999985	3620.30322	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	104.918	70.937	0.000	104.918	70.937
6	-85	1	117	54.5999985	3674.90332	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	107.605	72.280	0.000	107.605	72.280
6	-86	1	117	54.5999985	3729.50342	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	110.292	73.624	0.000	110.292	73.624
6	-87	1	117	54.5999985	3784.10352	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	112.979	74.967	0.000	112.979	74.967
6	-88	1	117	54.5999985	3838.70361	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	115.666	76.311	0.000	115.666	76.311
6	-89	1	117	54.5999985	3893.30371	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	118.353	77.654	0.000	118.353	77.654
6	-90	1	117	54.5999985	3947.90381	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	121.040	78.998	0.000	121.040	78.998
6	-91	1	117	54.5999985	4002.50391	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	123.727	80.341	0.000	123.727	80.341
6	-92	1	117	54.5999985	4057.104	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	126.414	81.685	0.000	126.414	81.685
6	-93	1	117	54.5999985	4111.7041	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	129.101	83.028	0.000	129.101	83.028
7	-94	1	115	52.5999985	4165.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	131.275	84.550	0.000	131.275	84.550
7	-95	1	115	52.5999985	4217.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	133.448	86.071	0.000	133.448	86.071
7	-96	1	115	52.5999985	4270.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	135.622	87.593	0.000	135.622	87.593
7	-97	1	115	52.5999985	4323.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	137.795	89.114	0.000	137.795	89.114
7	-98	1	115	52.5999985	4375.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	139.969	90.636	0.000	139.969	90.636
7	-99	1	115	52.5999985	4428.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	142.142	92.157	0.000	142.142	92.157
7	-100	1	115	52.5999985	4480.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	144.316	93.679	0.000	144.316	93.679
7	-101	1	115	52.5999985	4533.50439	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	146.490	95.200	0.000	146.490	95.200

1030

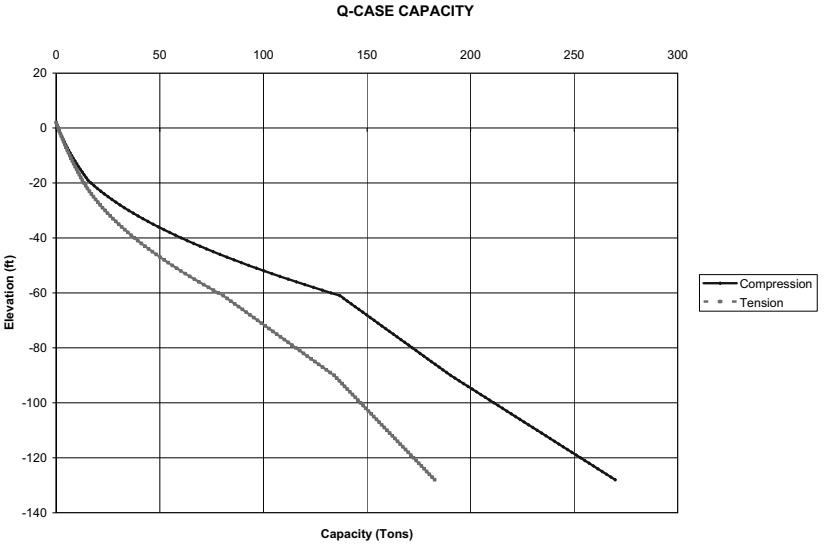
7	-102	1	115	52.5999985	4586.10449	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	148.663	96.722	0.000	148.663	96.722
7	-103	1	115	52.5999985	4638.70459	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	150.837	98.243	0.000	150.837	98.243
7	-104	1	115	52.5999985	4691.30469	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	153.010	99.765	0.000	153.010	99.765
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	156.635	101.794	0.000	156.635	101.794
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	160.259	103.824	0.000	160.259	103.824
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	163.883	105.854	0.000	163.883	105.854
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	167.508	107.883	0.000	167.508	107.883
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	171.132	109.913	0.000	171.132	109.913
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	174.756	111.943	0.000	174.756	111.943
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	178.381	113.972	0.000	178.381	113.972
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	182.005	116.002	0.000	182.005	116.002
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	185.630	118.031	0.000	185.630	118.031
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	189.254	120.061	0.000	189.254	120.061
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	192.878	122.091	0.000	192.878	122.091
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	196.503	124.120	0.000	196.503	124.120
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	200.127	126.150	0.000	200.127	126.150
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	203.751	128.180	0.000	203.751	128.180
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	207.376	130.209	0.000	207.376	130.209
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	211.000	132.239	0.000	211.000	132.239
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	214.625	134.269	0.000	214.625	134.269
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	218.249	136.298	0.000	218.249	136.298
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	221.873	138.328	0.000	221.873	138.328

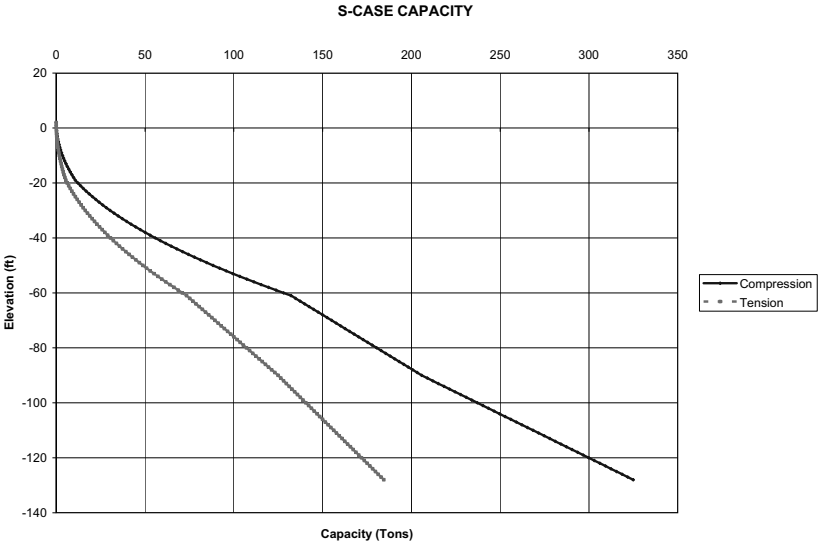
795

800

805

Boring
810 **R-59.75-LU**
14x14 Concrete Pile Capacities


Q-CASE CAPACITY
0
50
100
150
200
250
300
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension


S-CASE CAPACITY
0
50
100
150
200
250
300
350
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

Boring R-59.75-LU_14x14 Concrete Pile_Q-Case

								Q-CASE															
Stratum	Tip	Increment	$\gamma_{pervious}$	γ_{Undrn}	γ_{fs}	Mid-layer γ_{fs} (used)	Bottom γ_{fs} (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.467	0.013	0.006	0.000	0.479	0.473
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.933	0.051	0.025	0.000	0.984	0.959
1	-1	1	117	54.5999985	136.5	136.5	163.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.400	0.114	0.057	0.000	1.514	1.457
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.867	0.203	0.101	0.000	2.069	1.968
1	-3	1	117	54.5999985	245.699997	245.699997	273	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.333	0.317	0.158	0.000	2.650	2.492
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.800	0.456	0.228	0.000	3.256	3.028
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.267	0.621	0.310	0.000	3.888	3.577
1	-6	1	117	54.5999985	409.5	409.5	436.800018	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.733	0.811	0.405	0.000	4.544	4.139
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.200	1.026	0.513	0.000	5.226	4.713
1	-8	1	117	54.5999985	518.700012	518.700012	546	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.667	1.267	0.634	0.000	5.934	5.300
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.133	1.533	0.767	0.000	6.666	5.900
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.600	1.825	0.912	0.000	7.425	6.512
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.067	2.141	1.071	0.000	8.208	7.137
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.533	2.483	1.242	0.000	9.017	7.775
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.000	2.851	1.425	0.000	9.851	8.425
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.467	3.244	1.622	0.000	10.710	9.089
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.933	3.662	1.831	0.000	11.595	9.764
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.400	4.105	2.053	0.000	12.505	10.453
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.867	4.574	2.287	0.000	13.441	11.154
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.333	5.068	2.534	0.000	14.402	11.867
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.800	5.588	2.794	0.000	15.388	12.594
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	7.009	3.590	0.000	16.809	13.390
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	8.502	4.426	0.000	18.302	14.226
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	10.068	5.303	0.000	19.868	15.103
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	11.705	6.219	0.000	21.505	16.019
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	13.414	7.177	0.000	23.214	16.977
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	15.195	8.174	0.000	24.995	17.974
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	17.049	9.212	0.000	26.849	19.012
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	18.974	10.290	0.000	28.774	20.090
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	20.971	11.409	0.000	30.771	21.209
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	23.040	12.567	0.000	32.840	22.367
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	25.182	13.766	0.000	34.982	23.566
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	27.395	15.006	0.000	37.195	24.806
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	29.680	16.286	0.000	39.480	26.086
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	32.037	17.606	0.000	41.837	27.406
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	34.467	18.966	0.000	44.267	28.766
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	36.968	20.367	0.000	46.768	30.167
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	39.541	21.808	0.000	49.341	31.608
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	42.187	23.289	0.000	51.987	33.089
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	44.904	24.811	0.000	54.704	34.611
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	47.693	26.373	0.000	57.493	36.173
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	50.555	27.975	0.000	60.355	37.775
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	53.488	29.618	0.000	63.288	39.418
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	56.493	31.301	0.000	66.293	41.101
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	59.571	33.024	0.000	69.371	42.824
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	62.720	34.788	0.000	72.520	44.588
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	65.941	36.592	0.000	75.741	46.392
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	69.235	38.436	0.000	79.035	48.236

1035

815

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	72.600	40.321	0.000	82.400	50.121
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	76.037	42.246	0.000	85.837	52.046
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	79.547	44.211	0.000	89.347	54.011
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	83.128	46.216	0.000	92.928	56.016
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	86.781	48.262	0.000	96.581	58.062
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	90.507	50.349	0.000	100.307	60.148
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	94.304	52.475	0.000	104.104	62.275
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	98.173	54.642	0.000	107.973	64.442
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	102.115	56.849	0.000	111.915	66.649
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	106.128	59.097	0.000	115.928	68.897
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	110.214	61.384	0.000	120.014	71.184
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	114.371	63.713	0.000	124.171	73.513
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	118.599	66.080	0.000	128.399	75.880
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	122.828	68.448	0.000	132.628	78.248
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.800	127.056	70.816	0.000	136.856	80.616
3	-62	1	105	42.5999985	3671.10205	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	11.643	127.056	70.816	0.000	138.700	82.460
3	-63	1	105	42.5999985	3713.70215	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	13.487	127.056	70.816	0.000	140.543	84.303
3	-64	1	105	42.5999985	3756.30225	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	15.330	127.056	70.816	0.000	142.386	86.146
3	-65	1	105	42.5999985	3798.90234	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	17.173	127.056	70.816	0.000	144.230	87.990
3	-66	1	105	42.5999985	3841.50244	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	19.017	127.056	70.816	0.000	146.073	89.833
3	-67	1	105	42.5999985	3884.10254	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	20.860	127.056	70.816	0.000	147.916	91.676
3	-68	1	105	42.5999985	3926.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	22.703	127.056	70.816	0.000	149.760	93.520
3	-69	1	105	42.5999985	3969.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	24.547	127.056	70.816	0.000	151.603	95.363
3	-70	1	105	42.5999985	4011.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	26.390	127.056	70.816	0.000	153.446	97.206
3	-71	1	105	42.5999985	4054.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	28.233	127.056	70.816	0.000	155.290	99.050
3	-72	1	105	42.5999985	4097.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	30.077	127.056	70.816	0.000	157.133	100.893
3	-73	1	105	42.5999985	4139.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	31.920	127.056	70.816	0.000	158.976	102.736
3	-74	1	105	42.5999985	4182.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	33.763	127.056	70.816	0.000	160.820	104.580
3	-75	1	105	42.5999985	4224.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	35.607	127.056	70.816	0.000	162.663	106.423
3	-76	1	105	42.5999985	4267.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	37.450	127.056	70.816	0.000	164.506	108.266
3	-77	1	105	42.5999985	4310.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	39.293	127.056	70.816	0.000	166.350	110.110
3	-78	1	105	42.5999985	4352.70313	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	41.137	127.056	70.816	0.000	168.193	111.953
3	-79	1	105	42.5999985	4395.30322	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	42.980	127.056	70.816	0.000	170.036	113.796
3	-80	1	105	42.5999985	4437.90332	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	44.823	127.056	70.816	0.000	171.880	115.640
3	-81	1	105	42.5999985	4480.50342	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	46.667	127.056	70.816	0.000	173.723	117.483
3	-82	1	105	42.5999985	4523.10352	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	48.510	127.056	70.816	0.000	175.566	119.326
3	-83	1	105	42.5999985	4565.70361	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	50.353	127.056	70.816	0.000	177.410	121.170
3	-84	1	105	42.5999985	4608.30371	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	52.197	127.056	70.816	0.000	179.253	123.013
3	-85	1	105	42.5999985	4650.90381	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	54.040	127.056	70.816	0.000	181.096	124.856
3	-86	1	105	42.5999985	4693.50391	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	55.883	127.056	70.816	0.000	182.940	126.700
3	-87	1	105	42.5999985	4736.104	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	57.727	127.056	70.816	0.000	184.783	128.543
3	-88	1	105	42.5999985	4778.7041	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	59.570	127.056	70.816	0.000	186.626	130.386
3	-89	1	105	42.5999985	4821.3042	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	61.413	127.056	70.816	0.000	188.470	132.230
3	-90	1	105	42.5999985	4863.9043	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	63.257	127.056	70.816	0.000	190.313	134.073
4	-91	1	117	54.5999985	4912.50439	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	63.723	128.681	71.829	0.000	192.404	135.352
4	-92	1	117	54.5999985	4967.10449	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	64.190	130.305	72.441	0.000	194.495	136.631
4	-93	1	117	54.5999985	5021.70459	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	64.657	131.930	73.253	0.000	196.586	137.910
4	-94	1	117	54.5999985	5076.30469	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	65.123	133.554	74.065	0.000	198.678	139.188
4	-95	1	117	54.5999985	5130.90479	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	65.590	135.179	74.877	0.000	200.769	140.467
4	-96	1	117	54.5999985	5185.50488	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	66.057	136.803	75.690	0.000	202.860	141.746
4	-97	1	117	54.5999985	5240.10498	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	66.523	138.428	76.502	0.000	204.951	143.025
4	-98	1	117	54.5999985	5294.70508	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	66.990	140.052	77.314	0.000	207.042	144.304
4	-99	1	117	54.5999985	5349.30518	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.457	141.676	78.126	0.000	209.133	145.583
4	-100	1	117	54.5999985	5403.90527	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	67.923	143.301	78.939	0.000	211.224	146.862
4	-101	1	117	54.5999985	5458.50537	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.390	144.925	79.751	0.000	213.315	148.141

1036

4	-102	1	117	54.5999685	5513.10547	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	68.857	146.550	80.563	0.000	215.406	149.419
4	-103	1	117	54.5999685	5567.70557	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.323	148.174	81.375	0.000	217.498	150.698
4	-104	1	117	54.5999685	5622.30566	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	69.790	149.799	82.187	0.000	219.589	151.977
4	-105	1	117	54.5999685	5676.90576	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	70.257	151.423	83.000	0.000	221.680	153.256
4	-106	1	117	54.5999685	5731.50586	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	70.723	153.048	83.812	0.000	223.771	154.535
4	-107	1	117	54.5999685	5786.10596	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	71.190	154.672	84.624	0.000	225.862	155.814
4	-108	1	117	54.5999685	5840.70605	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	71.657	156.296	85.436	0.000	227.953	157.093
4	-109	1	117	54.5999685	5895.30615	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	72.123	157.921	86.249	0.000	230.044	158.372
4	-110	1	117	54.5999685	5949.90625	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	72.590	159.545	87.061	0.000	232.135	159.651
4	-111	1	117	54.5999685	6004.50635	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	73.057	161.170	87.873	0.000	234.226	160.929
4	-112	1	117	54.5999685	6059.10645	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	73.523	162.794	88.685	0.000	236.318	162.208
4	-113	1	117	54.5999685	6113.70654	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	73.990	164.419	89.497	0.000	238.409	163.487
4	-114	1	117	54.5999685	6168.30664	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	74.457	166.043	90.310	0.000	240.500	164.766
4	-115	1	117	54.5999685	6222.90674	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	74.923	167.668	91.122	0.000	242.591	166.045
4	-116	1	117	54.5999685	6277.50684	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	75.390	169.292	91.934	0.000	244.682	167.324
4	-117	1	117	54.5999685	6332.10693	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	75.857	170.917	92.746	0.000	246.773	168.603
4	-118	1	117	54.5999685	6386.70703	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	76.323	172.541	93.559	0.000	248.864	169.882
4	-119	1	117	54.5999685	6441.30713	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	76.790	174.165	94.371	0.000	250.955	171.161
4	-120	1	117	54.5999685	6495.90723	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	77.257	175.790	95.183	0.000	253.046	172.439
4	-121	1	117	54.5999685	6550.50732	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	77.723	177.414	95.995	0.000	255.138	173.718
4	-122	1	117	54.5999685	6605.10742	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	78.190	179.039	96.807	0.000	257.229	174.997
4	-123	1	117	54.5999685	6659.70752	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	78.657	180.663	97.620	0.000	259.320	176.276
4	-124	1	117	54.5999685	6714.30762	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	79.123	182.288	98.432	0.000	261.411	177.555
4	-125	1	117	54.5999685	6768.90771	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	79.590	183.912	99.244	0.000	263.502	178.834
4	-126	1	117	54.5999685	6823.50781	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	80.057	185.537	100.056	0.000	265.593	180.113
4	-127	1	117	54.5999685	6878.10791	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	80.523	187.161	100.869	0.000	267.684	181.392
4	-128	1	117	54.5999685	6932.70801	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	80.990	188.785	101.681	0.000	269.775	182.671

Boring R-59.75-LU_14x14 Concrete Pile_S-Case

S-CASE

Stratum	Tip	Increment	$\gamma_{(weak)}$	$\gamma_{(soft)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.024	0.012	0.000	0.024	0.012
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.098	0.049	0.000	0.098	0.049
1	-1	1	117	54.5999985	136.5	136.5	163.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.220	0.110	0.000	0.220	0.110
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.391	0.196	0.000	0.391	0.196
1	-3	1	117	54.5999985	245.699997	245.699997	273	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.611	0.306	0.000	0.611	0.306
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.880	0.440	0.000	0.880	0.440
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.198	0.599	0.000	1.198	0.599
1	-6	1	117	54.5999985	409.5	409.5	436.800018	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.565	0.782	0.000	1.565	0.782
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.981	0.990	0.000	1.981	0.990
1	-8	1	117	54.5999985	518.700012	518.700012	546	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.445	1.223	0.000	2.445	1.223
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.959	1.479	0.000	2.959	1.479
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.521	1.761	0.000	3.521	1.761
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.132	2.066	0.000	4.132	2.066
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.793	2.396	0.000	4.793	2.396
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.502	2.751	0.000	5.502	2.751
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.260	3.130	0.000	6.260	3.130
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.067	3.533	0.000	7.067	3.533
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.922	3.961	0.000	7.922	3.961
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.827	4.414	0.000	8.827	4.414
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	9.781	4.890	0.000	9.781	4.890
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	10.783	5.392	0.000	10.783	5.392
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	12.205	6.188	0.000	12.205	6.188
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	13.698	7.024	0.000	13.698	7.024
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	15.283	7.900	0.000	15.283	7.900
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	16.900	8.817	0.000	16.900	8.817
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	18.610	9.774	0.000	18.610	9.774
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	20.391	10.772	0.000	20.391	10.772
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	22.244	11.810	0.000	22.244	11.810
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	24.169	12.888	0.000	24.169	12.888
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	26.167	14.006	0.000	26.167	14.006
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	28.236	15.165	0.000	28.236	15.165
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	30.377	16.364	0.000	30.377	16.364
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	32.590	17.604	0.000	32.590	17.604
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	34.876	18.883	0.000	34.876	18.883
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	37.233	20.204	0.000	37.233	20.204
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	39.662	21.564	0.000	39.662	21.564
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	42.164	22.965	0.000	42.164	22.965
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	44.737	24.406	0.000	44.737	24.406
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	47.382	25.887	0.000	47.382	25.887
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	50.100	27.409	0.000	50.100	27.409
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	52.889	28.971	0.000	52.889	28.971
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	55.750	30.573	0.000	55.750	30.573
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	58.684	32.216	0.000	58.684	32.216
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	61.689	33.899	0.000	61.689	33.899
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	64.766	35.622	0.000	64.766	35.622
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	67.916	37.388	0.000	67.916	37.388
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	71.137	39.190	0.000	71.137	39.190
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	74.430	41.034	0.000	74.430	41.034

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	77.796	42.918	0.000	77.796	42.918
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	81.233	44.843	0.000	81.233	44.843
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	84.742	46.809	0.000	84.742	46.809
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	88.324	48.814	0.000	88.324	48.814
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	91.977	50.860	0.000	91.977	50.860
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	95.702	52.946	0.000	95.702	52.946
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	99.500	55.073	0.000	99.500	55.073
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	103.369	57.240	0.000	103.369	57.240
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	107.310	59.447	0.000	107.310	59.447
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	111.324	61.694	0.000	111.324	61.694
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	115.409	63.982	0.000	115.409	63.982
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	119.567	66.310	0.000	119.567	66.310
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	123.795	68.678	0.000	123.795	68.678
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	128.024	71.046	0.000	128.024	71.046
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	132.252	73.414	0.000	132.252	73.414
3	-62	1	105	42.5999985	3671.10205	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	134.788	75.189	0.000	134.788	75.189
3	-63	1	105	42.5999985	3713.70215	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	137.324	76.964	0.000	137.324	76.964
3	-64	1	105	42.5999985	3756.30225	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	139.859	78.739	0.000	139.859	78.739
3	-65	1	105	42.5999985	3798.90234	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	142.395	80.514	0.000	142.395	80.514
3	-66	1	105	42.5999985	3841.50244	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	144.931	82.289	0.000	144.931	82.289
3	-67	1	105	42.5999985	3884.10254	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	147.467	84.064	0.000	147.467	84.064
3	-68	1	105	42.5999985	3926.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	150.003	85.840	0.000	150.003	85.840
3	-69	1	105	42.5999985	3969.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	152.538	87.615	0.000	152.538	87.615
3	-70	1	105	42.5999985	4011.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	155.074	89.390	0.000	155.074	89.390
3	-71	1	105	42.5999985	4054.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	157.610	91.165	0.000	157.610	91.165
3	-72	1	105	42.5999985	4097.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	160.146	92.940	0.000	160.146	92.940
3	-73	1	105	42.5999985	4139.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	162.682	94.715	0.000	162.682	94.715
3	-74	1	105	42.5999985	4182.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	165.217	96.490	0.000	165.217	96.490
3	-75	1	105	42.5999985	4224.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	167.753	98.265	0.000	167.753	98.265
3	-76	1	105	42.5999985	4267.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	170.289	100.040	0.000	170.289	100.040
3	-77	1	105	42.5999985	4310.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	172.825	101.815	0.000	172.825	101.815
3	-78	1	105	42.5999985	4352.70313	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	175.361	103.590	0.000	175.361	103.590
3	-79	1	105	42.5999985	4395.30322	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	177.897	105.365	0.000	177.897	105.365
3	-80	1	105	42.5999985	4437.90332	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	180.432	107.140	0.000	180.432	107.140
3	-81	1	105	42.5999985	4480.50342	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	182.968	108.915	0.000	182.968	108.915
3	-82	1	105	42.5999985	4523.10352	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	185.504	110.691	0.000	185.504	110.691
3	-83	1	105	42.5999985	4565.70361	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	188.040	112.466	0.000	188.040	112.466
3	-84	1	105	42.5999985	4608.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	190.576	114.241	0.000	190.576	114.241
3	-85	1	105	42.5999985	4650.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	193.111	116.016	0.000	193.111	116.016
3	-86	1	105	42.5999985	4693.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	195.647	117.791	0.000	195.647	117.791
3	-87	1	105	42.5999985	4736.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	198.183	119.566	0.000	198.183	119.566
3	-88	1	105	42.5999985	4778.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	200.719	121.341	0.000	200.719	121.341
3	-89	1	105	42.5999985	4821.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	203.255	123.116	0.000	203.255	123.116
3	-90	1	105	42.5999985	4863.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	205.790	124.891	0.000	205.790	124.891
4	-91	1	117	54.5999985	4912.50439	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	208.925	126.459	0.000	208.925	126.459
4	-92	1	117	54.5999985	4967.10449	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	212.060	128.026	0.000	212.060	128.026
4	-93	1	117	54.5999985	5021.70459	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	215.195	129.593	0.000	215.195	129.593
4	-94	1	117	54.5999985	5076.30469	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	218.330	131.161	0.000	218.330	131.161
4	-95	1	117	54.5999985	5130.90479	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	221.465	132.728	0.000	221.465	132.728
4	-96	1	117	54.5999985	5185.50488	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	224.600	134.296	0.000	224.600	134.296
4	-97	1	117	54.5999985	5240.10498	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	227.735	135.863	0.000	227.735	135.863
4	-98	1	117	54.5999985	5294.70508	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	230.870	137.431	0.000	230.870	137.431
4	-99	1	117	54.5999985	5349.30518	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	234.004	138.998	0.000	234.004	138.998
4	-100	1	117	54.5999985	5403.90527	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	237.139	140.566	0.000	237.139	140.566
4	-101	1	117	54.5999985	5458.50537	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	240.274	142.133	0.000	240.274	142.133

1039

4	-102	1	117	54.5999685	5513.10547	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	243.409	143.700	0.000	243.409	143.700
4	-103	1	117	54.5999685	5567.70557	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	246.544	145.268	0.000	246.544	145.268
4	-104	1	117	54.5999685	5622.30566	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	249.679	146.835	0.000	249.679	146.835
4	-105	1	117	54.5999685	5676.90576	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	252.814	148.403	0.000	252.814	148.403
4	-106	1	117	54.5999685	5731.50586	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	255.949	149.970	0.000	255.949	149.970
4	-107	1	117	54.5999685	5786.10596	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	259.084	151.538	0.000	259.084	151.538
4	-108	1	117	54.5999685	5840.70605	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	262.218	153.105	0.000	262.218	153.105
4	-109	1	117	54.5999685	5895.30615	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	265.353	154.673	0.000	265.353	154.673
4	-110	1	117	54.5999685	5949.90625	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	268.488	156.240	0.000	268.488	156.240
4	-111	1	117	54.5999685	6004.50635	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	271.623	157.807	0.000	271.623	157.807
4	-112	1	117	54.5999685	6059.10645	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	274.758	159.375	0.000	274.758	159.375
4	-113	1	117	54.5999685	6113.70654	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	277.893	160.942	0.000	277.893	160.942
4	-114	1	117	54.5999685	6168.30664	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	281.028	162.510	0.000	281.028	162.510
4	-115	1	117	54.5999685	6222.90674	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	284.163	164.077	0.000	284.163	164.077
4	-116	1	117	54.5999685	6277.50684	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	287.298	165.645	0.000	287.298	165.645
4	-117	1	117	54.5999685	6332.10693	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	290.432	167.212	0.000	290.432	167.212
4	-118	1	117	54.5999685	6386.70703	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	293.567	168.780	0.000	293.567	168.780
4	-119	1	117	54.5999685	6441.30713	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	296.702	170.347	0.000	296.702	170.347
4	-120	1	117	54.5999685	6495.90723	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	299.837	171.914	0.000	299.837	171.914
4	-121	1	117	54.5999685	6550.50732	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	302.972	173.482	0.000	302.972	173.482
4	-122	1	117	54.5999685	6605.10742	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	306.107	175.049	0.000	306.107	175.049
4	-123	1	117	54.5999685	6659.70752	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	309.242	176.617	0.000	309.242	176.617
4	-124	1	117	54.5999685	6714.30762	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	312.377	178.184	0.000	312.377	178.184
4	-125	1	117	54.5999685	6768.90771	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	315.512	179.752	0.000	315.512	179.752
4	-126	1	117	54.5999685	6823.50781	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	318.646	181.319	0.000	318.646	181.319
4	-127	1	117	54.5999685	6878.10791	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	321.781	182.887	0.000	321.781	182.887
4	-128	1	117	54.5999685	6932.70801	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	324.916	184.454	0.000	324.916	184.454

1040

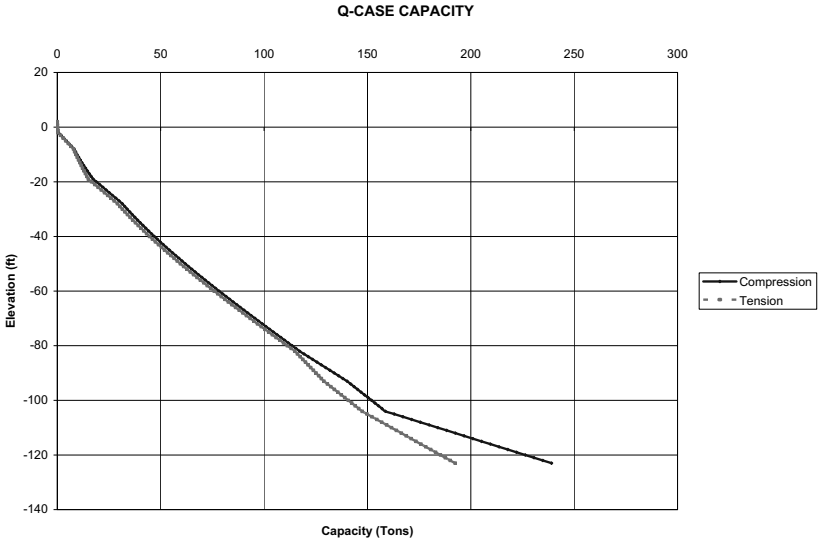
820

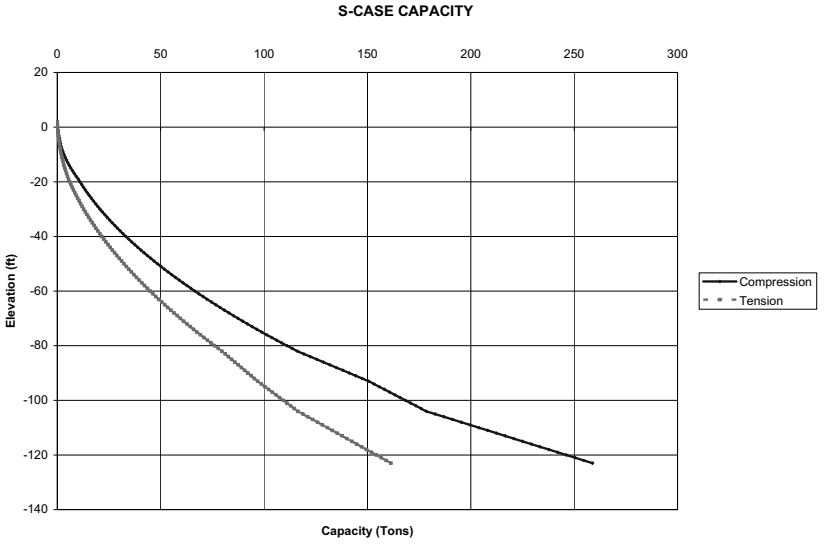
825

830

835

Boring
R-60.3-UL
840 **14x14 Concrete Pile Capacities**


Q-CASE CAPACITY
0
50
100
150
200
250
300
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension


S-CASE CAPACITY
0
50
100
150
200
250
300
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

Boring R-60.3-UL_14x14 Concrete Pile_Q-Case

								Q-CASE														
Stratum	Tip	Increment	$\gamma_{(moist)}$	$\gamma_{(sub)}$	זין	Mid-layer זין (used)	Bottom זין (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.036	0.020	0.000	0.036	0.020
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.144	0.081	0.000	0.144	0.081
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.324	0.181	0.000	0.324	0.181
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.576	0.323	0.000	0.576	0.323
2	-3	1	107	44.5999985	260.699982	260.699982	283	550	536.25	0	0	1.00	1.00	1.00	9.00	No	1.251	0.576	0.323	0.000	1.827	1.574
2	-4	1	107	44.5999985	305.299988	305.299988	327.600006	550	536.25	0	0	1.00	1.00	1.00	9.00	No	2.502	0.576	0.323	0.000	3.079	2.825
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	550	536.25	0	0	1.00	1.00	1.00	9.00	No	3.754	0.576	0.323	0.000	4.330	4.076
2	-6	1	107	44.5999985	394.5	394.5	416.800018	550	536.25	0	0	1.00	1.00	1.00	9.00	No	5.005	0.576	0.323	0.000	5.581	5.328
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	550	536.25	0	0	1.00	1.00	1.00	9.00	No	6.256	0.576	0.323	0.000	6.832	6.579
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	550	536.25	0	0	1.00	1.00	1.00	9.00	No	7.507	0.576	0.323	0.000	8.084	7.830
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.974	0.824	0.446	0.000	8.798	8.421
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.441	1.096	0.583	0.000	9.537	9.024
3	-11	1	117	54.5999985	642.5	642.5	669.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.907	1.395	0.732	0.000	10.302	9.639
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.374	1.718	0.894	0.000	11.092	10.266
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.841	2.067	1.068	0.000	11.908	10.909
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.307	2.441	1.255	0.000	12.749	11.563
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.774	2.841	1.455	0.000	13.615	12.229
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	200	200	15	11.25	1.00	0.50	4.40	12.90	No	11.241	3.266	1.667	0.000	14.507	12.908
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	200	200	15	11.25	1.00	0.50	4.40	12.90	No	11.707	3.716	1.893	0.000	15.424	13.600
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99968	200	200	15	11.25	1.00	0.50	4.40	12.90	No	12.174	4.192	2.130	0.000	16.366	14.305
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	12.641	4.693	2.381	0.000	17.333	15.022
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	14.206	4.693	2.381	0.000	18.899	16.587
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	15.771	4.693	2.381	0.000	20.464	18.152
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	17.336	4.693	2.381	0.000	22.029	19.717
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	18.902	4.693	2.381	0.000	23.594	21.282
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	20.467	4.693	2.381	0.000	25.159	22.848
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	22.032	4.693	2.381	0.000	26.725	24.413
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	23.597	4.693	2.381	0.000	28.290	25.978
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	25.162	4.693	2.381	0.000	29.855	27.543
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	26.728	4.693	2.381	0.000	31.420	29.108
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59961	512.962952	504.819092	0	0	1.00	1.00	1.00	9.00	No	27.906	4.693	2.381	0.000	32.598	30.286
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	525.925903	514.373291	0	0	1.00	1.00	1.00	9.00	No	29.106	4.693	2.381	0.000	33.798	31.487
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	538.888916	523.756399	0	0	1.00	1.00	1.00	9.00	No	30.328	4.693	2.381	0.000	35.020	32.709
5	-32	1	101	38.5999985	1589.09961	1588.09961	1608.39954	551.851868	532.977539	0	0	1.00	1.00	1.00	9.00	No	31.571	4.693	2.381	0.000	36.264	33.952
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	564.814819	542.027588	0	0	1.00	1.00	1.00	9.00	No	32.836	4.693	2.381	0.000	37.529	35.217
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	577.777771	550.909668	0	0	1.00	1.00	1.00	9.00	No	34.122	4.693	2.381	0.000	38.814	36.502
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	590.740723	559.623657	0	0	1.00	1.00	1.00	9.00	No	35.427	4.693	2.381	0.000	40.120	37.808
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	603.703674	568.169556	0	0	1.00	1.00	1.00	9.00	No	36.753	4.693	2.381	0.000	41.446	39.134
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	616.666687	576.547485	0	0	1.00	1.00	1.00	9.00	No	38.098	4.693	2.381	0.000	42.791	40.479
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	629.629639	584.757385	0	0	1.00	1.00	1.00	9.00	No	39.463	4.693	2.381	0.000	44.155	41.844
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	642.59259	592.799194	0	0	1.00	1.00	1.00	9.00	No	40.846	4.693	2.381	0.000	45.539	43.227
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	655.555542	600.672974	0	0	1.00	1.00	1.00	9.00	No	42.248	4.693	2.381	0.000	46.940	44.628
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	668.518494	608.378784	0	0	1.00	1.00	1.00	9.00	No	43.667	4.693	2.381	0.000	48.360	46.048
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	681.481506	615.916504	0	0	1.00	1.00	1.00	9.00	No	45.104	4.693	2.381	0.000	49.797	47.485
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	694.444458	623.286194	0	0	1.00	1.00	1.00	9.00	No	46.559	4.693	2.381	0.000	51.251	48.940
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	707.40741	630.487793	0	0	1.00	1.00	1.00	9.00	No	48.030	4.693	2.381	0.000	52.722	50.411
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	720.370361	637.521423	0	0	1.00	1.00	1.00	9.00	No	49.517	4.693	2.381	0.000	54.210	51.898
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	733.333313	644.386963	0	0	1.00	1.00	1.00	9.00	No	51.021	4.693	2.381	0.000	55.713	53.402

1045

5	-47	1	101	38.5999985	2168.09961	2168.09961	2187.39966	746.296326	651.084534	0	0	1.00	1.00	1.00	9.00	No	52.540	4.693	2.381	0.000	57.233	54.921
5	-48	1	101	38.5999985	2206.69971	2206.69971	2225.99976	759.259277	657.614014	0	0	1.00	1.00	1.00	9.00	No	54.075	4.693	2.381	0.000	58.767	56.455
5	-49	1	101	38.5999985	2245.2998	2245.2998	2264.59985	772.222229	663.975464	0	0	1.00	1.00	1.00	9.00	No	55.624	4.693	2.381	0.000	60.316	58.005
5	-50	1	101	38.5999985	2283.8999	2283.8999	2303.19995	785.185181	670.168884	0	0	1.00	1.00	1.00	9.00	No	57.188	4.693	2.381	0.000	61.880	59.568
5	-51	1	101	38.5999985	2322.5	2322.5	2341.80005	798.148132	676.194214	0	0	1.00	1.00	1.00	9.00	No	58.765	4.693	2.381	0.000	63.458	61.146
5	-52	1	101	38.5999985	2361.1001	2361.1001	2380.40015	811.111084	682.051575	0	0	1.00	1.00	1.00	9.00	No	60.357	4.693	2.381	0.000	65.049	62.738
5	-53	1	101	38.5999985	2399.7002	2399.7002	2419.00024	824.074097	687.740906	0	0	1.00	1.00	1.00	9.00	No	61.962	4.693	2.381	0.000	66.654	64.342
5	-54	1	101	38.5999985	2438.30029	2438.30029	2457.60034	837.037048	693.262207	0	0	1.00	1.00	1.00	9.00	No	63.579	4.693	2.381	0.000	68.272	65.960
5	-55	1	101	38.5999985	2476.90039	2476.90039	2496.20044	850	698.615356	0	0	1.00	1.00	1.00	9.00	No	65.209	4.693	2.381	0.000	69.902	67.590
5	-56	1	101	38.5999985	2515.50049	2515.50049	2534.80054	862.962952	703.800537	0	0	1.00	1.00	1.00	9.00	No	66.851	4.693	2.381	0.000	71.544	69.232
5	-57	1	101	38.5999985	2554.10059	2554.10059	2573.40063	875.925903	708.817749	0	0	1.00	1.00	1.00	9.00	No	68.505	4.693	2.381	0.000	73.198	70.886
5	-58	1	101	38.5999985	2592.70068	2592.70068	2612.00073	888.888916	713.69687	0	0	1.00	1.00	1.00	9.00	No	70.171	4.693	2.381	0.000	74.863	72.551
5	-59	1	101	38.5999985	2631.30078	2631.30078	2650.60083	901.851868	718.3479	0	0	1.00	1.00	1.00	9.00	No	71.847	4.693	2.381	0.000	76.539	74.228
5	-60	1	101	38.5999985	2669.90088	2669.90088	2689.20093	914.814819	722.880962	0	0	1.00	1.00	1.00	9.00	No	73.533	4.693	2.381	0.000	78.226	75.914
5	-61	1	101	38.5999985	2708.50098	2708.50098	2727.80103	927.777771	727.205933	0	0	1.00	1.00	1.00	9.00	No	75.230	4.693	2.381	0.000	79.923	77.611
5	-62	1	101	38.5999985	2747.10107	2747.10107	2766.40112	940.740723	731.382874	0	0	1.00	1.00	1.00	9.00	No	76.937	4.693	2.381	0.000	81.629	79.318
5	-63	1	101	38.5999985	2785.70117	2785.70117	2805.00122	953.703674	735.391785	0	0	1.00	1.00	1.00	9.00	No	78.653	4.693	2.381	0.000	83.345	81.034
5	-64	1	101	38.5999985	2824.30127	2824.30127	2843.60132	966.666687	739.232666	0	0	1.00	1.00	1.00	9.00	No	80.378	4.693	2.381	0.000	85.070	82.758
5	-65	1	101	38.5999985	2862.90137	2862.90137	2882.20142	979.629639	742.905518	0	0	1.00	1.00	1.00	9.00	No	82.111	4.693	2.381	0.000	86.804	84.492
5	-66	1	101	38.5999985	2901.50146	2901.50146	2920.80151	992.59259	746.410339	0	0	1.00	1.00	1.00	9.00	No	83.853	4.693	2.381	0.000	88.545	86.233
5	-67	1	101	38.5999985	2940.10156	2940.10156	2959.40161	1005.55554	749.74707	0	0	1.00	1.00	1.00	9.00	No	85.602	4.693	2.381	0.000	90.295	87.983
5	-68	1	101	38.5999985	2978.70166	2978.70166	2998.00171	1018.51849	752.915771	0	0	1.00	1.00	1.00	9.00	No	87.359	4.693	2.381	0.000	92.051	89.740
5	-69	1	101	38.5999985	3017.30176	3017.30176	3036.60181	1031.48145	755.916504	0	0	1.00	1.00	1.00	9.00	No	89.123	4.693	2.381	0.000	93.815	91.503
5	-70	1	101	38.5999985	3055.90186	3055.90186	3075.2019	1044.44448	758.749146	0	0	1.00	1.00	1.00	9.00	No	90.893	4.693	2.381	0.000	95.586	93.274
5	-71	1	101	38.5999985	3094.50195	3094.50195	3113.802	1057.40735	761.413757	0	0	1.00	1.00	1.00	9.00	No	92.670	4.693	2.381	0.000	97.362	95.051
5	-72	1	101	38.5999985	3133.10205	3133.10205	3152.4021	1070.37036	763.910278	0	0	1.00	1.00	1.00	9.00	No	94.452	4.693	2.381	0.000	99.145	96.833
5	-73	1	101	38.5999985	3171.70215	3171.70215	3191.0022	1083.33337	766.238892	0	0	1.00	1.00	1.00	9.00	No	96.240	4.693	2.381	0.000	100.933	98.621
5	-74	1	101	38.5999985	3210.30225	3210.30225	3229.60229	1096.29626	768.396353	0	0	1.00	1.00	1.00	9.00	No	98.033	4.693	2.381	0.000	102.726	100.414
5	-75	1	101	38.5999985	3248.90234	3248.90234	3268.20239	1109.25928	770.391785	0	0	1.00	1.00	1.00	9.00	No	99.831	4.693	2.381	0.000	104.523	102.211
5	-76	1	101	38.5999985	3287.50244	3287.50244	3306.80249	1122.22217	772.216187	0	0	1.00	1.00	1.00	9.00	No	101.632	4.693	2.381	0.000	106.325	104.013
5	-77	1	101	38.5999985	3326.10254	3326.10254	3345.40259	1135.18518	773.872559	0	0	1.00	1.00	1.00	9.00	No	103.438	4.693	2.381	0.000	108.131	105.819
5	-78	1	101	38.5999985	3364.70264	3364.70264	3384.00269	1148.14819	775.360962	0	0	1.00	1.00	1.00	9.00	No	105.247	4.693	2.381	0.000	109.940	107.628
5	-79	1	101	38.5999985	3403.30273	3403.30273	3422.60278	1161.11108	776.681274	0	0	1.00	1.00	1.00	9.00	No	107.060	4.693	2.381	0.000	111.752	109.440
5	-80	1	101	38.5999985	3441.90283	3441.90283	3461.20288	1174.0741	777.833496	0	0	1.00	1.00	1.00	9.00	No	108.874	4.693	2.381	0.000	113.567	111.255
5	-81	1	101	38.5999985	3480.50293	3480.50293	3499.80298	1187.03699	778.817749	0	0	1.00	1.00	1.00	9.00	No	110.692	4.693	2.381	0.000	115.384	113.073
5	-82	1	101	38.5999985	3519.10303	3500	3500	1200	779.633911	0	0	1.00	1.00	1.00	9.00	No	112.511	4.693	2.381	0.000	117.203	114.892
6	-83	1	117	54.5999985	3585.70313	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	112.978	6.317	3.193	0.000	119.295	116.171
6	-84	1	117	54.5999985	3620.30322	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	113.444	7.941	4.005	0.000	121.386	117.449
6	-85	1	117	54.5999985	3674.90332	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	113.911	9.566	4.818	0.000	123.477	118.728
6	-86	1	117	54.5999985	3729.50342	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	114.378	11.190	5.630	0.000	125.568	120.007
6	-87	1	117	54.5999985	3784.10352	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	114.844	12.815	6.442	0.000	127.659	121.286
6	-88	1	117	54.5999985	3838.70361	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	115.311	14.439	7.254	0.000	129.750	122.565
6	-89	1	117	54.5999985	3893.30371	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	115.778	16.064	8.066	0.000	131.841	123.844
6	-90	1	117	54.5999985	3947.90381	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	116.244	17.688	8.879	0.000	133.932	125.123
6	-91	1	117	54.5999985	4002.50391	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	116.711	19.313	9.691	0.000	136.023	126.402
6	-92	1	117	54.5999985	4057.104	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	117.178	20.937	10.503	0.000	138.115	127.681
6	-93	1	117	54.5999985	4111.7041	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	117.644	22.561	11.315	0.000	140.206	128.960
7	-94	1	115	52.5999985	4165.30371	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	119.324	22.561	11.315	0.000	141.886	130.639
7	-95	1	115	52.5999985	4217.90381	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	121.004	22.561	11.315	0.000	143.566	132.319
7	-96	1	115	52.5999985	4270.50391	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	122.684	22.561	11.315	0.000	145.246	133.999
7	-97	1	115	52.5999985	4323.104	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	124.364	22.561	11.315	0.000	146.926	135.679
7	-98	1	115	52.5999985	4375.7041	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	126.044	22.561	11.315	0.000	148.606	137.359
7	-99	1	115	52.5999985	4428.3042	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	127.724	22.561	11.315	0.000	150.286	139.039
7	-100	1	115	52.5999985	4480.9043	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	129.404	22.561	11.315	0.000	151.966	140.719
7	-101	1	115	52.5999985	4533.50439	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	131.084	22.561	11.315	0.000	153.646	142.399

1046

845

7	-102	1	115	52.5999985	4586.10449	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	132.764	22.561	11.315	0.000	155.326	144.079
7	-103	1	115	52.5999985	4638.70459	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	134.444	22.561	11.315	0.000	157.006	145.759
7	-104	1	115	52.5999985	4691.30469	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	136.124	22.561	11.315	0.000	158.686	147.439
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	26.790	13.683	0.000	162.914	149.807
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	31.018	16.051	0.000	167.142	152.175
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	35.247	18.419	0.000	171.371	154.543
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	39.475	20.787	0.000	175.599	156.911
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	43.704	23.155	0.000	179.828	159.279
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	47.932	25.523	0.000	184.056	161.647
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	52.161	27.891	0.000	188.285	164.015
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	56.389	30.259	0.000	192.513	166.383
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	60.617	32.627	0.000	196.741	168.751
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	64.846	34.995	0.000	200.970	171.119
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	69.074	37.362	0.000	205.198	173.487
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	73.303	39.730	0.000	209.427	175.854
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	77.531	42.098	0.000	213.655	178.222
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	81.760	44.466	0.000	217.883	180.590
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	85.988	46.834	0.000	222.112	182.958
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	90.216	49.202	0.000	226.340	185.326
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	94.445	51.570	0.000	230.569	187.694
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	98.673	53.938	0.000	234.797	190.062
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	136.124	102.902	56.306	0.000	239.026	192.430

Boring R-60.3-UL_14x14 Concrete Pile_S-Case

S-CASE

Stratum	Tip	Increment	$\gamma_{(weak)}$	$\gamma_{(soft)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.036	0.020	0.000	0.036	0.020
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.144	0.081	0.000	0.144	0.081
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.324	0.181	0.000	0.324	0.181
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.576	0.323	0.000	0.576	0.323
2	-3	1	107	44.5999985	260.699982	260.699982	283	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	0.765	0.455	0.000	0.765	0.455
2	-4	1	107	44.5999985	305.299988	305.299988	327.600006	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	0.986	0.610	0.000	0.986	0.610
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.240	0.787	0.000	1.240	0.787
2	-6	1	107	44.5999985	394.5	394.5	416.800018	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.525	0.987	0.000	1.525	0.987
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.844	1.210	0.000	1.844	1.210
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	2.194	1.455	0.000	2.194	1.455
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.672	1.694	0.000	2.672	1.694
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.198	1.957	0.000	3.198	1.957
3	-11	1	117	54.5999985	642.5	642.5	669.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.774	2.245	0.000	3.774	2.245
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.398	2.557	0.000	4.398	2.557
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.071	2.894	0.000	5.071	2.894
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.794	3.255	0.000	5.794	3.255
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.565	3.641	0.000	6.565	3.641
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.385	4.051	0.000	7.385	4.051
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.254	4.485	0.000	8.254	4.485
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	9.171	4.944	0.000	9.171	4.944
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	10.138	5.427	0.000	10.138	5.427
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	10.954	5.998	0.000	10.954	5.998
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	11.798	6.589	0.000	11.798	6.589
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	12.669	7.199	0.000	12.669	7.199
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	13.569	7.829	0.000	13.569	7.829
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	14.496	8.478	0.000	14.496	8.478
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	15.452	9.147	0.000	15.452	9.147
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	16.436	9.835	0.000	16.436	9.835
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	17.447	10.543	0.000	17.447	10.543
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	18.487	11.271	0.000	18.487	11.271
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59961	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	19.554	12.018	0.000	19.554	12.018
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	20.649	12.785	0.000	20.649	12.785
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	21.773	13.571	0.000	21.773	13.571
5	-32	1	101	38.5999985	1589.09961	1589.09961	1608.39954	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	22.924	14.377	0.000	22.924	14.377
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	24.103	15.203	0.000	24.103	15.203
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	25.311	16.048	0.000	25.311	16.048
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	26.546	16.913	0.000	26.546	16.913
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	27.809	17.797	0.000	27.809	17.797
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	29.100	18.701	0.000	29.100	18.701
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	30.419	19.624	0.000	30.419	19.624
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	31.766	20.567	0.000	31.766	20.567
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	33.142	21.530	0.000	33.142	21.530
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	34.545	22.512	0.000	34.545	22.512
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	35.976	23.513	0.000	35.976	23.513
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	37.435	24.535	0.000	37.435	24.535
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	38.921	25.576	0.000	38.921	25.576
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	40.436	26.636	0.000	40.436	26.636
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	41.979	27.716	0.000	41.979	27.716

1048

5	-47	1	101	38.5999685	2168.09961	2168.09961	2187.39996	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	43.550	28.816	0.000	43.550	28.816
5	-48	1	101	38.5999685	2206.69971	2206.69971	2225.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	45.149	29.935	0.000	45.149	29.935
5	-49	1	101	38.5999685	2245.2998	2245.2998	2264.59985	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	46.776	31.073	0.000	46.776	31.073
5	-50	1	101	38.5999685	2283.8999	2283.8999	2303.19995	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	48.430	32.232	0.000	48.430	32.232
5	-51	1	101	38.5999685	2322.5	2322.5	2341.80005	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	50.113	33.410	0.000	50.113	33.410
5	-52	1	101	38.5999685	2361.1001	2361.1001	2380.40015	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	51.824	34.607	0.000	51.824	34.607
5	-53	1	101	38.5999685	2399.7002	2399.7002	2419.00024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	53.562	35.824	0.000	53.562	35.824
5	-54	1	101	38.5999685	2438.30029	2438.30029	2457.60034	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	55.329	37.061	0.000	55.329	37.061
5	-55	1	101	38.5999685	2476.90039	2476.90039	2496.20044	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	57.123	38.317	0.000	57.123	38.317
5	-56	1	101	38.5999685	2515.50049	2515.50049	2534.80054	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	58.946	39.593	0.000	58.946	39.593
5	-57	1	101	38.5999685	2554.10059	2554.10059	2573.40063	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	60.796	40.888	0.000	60.796	40.888
5	-58	1	101	38.5999685	2592.70068	2592.70068	2612.00073	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	62.675	42.203	0.000	62.675	42.203
5	-59	1	101	38.5999685	2631.30078	2631.30078	2650.60083	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	64.581	43.538	0.000	64.581	43.538
5	-60	1	101	38.5999685	2669.90088	2669.90088	2689.20093	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	66.516	44.892	0.000	66.516	44.892
5	-61	1	101	38.5999685	2708.50098	2708.50098	2727.80103	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	68.478	46.265	0.000	68.478	46.265
5	-62	1	101	38.5999685	2747.10107	2747.10107	2766.40112	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	70.468	47.658	0.000	70.468	47.658
5	-63	1	101	38.5999685	2785.70117	2785.70117	2805.00122	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	72.487	49.071	0.000	72.487	49.071
5	-64	1	101	38.5999685	2824.30127	2824.30127	2843.60132	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	74.533	50.504	0.000	74.533	50.504
5	-65	1	101	38.5999685	2862.90137	2862.90137	2882.20142	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	76.607	51.956	0.000	76.607	51.956
5	-66	1	101	38.5999685	2901.50146	2901.50146	2920.80151	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	78.709	53.427	0.000	78.709	53.427
5	-67	1	101	38.5999685	2940.10156	2940.10156	2959.40161	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	80.840	54.918	0.000	80.840	54.918
5	-68	1	101	38.5999685	2978.70166	2978.70166	2998.00171	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	82.998	56.429	0.000	82.998	56.429
5	-69	1	101	38.5999685	3017.30176	3017.30176	3036.60181	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	85.184	57.959	0.000	85.184	57.959
5	-70	1	101	38.5999685	3055.90186	3056.90186	3075.2019	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	87.398	59.509	0.000	87.398	59.509
5	-71	1	101	38.5999685	3094.50195	3094.50195	3113.802	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	89.640	61.078	0.000	89.640	61.078
5	-72	1	101	38.5999685	3133.10205	3133.10205	3152.4021	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	91.910	62.667	0.000	91.910	62.667
5	-73	1	101	38.5999685	3171.70215	3171.70215	3191.0022	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	94.208	64.276	0.000	94.208	64.276
5	-74	1	101	38.5999685	3210.30225	3210.30225	3229.60229	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	96.534	65.904	0.000	96.534	65.904
5	-75	1	101	38.5999685	3248.90234	3248.90234	3268.20239	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	98.888	67.552	0.000	98.888	67.552
5	-76	1	101	38.5999685	3287.50244	3287.50244	3306.80249	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	101.270	69.219	0.000	101.270	69.219
5	-77	1	101	38.5999685	3326.10254	3326.10254	3345.40259	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	103.679	70.906	0.000	103.679	70.906
5	-78	1	101	38.5999685	3364.70264	3364.70264	3384.00269	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	106.117	72.613	0.000	106.117	72.613
5	-79	1	101	38.5999685	3403.30273	3403.30273	3422.60278	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	108.583	74.339	0.000	108.583	74.339
5	-80	1	101	38.5999685	3441.90283	3441.90283	3461.20288	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	111.077	76.084	0.000	111.077	76.084
5	-81	1	101	38.5999685	3480.50293	3480.50293	3499.80298	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	113.598	77.849	0.000	113.598	77.849
5	-82	1	101	38.5999685	3519.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	116.134	79.624	0.000	116.134	79.624
6	-83	1	117	54.5999685	3565.70313	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	119.269	81.192	0.000	119.269	81.192
6	-84	1	117	54.5999685	3620.30322	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	122.404	82.759	0.000	122.404	82.759
6	-85	1	117	54.5999685	3674.90332	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	125.539	84.327	0.000	125.539	84.327
6	-86	1	117	54.5999685	3729.50342	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	128.674	85.894	0.000	128.674	85.894
6	-87	1	117	54.5999685	3784.10352	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	131.809	87.462	0.000	131.809	87.462
6	-88	1	117	54.5999685	3838.70361	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	134.943	89.029	0.000	134.943	89.029
6	-89	1	117	54.5999685	3893.30371	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	138.078	90.597	0.000	138.078	90.597
6	-90	1	117	54.5999685	3947.90381	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	141.213	92.164	0.000	141.213	92.164
6	-91	1	117	54.5999685	4002.50391	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	144.348	93.731	0.000	144.348	93.731
6	-92	1	117	54.5999685	4057.104	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	147.483	95.299	0.000	147.483	95.299
6	-93	1	117	54.5999685	4111.7041	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	150.618	96.866	0.000	150.618	96.866
7	-94	1	115	52.5999685	4165.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	153.154	98.641	0.000	153.154	98.641
7	-95	1	115	52.5999685	4217.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	155.690	100.416	0.000	155.690	100.416
7	-96	1	115	52.5999685	4270.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	158.225	102.192	0.000	158.225	102.192
7	-97	1	115	52.5999685	4323.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	160.761	103.967	0.000	160.761	103.967
7	-98	1	115	52.5999685	4375.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	163.297	105.742	0.000	163.297	105.742
7	-99	1	115	52.5999685	4428.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	165.833	107.517	0.000	165.833	107.517
7	-100	1	115	52.5999685	4480.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	168.369	109.292	0.000	168.369	109.292
7	-101	1	115	52.5999685	4533.50439	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	170.904	111.067	0.000	170.904	111.067

1049

7	-102	1	115	52.5999985	4586.10449	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	173.440	112.842	0.000	173.440	112.842
7	-103	1	115	52.5999985	4638.70459	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	175.976	114.617	0.000	175.976	114.617
7	-104	1	115	52.5999985	4691.30469	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	178.512	116.392	0.000	178.512	116.392
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	182.740	118.760	0.000	182.740	118.760
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	186.969	121.128	0.000	186.969	121.128
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	191.197	123.496	0.000	191.197	123.496
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	195.426	125.864	0.000	195.426	125.864
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	199.654	128.232	0.000	199.654	128.232
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	203.882	130.600	0.000	203.882	130.600
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	208.111	132.968	0.000	208.111	132.968
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	212.339	135.335	0.000	212.339	135.335
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	216.568	137.703	0.000	216.568	137.703
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	220.796	140.071	0.000	220.796	140.071
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	225.024	142.439	0.000	225.024	142.439
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	229.253	144.807	0.000	229.253	144.807
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	233.481	147.175	0.000	233.481	147.175
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	237.710	149.543	0.000	237.710	149.543
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	241.938	151.911	0.000	241.938	151.911
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	246.167	154.279	0.000	246.167	154.279
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	250.395	156.647	0.000	250.395	156.647
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	254.623	159.015	0.000	254.623	159.015
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	258.852	161.383	0.000	258.852	161.383

1050

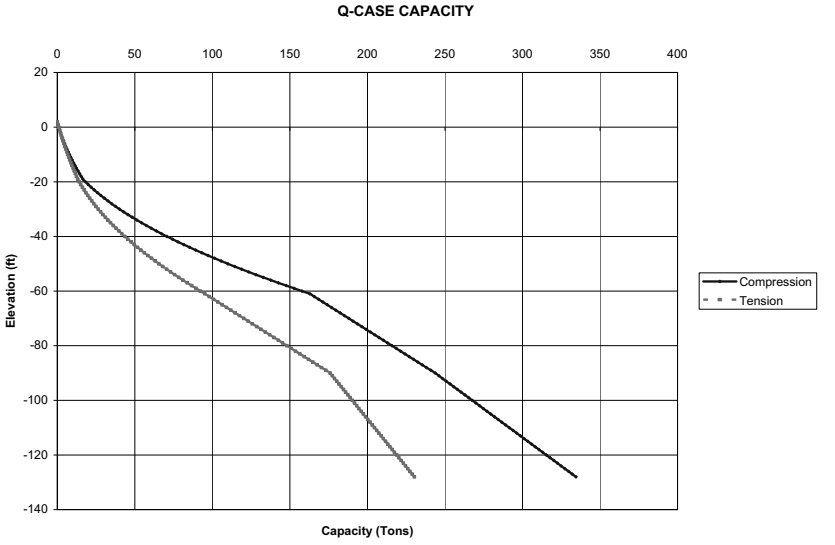
850

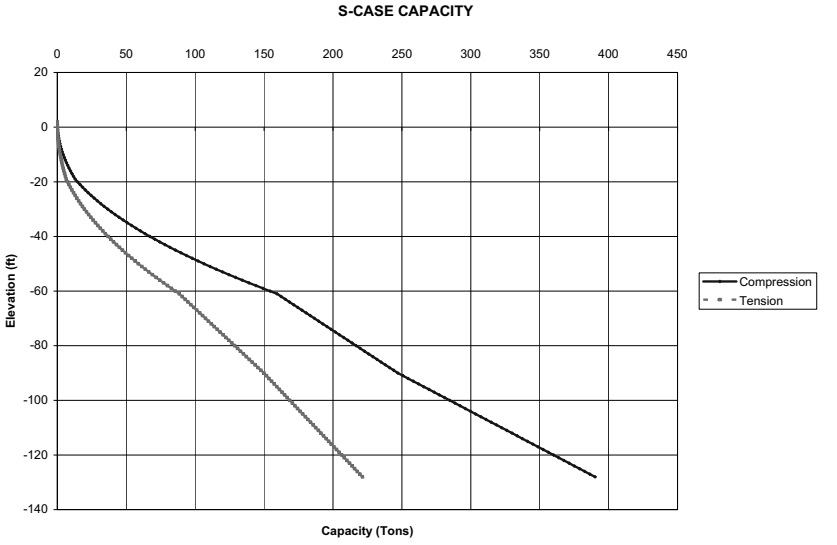
855

860

865

Boring
R-59.75-LU
HP14x73 Steel Pile Capacities


Q-CASE CAPACITY
0
50
100
150
200
250
300
350
400
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension


S-CASE CAPACITY
0
50
100
150
200
250
300
350
400
450
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

870

Boring R-59.75-LU_HP14x73 Steel Pile_Q-Case

								Q-CASE															
Stratum	Tip	Increment	$\gamma_{prevail}$	γ_{Used}	γ_h	Mid-layer γ_h (used)	Bottom γ_h (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.470	0.015	0.007	0.000	0.485	0.477
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	200	200	15	11.25	1.00	0.50	4.40	12.90	No	0.940	0.060	0.030	0.000	1.000	0.970
1	-1	1	117	54.5999985	136.5	136.5	163.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.410	0.135	0.067	0.000	1.545	1.477
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	200	200	15	11.25	1.00	0.50	4.40	12.90	No	1.880	0.240	0.120	0.000	2.120	2.000
1	-3	1	117	54.5999985	245.699997	245.699997	273	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.350	0.374	0.187	0.000	2.724	2.537
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	200	200	15	11.25	1.00	0.50	4.40	12.90	No	2.820	0.539	0.270	0.000	3.359	3.090
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.290	0.734	0.367	0.000	4.024	3.657
1	-6	1	117	54.5999985	409.5	409.5	436.800018	200	200	15	11.25	1.00	0.50	4.40	12.90	No	3.760	0.958	0.479	0.000	4.718	4.239
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.230	1.213	0.607	0.000	5.443	4.837
1	-8	1	117	54.5999985	518.700012	518.700012	546	200	200	15	11.25	1.00	0.50	4.40	12.90	No	4.700	1.498	0.749	0.000	6.198	5.449
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.170	1.812	0.906	0.000	6.982	6.076
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	200	200	15	11.25	1.00	0.50	4.40	12.90	No	5.640	2.157	1.078	0.000	7.797	6.718
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.110	2.531	1.265	0.000	8.641	7.375
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	200	200	15	11.25	1.00	0.50	4.40	12.90	No	6.580	2.935	1.468	0.000	9.515	8.048
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.050	3.370	1.685	0.000	10.420	8.735
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.520	3.834	1.917	0.000	11.354	9.437
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	200	200	15	11.25	1.00	0.50	4.40	12.90	No	7.990	4.328	2.164	0.000	12.318	10.154
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.460	4.852	2.426	0.000	13.312	10.886
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.930	5.408	2.703	0.000	14.336	11.633
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.400	5.990	2.995	0.000	15.390	12.395
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.870	6.604	3.302	0.000	16.474	13.172
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	8.318	4.262	0.000	18.188	14.132
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	10.118	5.270	0.000	19.988	15.140
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	12.004	6.326	0.000	21.874	16.196
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	13.978	7.432	0.000	23.848	17.302
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	16.039	8.585	0.000	25.909	18.455
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	18.186	9.788	0.000	28.056	19.658
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	20.420	11.039	0.000	30.290	20.909
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	22.741	12.339	0.000	32.611	22.209
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	25.148	13.687	0.000	35.018	23.557
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	27.643	15.084	0.000	37.513	24.954
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	30.224	16.529	0.000	40.094	26.399
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	32.892	18.023	0.000	42.762	27.893
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	35.647	19.566	0.000	45.517	29.436
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	38.489	21.157	0.000	48.359	31.027
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	41.417	22.797	0.000	51.287	32.667
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	44.432	24.486	0.000	54.302	34.356
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	47.534	26.223	0.000	57.404	36.093
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	50.723	28.009	0.000	60.593	37.879
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	53.999	29.843	0.000	63.869	39.713
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	57.361	31.726	0.000	67.231	41.596
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	60.811	33.658	0.000	70.681	43.528
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	64.347	35.638	0.000	74.217	45.508
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	67.969	37.667	0.000	77.839	47.537
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	71.679	39.744	0.000	81.549	49.614
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	75.476	41.870	0.000	85.346	51.740
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	79.359	44.045	0.000	89.229	53.915
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	83.329	46.268	0.000	93.199	56.138

1054

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	87.386	48.540	0.000	97.256	58.410
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	91.529	50.860	0.000	101.399	60.730
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	95.760	53.229	0.000	105.630	63.099
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	100.077	55.647	0.000	109.947	65.517
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	104.481	58.113	0.000	114.351	67.983
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	108.972	60.628	0.000	118.842	70.498
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	113.549	63.191	0.000	123.419	73.061
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	118.214	65.804	0.000	128.084	75.673
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	122.965	68.464	0.000	132.835	78.334
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	127.803	71.173	0.000	137.673	81.043
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	132.728	73.931	0.000	142.598	83.801
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	137.740	76.738	0.000	147.610	86.608
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	142.837	79.592	0.000	152.707	89.462
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	147.934	82.447	0.000	157.804	92.317
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	9.870	153.031	85.301	0.000	162.901	95.171
3	-62	1	105	42.5999985	3671.10205	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	12.655	153.031	85.301	0.000	165.686	97.956
3	-63	1	105	42.5999985	3713.70215	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	15.439	153.031	85.301	0.000	168.471	100.741
3	-64	1	105	42.5999985	3756.30225	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	18.224	153.031	85.301	0.000	171.256	103.526
3	-65	1	105	42.5999985	3798.90234	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	21.009	153.031	85.301	0.000	174.040	106.310
3	-66	1	105	42.5999985	3841.50244	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	23.794	153.031	85.301	0.000	176.825	109.095
3	-67	1	105	42.5999985	3884.10254	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	26.578	153.031	85.301	0.000	179.610	111.880
3	-68	1	105	42.5999985	3926.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	29.363	153.031	85.301	0.000	182.395	114.665
3	-69	1	105	42.5999985	3969.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	32.148	153.031	85.301	0.000	185.179	117.449
3	-70	1	105	42.5999985	4011.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	34.933	153.031	85.301	0.000	187.964	120.234
3	-71	1	105	42.5999985	4054.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	37.717	153.031	85.301	0.000	190.749	123.019
3	-72	1	105	42.5999985	4097.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	40.502	153.031	85.301	0.000	193.534	125.804
3	-73	1	105	42.5999985	4139.70264	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	43.287	153.031	85.301	0.000	196.318	128.588
3	-74	1	105	42.5999985	4182.30273	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	46.072	153.031	85.301	0.000	199.103	131.373
3	-75	1	105	42.5999985	4224.90283	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	48.857	153.031	85.301	0.000	201.888	134.158
3	-76	1	105	42.5999985	4267.50293	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	51.641	153.031	85.301	0.000	204.673	136.943
3	-77	1	105	42.5999985	4310.10303	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	54.426	153.031	85.301	0.000	207.457	139.727
3	-78	1	105	42.5999985	4352.70313	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	57.211	153.031	85.301	0.000	210.242	142.512
3	-79	1	105	42.5999985	4395.30322	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	59.996	153.031	85.301	0.000	213.027	145.297
3	-80	1	105	42.5999985	4437.90332	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	62.780	153.031	85.301	0.000	215.811	148.082
3	-81	1	105	42.5999985	4480.50342	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	65.565	153.031	85.301	0.000	218.596	150.866
3	-82	1	105	42.5999985	4523.10352	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	68.350	153.031	85.301	0.000	221.381	153.651
3	-83	1	105	42.5999985	4565.70361	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	71.135	153.031	85.301	0.000	224.166	156.436
3	-84	1	105	42.5999985	4608.30371	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	73.919	153.031	85.301	0.000	226.950	159.220
3	-85	1	105	42.5999985	4650.90381	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	76.704	153.031	85.301	0.000	229.735	162.005
3	-86	1	105	42.5999985	4693.50391	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	79.489	153.031	85.301	0.000	232.520	164.790
3	-87	1	105	42.5999985	4736.104	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	82.274	153.031	85.301	0.000	235.305	167.575
3	-88	1	105	42.5999985	4778.7041	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	85.058	153.031	85.301	0.000	238.089	170.359
3	-89	1	105	42.5999985	4821.3042	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	87.843	153.031	85.301	0.000	240.874	173.144
3	-90	1	105	42.5999985	4863.9043	3500	3500	1580	790	0	0	1.00	1.00	1.00	9.00	No	90.628	153.031	85.301	0.000	243.659	175.929
4	-91	1	117	54.5999985	4912.50439	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	91.098	154.951	88.281	0.000	246.049	177.359
4	-92	1	117	54.5999985	4967.10449	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	91.568	156.871	87.221	0.000	248.439	178.788
4	-93	1	117	54.5999985	5021.70459	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	92.038	158.791	88.181	0.000	250.829	180.219
4	-94	1	117	54.5999985	5076.30469	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	92.508	160.711	89.141	0.000	253.219	181.649
4	-95	1	117	54.5999985	5130.90479	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	92.978	162.631	90.101	0.000	255.609	183.079
4	-96	1	117	54.5999985	5185.50488	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	93.448	164.551	91.061	0.000	257.999	184.509
4	-97	1	117	54.5999985	5240.10498	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	93.918	166.471	92.021	0.000	260.389	185.939
4	-98	1	117	54.5999985	5294.70508	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	94.388	168.391	92.981	0.000	262.779	187.369
4	-99	1	117	54.5999985	5349.30518	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	94.858	170.311	93.941	0.000	265.169	188.799
4	-100	1	117	54.5999985	5403.90527	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	95.328	172.231	94.901	0.000	267.559	190.229
4	-101	1	117	54.5999985	5458.50537	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	95.798	174.151	95.861	0.000	269.949	191.659

1055

4	-102	1	117	54.5999685	5513.10547	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	96.268	176.071	96.821	0.000	272.338	193.089
4	-103	1	117	54.5999685	5567.70557	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	96.738	177.991	97.781	0.000	274.728	194.519
4	-104	1	117	54.5999685	5622.30566	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	97.208	179.911	98.741	0.000	277.118	195.949
4	-105	1	117	54.5999685	5676.90576	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	97.678	181.831	99.701	0.000	279.508	197.379
4	-106	1	117	54.5999685	5731.50586	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	98.148	183.751	100.661	0.000	281.898	198.809
4	-107	1	117	54.5999685	5786.10596	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	98.618	185.671	101.621	0.000	284.288	200.239
4	-108	1	117	54.5999685	5840.70605	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	99.088	187.591	102.581	0.000	286.678	201.669
4	-109	1	117	54.5999685	5895.30615	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	99.558	189.511	103.541	0.000	289.068	203.099
4	-110	1	117	54.5999685	5949.90625	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.028	191.431	104.501	0.000	291.458	204.529
4	-111	1	117	54.5999685	6004.50635	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.498	193.351	105.461	0.000	293.848	205.958
4	-112	1	117	54.5999685	6059.10645	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	100.968	195.271	106.421	0.000	296.238	207.388
4	-113	1	117	54.5999685	6113.70654	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	101.438	197.191	107.381	0.000	298.628	208.818
4	-114	1	117	54.5999685	6168.30664	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	101.908	199.111	108.341	0.000	301.018	210.248
4	-115	1	117	54.5999685	6222.90674	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	102.378	201.031	109.301	0.000	303.408	211.678
4	-116	1	117	54.5999685	6277.50684	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	102.848	202.951	110.261	0.000	305.798	213.108
4	-117	1	117	54.5999685	6332.10693	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	103.318	204.870	111.221	0.000	308.188	214.538
4	-118	1	117	54.5999685	6386.70703	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	103.788	206.790	112.181	0.000	310.578	215.968
4	-119	1	117	54.5999685	6441.30713	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	104.258	208.710	113.141	0.000	312.968	217.398
4	-120	1	117	54.5999685	6495.90723	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	104.728	210.630	114.101	0.000	315.358	218.828
4	-121	1	117	54.5999685	6550.50732	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	105.198	212.550	115.061	0.000	317.748	220.258
4	-122	1	117	54.5999685	6605.10742	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	105.668	214.470	116.021	0.000	320.138	221.688
4	-123	1	117	54.5999685	6659.70752	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	106.138	216.390	116.981	0.000	322.527	223.118
4	-124	1	117	54.5999685	6714.30762	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	106.608	218.310	117.941	0.000	324.917	224.548
4	-125	1	117	54.5999685	6768.90771	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	107.078	220.230	118.901	0.000	327.307	225.978
4	-126	1	117	54.5999685	6823.50781	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	107.548	222.150	119.861	0.000	329.697	227.408
4	-127	1	117	54.5999685	6878.10791	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	108.018	224.070	120.821	0.000	332.087	228.838
4	-128	1	117	54.5999685	6932.70801	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	108.488	225.990	121.781	0.000	334.477	230.268

1056

Boring R-59.75-LU_HP14x73 Steel Pile_S-Case

								S-CASE														
Stratum	Tip	Increment	$\gamma_{(weight)}$	$\gamma_{(sub)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	117	54.5999985	0	0	0	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	117	54.5999985	27.2999992	27.2999992	54.5999985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.029	0.015	0.000	0.029	0.015
1	0	1	117	54.5999985	81.8999939	81.8999939	109.199997	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.117	0.059	0.000	0.117	0.059
1	-1	1	117	54.5999985	136.5	136.5	163.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.264	0.132	0.000	0.264	0.132
1	-2	1	117	54.5999985	191.099991	191.099991	218.399994	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.470	0.235	0.000	0.470	0.235
1	-3	1	117	54.5999985	245.699997	245.699997	273	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	0.734	0.367	0.000	0.734	0.367
1	-4	1	117	54.5999985	300.299988	300.299988	327.600006	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.057	0.529	0.000	1.057	0.529
1	-5	1	117	54.5999985	354.899994	354.899994	382.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.439	0.720	0.000	1.439	0.720
1	-6	1	117	54.5999985	409.5	409.5	436.800018	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	1.880	0.940	0.000	1.880	0.940
1	-7	1	117	54.5999985	464.100006	464.100006	491.400024	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.379	1.189	0.000	2.379	1.189
1	-8	1	117	54.5999985	518.700012	518.700012	546	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	2.937	1.468	0.000	2.937	1.468
1	-9	1	117	54.5999985	573.299988	573.299988	600.599976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.554	1.777	0.000	3.554	1.777
1	-10	1	117	54.5999985	627.899963	627.899963	655.199951	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.229	2.115	0.000	4.229	2.115
1	-11	1	117	54.5999985	682.499939	682.499939	709.799927	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.963	2.482	0.000	4.963	2.482
1	-12	1	117	54.5999985	737.099915	737.099915	764.399902	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.756	2.878	0.000	5.756	2.878
1	-13	1	117	54.5999985	791.69989	791.69989	818.999878	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.608	3.304	0.000	6.608	3.304
1	-14	1	117	54.5999985	846.299866	846.299866	873.599854	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.519	3.759	0.000	7.519	3.759
1	-15	1	117	54.5999985	900.899841	900.899841	928.199829	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.488	4.244	0.000	8.488	4.244
1	-16	1	117	54.5999985	955.499817	955.499817	982.799805	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	9.516	4.758	0.000	9.516	4.758
1	-17	1	117	54.5999985	1010.09979	1010.09979	1037.39978	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	10.602	5.301	0.000	10.602	5.301
1	-18	1	117	54.5999985	1064.69983	1064.69983	1091.99976	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	11.748	5.874	0.000	11.748	5.874
1	-19	1	117	54.5999985	1119.2998	1119.2998	1146.59973	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	12.952	6.476	0.000	12.952	6.476
2	-20	1	122	59.5999985	1176.39978	1176.39978	1206.19971	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	14.665	7.435	0.000	14.665	7.435
2	-21	1	122	59.5999985	1235.99976	1235.99976	1265.79968	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	16.465	8.443	0.000	16.465	8.443
2	-22	1	122	59.5999985	1295.59973	1295.59973	1325.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	18.352	9.500	0.000	18.352	9.500
2	-23	1	122	59.5999985	1355.19971	1355.19971	1384.99963	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	20.326	10.605	0.000	20.326	10.605
2	-24	1	122	59.5999985	1414.79968	1414.79968	1444.59961	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	22.386	11.759	0.000	22.386	11.759
2	-25	1	122	59.5999985	1474.39966	1474.39966	1504.19958	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	24.533	12.962	0.000	24.533	12.962
2	-26	1	122	59.5999985	1533.99963	1533.99963	1563.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	26.767	14.213	0.000	26.767	14.213
2	-27	1	122	59.5999985	1593.59961	1593.59961	1623.39954	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	29.088	15.512	0.000	29.088	15.512
2	-28	1	122	59.5999985	1653.19958	1653.19958	1682.99951	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	31.496	16.861	0.000	31.496	16.861
2	-29	1	122	59.5999985	1712.79956	1712.79956	1742.59949	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	33.990	18.258	0.000	33.990	18.258
2	-30	1	122	59.5999985	1772.39954	1772.39954	1802.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	36.572	19.703	0.000	36.572	19.703
2	-31	1	122	59.5999985	1831.99951	1831.99951	1861.79944	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	39.240	21.197	0.000	39.240	21.197
2	-32	1	122	59.5999985	1891.59949	1891.59949	1921.39941	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	41.995	22.740	0.000	41.995	22.740
2	-33	1	122	59.5999985	1951.19946	1951.19946	1980.99939	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	44.836	24.331	0.000	44.836	24.331
2	-34	1	122	59.5999985	2010.79944	2010.79944	2040.59937	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	47.765	25.971	0.000	47.765	25.971
2	-35	1	122	59.5999985	2070.39941	2070.39941	2100.19946	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	50.780	27.660	0.000	50.780	27.660
2	-36	1	122	59.5999985	2129.99951	2129.99951	2159.79956	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	53.882	29.397	0.000	53.882	29.397
2	-37	1	122	59.5999985	2189.59961	2189.59961	2219.39966	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	57.071	31.183	0.000	57.071	31.183
2	-38	1	122	59.5999985	2249.19971	2249.19971	2278.99976	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	60.346	33.017	0.000	60.346	33.017
2	-39	1	122	59.5999985	2308.7998	2308.7998	2338.59985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	63.709	34.900	0.000	63.709	34.900
2	-40	1	122	59.5999985	2368.3999	2368.3999	2398.19995	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	67.158	36.831	0.000	67.158	36.831
2	-41	1	122	59.5999985	2428	2428	2457.80005	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	70.694	38.812	0.000	70.694	38.812
2	-42	1	122	59.5999985	2487.6001	2487.6001	2517.40015	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	74.317	40.840	0.000	74.317	40.840
2	-43	1	122	59.5999985	2547.2002	2547.2002	2577.00024	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	78.027	42.918	0.000	78.027	42.918
2	-44	1	122	59.5999985	2606.80029	2606.80029	2636.60034	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	81.823	45.044	0.000	81.823	45.044
2	-45	1	122	59.5999985	2666.40039	2666.40039	2696.20044	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	85.706	47.218	0.000	85.706	47.218
2	-46	1	122	59.5999985	2726.00049	2726.00049	2755.80054	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	89.676	49.442	0.000	89.676	49.442

1057

2	-47	1	122	59.5999985	2785.60059	2785.60059	2815.40063	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	93.733	51.713	0.000	93.733	51.713
2	-48	1	122	59.5999985	2845.20068	2845.20068	2875.00073	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	97.877	54.034	0.000	97.877	54.034
2	-49	1	122	59.5999985	2904.80078	2904.80078	2934.60083	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	102.107	56.403	0.000	102.107	56.403
2	-50	1	122	59.5999985	2964.40088	2964.40088	2994.20093	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	106.424	58.821	0.000	106.424	58.821
2	-51	1	122	59.5999985	3024.00098	3024.00098	3053.80103	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	110.829	61.287	0.000	110.829	61.287
2	-52	1	122	59.5999985	3083.60107	3083.60107	3113.40112	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	115.319	63.802	0.000	115.319	63.802
2	-53	1	122	59.5999985	3143.20117	3143.20117	3173.00122	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	119.897	66.365	0.000	119.897	66.365
2	-54	1	122	59.5999985	3202.80127	3202.80127	3232.60132	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	124.561	68.977	0.000	124.561	68.977
2	-55	1	122	59.5999985	3262.40137	3262.40137	3292.20142	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	129.313	71.638	0.000	129.313	71.638
2	-56	1	122	59.5999985	3322.00146	3322.00146	3351.80151	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	134.151	74.347	0.000	134.151	74.347
2	-57	1	122	59.5999985	3381.60156	3381.60156	3411.40161	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	139.075	77.105	0.000	139.075	77.105
2	-58	1	122	59.5999985	3441.20166	3441.20166	3471.00171	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	144.087	79.912	0.000	144.087	79.912
2	-59	1	122	59.5999985	3500.80176	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	149.184	82.766	0.000	149.184	82.766
2	-60	1	122	59.5999985	3560.40186	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	154.282	85.621	0.000	154.282	85.621
2	-61	1	122	59.5999985	3620.00195	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	159.379	88.475	0.000	159.379	88.475
3	-62	1	105	42.5999985	3671.10205	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	162.402	90.591	0.000	162.402	90.591
3	-63	1	105	42.5999985	3713.70215	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	165.424	92.707	0.000	165.424	92.707
3	-64	1	105	42.5999985	3756.30225	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	168.447	94.823	0.000	168.447	94.823
3	-65	1	105	42.5999985	3798.90234	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	171.469	96.938	0.000	171.469	96.938
3	-66	1	105	42.5999985	3841.50244	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	174.492	99.054	0.000	174.492	99.054
3	-67	1	105	42.5999985	3884.10254	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	177.515	101.170	0.000	177.515	101.170
3	-68	1	105	42.5999985	3926.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	180.537	103.286	0.000	180.537	103.286
3	-69	1	105	42.5999985	3969.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	183.560	105.402	0.000	183.560	105.402
3	-70	1	105	42.5999985	4011.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	186.582	107.518	0.000	186.582	107.518
3	-71	1	105	42.5999985	4054.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	189.605	109.633	0.000	189.605	109.633
3	-72	1	105	42.5999985	4097.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	192.628	111.749	0.000	192.628	111.749
3	-73	1	105	42.5999985	4139.70264	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	195.650	113.865	0.000	195.650	113.865
3	-74	1	105	42.5999985	4182.30273	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	198.673	115.981	0.000	198.673	115.981
3	-75	1	105	42.5999985	4224.90283	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	201.695	118.097	0.000	201.695	118.097
3	-76	1	105	42.5999985	4267.50293	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	204.718	120.213	0.000	204.718	120.213
3	-77	1	105	42.5999985	4310.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	207.741	122.328	0.000	207.741	122.328
3	-78	1	105	42.5999985	4352.70313	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	210.763	124.444	0.000	210.763	124.444
3	-79	1	105	42.5999985	4395.30322	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	213.786	126.560	0.000	213.786	126.560
3	-80	1	105	42.5999985	4437.90332	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	216.809	128.676	0.000	216.809	128.676
3	-81	1	105	42.5999985	4480.50342	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	219.831	130.792	0.000	219.831	130.792
3	-82	1	105	42.5999985	4523.10352	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	222.854	132.908	0.000	222.854	132.908
3	-83	1	105	42.5999985	4565.70361	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	225.876	135.023	0.000	225.876	135.023
3	-84	1	105	42.5999985	4608.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	228.899	137.139	0.000	228.899	137.139
3	-85	1	105	42.5999985	4650.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	231.922	139.255	0.000	231.922	139.255
3	-86	1	105	42.5999985	4693.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	234.944	141.371	0.000	234.944	141.371
3	-87	1	105	42.5999985	4736.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	237.967	143.487	0.000	237.967	143.487
3	-88	1	105	42.5999985	4778.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	240.989	145.602	0.000	240.989	145.602
3	-89	1	105	42.5999985	4821.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	244.012	147.718	0.000	244.012	147.718
3	-90	1	105	42.5999985	4863.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	247.035	149.834	0.000	247.035	149.834
4	-91	1	117	54.5999985	4912.50439	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	250.800	151.717	0.000	250.800	151.717
4	-92	1	117	54.5999985	4967.10449	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	254.565	153.599	0.000	254.565	153.599
4	-93	1	117	54.5999985	5021.70459	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	258.331	155.482	0.000	258.331	155.482
4	-94	1	117	54.5999985	5076.30469	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	262.096	157.365	0.000	262.096	157.365
4	-95	1	117	54.5999985	5130.90479	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	265.861	159.247	0.000	265.861	159.247
4	-96	1	117	54.5999985	5185.50488	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	269.626	161.130	0.000	269.626	161.130
4	-97	1	117	54.5999985	5240.10498	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	273.392	163.013	0.000	273.392	163.013
4	-98	1	117	54.5999985	5294.70508	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	277.157	164.895	0.000	277.157	164.895
4	-99	1	117	54.5999985	5349.30518	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	280.922	166.778	0.000	280.922	166.778
4	-100	1	117	54.5999985	5403.90527	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	284.688	168.661	0.000	284.688	168.661
4	-101	1	117	54.5999985	5458.50537	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	288.453	170.543	0.000	288.453	170.543

875

1058

4	-102	1	117	54.5999985	5513.10547	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	292.218	172.426	0.000	292.218	172.426
4	-103	1	117	54.5999985	5567.70557	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	295.983	174.309	0.000	295.983	174.309
4	-104	1	117	54.5999985	5622.30566	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	299.749	176.191	0.000	299.749	176.191
4	-105	1	117	54.5999985	5676.90576	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	303.514	178.074	0.000	303.514	178.074
4	-106	1	117	54.5999985	5731.50586	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	307.279	179.956	0.000	307.279	179.956
4	-107	1	117	54.5999985	5786.10596	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	311.045	181.839	0.000	311.045	181.839
4	-108	1	117	54.5999985	5840.70605	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	314.810	183.722	0.000	314.810	183.722
4	-109	1	117	54.5999985	5895.30615	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	318.575	185.604	0.000	318.575	185.604
4	-110	1	117	54.5999985	5949.90625	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	322.340	187.487	0.000	322.340	187.487
4	-111	1	117	54.5999985	6004.50635	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	326.106	189.370	0.000	326.106	189.370
4	-112	1	117	54.5999985	6059.10645	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	329.871	191.252	0.000	329.871	191.252
4	-113	1	117	54.5999985	6113.70654	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	333.636	193.135	0.000	333.636	193.135
4	-114	1	117	54.5999985	6168.30664	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	337.402	195.018	0.000	337.402	195.018
4	-115	1	117	54.5999985	6222.90674	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	341.167	196.900	0.000	341.167	196.900
4	-116	1	117	54.5999985	6277.50684	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	344.932	198.783	0.000	344.932	198.783
4	-117	1	117	54.5999985	6332.10693	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	348.698	200.666	0.000	348.698	200.666
4	-118	1	117	54.5999985	6386.70703	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	352.463	202.548	0.000	352.463	202.548
4	-119	1	117	54.5999985	6441.30713	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	356.228	204.431	0.000	356.228	204.431
4	-120	1	117	54.5999985	6495.90723	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	359.993	206.313	0.000	359.993	206.313
4	-121	1	117	54.5999985	6550.50732	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	363.759	208.196	0.000	363.759	208.196
4	-122	1	117	54.5999985	6605.10742	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	367.524	210.079	0.000	367.524	210.079
4	-123	1	117	54.5999985	6659.70752	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	371.289	211.961	0.000	371.289	211.961
4	-124	1	117	54.5999985	6714.30762	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	375.055	213.844	0.000	375.055	213.844
4	-125	1	117	54.5999985	6768.90771	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	378.820	215.727	0.000	378.820	215.727
4	-126	1	117	54.5999985	6823.50781	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	382.585	217.609	0.000	382.585	217.609
4	-127	1	117	54.5999985	6878.10791	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	386.350	219.492	0.000	386.350	219.492
4	-128	1	117	54.5999985	6932.70801	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	390.116	221.375	0.000	390.116	221.375

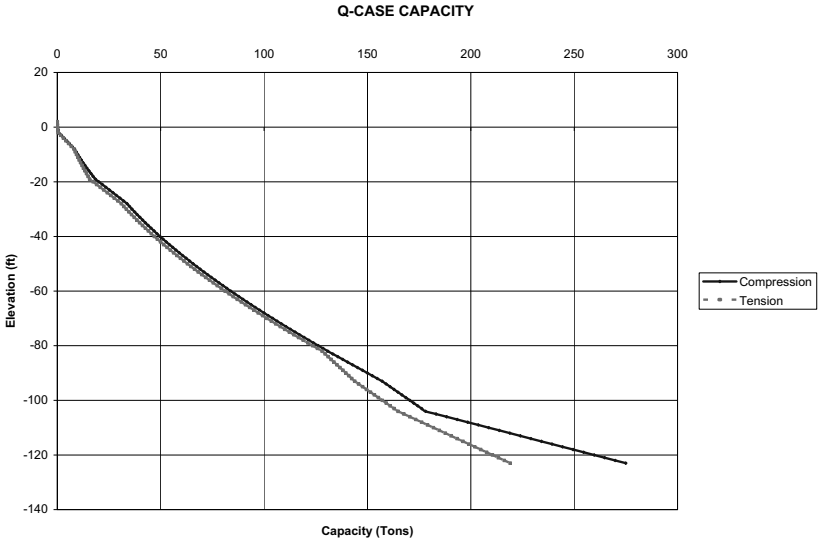
880

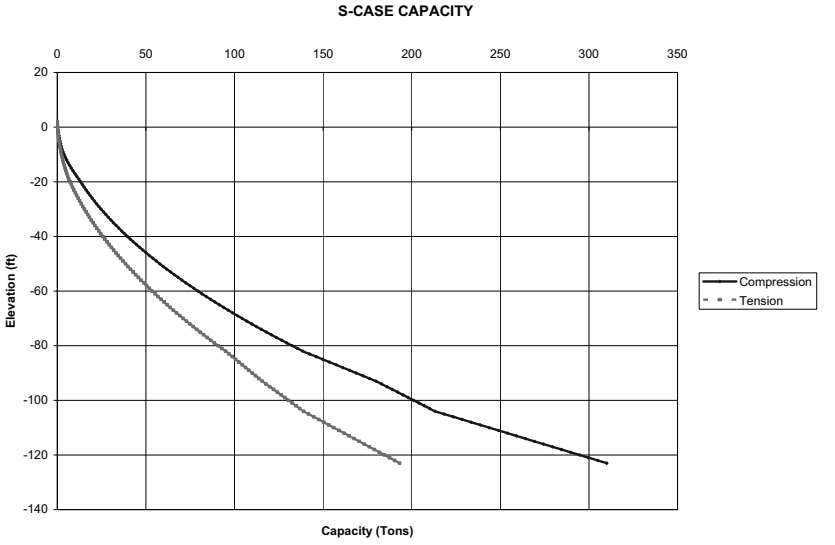
885

890

Boring
R-60.3-LU
HP14x73 Steel Pile Capacities

895


Q-CASE CAPACITY
0
50
100
150
200
250
300
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension


S-CASE CAPACITY
0
50
100
150
200
250
300
350
20
0
-20
-40
-60
-80
-100
-120
-140
Elevation (ft)
Capacity (Tons)
Compression
Tension

Boring R-60.3-UL_HP14x73 Steel Pile_Q-Case

								Q-CASE													
Stratum	Tip	Increment	$\gamma_{pile(sat)}$	$\gamma_{(sub)}$	Δz	Mid-layer Δz (used)	Bottom Δz (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.043	0.024	0.000	0.043	0.024
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.174	0.097	0.000	0.174	0.097
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.391	0.219	0.000	0.391	0.219
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.694	0.389	0.000	0.694	0.389
2	-3	1	107	44.5999985	260.699982	260.699982	283	550	536.25	0	0	1.00	1.00	1.00	9.00	No	1.276	0.694	0.389	0.000	1.971	1.665
2	-4	1	107	44.5999985	305.299988	305.299988	327.800006	550	536.25	0	0	1.00	1.00	1.00	9.00	No	2.553	0.694	0.389	0.000	3.247	2.942
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	550	536.25	0	0	1.00	1.00	1.00	9.00	No	3.829	0.694	0.389	0.000	4.523	4.218
2	-6	1	107	44.5999985	394.5	394.5	416.800018	550	536.25	0	0	1.00	1.00	1.00	9.00	No	5.105	0.694	0.389	0.000	5.800	5.494
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	550	536.25	0	0	1.00	1.00	1.00	9.00	No	6.382	0.694	0.389	0.000	7.076	6.771
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	550	536.25	0	0	1.00	1.00	1.00	9.00	No	7.658	0.694	0.389	0.000	8.352	8.047
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.128	0.987	0.535	0.000	9.115	8.663
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	200	200	15	11.25	1.00	0.50	4.40	12.90	No	8.598	1.309	0.696	0.000	9.908	9.294
3	-11	1	117	54.5999985	642.5	642.5	669.799988	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.068	1.662	0.873	0.000	10.730	9.941
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	200	200	15	11.25	1.00	0.50	4.40	12.90	No	9.536	2.044	1.064	0.000	11.582	10.602
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.008	2.457	1.270	0.000	12.465	11.278
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.478	2.899	1.491	0.000	13.377	11.969
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	200	200	15	11.25	1.00	0.50	4.40	12.90	No	10.948	3.371	1.727	0.000	14.319	12.675
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	200	200	15	11.25	1.00	0.50	4.40	12.90	No	11.418	3.873	1.978	0.000	15.291	13.396
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	200	200	15	11.25	1.00	0.50	4.40	12.90	No	11.888	4.408	2.244	0.000	16.294	14.133
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99968	200	200	15	11.25	1.00	0.50	4.40	12.90	No	12.358	4.968	2.526	0.000	17.326	14.884
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	200	200	15	11.25	1.00	0.50	4.40	12.90	No	12.828	5.560	2.822	0.000	18.388	15.650
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	14.533	5.560	2.822	0.000	20.093	17.354
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	16.237	5.560	2.822	0.000	21.797	19.059
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	17.942	5.560	2.822	0.000	23.502	20.764
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	19.647	5.560	2.822	0.000	25.207	22.468
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	21.352	5.560	2.822	0.000	26.911	24.173
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	23.056	5.560	2.822	0.000	28.616	25.878
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	24.761	5.560	2.822	0.000	30.321	27.582
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	26.466	5.560	2.822	0.000	32.025	29.287
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	780	670.799988	0	0	1.00	1.00	1.00	9.00	No	28.170	5.560	2.822	0.000	33.730	30.992
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59961	512.962952	504.819092	0	0	1.00	1.00	1.00	9.00	No	29.359	5.560	2.822	0.000	34.918	32.180
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	525.925903	514.373291	0	0	1.00	1.00	1.00	9.00	No	30.573	5.560	2.822	0.000	36.133	33.395
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	538.888916	523.756399	0	0	1.00	1.00	1.00	9.00	No	31.814	5.560	2.822	0.000	37.374	34.636
5	-32	1	101	38.5999985	1589.09961	1589.09961	1608.39954	551.851868	532.977539	0	0	1.00	1.00	1.00	9.00	No	33.081	5.560	2.822	0.000	38.641	35.903
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	564.814819	542.027588	0	0	1.00	1.00	1.00	9.00	No	34.374	5.560	2.822	0.000	39.934	37.196
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	577.777771	550.909668	0	0	1.00	1.00	1.00	9.00	No	35.693	5.560	2.822	0.000	41.253	38.514
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	590.740723	559.623657	0	0	1.00	1.00	1.00	9.00	No	37.037	5.560	2.822	0.000	42.597	39.858
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	603.703674	568.169556	0	0	1.00	1.00	1.00	9.00	No	38.406	5.560	2.822	0.000	43.966	41.228
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	616.666687	576.547485	0	0	1.00	1.00	1.00	9.00	No	39.801	5.560	2.822	0.000	45.360	42.622
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	629.629639	584.757385	0	0	1.00	1.00	1.00	9.00	No	41.220	5.560	2.822	0.000	46.780	44.041
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	642.59259	592.799194	0	0	1.00	1.00	1.00	9.00	No	42.664	5.560	2.822	0.000	48.224	45.485
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	655.555542	600.672974	0	0	1.00	1.00	1.00	9.00	No	44.132	5.560	2.822	0.000	49.692	46.954
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	668.518494	608.378784	0	0	1.00	1.00	1.00	9.00	No	45.625	5.560	2.822	0.000	51.185	48.447
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	681.481506	615.916504	0	0	1.00	1.00	1.00	9.00	No	47.142	5.560	2.822	0.000	52.702	49.963
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	694.444458	623.286194	0	0	1.00	1.00	1.00	9.00	No	48.683	5.560	2.822	0.000	54.242	51.504
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	707.40741	630.487793	0	0	1.00	1.00	1.00	9.00	No	50.247	5.560	2.822	0.000	55.807	53.069
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	720.370361	637.521423	0	0	1.00	1.00	1.00	9.00	No	51.835	5.560	2.822	0.000	57.395	54.657
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	733.333313	644.386963	0	0	1.00	1.00	1.00	9.00	No	53.446	5.560	2.822	0.000	59.006	56.268

1063

5	-47	1	101	38.5999985	2168.09961	2168.09961	2187.39966	746.296326	651.084534	0	0	1.00	1.00	1.00	9.00	No	55.080	5.560	2.822	0.000	60.640	57.902
5	-48	1	101	38.5999985	2206.69971	2206.69971	2225.99976	759.259277	657.614014	0	0	1.00	1.00	1.00	9.00	No	56.738	5.560	2.822	0.000	62.297	59.559
5	-49	1	101	38.5999985	2245.2998	2245.2998	2264.59985	772.222229	663.975464	0	0	1.00	1.00	1.00	9.00	No	58.418	5.560	2.822	0.000	63.977	61.239
5	-50	1	101	38.5999985	2283.8999	2283.8999	2303.19995	785.185181	670.168884	0	0	1.00	1.00	1.00	9.00	No	60.120	5.560	2.822	0.000	65.680	62.942
5	-51	1	101	38.5999985	2322.5	2322.5	2341.80005	798.148132	676.194214	0	0	1.00	1.00	1.00	9.00	No	61.845	5.560	2.822	0.000	67.405	64.666
5	-52	1	101	38.5999985	2361.1001	2361.1001	2380.40015	811.111084	682.051575	0	0	1.00	1.00	1.00	9.00	No	63.592	5.560	2.822	0.000	69.151	66.413
5	-53	1	101	38.5999985	2399.7002	2399.7002	2419.00024	824.074097	687.740906	0	0	1.00	1.00	1.00	9.00	No	65.360	5.560	2.822	0.000	70.920	68.182
5	-54	1	101	38.5999985	2438.30029	2438.30029	2457.60034	837.037048	693.262207	0	0	1.00	1.00	1.00	9.00	No	67.151	5.560	2.822	0.000	72.711	69.972
5	-55	1	101	38.5999985	2476.90039	2476.90039	2496.20044	850	698.615356	0	0	1.00	1.00	1.00	9.00	No	68.963	5.560	2.822	0.000	74.523	71.784
5	-56	1	101	38.5999985	2515.50049	2515.50049	2534.80054	862.962952	703.800537	0	0	1.00	1.00	1.00	9.00	No	70.798	5.560	2.822	0.000	76.356	73.618
5	-57	1	101	38.5999985	2554.10059	2554.10059	2573.40063	875.925903	708.817749	0	0	1.00	1.00	1.00	9.00	No	72.651	5.560	2.822	0.000	78.210	75.472
5	-58	1	101	38.5999985	2592.70068	2592.70068	2612.00073	888.888916	713.69687	0	0	1.00	1.00	1.00	9.00	No	74.526	5.560	2.822	0.000	80.086	77.348
5	-59	1	101	38.5999985	2631.30078	2631.30078	2650.60083	901.851868	718.3479	0	0	1.00	1.00	1.00	9.00	No	76.422	5.560	2.822	0.000	81.982	79.244
5	-60	1	101	38.5999985	2669.90088	2669.90088	2689.20093	914.814819	722.880962	0	0	1.00	1.00	1.00	9.00	No	78.339	5.560	2.822	0.000	83.899	81.160
5	-61	1	101	38.5999985	2708.50098	2708.50098	2727.80103	927.777771	727.205933	0	0	1.00	1.00	1.00	9.00	No	80.276	5.560	2.822	0.000	85.836	83.097
5	-62	1	101	38.5999985	2747.10107	2747.10107	2766.40112	940.740723	731.382874	0	0	1.00	1.00	1.00	9.00	No	82.233	5.560	2.822	0.000	87.793	85.054
5	-63	1	101	38.5999985	2785.70117	2785.70117	2805.00122	953.703674	735.391785	0	0	1.00	1.00	1.00	9.00	No	84.210	5.560	2.822	0.000	89.770	87.032
5	-64	1	101	38.5999985	2824.30127	2824.30127	2843.60132	966.666687	739.232666	0	0	1.00	1.00	1.00	9.00	No	86.207	5.560	2.822	0.000	91.767	89.028
5	-65	1	101	38.5999985	2862.90137	2862.90137	2882.20142	979.629639	742.905518	0	0	1.00	1.00	1.00	9.00	No	88.223	5.560	2.822	0.000	93.783	91.045
5	-66	1	101	38.5999985	2901.50146	2901.50146	2920.80151	992.59259	746.410339	0	0	1.00	1.00	1.00	9.00	No	90.259	5.560	2.822	0.000	95.819	93.080
5	-67	1	101	38.5999985	2940.10156	2940.10156	2959.40161	1005.55554	749.74707	0	0	1.00	1.00	1.00	9.00	No	92.314	5.560	2.822	0.000	97.874	95.135
5	-68	1	101	38.5999985	2978.70166	2978.70166	2998.00171	1018.51849	752.915771	0	0	1.00	1.00	1.00	9.00	No	94.388	5.560	2.822	0.000	99.947	97.209
5	-69	1	101	38.5999985	3017.30176	3017.30176	3036.60181	1031.48145	755.916504	0	0	1.00	1.00	1.00	9.00	No	96.480	5.560	2.822	0.000	102.040	99.302
5	-70	1	101	38.5999985	3055.90186	3055.90186	3075.2019	1044.44448	758.749146	0	0	1.00	1.00	1.00	9.00	No	98.591	5.560	2.822	0.000	104.151	101.413
5	-71	1	101	38.5999985	3094.50195	3094.50195	3113.802	1057.40735	761.413757	0	0	1.00	1.00	1.00	9.00	No	100.721	5.560	2.822	0.000	106.281	103.542
5	-72	1	101	38.5999985	3133.10205	3133.10205	3152.4021	1070.37036	763.910278	0	0	1.00	1.00	1.00	9.00	No	102.868	5.560	2.822	0.000	108.428	105.690
5	-73	1	101	38.5999985	3171.70215	3171.70215	3191.0022	1083.33337	766.238892	0	0	1.00	1.00	1.00	9.00	No	105.034	5.560	2.822	0.000	110.594	107.856
5	-74	1	101	38.5999985	3210.30225	3210.30225	3229.60229	1096.29626	768.399353	0	0	1.00	1.00	1.00	9.00	No	107.218	5.560	2.822	0.000	112.777	110.039
5	-75	1	101	38.5999985	3248.90234	3248.90234	3268.20239	1109.25928	770.391785	0	0	1.00	1.00	1.00	9.00	No	109.418	5.560	2.822	0.000	114.978	112.240
5	-76	1	101	38.5999985	3287.50244	3287.50244	3306.80249	1122.22217	772.216187	0	0	1.00	1.00	1.00	9.00	No	111.637	5.560	2.822	0.000	117.197	114.458
5	-77	1	101	38.5999985	3326.10254	3326.10254	3345.40259	1135.18518	773.872559	0	0	1.00	1.00	1.00	9.00	No	113.872	5.560	2.822	0.000	119.432	116.694
5	-78	1	101	38.5999985	3364.70264	3364.70264	3384.00269	1148.14819	775.360962	0	0	1.00	1.00	1.00	9.00	No	116.125	5.560	2.822	0.000	121.685	118.946
5	-79	1	101	38.5999985	3403.30273	3403.30273	3422.60278	1161.11108	776.681274	0	0	1.00	1.00	1.00	9.00	No	118.394	5.560	2.822	0.000	123.954	121.216
5	-80	1	101	38.5999985	3441.90283	3441.90283	3461.20288	1174.0741	777.833496	0	0	1.00	1.00	1.00	9.00	No	120.680	5.560	2.822	0.000	126.240	123.502
5	-81	1	101	38.5999985	3480.50293	3480.50293	3499.80298	1187.03699	778.817749	0	0	1.00	1.00	1.00	9.00	No	122.982	5.560	2.822	0.000	128.542	125.804
5	-82	1	101	38.5999985	3519.10303	3500	3500	1200	779.633911	0	0	1.00	1.00	1.00	9.00	No	125.301	5.560	2.822	0.000	130.861	128.122
6	-83	1	117	54.5999985	3585.70313	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	125.771	7.480	3.782	0.000	133.250	129.552
6	-84	1	117	54.5999985	3620.30322	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	126.241	9.400	4.742	0.000	135.640	130.982
6	-85	1	117	54.5999985	3674.90332	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	126.711	11.320	5.701	0.000	138.030	132.412
6	-86	1	117	54.5999985	3729.50342	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	127.181	13.240	6.661	0.000	140.420	133.842
6	-87	1	117	54.5999985	3784.10352	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	127.651	15.160	7.621	0.000	142.810	135.272
6	-88	1	117	54.5999985	3838.70361	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	128.121	17.080	8.581	0.000	145.200	136.702
6	-89	1	117	54.5999985	3893.30371	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	128.591	19.000	9.541	0.000	147.590	138.132
6	-90	1	117	54.5999985	3947.90381	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	129.061	20.919	10.501	0.000	149.980	139.562
6	-91	1	117	54.5999985	4002.50391	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	129.531	22.839	11.461	0.000	152.370	140.992
6	-92	1	117	54.5999985	4057.104	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	130.001	24.759	12.421	0.000	154.760	142.422
6	-93	1	117	54.5999985	4111.7041	3500	3500	200	200	15	11.25	1.00	0.50	4.40	12.90	No	130.471	26.679	13.381	0.000	157.150	143.852
7	-94	1	115	52.5999985	4165.30371	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	132.374	26.679	13.381	0.000	159.054	145.756
7	-95	1	115	52.5999985	4217.90381	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	134.278	26.679	13.381	0.000	160.957	147.659
7	-96	1	115	52.5999985	4270.50391	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	136.181	26.679	13.381	0.000	162.861	149.563
7	-97	1	115	52.5999985	4323.104	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	138.085	26.679	13.381	0.000	164.764	151.466
7	-98	1	115	52.5999985	4375.7041	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	139.988	26.679	13.381	0.000	166.668	153.370
7	-99	1	115	52.5999985	4428.3042	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	141.892	26.679	13.381	0.000	168.571	155.273
7	-100	1	115	52.5999985	4480.9043	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	143.795	26.679	13.381	0.000	170.475	157.177
7	-101	1	115	52.5999985	4533.50439	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	145.699	26.679	13.381	0.000	172.378	159.080

1064

7	-102	1	115	52.5999985	4586.10449	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	147.602	26.679	13.381	0.000	174.282	160.984
7	-103	1	115	52.5999985	4638.70459	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	149.506	26.679	13.381	0.000	176.185	162.887
7	-104	1	115	52.5999985	4691.30469	3500	3500	900	720	0	0	1.00	1.00	1.00	9.00	No	151.409	26.679	13.381	0.000	178.089	164.791
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	31.777	16.236	0.000	183.188	167.645
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	36.874	19.090	0.000	188.283	170.500
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	41.971	21.945	0.000	193.380	173.354
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	47.068	24.799	0.000	198.478	176.208
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	52.166	27.654	0.000	203.575	179.063
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	57.263	30.508	0.000	208.672	181.917
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	62.360	33.363	0.000	213.770	184.772
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	67.457	36.217	0.000	218.867	187.626
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	72.555	39.072	0.000	223.964	190.481
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	77.652	41.926	0.000	229.061	193.335
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	82.749	44.780	0.000	234.159	196.190
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	87.847	47.635	0.000	239.256	199.044
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	92.944	50.489	0.000	244.353	201.899
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	98.041	53.344	0.000	249.450	204.753
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	103.138	56.198	0.000	254.548	207.608
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	108.236	59.053	0.000	259.645	210.462
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	113.333	61.907	0.000	264.742	213.316
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	118.430	64.762	0.000	269.839	216.171
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	151.409	123.527	67.616	0.000	274.937	219.025

1065

900

Boring R-60.3-UL_HP14x73 Steel Pile_S-Case

								S-CASE														
Stratum	Tip	Increment	$\gamma_{(weak)}$	$\gamma_{(soft)}$	γh	Mid-layer γh (used)	Bottom γh (used)	Cohesion	Mid-Layer Adhesion	ϕ	δ	Kc	Kt	Nq	Nc	End Bearing	Coh./Adh Resistance	Friction Compression	Friction Tension	End Bearing	Pile Capacity Compression	Pile Capacity Tension
1	2	0	122	59.5999985	0	0	0	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.000	0.000	0.000	0.000	0.000
1	1	1	122	59.5999985	29.7999992	29.7999992	59.5999985	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.043	0.024	0.000	0.043	0.024
1	0	1	122	59.5999985	89.3999939	89.3999939	119.199997	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.174	0.097	0.000	0.174	0.097
1	-1	1	122	59.5999985	149	149	178.799988	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.391	0.219	0.000	0.391	0.219
1	-2	1	122	59.5999985	208.599991	208.599991	238.399994	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	0.694	0.389	0.000	0.694	0.389
2	-3	1	107	44.5999985	260.699982	260.699982	283	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	0.920	0.546	0.000	0.920	0.546
2	-4	1	107	44.5999985	305.299988	305.299988	327.600006	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.183	0.731	0.000	1.183	0.731
2	-5	1	107	44.5999985	349.899994	349.899994	372.200012	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.485	0.943	0.000	1.485	0.943
2	-6	1	107	44.5999985	394.5	394.5	416.800018	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	1.826	1.181	0.000	1.826	1.181
2	-7	1	107	44.5999985	439.100006	439.100006	461.400024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	2.205	1.446	0.000	2.205	1.446
2	-8	1	107	44.5999985	483.700012	483.700012	506.000031	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	2.623	1.739	0.000	2.623	1.739
3	-9	1	117	54.5999985	533.300049	533.300049	560.600037	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.197	2.026	0.000	3.197	2.026
3	-10	1	117	54.5999985	587.900024	587.900024	615.200012	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	3.829	2.342	0.000	3.829	2.342
3	-11	1	117	54.5999985	642.5	642.5	669.799988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	4.520	2.688	0.000	4.520	2.688
3	-12	1	117	54.5999985	697.099976	697.099976	724.399963	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	5.270	3.063	0.000	5.270	3.063
3	-13	1	117	54.5999985	751.699951	751.699951	778.999939	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.079	3.467	0.000	6.079	3.467
3	-14	1	117	54.5999985	806.299927	806.299927	833.599915	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	6.946	3.901	0.000	6.946	3.901
3	-15	1	117	54.5999985	860.899902	860.899902	888.19989	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	7.873	4.364	0.000	7.873	4.364
3	-16	1	117	54.5999985	915.499878	915.499878	942.799866	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	8.857	4.856	0.000	8.857	4.856
3	-17	1	117	54.5999985	970.099854	970.099854	997.399841	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	9.901	5.378	0.000	9.901	5.378
3	-18	1	117	54.5999985	1024.69983	1024.69983	1051.99988	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	11.003	5.929	0.000	11.003	5.929
3	-19	1	117	54.5999985	1079.29993	1079.29993	1106.59985	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	12.165	6.510	0.000	12.165	6.510
4	-20	1	101	38.5999985	1125.8999	1125.8999	1145.19983	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	13.137	7.190	0.000	13.137	7.190
4	-21	1	101	38.5999985	1164.49988	1164.49988	1183.7998	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	14.143	7.894	0.000	14.143	7.894
4	-22	1	101	38.5999985	1203.09985	1203.09985	1222.39978	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	15.182	8.622	0.000	15.182	8.622
4	-23	1	101	38.5999985	1241.69983	1241.69983	1260.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	16.254	9.372	0.000	16.254	9.372
4	-24	1	101	38.5999985	1280.2998	1280.2998	1299.59973	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	17.360	10.146	0.000	17.360	10.146
4	-25	1	101	38.5999985	1318.89978	1318.89978	1338.19971	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	18.499	10.943	0.000	18.499	10.943
4	-26	1	101	38.5999985	1357.49976	1357.49976	1376.79968	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	19.671	11.764	0.000	19.671	11.764
4	-27	1	101	38.5999985	1396.09973	1396.09973	1415.39966	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	20.877	12.608	0.000	20.877	12.608
4	-28	1	101	38.5999985	1434.69971	1434.69971	1453.99963	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	22.116	13.475	0.000	22.116	13.475
5	-29	1	101	38.5999985	1473.29968	1473.29968	1492.59961	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	23.388	14.366	0.000	23.388	14.366
5	-30	1	101	38.5999985	1511.89966	1511.89966	1531.19958	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	24.694	15.280	0.000	24.694	15.280
5	-31	1	101	38.5999985	1550.49963	1550.49963	1569.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	26.033	16.217	0.000	26.033	16.217
5	-32	1	101	38.5999985	1589.09961	1589.09961	1608.39954	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	27.405	17.178	0.000	27.405	17.178
5	-33	1	101	38.5999985	1627.69958	1627.69958	1646.99951	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	28.811	18.162	0.000	28.811	18.162
5	-34	1	101	38.5999985	1666.29956	1666.29956	1685.59949	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	30.250	19.169	0.000	30.250	19.169
5	-35	1	101	38.5999985	1704.89954	1704.89954	1724.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	31.722	20.200	0.000	31.722	20.200
5	-36	1	101	38.5999985	1743.49951	1743.49951	1762.79944	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	33.228	21.254	0.000	33.228	21.254
5	-37	1	101	38.5999985	1782.09949	1782.09949	1801.39941	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	34.767	22.331	0.000	34.767	22.331
5	-38	1	101	38.5999985	1820.69946	1820.69946	1839.99939	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	36.339	23.432	0.000	36.339	23.432
5	-39	1	101	38.5999985	1859.29944	1859.29944	1878.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	37.945	24.556	0.000	37.945	24.556
5	-40	1	101	38.5999985	1897.89941	1897.89941	1917.19934	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	39.584	25.703	0.000	39.584	25.703
5	-41	1	101	38.5999985	1936.49939	1936.49939	1955.79932	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	41.256	26.874	0.000	41.256	26.874
5	-42	1	101	38.5999985	1975.09937	1975.09937	1994.39929	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	42.962	28.068	0.000	42.962	28.068
5	-43	1	101	38.5999985	2013.69934	2013.69934	2032.99927	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	44.701	29.285	0.000	44.701	29.285
5	-44	1	101	38.5999985	2052.29932	2052.29932	2071.59937	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	46.473	30.526	0.000	46.473	30.526
5	-45	1	101	38.5999985	2090.89941	2090.89941	2110.19946	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	48.279	31.790	0.000	48.279	31.790
5	-46	1	101	38.5999985	2129.49951	2129.49951	2148.79956	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	50.118	33.077	0.000	50.118	33.077

5	-47	1	101	38.5999985	2168.09961	2168.09961	2187.39996	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	51.991	34.388	0.000	51.991	34.388
5	-48	1	101	38.5999985	2206.69971	2206.69971	2225.99976	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	53.896	35.722	0.000	53.896	35.722
5	-49	1	101	38.5999985	2245.2998	2245.2998	2264.59985	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	55.835	37.079	0.000	55.835	37.079
5	-50	1	101	38.5999985	2283.8999	2283.8999	2303.19995	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	57.808	38.460	0.000	57.808	38.460
5	-51	1	101	38.5999985	2322.5	2322.5	2341.80005	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	59.813	39.864	0.000	59.813	39.864
5	-52	1	101	38.5999985	2361.1001	2361.1001	2380.40015	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	61.853	41.291	0.000	61.853	41.291
5	-53	1	101	38.5999985	2399.7002	2399.7002	2419.00024	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	63.925	42.742	0.000	63.925	42.742
5	-54	1	101	38.5999985	2438.30029	2438.30029	2457.60034	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	66.031	44.216	0.000	66.031	44.216
5	-55	1	101	38.5999985	2476.90039	2476.90039	2496.20044	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	68.170	45.713	0.000	68.170	45.713
5	-56	1	101	38.5999985	2515.50049	2515.50049	2534.80054	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	70.342	47.234	0.000	70.342	47.234
5	-57	1	101	38.5999985	2554.10059	2554.10059	2573.40063	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	72.548	48.778	0.000	72.548	48.778
5	-58	1	101	38.5999985	2592.70068	2592.70068	2612.00073	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	74.787	50.345	0.000	74.787	50.345
5	-59	1	101	38.5999985	2631.30078	2631.30078	2650.60083	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	77.059	51.936	0.000	77.059	51.936
5	-60	1	101	38.5999985	2669.90088	2669.90088	2689.20093	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	79.365	53.550	0.000	79.365	53.550
5	-61	1	101	38.5999985	2708.50098	2708.50098	2727.80103	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	81.704	55.187	0.000	81.704	55.187
5	-62	1	101	38.5999985	2747.10107	2747.10107	2766.40112	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	84.077	56.848	0.000	84.077	56.848
5	-63	1	101	38.5999985	2785.70117	2785.70117	2805.00122	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	86.482	58.532	0.000	86.482	58.532
5	-64	1	101	38.5999985	2824.30127	2824.30127	2843.60132	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	88.921	60.239	0.000	88.921	60.239
5	-65	1	101	38.5999985	2862.90137	2862.90137	2882.20142	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	91.394	61.970	0.000	91.394	61.970
5	-66	1	101	38.5999985	2901.50146	2901.50146	2920.80151	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	93.900	63.724	0.000	93.900	63.724
5	-67	1	101	38.5999985	2940.10156	2940.10156	2959.40161	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	96.439	65.502	0.000	96.439	65.502
5	-68	1	101	38.5999985	2978.70166	2978.70166	2998.00171	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	99.011	67.302	0.000	99.011	67.302
5	-69	1	101	38.5999985	3017.30176	3017.30176	3036.60181	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	101.617	69.126	0.000	101.617	69.126
5	-70	1	101	38.5999985	3055.90186	3056.90186	3075.2019	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	104.256	70.974	0.000	104.256	70.974
5	-71	1	101	38.5999985	3094.50195	3094.50195	3113.802	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	106.928	72.844	0.000	106.928	72.844
5	-72	1	101	38.5999985	3133.10205	3133.10205	3152.4021	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	109.634	74.738	0.000	109.634	74.738
5	-73	1	101	38.5999985	3171.70215	3171.70215	3191.0022	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	112.373	76.656	0.000	112.373	76.656
5	-74	1	101	38.5999985	3210.30225	3210.30225	3229.60229	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	115.146	78.596	0.000	115.146	78.596
5	-75	1	101	38.5999985	3248.90234	3248.90234	3268.20239	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	117.951	80.560	0.000	117.951	80.560
5	-76	1	101	38.5999985	3287.50244	3287.50244	3306.80249	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	120.790	82.548	0.000	120.790	82.548
5	-77	1	101	38.5999985	3326.10254	3326.10254	3345.40259	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	123.663	84.559	0.000	123.663	84.559
5	-78	1	101	38.5999985	3364.70264	3364.70264	3384.00269	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	126.569	86.593	0.000	126.569	86.593
5	-79	1	101	38.5999985	3403.30273	3403.30273	3422.60278	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	129.508	88.650	0.000	129.508	88.650
5	-80	1	101	38.5999985	3441.90283	3441.90283	3461.20288	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	132.480	90.731	0.000	132.480	90.731
5	-81	1	101	38.5999985	3480.50293	3480.50293	3499.80298	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	135.486	92.835	0.000	135.486	92.835
5	-82	1	101	38.5999985	3519.10303	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	138.509	94.951	0.000	138.509	94.951
6	-83	1	117	54.5999985	3565.70313	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	142.274	96.833	0.000	142.274	96.833
6	-84	1	117	54.5999985	3620.30322	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	146.039	98.716	0.000	146.039	98.716
6	-85	1	117	54.5999985	3674.90332	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	149.805	100.598	0.000	149.805	100.598
6	-86	1	117	54.5999985	3729.50342	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	153.570	102.481	0.000	153.570	102.481
6	-87	1	117	54.5999985	3784.10352	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	157.335	104.364	0.000	157.335	104.364
6	-88	1	117	54.5999985	3838.70361	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	161.100	106.246	0.000	161.100	106.246
6	-89	1	117	54.5999985	3893.30371	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	164.866	108.129	0.000	164.866	108.129
6	-90	1	117	54.5999985	3947.90381	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	168.631	110.012	0.000	168.631	110.012
6	-91	1	117	54.5999985	4002.50391	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	172.396	111.894	0.000	172.396	111.894
6	-92	1	117	54.5999985	4057.104	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	176.162	113.777	0.000	176.162	113.777
6	-93	1	117	54.5999985	4111.7041	3500	3500	0	0	28	21	1.00	0.50	19.50	0.00	No	0.000	179.927	115.660	0.000	179.927	115.660
7	-94	1	115	52.5999985	4165.30371	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	182.949	117.775	0.000	182.949	117.775
7	-95	1	115	52.5999985	4217.90381	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	185.972	119.891	0.000	185.972	119.891
7	-96	1	115	52.5999985	4270.50391	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	188.995	122.007	0.000	188.995	122.007
7	-97	1	115	52.5999985	4323.104	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	192.017	124.123	0.000	192.017	124.123
7	-98	1	115	52.5999985	4375.7041	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	195.040	126.239	0.000	195.040	126.239
7	-99	1	115	52.5999985	4428.3042	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	198.063	128.355	0.000	198.063	128.355
7	-100	1	115	52.5999985	4480.9043	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	201.085	130.470	0.000	201.085	130.470
7	-101	1	115	52.5999985	4533.50439	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	204.108	132.586	0.000	204.108	132.586

1067

7	-102	1	115	52.5999985	4586.10449	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	207.130	134.702	0.000	207.130	134.702
7	-103	1	115	52.5999985	4638.70459	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	210.153	136.818	0.000	210.153	136.818
7	-104	1	115	52.5999985	4691.30469	3500	3500	0	0	23	17.25	1.00	0.70	10.00	0.00	No	0.000	213.176	138.934	0.000	213.176	138.934
8	-105	1	122	59.5999985	4747.40479	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	218.273	141.788	0.000	218.273	141.788
8	-106	1	122	59.5999985	4807.00488	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	223.370	144.643	0.000	223.370	144.643
8	-107	1	122	59.5999985	4866.60498	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	228.467	147.497	0.000	228.467	147.497
8	-108	1	122	59.5999985	4926.20508	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	233.565	150.352	0.000	233.565	150.352
8	-109	1	122	59.5999985	4985.80518	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	238.662	153.206	0.000	238.662	153.206
8	-110	1	122	59.5999985	5045.40527	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	243.759	156.061	0.000	243.759	156.061
8	-111	1	122	59.5999985	5105.00537	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	248.856	158.915	0.000	248.856	158.915
8	-112	1	122	59.5999985	5164.60547	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	253.954	161.769	0.000	253.954	161.769
8	-113	1	122	59.5999985	5224.20557	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	259.051	164.624	0.000	259.051	164.624
8	-114	1	122	59.5999985	5283.80566	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	264.148	167.478	0.000	264.148	167.478
8	-115	1	122	59.5999985	5343.40576	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	269.245	170.333	0.000	269.245	170.333
8	-116	1	122	59.5999985	5403.00586	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	274.343	173.187	0.000	274.343	173.187
8	-117	1	122	59.5999985	5462.60596	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	279.440	176.042	0.000	279.440	176.042
8	-118	1	122	59.5999985	5522.20605	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	284.537	178.896	0.000	284.537	178.896
8	-119	1	122	59.5999985	5581.80615	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	289.634	181.751	0.000	289.634	181.751
8	-120	1	122	59.5999985	5641.40625	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	294.732	184.605	0.000	294.732	184.605
8	-121	1	122	59.5999985	5701.00635	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	299.829	187.460	0.000	299.829	187.460
8	-122	1	122	59.5999985	5760.60645	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	304.926	190.314	0.000	304.926	190.314
8	-123	1	122	59.5999985	5820.20654	3500	3500	0	0	30	22.5	1.25	0.70	22.50	0.00	No	0.000	310.023	193.169	0.000	310.023	193.169

905

910

915

920 **Plate L5.3**

925

930

935

Boring
R-59.75-LU

940

945

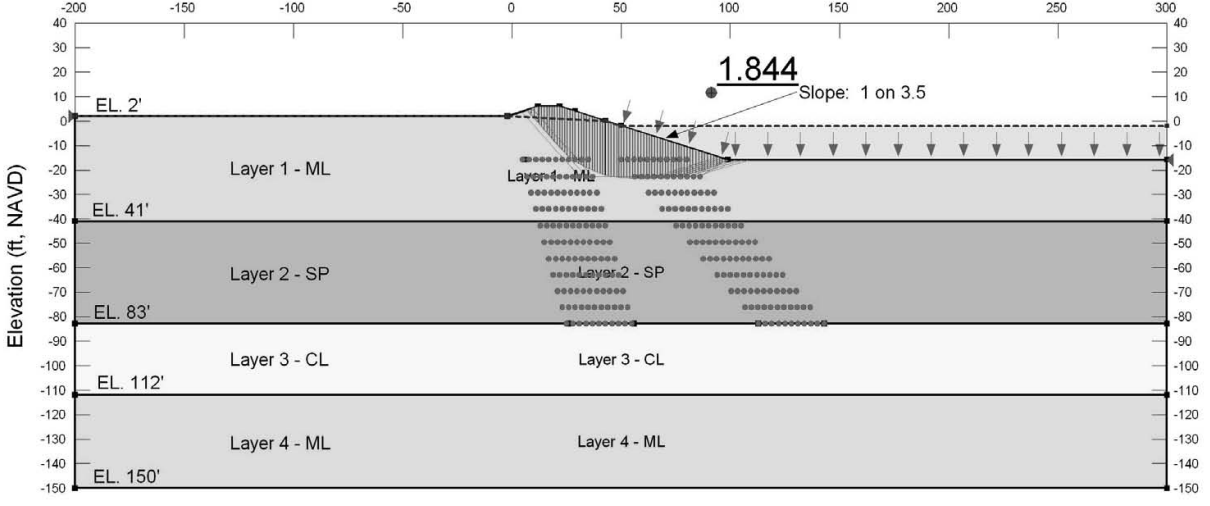
950

955

960

LCA MVN - WHITE DITCH
Location 3 - Transmission System
Spencer's Block Search
Boring: R-59.75-UL

Low Water (hurricane condition)
Optimization



Name: Layer 1 - ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1
Name: Layer 2 - SP	Model: Mohr-Coulomb	Unit Weight: 122 pcf	Cohesion: 0 psf	Phi: 33 °	Piezometric Line: 1
Name: Layer 3 - CL	Model: Mohr-Coulomb	Unit Weight: 105 pcf	Cohesion: 1580 psf	Phi: 0 °	Piezometric Line: 1
Name: Layer 4 - ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1

965

1071

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

41.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 76
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 2:46:08 PM
File Name: Location 3 - 35k cfs - MC_R-59.75-LU_1on3.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 2:47:01 PM

42.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

43.0 ANALYSIS SETTINGS

43.1 Low Water (hurricane condition)

Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block

Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

44.0 MATERIALS

44.1 Layer 1 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

44.2 Layer 2 - SP

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

1073

44.3 Layer 3 - CL
Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 1580 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

44.4 Layer 4 - ML
Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

45.0 SLIP SURFACE LIMITS
Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

46.0 SLIP SURFACE BLOCK
Left Grid
Upper Left: (5, -16) ft
Lower Left: (25, -83) ft
Lower Right: (55, -83) ft
X Increments: 10
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (50, -16) ft
Lower Left: (113, -83) ft
Lower Right: (143, -83) ft
X Increments: 10
Y Increments: 10

Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

47.0 PIEZOMETRIC LINES

47.1 Piezometric Line 1

47.1.1 Coordinates

	X (ft)	Y (ft)
	-200	2
	-2	2
	43	0
	50	-2
	300	-2

48.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 1 - ML	1,2,3,4,25,7,8,5,6,13,9	17411
Region 2	Layer 2 - SP	9,13,14,23,22,21,24,10	21000
Region 3	Layer 3 - CL	11,10,24,21,22,23,14,15	14500
Region 4	Layer 4 - ML	12,11,15,16	19000

49.0 POINTS

	X (ft)	Y (ft)
Point 1	-200	2
Point 2	-2	2
Point 3	12	6
Point 4	22	6
Point 5	99	-16
Point 6	300	-16

Point 7	43	0
Point 8	50	-2
Point 9	-200	-41
Point 10	-200	-83
Point 11	-200	-112
Point 12	-200	-150
Point 13	300	-41
Point 14	300	-83
Point 15	300	-112
Point 16	300	-150
Point 17	36	-16
Point 18	50	-16
Point 19	80	-16
Point 20	6	-16
Point 21	56	-83
Point 22	113	-83
Point 23	143	-83
Point 24	26	-83
Point 25	29	4

50.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.844	(56.457, 9.639)	44.17684	(7.41969, 4.69134)	(98.9963, -15.9989)
2	3678	1.973	(56.457, 9.639)	44.081	(6.78889, 4.51111)	(99.3047, -16)

50.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	8.1455825	3.881579	-145.54597	7.2864937	1.9524101	200
2	Optimized	9.597375	2.262059	-48.515322	195.39003	52.354602	200
3	Optimized	11.161635	0.51708	56.031921	404.58431	93.39433	200
4	Optimized	12.248425	-0.6952645	128.66829	547.27083	112.16421	200
5	Optimized	13.06283	-1.6159035	183.8568	634.71523	120.80715	200
6	Optimized	14.194795	-2.902931	261.02729	762.31172	134.31876	200
7	Optimized	15.326765	-4.189959	338.19779	889.96655	147.84599	200
8	Optimized	16.45873	-5.4769865	415.37412	1017.563	161.35603	200
9	Optimized	17.64662	-6.708378	488.91753	1190.4811	187.98338	200
10	Optimized	18.89044	-7.8841335	558.83551	1309.9615	201.26361	200
11	Optimized	20.134265	-9.059889	628.77685	1429.5004	214.55323	200
12	Optimized	21.37809	-10.235644	698.65393	1548.9809	227.84441	200
13	Optimized	22.56526	-11.357845	765.3991	1647.5976	236.38437	200
14	Optimized	23.695775	-12.426495	828.97344	1725.3138	240.17368	200
15	Optimized	24.8534	-13.37356	884.85524	1882.0401	267.19487	200
16	Optimized	26.038145	-14.19904	933.05586	1934.7422	268.40104	200
17	Optimized	27.22289	-15.024525	981.25647	1987.4443	269.60721	200
18	Optimized	28.40763	-15.85001	1029.5263	2040.1464	270.79483	200
19	Optimized	29.73613	-16.775655	1083.5982	2099.2626	272.14644	200
20	Optimized	31.10362	-17.584995	1130.2679	2244.6216	298.59017	200
21	Optimized	32.366345	-18.177865	1163.8168	2270.8586	296.63094	200
22	Optimized	33.62907	-18.770735	1197.294	2297.0955	294.69092	200
23	Optimized	34.891795	-19.363605	1230.7712	2323.3325	292.7509	200

1077

24	Optimized	36.15452	-19.956475	1264.2484	2349.5694	290.81088	200
25	Optimized	37.3735	-20.434415	1290.7076	2442.556	308.63684	200
26	Optimized	38.548735	-20.797425	1310.1381	2446.1331	304.38895	200
27	Optimized	39.72397	-21.160435	1329.4873	2449.629	300.14105	200
28	Optimized	40.899205	-21.523445	1348.9179	2453.2062	295.89316	200
29	Optimized	42.07444	-21.886455	1368.2671	2456.702	291.64526	200
30	Optimized	42.83103	-22.096955	1379.3204	2526.6639	307.42977	200
31	Optimized	43.62076	-22.232465	1376.2422	2516.3893	305.5015	200
32	Optimized	44.86228	-22.445495	1367.4303	2500.1945	303.52325	200
33	Optimized	46.103795	-22.65853	1358.539	2483.9203	301.545	200
34	Optimized	47.34531	-22.871565	1349.7271	2467.7255	299.56675	200
35	Optimized	48.474555	-23.011175	1338.3154	2503.1473	312.11577	200
36	Optimized	49.49152	-23.077365	1324.2837	2477.0463	308.88182	200
37	Optimized	50.63841	-23.15201	1319.8689	2459.2015	305.28325	200
38	Optimized	51.91523	-23.23511	1325.1053	2449.6667	301.32533	200
39	Optimized	53.19205	-23.31821	1330.2634	2440.1319	297.38836	200
40	Optimized	54.495005	-23.37417	1333.7596	2450.0527	299.10983	200
41	Optimized	55.824095	-23.40299	1335.5649	2433.2029	294.11122	200
42	Optimized	57.15318	-23.431815	1337.3702	2416.4285	289.13278	200
43	Optimized	58.482265	-23.46064	1339.1756	2399.5788	284.13418	200
44	Optimized	59.811355	-23.48946	1340.9057	2382.7291	279.15573	200
45	Optimized	61.08876	-23.479885	1340.3117	2393.9086	282.31046	200
46	Optimized	62.314475	-23.431915	1337.3769	2369.2888	276.49998	200
47	Optimized	63.54019	-23.383945	1334.3605	2344.5875	270.68951	200

48	Optimized	64.76591	-23.33598	1331.3442	2319.9677	264.90088	200
49	Optimized	65.99163	-23.288015	1328.4094	2295.3479	259.0904	200
50	Optimized	67.217345	-23.240045	1325.393	2270.7281	253.30177	200
51	Optimized	68.44306	-23.192075	1322.3767	2246.1083	247.51314	200
52	Optimized	69.66708	-23.10344	1316.8525	2249.6976	249.95509	200
53	Optimized	70.889405	-22.974145	1308.7981	2214.9579	242.80479	200
54	Optimized	72.11173	-22.84485	1300.7437	2180.2182	235.6545	200
55	Optimized	73.33405	-22.71555	1292.6893	2145.4786	228.5042	200
56	Optimized	74.556375	-22.586255	1284.5535	2110.7389	221.37571	200
57	Optimized	75.7787	-22.45696	1276.4992	2075.9993	214.22542	200
58	Optimized	77.04339	-22.27818	1265.3334	2066.5579	214.68747	200
59	Optimized	78.350455	-22.049925	1251.0891	2017.871	205.4586	200
60	Optimized	79.65752	-21.82167	1236.8447	1969.184	196.22972	200
61	Optimized	80.96458	-21.59341	1222.6004	1920.4971	187.00085	200
62	Optimized	82.271645	-21.365155	1208.3561	1871.8101	177.77197	200
63	Optimized	83.57871	-21.1369	1194.1117	1823.1231	168.5431	200
64	Optimized	84.89841	-20.848375	1176.1263	1803.1081	167.99926	200
65	Optimized	86.230745	-20.499585	1154.3435	1738.1227	156.42317	200
66	Optimized	87.56308	-20.150795	1132.6333	1673.1374	144.82762	200
67	Optimized	88.895415	-19.802005	1110.8505	1608.152	133.25153	200
68	Optimized	90.27097	-19.39268	1085.2736	1560.9339	127.45279	200
69	Optimized	91.689745	-18.922825	1055.9672	1478.3005	113.16388	200
70	Optimized	93.10852	-18.45297	1026.6608	1395.6672	98.874968	200
71	Optimized	94.46521	-17.940655	994.70555	1341.326	92.87667	200

72	Optimized	95.759805	-17.38588	960.05771	1248.1034	77.181616	200
73	Optimized	97.0544	-16.831105	925.48086	1154.9518	61.486562	200
74	Optimized	98.348995	-16.27633	890.83302	1061.7293	45.791508	200

080 **50.2 Slices of Slip Surface: 3678**

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	3678	7.548062	3.751938	-135.80059	19.260306	5.1607834	200
2	3678	9.066408	2.233592	-45.266865	205.27964	55.004515	200
3	3678	10.369186	0.93081415	32.413339	368.09305	89.945108	200
4	3678	11.456395	-0.15639535	97.239367	507.69863	109.98223	200
5	3678	12.625	-1.325	166.92245	640.75186	126.96221	200
6	3678	13.875	-2.575	241.4515	767.23912	140.88437	200
7	3678	15.125	-3.825	315.98621	893.66981	154.78985	200
8	3678	16.375	-5.075	390.52092	1020.1571	168.7105	200
9	3678	17.625	-6.325	465.05563	1146.6443	182.63114	200
10	3678	18.875	-7.575	539.58469	1273.1316	196.5533	200
11	3678	20.125	-8.825	614.10808	1399.6188	210.47697	200
12	3678	21.375	-10.075	688.66542	1526.0495	224.3764	200
13	3678	22.583335	-11.283335	760.70539	1632.4467	233.58239	200
14	3678	23.75	-12.45	830.28469	1718.7542	238.06468	200
15	3678	24.916665	-13.616665	899.80338	1805.001	242.54697	200
16	3678	26.083335	-14.783335	969.38268	1891.3084	247.02925	200
17	3678	27.25	-15.95	1038.962	1977.5552	251.4953	200
18	3678	28.416665	-17.116665	1108.5413	2063.8626	255.97759	200
19	3678	29.625	-18.325	1180.5855	2153.2249	260.61797	200

1080

20	3678	30.875	-19.575	1255.0862	2245.6579	265.42289	200
21	3678	32.125	-20.825	1329.6436	2338.0909	270.21266	200
22	3678	33.375	-22.075	1404.2009	2430.5239	275.00243	200
23	3678	34.642855	-22.7	1439.667	2968.234	409.57829	200
24	3678	35.92857	-22.7	1436.0892	2924.6784	398.86628	200
25	3678	37.214285	-22.7	1432.5114	2881.1229	388.15426	200
26	3678	38.5	-22.7	1428.9337	2837.5673	377.44225	200
27	3678	39.785715	-22.7	1425.3559	2794.0117	366.73023	200
28	3678	41.07143	-22.7	1421.8559	2750.4562	355.99738	200
29	3678	42.357145	-22.7	1418.2781	2706.9006	345.28536	200
30	3678	43.583335	-22.7	1406.0567	2665.4564	337.45512	200
31	3678	44.75	-22.7	1385.3139	2626.1992	332.49423	200
32	3678	45.916665	-22.7	1364.4853	2586.9421	327.55631	200
33	3678	47.083335	-22.7	1343.6568	2547.685	322.61839	200
34	3678	48.25	-22.7	1322.9139	2508.4279	317.6575	200
35	3678	49.416665	-22.7	1302.0853	2469.1707	312.71959	200
36	3678	50.6075	-22.7	1291.6872	2440.2469	307.75564	200
37	3678	51.8225	-22.7	1291.6872	2421.6461	302.77156	200
38	3678	53.0375	-22.7	1291.6872	2403.1276	297.80954	200
39	3678	54.2525	-22.7	1291.6872	2384.5267	292.82546	200
40	3678	55.4675	-22.7	1291.6872	2366.0082	287.86344	200
41	3678	56.6825	-22.7	1291.6872	2347.4074	282.87937	200
42	3678	57.8975	-22.7	1291.6872	2328.8889	277.91734	200
43	3678	59.1125	-22.7	1291.6872	2310.2881	272.93327	200

44	3678	60.3275	-22.7	1291.6872	2291.6872	267.94919	200
45	3678	61.5425	-22.7	1291.6872	2273.1687	262.98717	200
46	3678	62.7575	-22.7	1291.6872	2254.5679	258.00309	200
47	3678	63.9725	-22.7	1291.6872	2236.0494	253.04107	200
48	3678	65.1875	-22.7	1291.6872	2217.4486	248.057	200
49	3678	66.4025	-22.7	1291.6872	2198.93	243.09498	200
50	3678	67.6175	-22.7	1291.6872	2180.3292	238.1109	200
51	3678	68.8325	-22.7	1291.6872	2161.8107	233.14888	200
52	3678	70.0475	-22.7	1291.6872	2143.2099	228.1648	200
53	3678	71.2625	-22.7	1291.6872	2124.6091	223.18073	200
54	3678	72.4775	-22.7	1291.6872	2106.0905	218.2187	200
55	3678	73.6925	-22.7	1291.6872	2087.4897	213.23463	200
56	3678	74.9175	-22.53454	1281.3574	2172.6684	238.82608	200
57	3678	76.1525	-22.203625	1260.7093	2111.5844	227.9913	200
58	3678	77.3875	-21.87271	1240.0611	2050.5003	217.15653	200
59	3678	78.6225	-21.54179	1219.413	1989.3381	206.3008	200
60	3678	79.8575	-21.21087	1198.7649	1928.254	195.46602	200
61	3678	81.0925	-20.879955	1178.1167	1867.0917	184.61029	200
62	3678	82.3275	-20.54904	1157.4686	1806.0077	173.77552	200
63	3678	83.5625	-20.21812	1136.8205	1744.8454	162.91979	200
64	3678	84.7975	-19.8872	1116.1723	1683.7613	152.08501	200
65	3678	86.0325	-19.556285	1095.5242	1622.6773	141.25024	200
66	3678	87.2675	-19.22537	1074.8761	1561.515	130.39451	200
67	3678	88.5025	-18.89445	1054.2279	1500.431	119.55974	200

1082

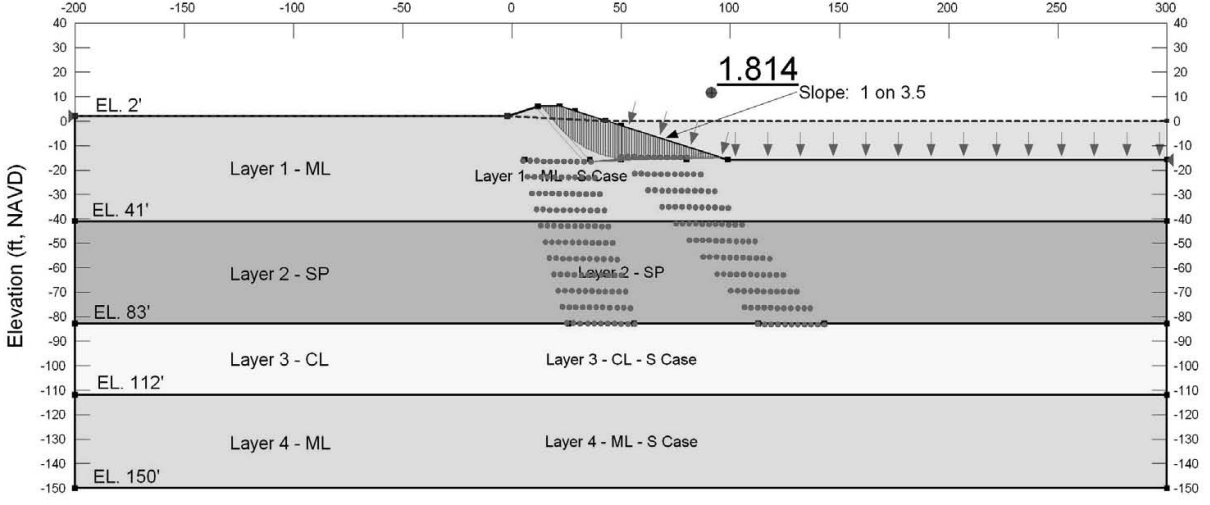
68	3678	89.7375	-18.563535	1033.5798	1439.2687	108.70401	200
69	3678	90.9725	-18.23262	1012.9317	1378.1846	97.869232	200
70	3678	92.2075	-17.9017	992.28354	1317.0224	87.013502	200
71	3678	93.4425	-17.57078	971.63541	1255.9383	76.178728	200
72	3678	94.6775	-17.239865	950.98728	1194.8542	65.343954	200
73	3678	95.9125	-16.90895	930.33915	1133.692	54.488224	200
74	3678	97.1475	-16.57803	909.69101	1072.6079	43.65345	200
75	3678	98.3825	-16.24711	889.04288	1011.4456	32.797719	200
76	3678	99.15237	-16.040825	876.1595	947.00157	18.982075	200

085

1083

LCA MVN - WHITE DITCH
Location 3 - Transmission System
Spencer's Block Search
Boring: R-59.75-UL

Low Water (non-hurricane condition) S-Case
Optimization



Name: Layer 2 - SP Model: Mohr-Coulomb Unit Weight: 122 pcf Cohesion: 0 psf Phi: 33 ° Piezometric Line: 1
Name: Layer 1 - ML - S Case Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1
Name: Layer 3 - CL - S Case Model: Mohr-Coulomb Unit Weight: 105 pcf Cohesion: 0 psf Phi: 23 ° Piezometric Line: 1
Name: Layer 4 - ML - S Case Model: Mohr-Coulomb Unit Weight: 117 pcf Cohesion: 0 psf Phi: 28 ° Piezometric Line: 1

1084

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

51.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 76
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 2:46:08 PM
File Name: Location 3 - 35k cfs - MC_R-59.75-LU_1on3.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 2:48:02 PM

52.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

53.0 ANALYSIS SETTINGS

53.1 Low Water (non-hurricane condition) S-Case

Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1

1085

Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

54.0 MATERIALS

54.1 Layer 2 - SP

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

54.2 Layer 1 - ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

54.3 Layer 3 - CL - S Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

54.4 Layer 4 - ML - S Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

55.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

56.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (5.2803, -16.2114) ft
Lower Left: (25.2901, -82.6562) ft
Lower Right: (56.3051, -83.1814) ft
X Increments: 10
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (50.0021, -14.6356) ft
Lower Left: (112.8326, -83.1814) ft
Lower Right: (143.1473, -83.5754) ft
X Increments: 10
Y Increments: 10

Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

57.0 PIEZOMETRIC LINES

195 ### 57.1 Piezometric Line 1

57.1.1 Coordinates

	X (ft)	Y (ft)
	-200	2
	-2	2
	43	0
	300	0

58.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 1 - ML - S Case	1,2,3,4,25,7,8,5,6,13,9	17411
Region 2	Layer 2 - SP	9,13,14,23,22,21,24,10	21000
Region 3	Layer 3 - CL - S Case	11,10,24,21,22,23,14,15	14500
Region 4	Layer 4 - ML - S Case	12,11,15,16	19000

59.0 POINTS

	X (ft)	Y (ft)
Point 1	-200	2
Point 2	-2	2
Point 3	12	6
Point 4	22	6
Point 5	99	-16
Point 6	300	-16
Point 7	43	0

1088

Point 8	50	-2
Point 9	-200	-41
Point 10	-200	-83
Point 11	-200	-112
Point 12	-200	-150
Point 13	300	-41
Point 14	300	-83
Point 15	300	-112
Point 16	300	-150
Point 17	36	-16
Point 18	50	-16
Point 19	80	-16
Point 20	6	-16
Point 21	56	-83
Point 22	113	-83
Point 23	143	-83
Point 24	26	-83
Point 25	29	4

60.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.814	(58.624, 11.257)	39.36311	(13.6629, 6)	(95.8818, -15.1091)
2	1933	2.049	(58.624, 11.257)	39.345	(13.5587, 6)	(95.6036, -15.0296)

200 **60.1 Slices of Slip Surface: Optimized**

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1089

1	Optimized	14.171655	5.4559975	-260.50041	45.366879	24.121997	0
2	Optimized	15.189125	4.3679925	-195.43069	136.10064	72.365992	0
3	Optimized	16.2066	3.2799875	-130.36097	226.83439	120.60999	0
4	Optimized	17.224075	2.1919825	-65.294606	317.56815	168.85398	0
5	Optimized	17.991895	1.373968	-16.380069	387.1074	205.82865	0
6	Optimized	18.875815	0.43912265	39.503025	473.13687	230.5672	0
7	Optimized	20.12549	-0.88254435	118.50962	599.36534	255.67552	0
8	Optimized	21.375165	-2.2042115	197.51787	725.53884	280.75373	0
9	Optimized	22.38843	-3.2758525	261.57299	818.59072	296.17158	0
10	Optimized	23.306425	-4.1045975	310.74577	931.26639	329.93667	0
11	Optimized	24.365555	-4.9404725	359.96614	987.2239	333.51886	0
12	Optimized	25.424685	-5.7763475	409.18652	1043.1814	337.10106	0
13	Optimized	26.483815	-6.6122225	458.40689	1099.1389	340.68326	0
14	Optimized	27.510035	-7.324373	500.0013	1195.7381	369.92984	0
15	Optimized	28.503345	-7.912799	533.96355	1229.172	369.6489	0
16	Optimized	29.513105	-8.51097	568.48964	1263.2078	369.38822	0
17	Optimized	30.539315	-9.1188855	603.57642	1297.7497	369.09846	0
18	Optimized	31.565525	-9.7268015	638.6632	1332.2915	368.8087	0
19	Optimized	32.591735	-10.334715	673.74998	1366.8333	368.51895	0
20	Optimized	33.617945	-10.94263	708.83675	1401.3751	368.22919	0
21	Optimized	34.68081	-11.44973	737.53905	1497.2931	403.96838	0
22	Optimized	35.78033	-11.85601	759.83934	1508.4688	398.05335	0
23	Optimized	36.87985	-12.262285	782.13963	1519.5592	392.09296	0
24	Optimized	37.979375	-12.66856	804.43992	1530.735	386.17794	0

1090

25	Optimized	39.0789	-13.07484	826.74875	1541.8254	380.21301	0
26	Optimized	40.17842	-13.48112	849.04904	1553.0012	374.29798	0
27	Optimized	41.296135	-13.81673	866.85751	1604.8567	392.40111	0
28	Optimized	42.432045	-14.081665	880.23203	1598.6838	382.00759	0
29	Optimized	43.52619	-14.33686	894.61868	1601.9389	376.08882	0
30	Optimized	44.578575	-14.582315	909.93385	1614.6167	374.68651	0
31	Optimized	45.63096	-14.82777	925.24902	1627.2945	373.2842	0
32	Optimized	46.68334	-15.073225	940.56419	1639.9723	371.8819	0
33	Optimized	47.67461	-15.231855	950.46297	1705.1759	401.28796	0
34	Optimized	48.604765	-15.303665	954.9435	1699.602	395.94194	0
35	Optimized	49.53492	-15.37547	959.42404	1693.9209	390.53893	0
36	Optimized	50.19992	-15.426805	962.62197	1689.9496	386.72699	0
37	Optimized	50.958185	-15.454835	964.39129	1704.4264	393.48366	0
38	Optimized	52.074875	-15.48002	965.91326	1690.2811	385.15319	0
39	Optimized	53.191565	-15.505205	967.52476	1676.0462	376.72752	0
40	Optimized	54.33328	-15.54119	969.79123	1655.6847	364.69604	0
41	Optimized	55.500015	-15.587975	972.703	1643.3525	356.59067	0
42	Optimized	56.66675	-15.63476	975.61477	1631.0203	348.4853	0
43	Optimized	57.773945	-15.661875	977.30969	1629.9949	347.03887	0
44	Optimized	58.82159	-15.66932	977.78694	1614.7229	338.66487	0
45	Optimized	59.869235	-15.67676	978.26419	1599.3555	330.24012	0
46	Optimized	60.91688	-15.684205	978.74144	1583.9881	321.81537	0
47	Optimized	61.964525	-15.69165	979.12324	1568.6207	313.44137	0
48	Optimized	63.012175	-15.699095	979.60049	1553.3488	305.06737	0

49	Optimized	64.05982	-15.706545	980.07773	1537.9814	296.64262	0
50	Optimized	65.107465	-15.71399	980.55498	1522.6139	288.21786	0
51	Optimized	66.15511	-15.72143	981.03223	1507.2465	279.79311	0
52	Optimized	67.202755	-15.728875	981.50948	1491.8791	271.36836	0
53	Optimized	68.27925	-15.727635	981.37309	1480.3825	265.328	0
54	Optimized	69.384595	-15.71771	980.73983	1461.9275	255.852	0
55	Optimized	70.48994	-15.70779	980.19703	1443.4724	246.3279	0
56	Optimized	71.595285	-15.697865	979.56377	1425.1079	236.9	0
57	Optimized	72.70063	-15.687935	978.93051	1406.6529	227.424	0
58	Optimized	73.805975	-15.67801	978.29725	1388.2883	217.9961	0
59	Optimized	74.915375	-15.660235	977.15541	1372.8481	210.39355	0
60	Optimized	76.028825	-15.63461	975.62903	1352.2868	200.27251	0
61	Optimized	77.14227	-15.608985	974.01286	1331.7255	190.19921	0
62	Optimized	78.255715	-15.58336	972.39668	1311.254	180.17365	0
63	Optimized	79.369165	-15.557735	970.78051	1290.6927	170.10035	0
64	Optimized	80.475775	-15.527915	968.91845	1271.6543	160.96753	0
65	Optimized	81.57555	-15.4939	966.82811	1250.2965	150.72282	0
66	Optimized	82.675325	-15.459885	964.73777	1228.9387	140.47812	0
67	Optimized	83.775095	-15.425875	962.55654	1207.49	130.23341	0
68	Optimized	84.874865	-15.391865	960.4662	1186.1321	119.9887	0
69	Optimized	85.97464	-15.35785	958.28498	1164.6834	109.744	0
70	Optimized	87.074415	-15.323835	956.19463	1143.3256	99.499292	0
71	Optimized	88.174895	-15.291735	954.24057	1121.5413	88.955381	0
72	Optimized	89.27609	-15.261545	952.33427	1100.572	78.819391	0

73	Optimized	90.37729	-15.231355	950.42796	1079.6027	68.6834	0
74	Optimized	91.478485	-15.201165	948.52166	1058.7241	58.595677	0
75	Optimized	92.51067	-15.176445	947.01519	1038.4335	48.607955	0
76	Optimized	93.47385	-15.1572	945.81109	1020.9947	39.975862	0
77	Optimized	94.437035	-15.137955	944.60699	1003.5976	31.365846	0
78	Optimized	95.40022	-15.11871	943.40289	986.21076	22.76135	0

60.2 Slices of Slip Surface: 1933

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1933	14.172415	5.3862865	-256.15781	53.095785	28.23153	0
2	1933	15.39984	4.15886	-182.96575	159.28851	84.695202	0
3	1933	16.627265	2.9314335	-109.77945	265.47893	141.15765	0
4	1933	17.854695	1.7040065	-36.593726	371.66934	197.6201	0
5	1933	19.057005	0.50169418	35.095918	481.58077	237.40021	0
6	1933	20.2342	-0.67550332	105.29136	595.21543	260.49725	0
7	1933	21.4114	-1.852701	175.47959	708.85008	283.59812	0
8	1933	22.583335	-3.0246335	245.35795	807.55626	298.92615	0
9	1933	23.75	-4.1913	314.92512	891.3181	306.47358	0
10	1933	24.916665	-5.3579665	384.48624	975.07994	314.02424	0
11	1933	26.083335	-6.5246335	454.05342	1058.9024	321.6039	0
12	1933	27.25	-7.6913	523.61454	1142.6642	329.15456	0
13	1933	28.416665	-8.8579665	593.18171	1226.4261	336.702	0
14	1933	29.521095	-9.962395	659.03236	1305.7434	343.86238	0
15	1933	30.56328	-11.00458	721.16119	1380.5803	350.61935	0
16	1933	31.605465	-12.046765	783.31037	1455.4171	357.3655	0

17	1933	32.64765	-13.08895	845.45955	1530.254	364.11165	0
18	1933	33.689835	-14.131135	907.60873	1605.0908	370.8578	0
19	1933	34.73202	-15.17332	969.75791	1679.9276	377.60395	0
20	1933	35.774205	-16.215505	1031.9071	1754.7645	384.3501	0
21	1933	36.854025	-16.714935	1060.1007	2221.2485	617.39325	0
22	1933	37.971475	-16.671605	1054.2882	2176.9845	596.94819	0
23	1933	39.088925	-16.628275	1048.4758	2132.7205	576.50313	0
24	1933	40.206375	-16.584945	1042.6634	2088.4565	556.05807	0
25	1933	41.323825	-16.541615	1036.8509	2044.1925	535.61301	0
26	1933	42.441275	-16.498285	1031.0385	1999.9285	515.16795	0
27	1933	43.583335	-16.454	1026.7716	1965.9233	499.35582	0
28	1933	44.75	-16.40876	1023.9452	1942.1126	488.1983	0
29	1933	45.916665	-16.36352	1021.1187	1918.3876	477.08633	0
30	1933	47.083335	-16.31828	1018.2923	1894.6626	465.97435	0
31	1933	48.25	-16.27304	1015.4658	1870.8519	454.81683	0
32	1933	49.416665	-16.2278	1012.6394	1847.1268	443.70486	0
33	1933	50.54137	-16.184185	1009.9146	1824.1772	432.95113	0
34	1933	51.624115	-16.1422	1007.2382	1802.2125	422.69535	0
35	1933	52.70686	-16.100215	1004.6541	1780.1555	412.34142	0
36	1933	53.7896	-16.05823	1002.07	1758.0986	401.9875	0
37	1933	54.87234	-16.016245	999.39366	1736.0416	391.68264	0
38	1933	55.955085	-15.97426	996.80958	1713.9846	381.32872	0
39	1933	57.03783	-15.932275	994.13321	1691.9276	371.02386	0
40	1933	58.12057	-15.89029	991.54913	1669.8706	360.66993	0

41	1933	59.203315	-15.848305	988.96505	1647.8136	350.31601	0
42	1933	60.28606	-15.80632	986.28868	1625.8489	340.06022	0
43	1933	61.3688	-15.764335	983.7046	1603.792	329.7063	0
44	1933	62.45154	-15.72235	981.12051	1581.735	319.35237	0
45	1933	63.534285	-15.680365	978.44414	1559.678	309.04752	0
46	1933	64.61703	-15.63838	975.86006	1537.621	298.69359	0
47	1933	65.69977	-15.596395	973.18369	1515.564	288.38874	0
48	1933	66.782515	-15.55441	970.59961	1493.507	278.03481	0
49	1933	67.86526	-15.512425	968.01553	1471.45	267.68088	0
50	1933	68.948	-15.47044	965.33916	1449.4854	257.4251	0
51	1933	70.03074	-15.428455	962.75507	1427.4284	247.07117	0
52	1933	71.113485	-15.38647	960.0787	1405.3714	236.76632	0
53	1933	72.19623	-15.344485	957.49462	1383.3144	226.41239	0
54	1933	73.27897	-15.3025	954.91054	1361.2574	216.05847	0
55	1933	74.361715	-15.260515	952.23417	1339.2004	205.75361	0
56	1933	75.44446	-15.21853	949.65009	1317.1434	195.39968	0
57	1933	76.5272	-15.176545	946.97372	1295.0865	185.09483	0
58	1933	77.60994	-15.13456	944.38964	1273.1218	174.78997	0
59	1933	78.692685	-15.092575	941.80555	1251.0648	164.43605	0
60	1933	79.77543	-15.05059	939.12918	1229.0078	154.13119	0
61	1933	80.862755	-15.0296	937.80279	1200.4608	139.65776	0
62	1933	81.95467	-15.0296	937.80279	1183.6097	130.69785	0
63	1933	83.046585	-15.0296	937.80279	1166.7586	121.73794	0
64	1933	84.1385	-15.0296	937.80279	1149.8158	112.72933	0

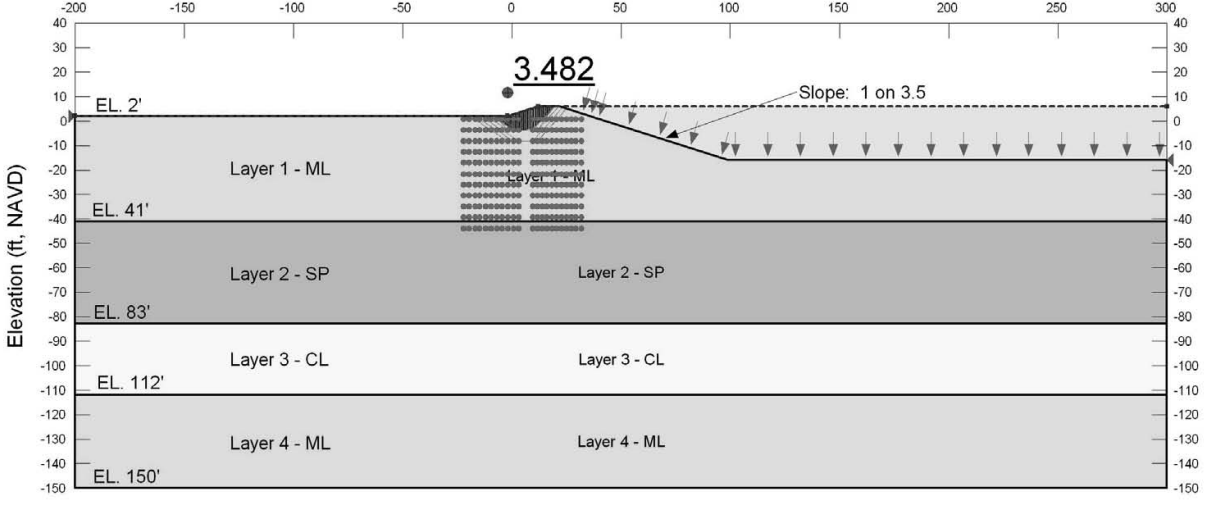
65	1933	85.230415	-15.0296	937.80279	1132.9647	103.76942	0
66	1933	86.32233	-15.0296	937.80279	1116.1135	94.809505	0
67	1933	87.414245	-15.0296	937.80279	1099.1708	85.800898	0
68	1933	88.506155	-15.0296	937.80279	1082.3197	76.840986	0
69	1933	89.59807	-15.0296	937.80279	1065.3769	67.832379	0
70	1933	90.689985	-15.0296	937.80279	1048.5258	58.872466	0
71	1933	91.7819	-15.0296	937.80279	1031.6747	49.912554	0
72	1933	92.873815	-15.0296	937.80279	1014.7319	40.903947	0
73	1933	93.96573	-15.0296	937.80279	997.88079	31.944035	0
74	1933	95.057645	-15.0296	937.80279	981.02964	22.984123	0

205

1096

LCA MVN - WHITE DITCH
Location 3 - Transmission System
Spencer's Block Search
Boring: R-59.75-UL

Water at Project Grade (levee)
Optimization



Name: Layer 1 - ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1
Name: Layer 2 - SP	Model: Mohr-Coulomb	Unit Weight: 122 pcf	Cohesion: 0 psf	Phi: 33 °	Piezometric Line: 1
Name: Layer 3 - CL	Model: Mohr-Coulomb	Unit Weight: 105 pcf	Cohesion: 1580 psf	Phi: 0 °	Piezometric Line: 1
Name: Layer 4 - ML	Model: Mohr-Coulomb	Unit Weight: 117 pcf	Cohesion: 200 psf	Phi: 15 °	Piezometric Line: 1

210

1097

Water at Project Grade (levee)

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

61.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 76
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 2:46:08 PM
File Name: Location 3 - 35k cfs - MC_R-59.75-LU_1on3.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 2:48:58 PM

62.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

63.0 ANALYSIS SETTINGS

63.1 Water at Project Grade (levee)

Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1

1098

Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

64.0 MATERIALS

64.1 Layer 1 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

64.2 Layer 2 - SP

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

1099

64.3 Layer 3 - CL

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 1580 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

64.4 Layer 4 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

65.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

66.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-22, 0.75) ft
Lower Left: (-22, -44) ft
Lower Right: (3.25, -44) ft
X Increments: 10
Y Increments: 10
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 3
Right Grid
Upper Left: (9.5, 0.75) ft
Lower Left: (9.5, -44) ft
Lower Right: (31.7145, -44) ft
X Increments: 10
Y Increments: 10

1100

Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 3

67.0 PIEZOMETRIC LINES

67.1 Piezometric Line 1

67.1.1 Coordinates

	X (ft)	Y (ft)
	-200	2
	-2	2
	12	6
	300	6

68.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 1 - ML	1,2,3,4,25,7,8,5,6,13,9	17411
Region 2	Layer 2 - SP	9,13,14,23,22,21,24,10	21000
Region 3	Layer 3 - CL	11,10,24,21,22,23,14,15	14500
Region 4	Layer 4 - ML	12,11,15,16	19000

69.0 POINTS

	X (ft)	Y (ft)
Point 1	-200	2
Point 2	-2	2
Point 3	12	6
Point 4	22	6
Point 5	99	-16
Point 6	300	-16
Point 7	43	0

1101

Point 8	50	-2
Point 9	-200	-41
Point 10	-200	-83
Point 11	-200	-112
Point 12	-200	-150
Point 13	300	-41
Point 14	300	-83
Point 15	300	-112
Point 16	300	-150
Point 17	36	-16
Point 18	50	-16
Point 19	80	-16
Point 20	6	-16
Point 21	56	-83
Point 22	113	-83
Point 23	143	-83
Point 24	26	-83
Point 25	29	4

70.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	3.482	(4.595, 7)	13.00373	(19.7249, 6)	(-7.62206, 2)
2	3565	3.719	(4.595, 7)	13.359	(19.225, 6)	(-9.19099, 2)

70.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

1	Optimized	-7.4328265	1.8498675	9.3682715	77.713247	18.312981	200
2	Optimized	-7.054362	1.5496025	28.105435	116.80998	23.768311	200
3	Optimized	-6.6758975	1.2493375	46.840322	155.90672	29.224252	200
4	Optimized	-6.2974325	0.9490725	65.577279	195.00345	34.679638	200
5	Optimized	-5.908756	0.654508	83.957735	226.37665	38.161032	200
6	Optimized	-5.509868	0.365644	101.98421	263.6357	43.314384	200
7	Optimized	-5.11098	0.07678	120.00866	300.87444	48.46284	200
8	Optimized	-4.712092	-0.212084	138.0331	338.11319	53.611296	200
9	Optimized	-4.313204	-0.500948	156.05958	375.37224	58.764649	200
10	Optimized	-3.9253275	-0.77269125	173.01627	404.3591	61.988125	200
11	Optimized	-3.5484625	-1.0273138	188.90393	436.9875	66.473794	200
12	Optimized	-3.1715975	-1.281936	204.79378	469.59391	70.952982	200
13	Optimized	-2.7947325	-1.5365585	220.68144	502.20033	75.43276	200
14	Optimized	-2.454725	-1.7543395	234.26958	519.17336	76.339738	200
15	Optimized	-2.151575	-1.935278	245.56002	542.08848	79.454561	200
16	Optimized	-1.8355415	-2.123906	260.26415	571.93682	83.512442	200
17	Optimized	-1.506625	-2.3202235	278.37148	608.69449	88.509785	200
18	Optimized	-1.1777085	-2.516541	296.48925	645.47827	93.511326	200
19	Optimized	-0.82208	-2.695074	313.96675	653.80404	91.059129	200
20	Optimized	-0.43974	-2.8558215	330.81998	687.22118	95.497414	200
21	Optimized	-0.0574	-3.0165685	347.67321	720.6142	99.929238	200
22	Optimized	0.32494	-3.177316	364.52644	754.03133	104.36752	200
23	Optimized	0.695751	-3.30288	378.97243	755.40758	100.86549	200
24	Optimized	1.055033	-3.39326	391.01101	778.75595	103.89594	200

1103

25	Optimized	1.414315	-3.48364	403.04959	802.13132	106.93362	200
26	Optimized	1.773597	-3.57402	415.08818	825.50668	109.97131	200
27	Optimized	2.132879	-3.6644	427.15375	848.88204	113.00176	200
28	Optimized	2.501518	-3.725149	437.49293	840.78901	108.06286	200
29	Optimized	2.879514	-3.756267	446.19375	857.2942	110.15403	200
30	Optimized	3.25751	-3.787385	454.8682	873.77302	112.24521	200
31	Optimized	3.635506	-3.818503	463.54265	890.27821	114.34345	200
32	Optimized	4.013502	-3.849621	472.2171	906.75703	116.43462	200
33	Optimized	4.3700325	-3.851335	478.6929	891.50381	110.61235	200
34	Optimized	4.7050975	-3.823645	482.94623	899.38585	111.58466	200
35	Optimized	5.0401625	-3.795955	487.16982	907.29764	112.57291	200
36	Optimized	5.3752275	-3.768265	491.42315	915.20943	113.55319	200
37	Optimized	5.7102925	-3.740575	495.67648	923.12122	114.53347	200
38	Optimized	6.0453575	-3.712885	499.92981	931.03301	115.51375	200
39	Optimized	6.408551	-3.649795	502.47085	908.12015	108.6934	200
40	Optimized	6.799873	-3.551305	503.28864	909.6566	108.88597	200
41	Optimized	7.191195	-3.452815	504.13121	911.16828	109.06525	200
42	Optimized	7.582517	-3.354325	504.949	912.67995	109.25118	200
43	Optimized	7.973839	-3.255835	505.79157	914.19163	109.43047	200
44	Optimized	8.3715985	-3.1224835	504.54257	886.35857	102.30729	200
45	Optimized	8.775796	-2.954271	501.25342	880.46551	101.60957	200
46	Optimized	9.1799935	-2.786059	497.96426	874.57244	100.91186	200
47	Optimized	9.584191	-2.6178465	494.67511	868.65653	100.20802	200
48	Optimized	9.9767	-2.421651	489.44743	834.2715	92.395332	200

1104

49	Optimized	10.35752	-2.1974735	482.22871	821.59914	90.934033	200
50	Optimized	10.738345	-1.9732965	475.03261	808.92678	89.466671	200
51	Optimized	11.11917	-1.749119	467.83652	796.27704	88.005372	200
52	Optimized	11.482185	-1.5021405	458.89045	755.15496	79.383836	200
53	Optimized	11.827395	-1.232361	448.23131	736.73543	77.304445	200
54	Optimized	12.186105	-0.95203195	433.79742	711.89602	74.516297	200
55	Optimized	12.558315	-0.6611538	415.65549	680.60808	70.993832	200
56	Optimized	12.93052	-0.37027555	397.51356	649.32013	67.471368	200
57	Optimized	13.302725	-0.07939731	379.35046	618.03219	63.954575	200
58	Optimized	13.674935	0.21148089	361.20854	586.74424	60.43211	200
59	Optimized	14.035995	0.50915085	342.629	545.33463	54.31481	200
60	Optimized	14.385905	0.8136125	323.63478	512.88707	50.709998	200
61	Optimized	14.735815	1.1180742	304.64056	480.43951	47.105186	200
62	Optimized	15.085725	1.422536	285.62478	447.99195	43.506151	200
63	Optimized	15.435635	1.7269975	266.63056	415.54439	39.901339	200
64	Optimized	15.785545	2.031459	247.63634	383.09683	36.296528	200
65	Optimized	16.13198	2.34798	227.89379	342.00912	30.57711	200
66	Optimized	16.47494	2.67656	207.3825	307.29026	26.770204	200
67	Optimized	16.817895	3.00514	186.87964	272.59247	22.966682	200
68	Optimized	17.16085	3.33372	166.37678	237.87361	19.157519	200
69	Optimized	17.50381	3.6623	145.87181	203.16318	15.351176	200
70	Optimized	17.84677	3.99088	125.36895	168.45275	11.54427	200
71	Optimized	18.188915	4.339653	103.60628	124.17395	5.5110895	200
72	Optimized	18.530245	4.708619	80.581561	85.670755	1.3636455	200

73	Optimized	18.87157	5.077585	57.558826	47.167559	-2.7843316	200
74	Optimized	19.212895	5.446551	34.536091	8.6631694	-6.9326286	200
75	Optimized	19.554225	5.815517	11.511765	-29.840822	-11.080392	200

70.2 Slices of Slip Surface: 3565

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	3565	-9.0017545	1.890744	6.817487	53.457116	12.497051	200
2	3565	-8.623281	1.6722325	20.45269	81.08494	16.246362	200
3	3565	-8.2448075	1.453721	34.087435	108.71048	19.995183	200
4	3565	-7.8663345	1.2352095	47.722867	136.3383	23.744434	200
5	3565	-7.4878615	1.016698	61.358299	163.96384	27.493071	200
6	3565	-7.1093885	0.7981862	74.99373	191.58937	31.241708	200
7	3565	-6.730915	0.5796746	88.629162	219.21719	34.990958	200
8	3565	-6.3524415	0.361163	102.26231	246.85188	38.742661	200
9	3565	-5.9739685	0.14265137	115.89774	274.47055	42.489458	200
10	3565	-5.5954955	-0.07586028	129.53317	302.08923	46.236256	200
11	3565	-5.2170225	-0.2943719	143.1686	329.73078	49.989185	200
12	3565	-4.838549	-0.5128835	156.80403	357.34945	53.735983	200
13	3565	-4.4600755	-0.7313951	170.43946	384.96812	57.48278	200
14	3565	-4.0816025	-0.94990645	184.0749	412.60967	61.235709	200
15	3565	-3.7031295	-1.168418	197.71033	440.22834	64.982507	200
16	3565	-3.3246565	-1.38693	211.34347	467.84702	68.729918	200
17	3565	-2.946183	-1.6054415	224.9789	495.48857	72.482847	200
18	3565	-2.5677095	-1.823953	238.61433	523.10724	76.229644	200
19	3565	-2.1892365	-2.042465	252.25205	550.72591	79.975829	200

1106

20	3565	-1.805357	-2.264098	269.5389	585.7955	84.740702	200
21	3565	-1.4160715	-2.488852	290.51737	628.26412	90.498968	200
22	3565	-1.026786	-2.713606	311.4736	670.73274	96.263196	200
23	3565	-0.6375	-2.93836	332.45207	713.2236	102.02742	200
24	3565	-0.24821426	-3.1631145	353.4083	755.69222	107.79165	200
25	3565	0.14107144	-3.387869	374.36453	798.18308	113.56184	200
26	3565	0.53035715	-3.612623	395.343	840.6517	119.32011	200
27	3565	0.915761	-3.725	409.22967	774.2941	97.818718	200
28	3565	1.2972825	-3.725	416.01828	787.08498	99.427024	200
29	3565	1.678804	-3.725	422.83309	799.87587	101.02831	200
30	3565	2.060326	-3.725	429.6217	812.66675	102.63661	200
31	3565	2.441848	-3.725	436.43651	825.45763	104.2379	200
32	3565	2.8233695	-3.725	443.22512	838.24852	105.8462	200
33	3565	3.204891	-3.725	450.03993	851.0394	107.44748	200
34	3565	3.586413	-3.725	456.82854	863.83029	109.05579	200
35	3565	3.967935	-3.725	463.64335	876.62117	110.65707	200
36	3565	4.3494565	-3.725	470.43196	889.41206	112.26538	200
37	3565	4.730978	-3.725	477.24677	902.20294	113.86666	200
38	3565	5.1125	-3.725	484.03538	914.99383	115.47497	200
39	3565	5.494022	-3.725	490.85019	927.78471	117.07625	200
40	3565	5.8755435	-3.725	497.6388	940.5756	118.68456	200
41	3565	6.257065	-3.725	504.45361	953.36648	120.28584	200
42	3565	6.638587	-3.725	511.24222	966.15736	121.89415	200
43	3565	7.020109	-3.725	518.05703	978.94825	123.49543	200

1107

44	3565	7.4016305	-3.725	524.84564	991.73913	125.10373	200
45	3565	7.783152	-3.725	531.66045	1004.53	126.70502	200
46	3565	8.164674	-3.725	538.44906	1017.3209	128.31332	200
47	3565	8.546196	-3.725	545.26387	1030.1118	129.91461	200
48	3565	8.9277175	-3.725	552.07869	1042.9289	131.52291	200
49	3565	9.309239	-3.725	558.86729	1055.7198	133.13122	200
50	3565	9.6785715	-3.5464285	554.31229	890.51892	90.086295	200
51	3565	10.035716	-3.1892855	538.3939	863.71109	87.168477	200
52	3565	10.39286	-2.8321425	522.47552	836.92305	84.255964	200
53	3565	10.75	-2.475	506.55713	810.11522	81.338147	200
54	3565	11.10714	-2.1178575	490.63874	783.32719	78.425634	200
55	3565	11.464285	-1.7607145	474.72035	756.53916	75.513122	200
56	3565	11.82143	-1.4035715	458.80197	729.73133	72.595304	200
57	3565	12.19013	-1.0348684	438.9768	696.3715	68.968703	200
58	3565	12.570395	-0.65460525	415.24933	656.42902	64.623904	200
59	3565	12.95066	-0.27434212	391.52186	616.48654	60.279105	200
60	3565	13.33092	0.10592104	367.79438	576.54406	55.934306	200
61	3565	13.711185	0.4861842	344.06691	536.60158	51.589507	200
62	3565	14.09145	0.8664474	320.33944	496.65909	47.244708	200
63	3565	14.47171	1.2467105	296.61197	456.71661	42.899909	200
64	3565	14.851975	1.6269735	272.8845	416.77413	38.55511	200
65	3565	15.23224	2.0072365	249.15703	376.83165	34.21031	200
66	3565	15.6125	2.3875	225.41097	336.88917	29.870494	200
67	3565	15.99276	2.7677635	201.6835	296.94669	25.525695	200

68	3565	16.373025	3.1480265	177.96347	257.00421	21.178903	200
69	3565	16.75329	3.5282895	154.23414	217.06172	16.834602	200
70	3565	17.13355	3.9085525	130.50667	177.11552	12.488806	200
71	3565	17.513815	4.2888155	106.77734	137.17304	8.1445053	200
72	3565	17.89408	4.669079	83.049865	97.230562	3.7997062	200
73	3565	18.27434	5.0493425	59.320535	57.28808	-0.54459466	200
74	3565	18.654605	5.4296055	35.593065	17.345413	-4.8894436	200
75	3565	19.03487	5.8098685	11.864293	-22.596882	-9.2338441	200

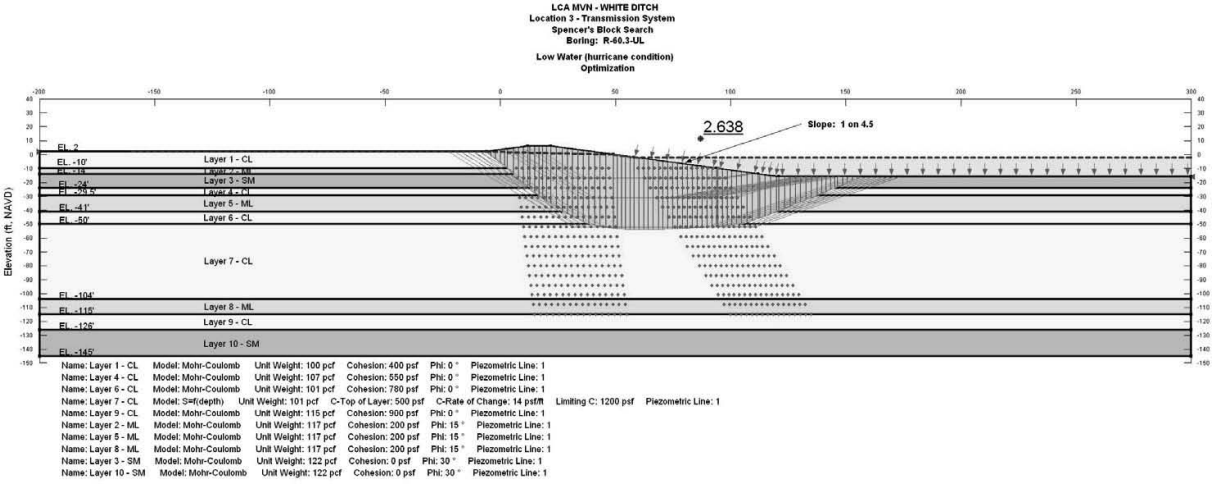
330

335

340

345

Boring
R-60.3-UL



Low Water (hurricane condition)

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

71.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 74
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 10:57:29 AM
File Name: Location 3 - 35k cfs - Main Channel_R-60.3-LU_1on4.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010

1111

Last Solved Time: 11:01:41 AM

72.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

73.0 ANALYSIS SETTINGS

73.1 Low Water (hurricane condition)

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: Yes
    Tension Crack
        Tension Crack Option: (none)
FOS Distribution
    FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
    Number of Slices: 75
    Optimization Tolerance: 0.01
    Minimum Slip Surface Depth: 0.1 ft
    Optimization Maximum Iterations: 5000
    Optimization Convergence Tolerance: 1e-007

1112

Starting Optimization Points: 8
Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

74.0 MATERIALS

74.1 Layer 1 - CL

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion: 400 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.2 Layer 4 - CL

Model: Mohr-Coulomb
Unit Weight: 107 pcf
Cohesion: 550 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.3 Layer 6 - CL

Model: Mohr-Coulomb
Unit Weight: 101 pcf
Cohesion: 780 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.4 Layer 7 - CL

Model: S=f(depth)
Unit Weight: 101 pcf
C-Top of Layer: 500 psf

C-Rate of Change: 14 psf/ft
Limiting C: 1200 psf
Pore Water Pressure
Piezometric Line: 1

74.5 Layer 9 - CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 900 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.6 Layer 2 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.7 Layer 5 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.8 Layer 8 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

74.9 Layer 3 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

74.10 Layer 10 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

75.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

76.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (7, -10) ft
Lower Left: (15, -115) ft
Lower Right: (55, -115) ft
X Increments: 15
Y Increments: 15
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (60, -10) ft
Lower Left: (100, -115) ft
Lower Right: (135, -115) ft

X Increments: 15
Y Increments: 15
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

77.0PIEZOMETRIC LINES

77.1 Piezometric Line 1

77.1.1 Coordinates

	X (ft)	Y (ft)
	-160	2
	-6	2
	49	0
	58	-2
	300	-2

78.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM	20,21,15,11	9500
Region 2	Layer 9 - CL	20,10,14,21	5500
Region 3	Layer 8 - ML	10,9,13,14	5500
Region 4	Layer 5 - ML	18,19,12,23	5750
Region 5	Layer 4 - CL	8,18,23,22	2750
Region 6	Layer 1 - CL	1,2,3,4,28,7,24,16	3316
Region 7	Layer 2 - ML	17,16,24,25	1212
Region 8	Layer 3 - SM	17,25,5,6,22,8	4633
Region 9	Layer 6 - CL	19,26,27,12	4500
Region 10	Layer 7 - CL	26,9,13,27	27000

1116

79.0 POINTS

	X (ft)	Y (ft)
Point 1	-200	2
Point 2	-6	2
Point 3	12	6
Point 4	22	6
Point 5	121	-16
Point 6	300	-16
Point 7	58	-2
Point 8	-200	-24
Point 9	-200	-104
Point 10	-200	-115
Point 11	-200	-145
Point 12	300	-41
Point 13	300	-104
Point 14	300	-115
Point 15	300	-145
Point 16	-200	-10
Point 17	-200	-14
Point 18	-200	-29.5
Point 19	-200	-41
Point 20	-200	-126
Point 21	300	-126
Point 22	300	-24

Point 23	300	-29.5
Point 24	94	-10
Point 25	112	-14
Point 26	-200	-50
Point 27	300	-50
Point 28	49	0

80.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	2.638	(76.138, 6.5)	75.4855	(-6.32844, 2)	(157.054, -16)
2	27631	2.758	(76.138, 6.5)	79.983	(-14.4667, 2)	(164.021, -16)

80.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-6.1642215	1.794791	12.805052	-156.18089	0	400
2	Optimized	-5.006771	0.34845795	100.80397	3.2180647	0	400
3	Optimized	-3.0203135	-2.1337901	251.18582	282.77513	0	400
4	Optimized	-1.0338562	-4.616038	401.57396	562.33565	0	400
5	Optimized	0.95260125	-7.098286	551.95581	841.89932	0	400
6	Optimized	2.500418	-9.169705	677.68177	1028.0652	0	400
7	Optimized	4.3908875	-12	850.02155	1396.5026	146.42915	200
8	Optimized	6.8136695	-15.62724	1070.8537	1814.1401	429.13661	0
9	Optimized	8.98747	-18.88172	1269.0038	2184.2246	528.40303	0
10	Optimized	11.037185	-21.7788	1445.1415	2559.2361	643.22282	0
11	Optimized	12.36067	-23.52432	1551.0343	2757.9899	696.83615	0

12	Optimized	13.76389	-25.375	1663.3499	3021.6383	0	550
13	Optimized	15.848995	-28.125	1830.2238	3302.4177	0	550
14	Optimized	17.646385	-30.49554	1974.0641	3523.588	415.19368	200
15	Optimized	19.300915	-32.51975	2096.6182	3795.9016	455.32161	200
16	Optimized	21.100305	-34.577085	2220.9043	4016.5212	481.13411	200
17	Optimized	23.17948	-36.954315	2364.549	4248.7423	504.86807	200
18	Optimized	25.59142	-39.712015	2531.1368	4497.9766	527.01314	200
19	Optimized	27.98083	-42.005455	2668.8234	4839.9829	0	780
20	Optimized	30.29473	-43.774065	2773.9598	4963.592	0	780
21	Optimized	32.60863	-45.542675	2879.0619	5087.2011	0	780
22	Optimized	34.92253	-47.311285	2984.164	5211.1535	0	780
23	Optimized	37.23643	-49.079895	3089.266	5334.7626	0	780
24	Optimized	39.68681	-50.39752	3165.9271	5651.3991	0	505.82
25	Optimized	42.220245	-51.246265	3213.1436	5679.2721	0	517.45
26	Optimized	44.70025	-52.07711	3259.3685	5706.4183	0	529.08
27	Optimized	47.470125	-52.750555	3295.2375	5779.9593	0	538.51
28	Optimized	49.910215	-53.162095	3304.6736	5767.1589	0	544.27
29	Optimized	51.73065	-53.469125	3298.6069	5757.4088	0	548.57
30	Optimized	53.551085	-53.776155	3292.5402	5748.2004	0	552.87
31	Optimized	55.345975	-53.920115	3276.6058	5798.4021	0	554.88
32	Optimized	57.115325	-53.901005	3250.8917	5757.1464	0	554.61
33	Optimized	59.05812	-53.88002	3237.3021	5726.3387	0	554.32
34	Optimized	61.174355	-53.85716	3235.8846	5706.4934	0	554
35	Optimized	63.29059	-53.8343	3234.4671	5686.648	0	553.68

36	Optimized	65.40683	-53.81144	3233.0496	5667.2751	0	553.36
37	Optimized	67.52307	-53.78858	3231.5848	5647.4297	0	553.04
38	Optimized	69.639305	-53.76572	3230.1673	5627.5843	0	552.72
39	Optimized	71.75554	-53.74286	3228.7497	5607.7389	0	552.4
40	Optimized	73.872975	-53.637525	3222.1847	5611.8126	0	550.93
41	Optimized	75.99161	-53.44971	3210.4778	5575.1403	0	548.3
42	Optimized	78.110245	-53.261895	3198.7238	5538.4679	0	545.67
43	Optimized	80.22888	-53.07408	3187.0169	5501.7955	0	543.04
44	Optimized	82.347515	-52.886265	3175.3099	5465.1232	0	540.41
45	Optimized	84.466145	-52.69845	3163.603	5428.4508	0	537.78
46	Optimized	86.58478	-52.510635	3151.849	5391.7784	0	535.15
47	Optimized	88.703415	-52.32282	3140.142	5355.1061	0	532.52
48	Optimized	90.82205	-52.135005	3128.4351	5318.4337	0	529.89
49	Optimized	92.940685	-51.947195	3116.7281	5281.7613	0	527.26
50	Optimized	94.246845	-51.831405	3109.4004	5258.3994	0	525.64
51	Optimized	95.50457	-51.62857	3096.8447	5257.8099	0	522.8
52	Optimized	97.52633	-51.266665	3074.2535	5196.4631	0	517.73
53	Optimized	99.548105	-50.90476	3051.6623	5134.6294	0	512.67
54	Optimized	101.56985	-50.542855	3029.0711	5072.7958	0	507.6
55	Optimized	103.6358	-50.173035	3006.0138	5009.9453	0	502.53
56	Optimized	105.9091	-49.33031	2953.4203	5093.4259	0	780
57	Optimized	108.34545	-48.02259	2871.7968	4928.5152	0	780
58	Optimized	110.7818	-46.71487	2790.2094	4763.9661	0	780
59	Optimized	112.3072	-45.896125	2739.139	4660.6952	0	780

60	Optimized	113.82185	-44.9427	2679.6314	4597.3983	0	780
61	Optimized	116.23675	-43.36562	2581.1999	4401.5061	0	780
62	Optimized	118.6516	-41.78854	2482.8031	4205.9607	0	780
63	Optimized	120.4295	-40.62744	2410.3317	4015.5073	430.10549	200
64	Optimized	122.27035	-39.425265	2335.3298	3850.0894	405.8786	200
65	Optimized	124.69765	-37.83768	2236.2765	3653.3213	379.69599	200
66	Optimized	127.0115	-36.32174	2141.6719	3464.9435	354.56955	200
67	Optimized	129.32535	-34.805795	2047.0673	3276.4211	329.40436	200
68	Optimized	131.63925	-33.28985	1952.4989	3087.9349	304.23918	200
69	Optimized	133.95315	-31.77391	1857.8943	2899.4487	279.08367	200
70	Optimized	136.32305	-30.22129	1760.9991	2706.7892	253.42369	200
71	Optimized	138.50255	-28.74831	1669.076	2577.9683	0	550
72	Optimized	140.43565	-27.39165	1584.4323	2428.9633	0	550
73	Optimized	142.36875	-26.03499	1499.7887	2280.0006	0	550
74	Optimized	144.30185	-24.67833	1415.1451	2130.9957	0	550
75	Optimized	145.84915	-23.59244	1347.3991	1946.8539	346.0954	0
76	Optimized	147.4923	-22.46639	1277.0987	1786.2385	293.95198	0
77	Optimized	149.6171	-21.029415	1187.434	1589.3269	232.033	0
78	Optimized	151.74195	-19.59244	1097.7693	1392.3764	170.09151	0
79	Optimized	153.8668	-18.155465	1008.1045	1195.4648	108.17253	0
80	Optimized	155.9916	-16.71849	918.43979	998.51429	46.231038	0

80.2 Slices of Slip Surface: 27631

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	27631	-13.408335	0.94166665	66.04154	-32.957631	0	400

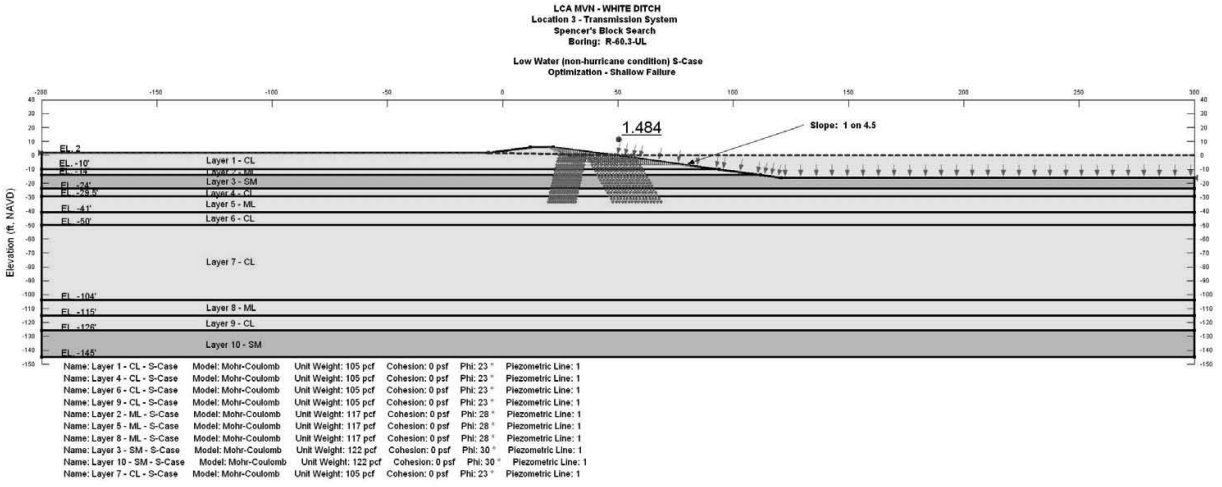
1121

2	27631	-11.291665	-1.1749999	198.12128	171.58974	0	400
3	27631	-9.1749985	-3.2916665	330.20102	376.12509	0	400
4	27631	-7.0583335	-5.4083335	462.28076	580.6738	0	400
5	27631	-4.2333335	-8.2333335	634.55495	891.63495	0	400
6	27631	-1.4666669	-11	800.90453	1260.8068	123.23044	200
7	27631	0.53333315	-13	921.1834	1517.5219	159.78843	200
8	27631	2.783333	-15.25	1056.4741	1802.3303	430.62029	0
9	27631	5.283333	-17.75	1206.805	2118.407	526.31368	0
10	27631	7.783333	-20.25	1357.1359	2434.4837	622.00708	0
11	27631	10.283331	-22.75	1507.4385	2750.5605	717.71681	0
12	27631	11.766665	-24.233335	1596.5967	3010.6083	0	550
13	27631	13.258335	-25.725	1686.3514	3169.8989	0	550
14	27631	15.775	-28.241665	1837.6816	3430.0768	0	550
15	27631	18.275	-30.741665	1988.0044	3666.8941	449.85713	200
16	27631	20.758335	-33.225	2137.3226	3936.8285	482.17616	200
17	27631	23.08889	-35.555555	2277.4538	4168.3943	506.67599	200
18	27631	25.26667	-37.73333	2408.402	4362.2353	523.52807	200
19	27631	27.444445	-39.91111	2539.3502	4556.0764	540.38015	200
20	27631	29.65833	-42.125	2672.4861	4727.8724	0	780
21	27631	31.90833	-44.375	2807.7792	4899.4636	0	780
22	27631	34.15833	-46.625	2943.0723	5070.7405	0	780
23	27631	36.40833	-48.875	3078.3653	5242.0175	0	780
24	27631	38.53333	-51	3206.1637	5493.5128	0	514
25	27631	40.716665	-52	3263.577	5923.9428	0	528

26	27631	43.083335	-52	3258.2108	5871.1259	0	528
27	27631	45.45	-52	3252.8446	5818.7316	0	528
28	27631	47.816665	-52	3247.4784	5765.9147	0	528
29	27631	50.125	-52	3229.2	5714.6667	0	528
30	27631	52.375	-52	3198	5664.8889	0	528
31	27631	54.625	-52	3166.8	5614.6667	0	528
32	27631	56.875	-52	3135.6	5564.8889	0	528
33	27631	59.2	-52	3120	5529.5833	0	528
34	27631	61.6	-52	3120	5510	0	528
35	27631	64	-52	3120	5490	0	528
36	27631	66.4	-52	3120	5470.4167	0	528
37	27631	68.8	-52	3120	5450.4167	0	528
38	27631	71.2	-52	3120	5430.8333	0	528
39	27631	73.6	-52	3120	5410.8333	0	528
40	27631	76	-52	3120	5391.25	0	528
41	27631	78.4	-52	3120	5371.25	0	528
42	27631	80.8	-52	3120	5351.6667	0	528
43	27631	83.2	-52	3120	5331.6667	0	528
44	27631	85.6	-52	3120	5312.0833	0	528
45	27631	88	-52	3120	5292.0833	0	528
46	27631	90.4	-52	3120	5272.5	0	528
47	27631	92.8	-52	3120	5252.5	0	528
48	27631	95.27778	-52	3119.9864	5227.4339	0	528
49	27631	97.833335	-52	3119.9864	5196.5208	0	528

50	27631	100.3889	-52	3119.9864	5165.9991	0	528
51	27631	103.39875	-51	3057.5	5241.5	0	514
52	27631	106.27565	-49.33901	2953.9681	5094.9917	0	780
53	27631	108.5654	-48.017025	2871.4784	4930.8445	0	780
54	27631	110.85515	-46.69504	2788.9888	4766.3191	0	780
55	27631	113.0899	-45.404795	2708.4764	4604.6442	0	780
56	27631	115.2697	-44.14628	2629.9312	4445.7264	0	780
57	27631	117.4495	-42.887765	2551.3861	4286.8085	0	780
58	27631	119.6293	-41.629255	2472.8807	4127.8907	0	780
59	27631	120.8596	-40.918945	2428.5464	4001.1055	421.36593	200
60	27631	122.22735	-40.129275	2379.2774	3894.5497	406.016	200
61	27631	124.6821	-38.71204	2290.8307	3719.9142	382.92177	200
62	27631	127.13685	-37.2948	2202.3839	3545.6314	359.92207	200
63	27631	129.59155	-35.877565	2113.9725	3371.1369	336.8562	200
64	27631	132.04625	-34.46033	2025.5257	3196.713	313.8187	200
65	27631	134.501	-33.04309	1937.079	3022.2891	290.78119	200
66	27631	136.95575	-31.625855	1848.6675	2847.83	267.72477	200
67	27631	139.41045	-30.20862	1760.2208	2673.4061	244.68726	200
68	27631	141.8286	-28.8125	1673.0909	2537.5636	0	550
69	27631	144.21015	-27.4375	1587.3091	2387.4545	0	550
70	27631	146.5917	-26.0625	1501.4909	2237.3091	0	550
71	27631	148.9733	-24.6875	1415.7091	2087.1636	0	550
72	27631	151.3188	-23.333335	1331.2123	1875.7123	314.36718	0
73	27631	153.6282	-22	1247.9998	1697.2498	259.37458	0

74	27631	155.9376	-20.666665	1164.7874	1518.8248	204.40362	0
75	27631	158.247	-19.333335	1081.6124	1340.3623	149.38936	0
76	27631	160.5564	-18	998.39988	1161.8999	94.396757	0
77	27631	162.8658	-16.666665	915.18739	983.43738	39.404151	0



Low Water S-Case - Flood Side - Shallow

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

81.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 74
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 10:57:29 AM
File Name: Location 3 - 35k cfs - Main Channel_R-60.3-LU_1on4.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 11:06:07 AM

1126

82.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

83.0 ANALYSIS SETTINGS

83.1 Low Water S-Case - Flood Side - Shallow

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
Apply Phreatic Correction: No
PWP Conditions Source: Piezometric Line
Use Staged Rapid Drawdown: No
SlipSurface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Block
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: Yes
Tension Crack
Tension Crack Option: (none)
FOS Distribution
FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
Number of Slices: 75
Optimization Tolerance: 0.01
Minimum Slip Surface Depth: 0.1 ft
Optimization Maximum Iterations: 5000
Optimization Convergence Tolerance: 1e-007
Starting Optimization Points: 8

Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

84.0 MATERIALS

84.1 Layer 1 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.2 Layer 4 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.3 Layer 6 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.4 Layer 9 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °

1128

Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.5 Layer 2 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.6 Layer 5 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.7 Layer 8 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.8 Layer 3 - SM - S-Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

84.9 Layer 10 - SM - S-Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

84.10 Layer 7 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

85.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

86.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (24.6008, 0) ft
Lower Left: (19.9471, -33.5) ft
Lower Right: (31.5812, -33.5) ft
X Increments: 15
Y Increments: 15
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (36.6357, 0) ft
Lower Left: (47.9905, -33.5) ft
Lower Right: (68.6991, -33.5) ft
X Increments: 15

Y Increments: 15
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

695 **87.0 PIEZOMETRIC LINES**

87.1 Piezometric Line 1

87.1.1 Coordinates

	X (ft)	Y (ft)
	-200	2
	-6	2
	49	0
	300	0

88.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM - S-Case	20,21,15,11	9500
Region 2	Layer 9 - CL - S-Case	20,10,14,21	5500
Region 3	Layer 8 - ML - S-Case	10,9,13,14	5500
Region 4	Layer 5 - ML - S-Case	18,19,12,23	5750
Region 5	Layer 4 - CL - S-Case	8,18,23,22	2750
Region 6	Layer 1 - CL - S-Case	1,2,3,4,28,7,24,16	3316
Region 7	Layer 2 - ML - S-Case	17,16,24,25	1212
Region 8	Layer 3 - SM - S-Case	17,25,5,6,22,8	4633
Region 9	Layer 6 - CL - S-Case	19,26,27,12	4500
Region 10	Layer 7 - CL - S-Case	26,9,13,27	27000

89.0 POINTS

	X (ft)	Y (ft)

1131

Point 1	-200	2
Point 2	-6	2
Point 3	12	6
Point 4	22	6
Point 5	121	-16
Point 6	300	-16
Point 7	58	-2
Point 8	-200	-24
Point 9	-200	-104
Point 10	-200	-115
Point 11	-200	-145
Point 12	300	-41
Point 13	300	-104
Point 14	300	-115
Point 15	300	-145
Point 16	-200	-10
Point 17	-200	-14
Point 18	-200	-29.5
Point 19	-200	-41
Point 20	-200	-126
Point 21	300	-126
Point 22	300	-24
Point 23	300	-29.5
Point 24	94	-10

Point 25	112	-14
Point 26	-200	-50
Point 27	300	-50
Point 28	49	0

700 **90.0 CRITICAL SLIP SURFACES**

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	1.484	(52.6, 9.175)	28.67836	(20.6797, 6)	(85.4425, -8.09833)
2	16117	1.650	(52.6, 9.175)	25.958	(21.8286, 6)	(79.15, -6.7)

90.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	21.00979	5.6961825	-291.92407	23.756726	10.084132	0
2	Optimized	21.66993	5.0885475	-255.51158	71.270177	30.252395	0
3	Optimized	22.390885	4.424935	-215.73999	116.36388	49.393538	0
4	Optimized	23.17265	3.705345	-172.60705	159.05448	67.514622	0
5	Optimized	23.954415	2.985755	-129.48352	201.73567	85.631712	0
6	Optimized	24.742605	2.323275	-89.93029	252.0771	107.00038	0
7	Optimized	25.537215	1.717905	-53.958174	287.31444	121.95774	0
8	Optimized	26.33183	1.1125348	-17.986058	322.55178	136.91511	0
9	Optimized	27.21776	0.43759719	22.119914	365.01317	145.54955	0
10	Optimized	28.195	-0.30690761	66.359742	414.69039	147.85759	0
11	Optimized	29.142185	-0.931291	103.1708	481.92552	160.77184	0
12	Optimized	30.05931	-1.435553	132.56081	511.4493	160.82862	0
13	Optimized	30.976435	-1.939815	161.94127	540.96353	160.8854	0
14	Optimized	31.89356	-2.444077	191.32173	570.47775	160.94218	0

1133

15	Optimized	32.810685	-2.948339	220.71174	599.99197	160.99491	0
16	Optimized	33.72914	-3.382438	245.71217	648.21306	170.85149	0
17	Optimized	34.64892	-3.746374	266.33561	664.49952	169.01055	0
18	Optimized	35.568705	-4.11031	286.95906	680.78598	167.16961	0
19	Optimized	36.48849	-4.474246	307.5825	697.08254	165.33296	0
20	Optimized	37.40827	-4.838182	328.20595	713.369	163.49201	0
21	Optimized	38.31437	-5.136275	344.75156	748.60464	171.42546	0
22	Optimized	39.206785	-5.368525	357.22252	752.3893	167.73834	0
23	Optimized	40.0992	-5.600775	369.68264	756.16312	164.05123	0
24	Optimized	40.991615	-5.833025	382.1536	759.94779	160.36412	0
25	Optimized	41.88403	-6.065275	394.62456	763.73245	156.677	0
26	Optimized	42.809035	-6.25524	404.37163	782.91013	160.68006	0
27	Optimized	43.766625	-6.40292	411.42078	776.32541	154.89283	0
28	Optimized	44.724215	-6.5506	418.45962	769.73038	149.10559	0
29	Optimized	45.61221	-6.6486935	422.57046	777.96925	150.85784	0
30	Optimized	46.430615	-6.6972	423.74142	763.78355	144.33932	0
31	Optimized	47.24902	-6.7457065	424.90019	749.59785	137.82598	0
32	Optimized	47.993665	-6.764812	424.40113	748.08225	137.39449	0
33	Optimized	48.664555	-6.754516	422.24007	730.7044	130.93534	0
34	Optimized	49.45014	-6.74246	420.72833	717.01072	125.76441	0
35	Optimized	50.350425	-6.7286435	419.86204	707.00396	121.88451	0
36	Optimized	51.250715	-6.714827	419.00685	696.98609	117.99518	0
37	Optimized	52.151	-6.701011	418.14056	686.97932	114.11528	0
38	Optimized	53.05128	-6.6871945	417.28538	676.96145	110.22595	0

1134

39	Optimized	53.951565	-6.673378	416.41909	666.95469	106.34605	0
40	Optimized	54.854935	-6.660895	415.64508	656.57781	102.26988	0
41	Optimized	55.761385	-6.649745	414.93909	646.80416	98.420884	0
42	Optimized	56.667835	-6.638595	414.24412	637.0305	94.567209	0
43	Optimized	57.56053	-6.633044	413.89628	626.20884	90.121334	0
44	Optimized	58.44488	-6.633093	413.90937	617.88572	86.582825	0
45	Optimized	59.33464	-6.6331425	413.90937	609.51268	83.028679	0
46	Optimized	60.2244	-6.6331915	413.90937	601.13963	79.474532	0
47	Optimized	61.11416	-6.6332405	413.90937	592.76659	75.920386	0
48	Optimized	62.00392	-6.6332895	413.92061	584.39354	72.361468	0
49	Optimized	62.89368	-6.6333385	413.92061	576.0205	68.807322	0
50	Optimized	63.78344	-6.6333875	413.92061	567.64746	65.253175	0
51	Optimized	64.6732	-6.6334365	413.93185	559.27441	61.694258	0
52	Optimized	65.56296	-6.6334855	413.93185	550.90137	58.140112	0
53	Optimized	66.411265	-6.6383875	414.23378	542.12885	54.288235	0
54	Optimized	67.218115	-6.6481425	414.84103	535.61016	51.263454	0
55	Optimized	68.02497	-6.6578975	415.44829	529.09148	48.238674	0
56	Optimized	68.831825	-6.6676525	416.05554	522.5604	45.208633	0
57	Optimized	69.728485	-6.687035	417.27569	514.58023	41.303328	0
58	Optimized	70.71496	-6.716045	419.07931	508.48033	37.948481	0
59	Optimized	71.61636	-6.753485	421.41237	501.71983	34.088496	0
60	Optimized	72.43268	-6.799355	424.27438	499.02906	31.731478	0
61	Optimized	73.249	-6.845225	427.13639	496.33828	29.374461	0
62	Optimized	74.06532	-6.891095	429.9984	493.65973	27.022635	0

63	Optimized	74.88164	-6.936965	432.87264	490.96896	24.660425	0
64	Optimized	75.69796	-6.982835	435.73464	488.27818	22.303408	0
65	Optimized	76.531585	-7.046219	439.68918	484.40334	18.980032	0
66	Optimized	77.38251	-7.127117	444.73152	485.11698	17.142614	0
67	Optimized	78.233435	-7.208015	449.78555	485.84233	15.305196	0
68	Optimized	79.08436	-7.288913	454.82788	486.56768	13.472744	0
69	Optimized	79.935285	-7.369811	459.88192	487.28133	11.63036	0
70	Optimized	80.784225	-7.467599	465.97442	487.10509	8.9694346	0
71	Optimized	81.63118	-7.582277	473.13498	491.39908	7.7526508	0
72	Optimized	82.478135	-7.696955	480.29554	495.68138	6.5309006	0
73	Optimized	83.325085	-7.8116325	487.4444	499.96367	5.3141168	0
74	Optimized	84.17204	-7.92631	494.60495	504.24596	4.0923666	0
75	Optimized	85.018995	-8.040988	501.75381	508.53996	2.8805493	0

90.2 Slices of Slip Surface: 16117

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	16117	21.914275	5.9142765	-307.59021	6.638973	2.8180768	0
2	16117	22.35926	5.469294	-280.83756	34.917467	14.821585	0
3	16117	23.07778	4.7507755	-237.62497	78.196979	33.192648	0
4	16117	23.7963	4.0322565	-194.42222	121.47944	51.564964	0
5	16117	24.514815	3.313738	-151.21947	164.76092	69.936863	0
6	16117	25.23333	2.5952195	-108.01672	208.03256	88.304584	0
7	16117	25.95185	1.8767005	-64.808063	251.31404	106.67648	0
8	16117	26.67037	1.1581818	-21.60236	294.59552	125.04838	0
9	16117	27.404575	0.42397638	22.545799	342.53396	135.82691	0

1136

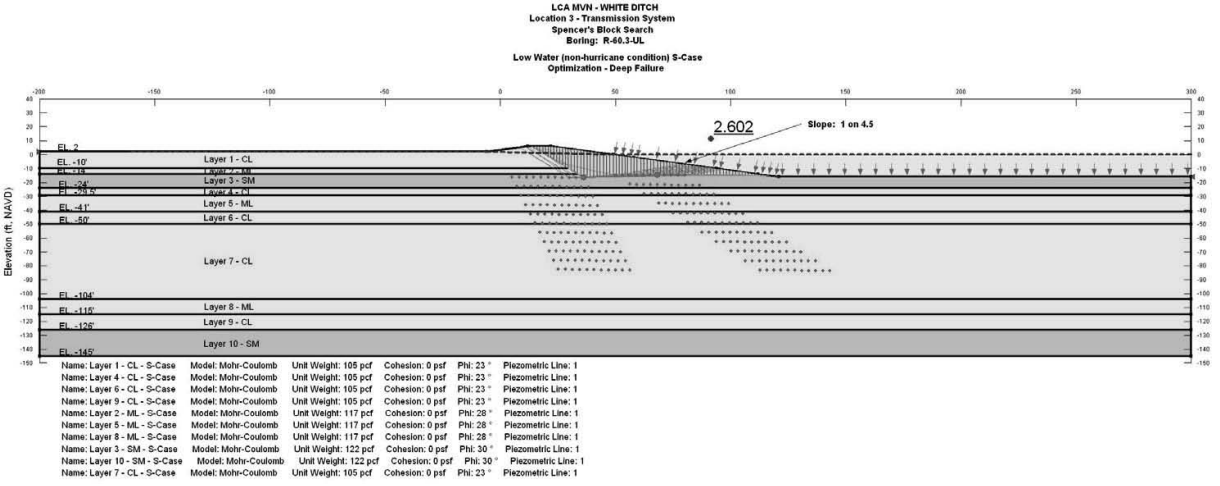
10	16117	28.15447	-0.32591587	67.637396	395.13139	139.01295	0
11	16117	28.904365	-1.075808	112.72899	447.72882	142.19899	0
12	16117	29.654255	-1.8257	157.82059	500.33569	145.38903	0
13	16117	30.404145	-2.5755925	202.91219	552.93312	148.57507	0
14	16117	31.154035	-3.325485	248.00379	605.53056	151.76111	0
15	16117	31.90393	-4.075377	293.09538	658.12799	154.94715	0
16	16117	32.653825	-4.825269	338.18698	710.72543	158.13319	0
17	16117	33.403715	-5.5751615	383.27858	763.32286	161.31923	0
18	16117	34.153605	-6.325054	428.37018	815.92029	164.50526	0
19	16117	34.90938	-6.7	450.05935	1052.7862	255.84238	0
20	16117	35.671035	-6.7	448.32628	1034.4446	248.79246	0
21	16117	36.43269	-6.7	446.59322	1016.103	241.74254	0
22	16117	37.194345	-6.7	444.87328	997.77445	234.69262	0
23	16117	37.956	-6.7	443.14021	979.43282	227.64271	0
24	16117	38.717655	-6.7	441.40714	961.10431	220.59836	0
25	16117	39.47931	-6.7	439.6872	942.76268	213.54287	0
26	16117	40.240965	-6.7	437.95413	924.42104	206.49295	0
27	16117	41.00262	-6.7	436.22107	906.09253	199.44861	0
28	16117	41.764275	-6.7	434.50113	887.7509	192.39311	0
29	16117	42.52593	-6.7	432.76806	869.40926	185.34319	0
30	16117	43.287585	-6.7	431.04812	851.08076	178.29328	0
31	16117	44.04924	-6.7	429.31505	832.73912	171.24336	0
32	16117	44.810895	-6.7	427.58199	814.39749	164.19344	0
33	16117	45.57255	-6.7	425.86205	796.06898	157.14352	0

34	16117	46.334205	-6.7	424.12898	777.72735	150.0936	0
35	16117	47.09586	-6.7	422.39591	759.39884	143.04926	0
36	16117	47.857515	-6.7	420.67597	741.05721	135.99376	0
37	16117	48.61917	-6.7	418.9429	722.71557	128.94385	0
38	16117	49.392705	-6.7	418.07394	709.8701	123.86012	0
39	16117	50.178115	-6.7	418.07394	702.49817	120.73092	0
40	16117	50.963525	-6.7	418.07394	695.13897	117.60712	0
41	16117	51.74894	-6.7	418.07394	687.76703	114.47792	0
42	16117	52.534355	-6.7	418.07394	680.40783	111.35413	0
43	16117	53.319765	-6.7	418.07394	673.0359	108.22493	0
44	16117	54.105175	-6.7	418.07394	665.6767	105.10113	0
45	16117	54.890585	-6.7	418.07394	658.3175	101.97734	0
46	16117	55.675995	-6.7	418.07394	650.94556	98.848137	0
47	16117	56.461405	-6.7	418.07394	643.58636	95.724341	0
48	16117	57.427055	-6.7	418.07787	634.52155	91.874892	0
49	16117	58.37768	-6.7	418.0804	625.61138	88.091675	0
50	16117	59.133035	-6.7	418.0804	618.52864	85.085229	0
51	16117	59.88839	-6.7	418.0804	611.4459	82.078783	0
52	16117	60.64375	-6.7	418.0804	604.36315	79.072337	0
53	16117	61.39911	-6.7	418.0804	597.28041	76.065891	0
54	16117	62.154465	-6.7	418.0804	590.19767	73.059445	0
55	16117	62.90982	-6.7	418.0804	583.11493	70.053	0
56	16117	63.66518	-6.7	418.0804	576.03218	67.046554	0
57	16117	64.420535	-6.7	418.0804	568.94944	64.040108	0
58	16117	65.17589	-6.7	418.0804	561.8667	61.033662	0

59	16117	65.93125	-6.7	418.0804	554.77072	58.021596	0
60	16117	66.68661	-6.7	418.0804	547.68797	55.01515	0
61	16117	67.441965	-6.7	418.0804	540.60523	52.008705	0
62	16117	68.19732	-6.7	418.0804	533.52249	49.002259	0
63	16117	68.95268	-6.7	418.0804	526.43975	45.995813	0
64	16117	69.708035	-6.7	418.0804	519.357	42.989367	0
65	16117	70.46339	-6.7	418.0804	512.27426	39.982921	0
66	16117	71.21875	-6.7	418.0804	505.19152	36.976475	0
67	16117	71.97411	-6.7	418.0804	498.10878	33.970029	0
68	16117	72.729465	-6.7	418.0804	491.02603	30.963583	0
69	16117	73.48482	-6.7	418.0804	483.94329	27.957137	0
70	16117	74.24018	-6.7	418.0804	476.86055	24.950691	0
71	16117	74.995535	-6.7	418.0804	469.7778	21.944245	0
72	16117	75.75089	-6.7	418.0804	462.69506	18.937799	0
73	16117	76.50625	-6.7	418.0804	455.61232	15.931354	0
74	16117	77.26161	-6.7	418.0804	448.52958	12.924908	0
75	16117	78.016965	-6.7	418.0804	441.44683	9.9184618	0
76	16117	78.77232	-6.7	418.0804	434.36409	6.9120158	0

705

1139



Low Water S-Case - Flood Side

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

91.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 76
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 1:00:10 PM
File Name: Location 3 - 35k cfs - Main Channel_R-60.3-LU_1on4.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 1:01:27 PM

1140

92.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

93.0 ANALYSIS SETTINGS

93.1 Low Water S-Case - Flood Side

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: Yes
    Tension Crack
        Tension Crack Option: (none)
FOS Distribution
    FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
    Number of Slices: 75
    Optimization Tolerance: 0.01
    Minimum Slip Surface Depth: 0.1 ft
    Optimization Maximum Iterations: 5000
    Optimization Convergence Tolerance: 1e-007
    Starting Optimization Points: 8

Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

94.0 MATERIALS

94.1 Layer 1 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.2 Layer 4 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.3 Layer 6 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.4 Layer 9 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °

Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.5 Layer 2 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.6 Layer 5 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.7 Layer 8 - ML - S-Case

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 0 psf
Phi: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.8 Layer 3 - SM - S-Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure

1143

Piezometric Line: 1

94.9 Layer 10 - SM - S-Case

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

94.10 Layer 7 - CL - S-Case

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Cohesion: 0 psf
Phi: 23 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

95.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

96.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (5.2803, -16.2114) ft
Lower Left: (25.2901, -82.6562) ft
Lower Right: (56.3051, -83.1814) ft
X Increments: 10
Y Increments: 10
Starting Angle: 115 °
Ending Angle: 135 °
Angle Increments: 3
Right Grid
Upper Left: (50.0021, -14.6356) ft
Lower Left: (112.8326, -83.1814) ft
Lower Right: (143.1473, -83.5754) ft
X Increments: 10

Y Increments: 10
Starting Angle: 0 °
Ending Angle: 45 °
Angle Increments: 3

97.0 PIEZOMETRIC LINES

97.1 Piezometric Line 1

97.1.1 Coordinates

	X (ft)	Y (ft)
	-160	2
	-6	2
	49	0
	300	0

98.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM - S-Case	20,21,15,11	9500
Region 2	Layer 9 - CL - S-Case	20,10,14,21	5500
Region 3	Layer 8 - ML - S-Case	10,9,13,14	5500
Region 4	Layer 5 - ML - S-Case	18,19,12,23	5750
Region 5	Layer 4 - CL - S-Case	8,18,23,22	2750
Region 6	Layer 1 - CL - S-Case	1,2,3,4,28,7,24,16	3316
Region 7	Layer 2 - ML - S-Case	17,16,24,25	1212
Region 8	Layer 3 - SM - S-Case	17,25,5,6,22,8	4633
Region 9	Layer 6 - CL - S-Case	19,26,27,12	4500
Region 10	Layer 7 - CL - S-Case	26,9,13,27	27000

99.0 POINTS

	X (ft)	Y (ft)

Point 1	-200	2
Point 2	-6	2
Point 3	12	6
Point 4	22	6
Point 5	121	-16
Point 6	300	-16
Point 7	58	-2
Point 8	-200	-24
Point 9	-200	-104
Point 10	-200	-115
Point 11	-200	-145
Point 12	300	-41
Point 13	300	-104
Point 14	300	-115
Point 15	300	-145
Point 16	-200	-10
Point 17	-200	-14
Point 18	-200	-29.5
Point 19	-200	-41
Point 20	-200	-126
Point 21	300	-126
Point 22	300	-24
Point 23	300	-29.5
Point 24	94	-10

Point 25	112	-14
Point 26	-200	-50
Point 27	300	-50
Point 28	49	0

100.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	2.187	(67.933, 11.218)	47.02012	(13.4298, 6)	(120.99, -15.9979)
2	1917	2.602	(67.933, 11.218)	45.214	(13.5587, 6)	(115.924, -14.872)

100.1 Slices of Slip Surface: Optimized

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	14.23555	5.186277	-244.74054	67.100292	28.482384	0
2	Optimized	15.847045	3.558831	-146.8452	201.30088	85.447152	0
3	Optimized	17.458535	1.9313855	-48.949855	335.50146	142.41192	0
4	Optimized	18.5473	0.8318415	17.192643	428.56681	174.61797	0
5	Optimized	19.62274	-0.1226788	74.3154	533.43518	194.88478	0
6	Optimized	21.20758	-1.4600763	154.17154	657.51118	213.655	0
7	Optimized	22.78061	-2.7875095	233.43631	765.80151	225.97562	0
8	Optimized	24.341835	-4.104978	312.10181	858.32036	231.85602	0
9	Optimized	25.90306	-5.422446	390.7673	950.8392	237.73642	0
10	Optimized	27.45553	-6.4077485	448.72873	1090.859	272.56812	0
11	Optimized	28.99925	-7.060885	485.98558	1122.5377	270.20036	0
12	Optimized	30.542965	-7.7140215	523.23646	1154.1568	267.80981	0
13	Optimized	32.08668	-8.3671585	560.48734	1185.8356	265.44459	0
14	Optimized	33.6304	-9.020295	597.72032	1217.4547	263.06164	0

15	Optimized	35.17412	-9.6734315	635.007	1249.0738	260.65589	0
16	Optimized	36.543555	-10.25283	668.04446	1271.1446	320.67406	0
17	Optimized	37.73871	-10.758495	696.87947	1301.1201	321.28045	0
18	Optimized	38.93387	-11.26416	725.72219	1331.0956	321.88274	0
19	Optimized	40.274185	-11.710655	750.55093	1393.3592	341.7872	0
20	Optimized	41.759655	-12.097985	771.3308	1404.1725	336.48791	0
21	Optimized	43.245125	-12.485315	792.11068	1414.9859	331.18861	0
22	Optimized	44.7306	-12.872645	812.9557	1425.7992	325.85468	0
23	Optimized	46.216075	-13.259975	833.73558	1436.5474	320.52075	0
24	Optimized	47.701545	-13.647305	854.51545	1447.3608	315.22146	0
25	Optimized	48.72214	-13.871935	866.24487	1491.2353	332.31328	0
26	Optimized	49.43561	-13.95145	870.57374	1490.0459	329.37918	0
27	Optimized	50.70291	-14.09269	879.3822	1495.2126	355.54987	0
28	Optimized	52.154375	-14.19252	885.5854	1524.9687	369.14812	0
29	Optimized	53.393925	-14.2068	886.47276	1515.1271	362.95374	0
30	Optimized	54.678085	-14.22952	887.94792	1502.1834	354.62901	0
31	Optimized	56.00685	-14.260685	889.90409	1493.6064	348.54767	0
32	Optimized	57.335615	-14.29185	891.78501	1485.0293	342.50976	0
33	Optimized	58.388745	-14.31655	893.34783	1478.1977	337.66325	0
34	Optimized	59.453825	-14.350665	895.4699	1468.4643	330.81844	0
35	Optimized	60.80649	-14.400655	898.57276	1462.0369	325.31618	0
36	Optimized	62.159155	-14.45065	901.74949	1455.6096	319.77126	0
37	Optimized	63.511825	-14.500645	904.85235	1449.1822	314.26899	0
38	Optimized	65.121885	-14.529585	906.62914	1447.0403	312.00653	0

39	Optimized	66.74872	-14.5343	906.92348	1433.245	303.87185	0
40	Optimized	68.134945	-14.53584	907.06776	1420.4043	296.37501	0
41	Optimized	69.52117	-14.537385	907.13989	1407.4916	288.87817	0
42	Optimized	70.907395	-14.53893	907.21203	1394.6509	281.42298	0
43	Optimized	72.29362	-14.54047	907.35631	1381.8103	273.92615	0
44	Optimized	73.68717	-14.543025	907.49517	1368.6309	266.23685	0
45	Optimized	75.088055	-14.546595	907.70932	1355.9247	258.77727	0
46	Optimized	76.48894	-14.550165	907.92347	1343.2185	251.31769	0
47	Optimized	77.889825	-14.55374	908.13762	1330.4409	243.8169	0
48	Optimized	79.29071	-14.557315	908.35177	1317.7347	236.35733	0
49	Optimized	80.691595	-14.560885	908.56592	1305.0284	228.89775	0
50	Optimized	82.09248	-14.564455	908.85145	1292.2508	221.35575	0
51	Optimized	83.493365	-14.568025	909.0656	1279.5446	213.89617	0
52	Optimized	84.89425	-14.571595	909.27975	1266.8384	206.43659	0
53	Optimized	86.295135	-14.57517	909.4939	1254.1322	198.97701	0
54	Optimized	87.69602	-14.578745	909.70805	1241.3546	191.47622	0
55	Optimized	89.096905	-14.582315	909.9222	1228.6484	184.01665	0
56	Optimized	90.49779	-14.585885	910.13635	1215.9422	176.55707	0
57	Optimized	91.898675	-14.589455	910.3505	1203.1646	169.05628	0
58	Optimized	93.29956	-14.593025	910.63603	1190.4583	161.55549	0
59	Optimized	94.75608	-14.59674	910.8133	1175.1363	152.60696	0
60	Optimized	96.26824	-14.600595	911.07783	1157.2811	142.14554	0
61	Optimized	97.7804	-14.60445	911.34235	1139.4259	131.68411	0
62	Optimized	99.29254	-14.608305	911.54074	1121.5046	121.22269	0

1149

63	Optimized	100.8047	-14.61216	911.80526	1103.6494	110.76127	0
64	Optimized	102.3169	-14.616015	912.06978	1085.7942	100.29985	0
65	Optimized	103.82905	-14.61987	912.26817	1067.939	89.876603	0
66	Optimized	105.2684	-14.653655	914.38855	1048.5242	77.443261	0
67	Optimized	106.63495	-14.717365	918.33587	1039.9717	70.226477	0
68	Optimized	108.00145	-14.781075	922.35628	1031.4923	63.009694	0
69	Optimized	109.20845	-14.840075	926.02267	1023.6282	56.352578	0
70	Optimized	110.29915	-14.910655	930.43665	1016.2609	49.550642	0
71	Optimized	111.43305	-14.997525	935.8886	1013.447	44.778346	0
72	Optimized	112.67175	-15.09242	941.73475	1009.5687	39.163975	0
73	Optimized	114.0152	-15.195345	948.1916	1004.6705	32.60808	0
74	Optimized	115.47485	-15.34069	957.2809	998.99496	24.083622	0
75	Optimized	117.0507	-15.52845	969.00116	1001.5154	18.772128	0
76	Optimized	118.62655	-15.71621	980.72143	1004.0359	13.460635	0
77	Optimized	120.2024	-15.90397	992.37868	1006.5564	8.1855211	0

100.2 Slices of Slip Surface: 1917

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1917	14.169825	5.388874	-257.23088	51.316585	21.782598	0
2	1917	15.392075	4.166622	-183.74047	153.95207	65.348776	0
3	1917	16.61433	2.94437	-110.24428	256.58292	108.91299	0
4	1917	17.836585	1.722118	-36.747516	359.21957	152.47966	0
5	1917	19.03976	0.51894348	35.600248	464.41856	182.02258	0
6	1917	20.223855	-0.66515402	106.80373	572.17776	197.53956	0
7	1917	21.40795	-1.8492515	178.00422	679.93696	213.05781	0

1150

8	1917	22.62989	-3.0711915	251.47578	779.41045	224.09497	0
9	1917	23.889675	-4.330975	327.22778	870.56432	230.63268	0
10	1917	25.14946	-5.5907585	402.97979	961.66205	237.14655	0
11	1917	26.40924	-6.8505415	478.73179	1052.8159	243.68425	0
12	1917	27.669025	-8.110325	554.4838	1143.9698	250.22196	0
13	1917	28.92881	-9.3701085	630.21897	1235.1236	256.7668	0
14	1917	30.225365	-10.666665	708.20283	1317.287	323.85578	0
15	1917	31.5587	-12	788.38874	1425.7395	338.88539	0
16	1917	32.892035	-13.333335	868.57465	1534.1389	353.88681	0
17	1917	34.24285	-14.68415	949.78574	1638.237	397.47752	0
18	1917	35.61115	-16.05245	1032.0568	1754.4086	417.05005	0
19	1917	37.001115	-16.69534	1068.9915	2179.9903	641.43543	0
20	1917	38.41275	-16.612815	1060.6467	2135.4372	620.53059	0
21	1917	39.824385	-16.53029	1052.3018	2090.8841	599.62576	0
22	1917	41.236015	-16.44777	1043.9569	2046.2603	578.68009	0
23	1917	42.64765	-16.365245	1035.6121	2001.7072	557.77526	0
24	1917	44.059285	-16.28272	1027.2672	1957.1541	536.87043	0
25	1917	45.470915	-16.2002	1018.9223	1912.5302	515.92476	0
26	1917	46.88255	-16.117675	1010.5775	1867.9771	495.01993	0
27	1917	48.294185	-16.03515	1002.1619	1823.3533	474.1151	0
28	1917	49.642855	-15.95631	995.64488	1790.2662	458.77486	0
29	1917	50.92857	-15.88115	990.98616	1768.6032	448.95741	0
30	1917	52.214285	-15.805985	986.32745	1746.9402	439.13997	0
31	1917	53.5	-15.73082	981.59109	1725.2772	429.36736	0
32	1917	54.785715	-15.65566	976.93238	1703.5365	419.50509	0

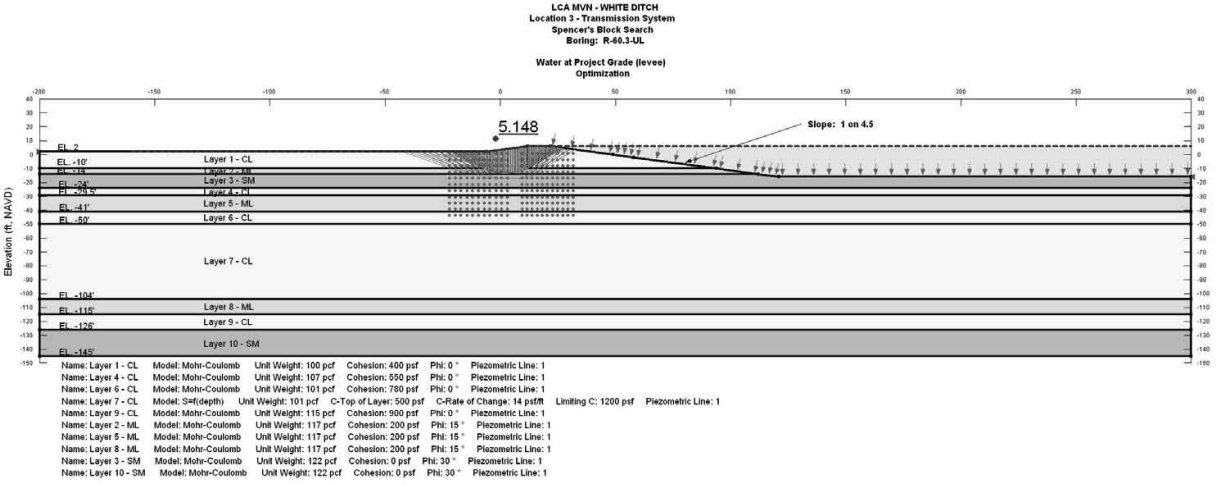
1151

33	1917	56.07143	-15.5805	972.19602	1681.8735	409.73248	0
34	1917	57.357145	-15.50534	967.5373	1660.2105	399.91504	0
35	1917	58.727925	-15.425205	962.53868	1637.1455	389.48441	0
36	1917	60.18377	-15.340095	957.1901	1612.5969	378.39927	0
37	1917	61.639615	-15.254985	951.91009	1588.0483	367.27454	0
38	1917	63.09546	-15.169875	946.63009	1563.4996	356.14981	0
39	1917	64.551305	-15.08477	941.28151	1538.951	345.06466	0
40	1917	66.00715	-14.999665	936.0015	1514.4024	333.93993	0
41	1917	67.462995	-14.914555	930.65292	1489.9224	322.89438	0
42	1917	68.870105	-14.872	928.02198	1454.7551	304.10949	0
43	1917	70.22848	-14.872	928.02198	1442.0192	296.75646	0
44	1917	71.586855	-14.872	928.02198	1429.357	289.44593	0
45	1917	72.945225	-14.872	928.02198	1416.6212	282.0929	0
46	1917	74.303595	-14.872	928.02198	1403.8854	274.73986	0
47	1917	75.66197	-14.872	928.02198	1391.1496	267.38683	0
48	1917	77.020345	-14.872	928.02198	1378.4874	260.0763	0
49	1917	78.378715	-14.872	928.02198	1365.7515	252.72327	0
50	1917	79.737085	-14.872	928.02198	1353.0157	245.37024	0
51	1917	81.09546	-14.872	928.02198	1340.2799	238.01721	0
52	1917	82.453835	-14.872	928.02198	1327.6177	230.70668	0
53	1917	83.812205	-14.872	928.02198	1314.8818	223.35365	0
54	1917	85.170575	-14.872	928.02198	1302.146	216.00062	0
55	1917	86.52895	-14.872	928.02198	1289.4838	208.69009	0
56	1917	87.887325	-14.872	928.02198	1276.748	201.33706	0
57	1917	89.245695	-14.872	928.02198	1264.0122	193.98403	0
58	1917	90.604065	-14.872	928.02198	1251.2763	186.63099	0

59	1917	91.96244	-14.872	928.02198	1238.6141	179.32047	0
60	1917	93.320815	-14.872	928.02198	1225.8783	171.96743	0
61	1917	94.69231	-14.872	927.98359	1211.167	163.49602	0
62	1917	96.076925	-14.872	927.98359	1194.4114	153.82219	0
63	1917	97.46154	-14.872	927.98359	1177.6559	144.14836	0
64	1917	98.846155	-14.872	927.98359	1160.9003	134.47454	0
65	1917	100.23078	-14.872	927.98359	1144.217	124.84241	0
66	1917	101.6154	-14.872	927.98359	1127.4614	115.16858	0
67	1917	103	-14.872	927.98359	1110.7059	105.49475	0
68	1917	104.3846	-14.872	927.98359	1093.9503	95.820926	0
69	1917	105.7692	-14.872	927.98359	1077.1947	86.147099	0
70	1917	107.15385	-14.872	927.98359	1060.5114	76.514969	0
71	1917	108.5385	-14.872	927.98359	1043.7558	66.841142	0
72	1917	109.9231	-14.872	927.98359	1027.0003	57.167315	0
73	1917	111.3077	-14.872	927.98359	1010.2447	47.493488	0
74	1917	112.654	-14.872	927.98165	993.27217	37.695499	0
75	1917	113.962	-14.872	927.98165	975.91743	27.675735	0
76	1917	115.27	-14.872	927.98165	958.63914	17.700111	0

870

1153



Water at Project Grade (levees)

Report generated using GeoStudio 2007, version 7.15. Copyright © 1991-2009 GEO-SLOPE International Ltd.

101.0 FILE INFORMATION

Created By: Goetz, Ryan MVS
Revision Number: 74
Last Edited By: Goetz, Ryan MVS
Date: 3/5/2010
Time: 10:57:29 AM
File Name: Location 3 - 35k cfs - Main Channel_R-60.3-LU_1on4.5 Slope.gsz
Directory: C:\Documents and Settings\B3ECGRPG\My Documents\White Ditch\
Last Solved Date: 3/5/2010
Last Solved Time: 11:07:39 AM

1154

102.0 PROJECT SETTINGS

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

103.0 ANALYSIS SETTINGS

103.1 Water at Project Grade (levees)

Description: Active and Passive Wedge Method
Kind: SLOPE/W
Method: Spencer
Settings
    Apply Phreatic Correction: No
    PWP Conditions Source: Piezometric Line
    Use Staged Rapid Drawdown: No
SlipSurface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Block
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: Yes
    Tension Crack
        Tension Crack Option: (none)
FOS Distribution
    FOS Calculation Option: Constant
Restrict Block Crossing: Yes
Advanced
    Number of Slices: 75
    Optimization Tolerance: 0.01
    Minimum Slip Surface Depth: 0.1 ft
    Optimization Maximum Iterations: 5000
    Optimization Convergence Tolerance: 1e-007
    Starting Optimization Points: 8

Ending Optimization Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °

104.0 MATERIALS

104.1 Layer 1 - CL

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion: 400 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.2 Layer 4 - CL

Model: Mohr-Coulomb
Unit Weight: 107 pcf
Cohesion: 550 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.3 Layer 6 - CL

Model: Mohr-Coulomb
Unit Weight: 101 pcf
Cohesion: 780 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.4 Layer 7 - CL

Model: S=f(depth)
Unit Weight: 101 pcf
C-Top of Layer: 500 psf
C-Rate of Change: 14 psf/ft

Limiting C: 1200 psf
Pore Water Pressure
Piezometric Line: 1

104.5 Layer 9 - CL

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion: 900 psf
Phi: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.6 Layer 2 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.7 Layer 5 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.8 Layer 8 - ML

Model: Mohr-Coulomb
Unit Weight: 117 pcf
Cohesion: 200 psf
Phi: 15 °
Phi-B: 0 °
Pore Water Pressure

1157

Piezometric Line: 1

104.9 Layer 3 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

104.10 Layer 10 - SM

Model: Mohr-Coulomb
Unit Weight: 122 pcf
Cohesion: 0 psf
Phi: 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

105.0 SLIP SURFACE LIMITS

Left Coordinate: (-200, 2) ft
Right Coordinate: (300, -16) ft

106.0 SLIP SURFACE BLOCK

Left Grid
Upper Left: (-22, 0.75) ft
Lower Left: (-22, -44) ft
Lower Right: (3.25, -44) ft
X Increments: 10
Y Increments: 10
Starting Angle: 135 °
Ending Angle: 180 °
Angle Increments: 3
Right Grid
Upper Left: (9.5, 0.75) ft
Lower Left: (9.5, -44) ft
Lower Right: (31.7145, -44) ft
X Increments: 10

Y Increments: 10
Starting Angle: 45 °
Ending Angle: 65 °
Angle Increments: 3

107.0 PIEZOMETRIC LINES

107.1 Piezometric Line 1

107.1.1Coordinates

	X (ft)	Y (ft)
	-160	2
	-6	2
	12	6
	22	6
	300	6

108.0 REGIONS

	Material	Points	Area (ft²)
Region 1	Layer 10 - SM	20,21,15,11	9500
Region 2	Layer 9 - CL	20,10,14,21	5500
Region 3	Layer 8 - ML	10,9,13,14	5500
Region 4	Layer 5 - ML	18,19,12,23	5750
Region 5	Layer 4 - CL	8,18,23,22	2750
Region 6	Layer 1 - CL	1,2,3,4,28,7,24,16	3316
Region 7	Layer 2 - ML	17,16,24,25	1212
Region 8	Layer 3 - SM	17,25,5,6,22,8	4633
Region 9	Layer 6 - CL	19,26,27,12	4500
Region 10	Layer 7 - CL	26,9,13,27	27000

1159

109.0 POINTS

	X (ft)	Y (ft)
Point 1	-200	2
Point 2	-6	2
Point 3	12	6
Point 4	22	6
Point 5	121	-16
Point 6	300	-16
Point 7	58	-2
Point 8	-200	-24
Point 9	-200	-104
Point 10	-200	-115
Point 11	-200	-145
Point 12	300	-41
Point 13	300	-104
Point 14	300	-115
Point 15	300	-145
Point 16	-200	-10
Point 17	-200	-14
Point 18	-200	-29.5
Point 19	-200	-41
Point 20	-200	-126
Point 21	300	-126
Point 22	300	-24

Point 23	300	-29.5
Point 24	94	-10
Point 25	112	-14
Point 26	-200	-50
Point 27	300	-50
Point 28	49	0

110.0 CRITICAL SLIP SURFACES

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	Optimized	5.148	(-0.197, 5.597)	22.84998	(27.7539, 4.72135)	(-21.8475, 2)
2	7261	5.447	(-0.197, 5.597)	24.266	(27.0523, 4.87727)	(-27.2178, 2)

035 **110.1 Slices of Slip Surface: Optimized**

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	Optimized	-21.49106	1.6675915	20.742061	110.4554	0	400
2	Optimized	-20.778165	1.002774	62.227208	178.61419	0	400
3	Optimized	-20.06527	0.33795625	103.71543	246.77297	0	400
4	Optimized	-19.352375	-0.32686125	145.19135	314.9215	0	400
5	Optimized	-18.628945	-0.984035	186.20427	378.02018	0	400
6	Optimized	-17.89497	-1.633565	226.73049	444.52317	0	400
7	Optimized	-17.160995	-2.283095	267.2669	511.02615	0	400
8	Optimized	-16.42702	-2.932625	307.79311	577.53934	0	400
9	Optimized	-15.699745	-3.5610085	347.00806	637.79273	0	400
10	Optimized	-14.97918	-4.168245	384.89359	699.89528	0	400
11	Optimized	-14.258615	-4.7754815	422.78972	761.99783	0	400
12	Optimized	-13.53108	-5.371695	459.99868	818.30547	0	400

1161

13	Optimized	-12.796585	-5.956885	496.51192	878.07474	0	400
14	Optimized	-12.062095	-6.542075	533.02516	937.85466	0	400
15	Optimized	-11.3276	-7.127265	569.5384	997.62392	0	400
16	Optimized	-10.622345	-7.675958	603.7853	1049.4703	0	400
17	Optimized	-9.946339	-8.188154	635.73786	1101.7381	0	400
18	Optimized	-9.270335	-8.70035	667.7022	1153.9941	0	400
19	Optimized	-8.594329	-9.212546	699.66654	1206.2972	0	400
20	Optimized	-7.918323	-9.724742	731.61909	1258.5296	0	400
21	Optimized	-7.177338	-10.22512	762.84827	1289.0446	140.99387	200
22	Optimized	-6.387178	-10.7041	792.73822	1346.7406	148.44449	200
23	Optimized	-5.6616215	-11.14392	824.86688	1407.6529	156.15703	200
24	Optimized	-4.984865	-11.55416	859.85603	1472.7284	164.21865	200
25	Optimized	-4.3081085	-11.9644	894.84517	1537.8039	172.28027	200
26	Optimized	-3.633315	-12.28104	923.95438	1558.7577	170.09504	200
27	Optimized	-2.960485	-12.504075	947.20384	1600.5165	175.05459	200
28	Optimized	-2.287655	-12.72711	970.4533	1642.2752	180.01413	200
29	Optimized	-1.614825	-12.950145	993.70275	1684.0339	184.97368	200
30	Optimized	-0.941995	-13.17318	1016.9381	1725.7927	189.93701	200
31	Optimized	-0.24735	-13.31199	1035.2437	1726.4268	185.20195	200
32	Optimized	0.46911	-13.36657	1048.5764	1748.8335	187.63332	200
33	Optimized	1.18557	-13.421155	1061.923	1771.2402	190.06097	200
34	Optimized	1.90203	-13.47574	1075.2556	1793.6468	192.49234	200
35	Optimized	2.61849	-13.53032	1088.6022	1816.0535	194.91998	200
36	Optimized	3.333657	-13.492205	1096.1466	1795.4956	187.39002	200

37	Optimized	4.047531	-13.36139	1097.8827	1796.0468	187.07251	200
38	Optimized	4.761405	-13.230575	1099.6188	1796.5979	186.755	200
39	Optimized	5.475279	-13.09976	1101.3549	1797.2869	186.47441	200
40	Optimized	6.189153	-12.968945	1103.091	1797.838	186.1569	200
41	Optimized	6.883003	-12.749075	1098.9832	1755.238	175.84293	200
42	Optimized	7.556829	-12.44015	1089.0543	1734.4628	172.93668	200
43	Optimized	8.230655	-12.131225	1079.1253	1713.8224	170.06657	200
44	Optimized	8.904481	-11.8223	1069.1829	1693.1821	167.20008	200
45	Optimized	9.578307	-11.513375	1059.254	1672.4068	164.29382	200
46	Optimized	10.213105	-11.132425	1044.279	1610.3449	151.6769	200
47	Optimized	10.80887	-10.679455	1024.2766	1572.1306	146.79703	200
48	Optimized	11.404635	-10.226485	1004.2743	1533.7827	141.88136	200
49	Optimized	11.85126	-9.88691	989.29305	1498.3361	0	400
50	Optimized	12.29563	-9.54905	970.26688	1468.4735	0	400
51	Optimized	12.886885	-9.09951	942.20876	1424.3129	0	400
52	Optimized	13.528845	-8.575649	909.52568	1361.5405	0	400
53	Optimized	14.221515	-7.9774675	872.19012	1303.0842	0	400
54	Optimized	14.914185	-7.379286	834.86549	1244.5186	0	400
55	Optimized	15.60686	-6.781104	797.54086	1186.0623	0	400
56	Optimized	16.299535	-6.1829225	760.21623	1127.606	0	400
57	Optimized	16.992205	-5.584741	722.89159	1069.0841	0	400
58	Optimized	17.636515	-5.004634	686.6832	1004.2731	0	400
59	Optimized	18.232465	-4.442602	651.6233	949.42488	0	400
60	Optimized	18.82842	-3.88057	616.5512	894.58886	0	400

61	Optimized	19.424375	-3.318538	581.4791	839.75284	0	400
62	Optimized	20.020325	-2.756506	546.407	784.90462	0	400
63	Optimized	20.598585	-2.193963	511.3012	724.2217	0	400
64	Optimized	21.15915	-1.6309085	476.17316	669.3711	0	400
65	Optimized	21.719715	-1.0678541	441.03253	614.52051	0	400
66	Optimized	22.32385	-0.4610388	403.17016	552.74136	0	400
67	Optimized	22.971555	0.189538	362.5721	484.03947	0	400
68	Optimized	23.61926	0.8401147	321.97405	415.33759	0	400
69	Optimized	24.26696	1.4906915	281.37599	346.6357	0	400
70	Optimized	24.90712	2.1065175	242.94941	288.5148	0	400
71	Optimized	25.53974	2.687592	206.69734	226.56963	0	400
72	Optimized	26.17236	3.2686665	170.43363	164.62445	0	400
73	Optimized	26.80498	3.8497415	134.18156	102.6851	0	400
74	Optimized	27.4376	4.430816	97.916682	40.739924	0	400

110.2 Slices of Slip Surface: 7261

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	7261	-26.85949	1.7931035	12.909833	66.031792	0	400
2	7261	-26.142775	1.3793105	38.730709	108.05158	0	400
3	7261	-25.426065	0.96551735	64.551584	150.075	0	400
4	7261	-24.709355	0.55172415	90.372459	192.08875	0	400
5	7261	-23.992645	0.13793104	116.19333	234.1025	0	400
6	7261	-23.275935	-0.27586206	142.01542	276.12834	0	400
7	7261	-22.559225	-0.68965515	167.8375	318.14209	0	400
8	7261	-21.842515	-1.1034484	193.65958	360.16792	0	400

1164

9	7261	-21.125805	-1.5172415	219.48167	402.18167	0	400
10	7261	-20.409095	-1.9310345	245.29167	444.2075	0	400
11	7261	-19.692385	-2.3448275	271.11375	486.22125	0	400
12	7261	-18.975675	-2.7586205	296.93584	528.24709	0	400
13	7261	-18.258965	-3.1724135	322.75792	570.26084	0	400
14	7261	-17.542255	-3.5862065	348.58	612.27459	0	400
15	7261	-16.825545	-4	374.40209	654.30042	0	400
16	7261	-16.10883	-4.4137935	400.22417	696.31417	0	400
17	7261	-15.392115	-4.8275865	426.04625	738.34001	0	400
18	7261	-14.675405	-5.2413795	451.85625	780.35376	0	400
19	7261	-13.958695	-5.6551725	477.67834	822.37959	0	400
20	7261	-13.241985	-6.0689655	503.50042	864.39334	0	400
21	7261	-12.525275	-6.4827585	529.3225	906.40709	0	400
22	7261	-11.808565	-6.8965515	555.14459	948.43292	0	400
23	7261	-11.091855	-7.3103445	580.96667	990.44667	0	400
24	7261	-10.375145	-7.7241375	606.78876	1032.4725	0	400
25	7261	-9.6584345	-8.137931	632.61084	1074.4863	0	400
26	7261	-8.9417235	-8.5517245	658.43292	1116.5121	0	400
27	7261	-8.2250125	-8.9655175	684.24292	1158.5258	0	400
28	7261	-7.508302	-9.3793105	710.06501	1200.5396	0	400
29	7261	-6.7915915	-9.7931035	735.88709	1242.5292	0	400
30	7261	-6.216618	-10.125065	756.61004	1271.4447	137.94953	200
31	7261	-5.65	-10.4522	781.87246	1318.8329	143.87813	200
32	7261	-4.95	-10.856345	816.79802	1383.5374	151.85736	200

33	7261	-4.25	-11.26049	851.72359	1448.2419	159.83659	200
34	7261	-3.55	-11.664635	886.64915	1513.0701	167.84897	200
35	7261	-2.85	-12.06878	921.57472	1577.7745	175.82821	200
36	7261	-2.15	-12.472925	956.50029	1642.479	183.80744	200
37	7261	-1.446875	-12.675	978.86018	1616	170.7211	200
38	7261	-0.740625	-12.675	988.64425	1631.7168	172.31077	200
39	7261	-0.034375	-12.675	998.44248	1647.292	173.85871	200
40	7261	0.671875	-12.675	1008.2407	1663.0088	175.44459	200
41	7261	1.378125	-12.675	1018.0248	1678.7257	177.03427	200
42	7261	2.084375	-12.675	1027.823	1694.4425	178.62015	200
43	7261	2.790625	-12.675	1037.6212	1710.1593	180.20603	200
44	7261	3.496875	-12.675	1047.4053	1725.8761	181.7957	200
45	7261	4.203125	-12.675	1057.2035	1741.5929	183.38158	200
46	7261	4.909375	-12.675	1067.0018	1757.3097	184.96746	200
47	7261	5.615625	-12.675	1076.7858	1773.0265	186.55714	200
48	7261	6.321875	-12.675	1086.5841	1788.7434	188.14302	200
49	7261	7.028125	-12.675	1096.3823	1804.3186	189.69096	200
50	7261	7.734375	-12.675	1106.1664	1820.0354	191.28063	200
51	7261	8.440625	-12.675	1115.9646	1835.7522	192.86651	200
52	7261	9.146875	-12.675	1125.7628	1851.469	194.45239	200
53	7261	9.916665	-12.258335	1110.4691	1708.5118	160.24508	200
54	7261	10.75	-11.425	1069.9943	1633.1625	150.90048	200
55	7261	11.583335	-10.591665	1029.5195	1557.8132	141.55588	200
56	7261	12.0875	-10.0875	1003.8491	1510.3799	135.72453	200
57	7261	12.525895	-9.649107	976.50832	1455.0494	0	400

1166

58	7261	13.22768	-8.9473215	932.70873	1386.6346	0	400
59	7261	13.929465	-8.245536	888.91921	1318.3205	0	400
60	7261	14.63125	-7.54375	845.12969	1249.9057	0	400
61	7261	15.333035	-6.841964	801.34016	1181.5916	0	400
62	7261	16.03482	-6.1401785	757.55064	1113.1768	0	400
63	7261	16.736605	-5.438393	713.75105	1044.7619	0	400
64	7261	17.438395	-4.736607	669.96153	976.41764	0	400
65	7261	18.14018	-4.0348215	626.17201	908.04312	0	400
66	7261	18.841965	-3.333036	582.38249	839.65851	0	400
67	7261	19.54375	-2.63125	538.59297	771.28399	0	400
68	7261	20.245535	-1.929464	494.80345	702.90946	0	400
69	7261	20.94732	-1.2276783	451.00385	634.53494	0	400
70	7261	21.649105	-0.52589285	407.21433	566.16041	0	400
71	7261	22.360875	0.1858766	362.80522	493.85087	0	400
72	7261	23.08263	0.9076296	317.76807	417.59045	0	400
73	7261	23.804385	1.629383	272.73092	341.33983	0	400
74	7261	24.526135	2.3511365	227.69378	265.07941	0	400
75	7261	25.24789	3.0728895	182.64684	188.82879	0	400
76	7261	25.969645	3.7946425	137.60969	112.57817	0	400
77	7261	26.691395	4.516396	92.576464	36.322649	0	400

L6. Environmental Engineering

The proposed project will make beneficial use of dredge spoil produced. Dredged material from the proposed channel enhancement features, in addition to any other spoil available, will allow new areas of marsh to be created.

Regenerative planting, with native species, will be done to stabilize the placed dredge spoil and prevent return of the material to the waterway. The use of native species plantings to quickly establish targeted vegetative communities will assist in reducing the risk of invasive species impacts. Native vegetation will trap sediment following into the marsh from the proposed project, accreting additional marsh area over time.

L7. Civil Design Criteria

L7.1 Site Recommendations

Multiple features were considered to reintroduce and distribute Mississippi River water into the marsh. An inlet and outfall channel, working in conjunction with a structure, would feed distributary channels containing strategically positioned culverts or openings that allow sediment and freshwater to flow into the marsh. Notched dikes to constrict flow, but still allow boat traffic through, would be placed in key locations to prevent the loss of the valuable sediments and nutrients from the freshwater diversion. Areas of new marsh would be created from dredged material out of the proposed channel enhancement features as well as any other beneficial spoil that is available.

Four alternatives, utilizing box culverts described in section C8, were considered at Location 2, White Ditch, LA. Six alternatives, utilizing box culverts and siphons, also described in section C8, were considered at Location 3, Phoenix, LA.

Modeling was done with Bentley InRoads XM Edition v08. Data used for the modeling included a topographic survey of the marsh area performed by FTN Associates, LTD (July 2009) and LIDAR flown within approximately 250 feet of the levee corridor. The topographic survey contained points, but the cross-sectional data was spread out over a large area, with cross-sections ranging from 915 feet apart to 3850 feet apart. Quantities were prepared by analyzing the proposed channel areas and using the closes cross-sectional data along the channel until the proposed channel changed.

The following assumptions were made concerning Marsh Creation:

- Berm: 6’ tall (feasibility quantities only – during construction contractor shall maintain a berm height of 5’), 10’ crown, 1 on 6 side slopes.
- This material will be pushed up from the interior of the footprint of the marsh creation area.
- Excavation will be in the wet, material will settle under its own weight.
- 1 unit of material pushed up with no compaction will result in 0.75 units in the containment dike.

- In marsh areas with no compaction, 1 unit dredged from the channel will result in 1 unit in the marsh creation area.
- All material for marsh creation will be all excess material dredged from the channel not used for the side berms on the channel.
- Marsh areas are calculated to be 4' thick

L7.2 Civil Site Design for Diversion Facility

L7.2.1 General

Ten alternatives were studied for this proposed diversion project. Each alternative consists of, at a minimum, an inlet channel, structure, outfall structure with a concrete apron, outfall channel, system of distributary channels in the marsh with culverts or cutoffs to smaller channels and plugs at Oak River. Following is a description of the features that will hold constant for each alternative, although quantities will change according to design template:

- Inlet: entire length will be reinforced with rock, on both side slopes and 15 feet past the top of the new bank. Top of rock should be the same elevation as the top of natural ground. Layers will match 400lb rip protection.
- Outlet: at the end of the concrete apron for 100 feet there will be 1000 lb rip protection. At 100 feet, transitions to 400lb rip rap protection.
- At culverts and cutoffs to smaller channels, anywhere there is a velocity change there will be 400lb rip rap for a minimum of 100 feet each side of cutoff.
- Rock protection, 400lb rip rap, will be placed adjacent to the box culvert and as protection for the proposed road perpendicular to the structure.
  - 400lb protection:
    Geotextile
    12" bedding material
    Geogrid
    12" bedding material
    30" 400lb rip rap
  - 1000lb protection:
    Geotextile
    12" bedding material
    Geogrid
    12" bedding material
    42" 1000lb rip rap

L7.2.2 Alternatives Array

Below are the alternatives for the proposed diversion project:

Alternative	Location	Outfall Capacity	Structure
2B	2	5,000 cfs	3-box culvert
2D	2	10,000 cfs	3-box culvert
2E	2	15,000 cfs	10-box culvert
2F	2	35,000 cfs	10-box culvert
3A	3	5,000 cfs	30-pipe siphon
3B	3	5,000 cfs	3-box culvert
3C	3	10,000 cfs	30-pipe siphon
3D	3	10,000 cfs	3-box culvert
3E	3	15,000 cfs	10-box culvert
3F	3	35,000 cfs	10-box culvert

Table 1

L7.2.3 Description of Civil Site Alternatives

Plan views of the alternatives are shown on the following plates:

Alternative	Location	Outfall Capacity	Sheet
2B	2	5,000 cfs	C1
2D	2	10,000 cfs	C2
2E	2	15,000 cfs	C3
2F	2	35,000 cfs	C4
3B	3	5,000 cfs	C5
3D	3	10,000 cfs	C6
3E	3	15,000 cfs	C7
3F	3	35,000 cfs	C8

Table 2

Quantities for the alternatives are shown in the tables below:

Location 2
15’ x 15’ Box Culverts

		3 5,000 cfs	3 10,000 cfs	10 15,000 cfs	10 35,000 cfs
Excavation	CY	1,487,300	2,316,200	4,962,000	6,278,700
Berm Fill	CY	116,600	98,300	99,600	122,900
Marsh Creation	CY	1,371,000	2,218,000	4,863,000	6,156,000
Bedding Material	TN	487,300	528,200	595,200	746,400
400 lb. Riprap	TN	444,200	478,700	545,500	692,000
1000lb. RipRap	TN	12,100	13,500	13,400	19,200
Geotextile	SY	179,900	218,500	290,100	368,100
Geogrid	SY	179,900	218,500	290,100	368,100
36" Culvert Pipe	LF	3,000	3,130	5,220	7,830
36" Flared End Section	EA	104	156	260	390
Striping	AC	75	75	75	75
Clearing & Grubbing	AC	15	15	15	15
Road Removal	SY	270	270	270	270
9" Cement Treated Sand Shell Base	SY	270	270	270	270
3.5" Asphaltic Concrete Binder Course	SY	270	270	270	270
1.5" Asphaltic Concrete Wearing Course	SY	270	270	270	270
Remove & Dispose of Articulated Concrete Mat	SY	950	950	950	950
Install Articulated Concrete Mat	SY	950	950	950	950
Dewatering	LS	1	1	1	1
Real Estate Costs	LS	1	1	1	1

Table 3

Location 2
30 Pipe Siphon

		5,000 cfs	10,000cfs
Excavation	CY	1,506,800	2,237,300
Berm Fill	CY	116,600	98,300
Marsh Creation	CY	1,390,000	2,139,000
Bedding Material	TN	326,500	363,700
400 lb. Riprap	TN	256,400	324,500
1000lb. RipRap	TN	12,100	13,500
Geotextile	SY	123,500	149,300
Geogrid	SY	123,500	149,300
Striping	AC	75	75
Clearing & Grubbing	AC	15	15
36" Culvert Pipe	LF	2,100	3,130
36" Flared End Section	EA	104	156
Road Removal	SY	1,210	1,210
9" Cement Treated Sand Shell Base Sand Shell Base	SY	1,210	1,210
3.5" Asphaltic Concrete Binder Course	SY	1,210	1,210
1.5" Asphaltic Concrete Wearing Course Concrete Wearing Course	SY	1,210	1,210
Remove & Dispose of Articulated Concrete Mat	SY	1,880	1,880
Install Articulated Concrete Mat	SY	1,880	1,880
Dewatering	LS	1	1
Real Estate Costs	LS	1	1

Table 4

Location 3
15’ x 15’ Box Culverts

		3 5,000 cfs	3 10,000 cfs	10 15,000 cfs	10 35,000 cfs
Excavation	CY	2,081,200	2,562,600	3,377,300	5,241,500
Fill	CY	2,080,500	2,561,500	3,370,500	524,500
Berms for Marsh Creation	CY	912,900	1,215,000	2,144,000	3,766,000
Bedding Material	TN	264,300	269,800	271,700	279,200
400 lb. Riprap	TN	268,000	272,700	273,500	284,300
1000lb. RipRap	TN	4,700	6,100	7,700	11,800
Geotextile	SY	197,800	199,700	201,500	202,500
Geogrid	SY	197,800	199,700	201,500	202,500
Striping	AC	35	35	35	35
Clearing & Grubbing	AC	8	10	13	19
Road Removal	SY	725	725	1,130	1,130
9" Cement Treated Sand Shell Base	SY	725	725	1,130	1,130
3.5" Asphaltic Concrete Binder Course	SY	725	725	1,130	1,130
1.5" Asphaltic Concrete Wearing Course	SY	725	725	1,130	1,130
Remove & Dispose of Articulated Concrete Mat	SY	610	610	940	940
Install Articulated Concrete Mat	SY	610	610	940	940
Dewatering	LS	1	1	1	1
Real Estate Costs	LS	1	1	1	1

Table 5

Location 3
30 Pipe Siphon

		5,000 cfs	10,000cfs
Excavation	CY	2,114,300	2,575,800
Fill	CY	2,114,300	2,575,800
Berms for Marsh Creation	CY	912,900	1,215,500
Bedding Material	TN	266,900	268,400
400 lb. Riprap	TN	268,300	269,500
1000lb. RipRap	TN	8,800	9,000
Geotextile	SY	262,300	263,100
Geogrid	SY	262,300	263,100
Striping	AC	35	35
Clearing & Grubbing	AC	8	10
Road Removal	SY	1,370	1,370
9" Cement Treated Sand Shell Base Sand Shell Base	SY	1,370	1,370
3.5" Asphaltic Concrete Binder Course	SY	1,370	1,370
1.5" Asphaltic Concrete Wearing Course Concrete Wearing Course	SY	1,370	1,370
Remove & Dispose of Articulated Concrete Mat	SY	0	0
Install Articulated Concrete Mat	SY	0	0
Dewatering	LS	1	1
Real Estate Costs	LS	1	1

3155 Table 6

FEASIBILITY
PLAN - LOCATION 2 - 5,000cfs
C-01

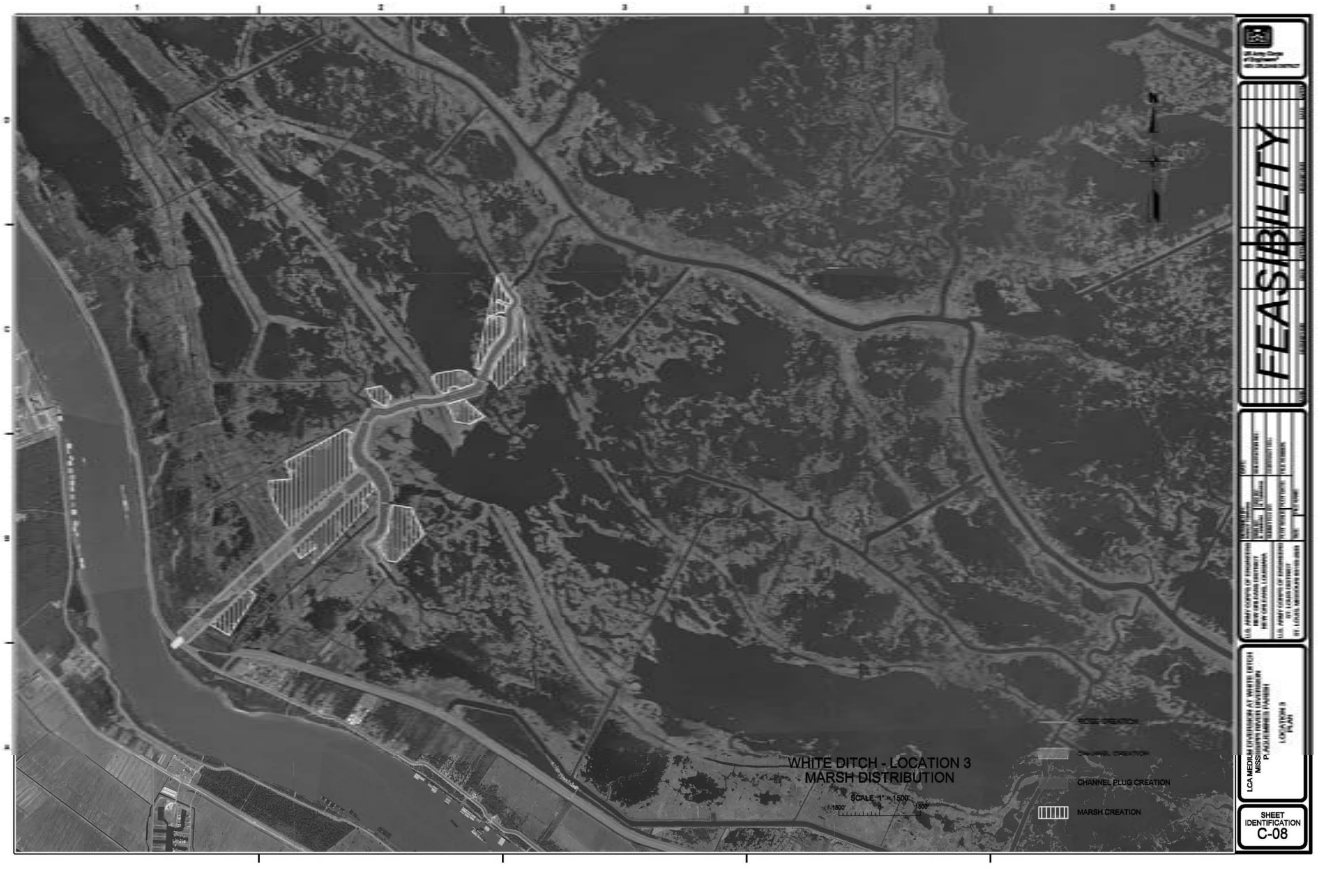
FEASIBILITY
SHEET IDENTIFICATION
C-03
PLAN - LOCATION 2: 15,000cfs

FEASIBILITY
PLAN - LOCATION 2: 35,000cfs
SHEET IDENTIFICATION
C-04

FEASIBILITY
WHITE DITCH - LOCATION 3
MARSH DISTRIBUTION
SCALE: 1" = 1500'
1500' 0 1500' 3000'
BORE SIGHTS
CHANNEL CREATION
CHANNEL PLUG CREATION
MARSH CREATION
LOCATION 3
PLAN
SHEET DESIGNATION
C-05

FEASIBILITY
WHITE DITCH - LOCATION 3
MARSH DISTRIBUTION
CHANNEL PLUG CREATION
MARSH CREATION
SHEET DESIGNATION
C-06

FEASIBILITY
WHITE DITCH - LOCATION 3
MARSH DISTRIBUTION
CHANNEL CREATION
CHANNEL PLUG CREATION
MARSH CREATION
SHEET DESIGNATION
C-07


WHITE DITCH - LOCATION 3
MARSH DISTRIBUTION
SCALE 1" = 1,500'
1,500
0
3,000
MARSH CREATION
CHANNEL PLUG CREATION
CHANNEL CREATION
SHEET IDENTIFICATION
C-08
FEASIBILITY

L8. Structural Design Criteria

L8.1 FOUNDATION RECOMMENDATIONS

L8.1.1 General

Development of this proposed diversion project would require various proposed features to accomplish the intended purpose. Among those would be a variety of structures. A description of the foundations for each structural feature will be shown below. The pile founded structures would incorporate the use of steel H-piles and sheet piles, precast prestressed concrete (PPC) piles, timber piles, and steel pipe piles where indicated on the drawings. Preliminary assumptions of pile sizes, spacing, and pile tip elevations were based on the design of similar structures found in the vicinity. Verification of the pile assumptions, along with any adjustments, was accomplished with the use of pile capacity curves that were developed for similar soils. A more accurate determination of soil properties was not possible due to the absence of reliable borings; therefore pile tip elevations may be adjusted in the next stage of design. All cast-in-place concrete structure monoliths exposed to lateral loadings were analyzed using the COE CASE program "CPGA" (X0080), Pile Group Analysis Program to determine adequacy of pile pattern assumptions. All designs were performed in accordance with applicable COE and technical publications, and industry codes. All structures will be constructed using conventional construction equipment and techniques. The contractor will be required to provide dewatering systems (where necessary) in order to construct foundations in a near dry atmosphere. The contractor will also be required to provide a system of shoring or open excavation to safely facilitate construction procedures.

L8.1.2 Description of Feature Foundations

a. Project Feature 3-15'x15' Gated Box Culverts. – The proposed concrete monolithic structures at this location will be supported on a combination of steel HP14x73 piles, 12"x12" PPC piles, and 14"x14" PPC piles. Location, spacing, and pile tip elevations of the piling is shown on drawings S-102, and S-103. A 4" stabilization slab will be placed between the concrete substructures and the soil foundation to act as a stable working surface during construction. A steel sheet pile seepage cut-off wall will be placed around the perimeter of the concrete substructures. The pile tip elevations of the cut-off walls are shown on drawing S-201.

b. Project Feature 10-15'x15' Gated Box Culverts. – The proposed concrete monolithic structures at this location will be supported on a combination of steel HP14x73 piles, 12"x12" PPC piles, and 14"x14" PPC piles. Location, spacing, and pile tip elevations of the piling is shown on drawings S-111, S-112, and S-113. A 4" stabilization slab will be placed between the concrete substructures and the soil foundation to act as a stable working surface during construction. A steel sheet pile seepage cut-off wall will be placed around the perimeter of the concrete substructures. The pile tip elevations of the cut-off walls are shown on drawing S-210.

c. Project Feature 4,000' Gated Weir. – The proposed concrete monolithic structures at this location will be supported on 18"x18" PPC piles. Location, spacing, and pile tip elevations of the piling is shown on drawing S-220. A 4" stabilization slab will be placed between the concrete substructures and the soil foundation.

d. Project Feature 3,000' Gated Weir. – The proposed concrete monolithic structures at this location will be supported on 18"x18" PPC piles. Location, spacing, and pile tip elevations of the piling is shown on drawing S-230. A 4" stabilization slab will be placed between the concrete substructures and the soil foundation.

e. Project Feature 2,000' Gated Weir. – The proposed concrete monolithic structures at this location will be supported on 18"x18" PPC piles. Location, spacing, and pile tip elevations of the piling is shown on drawing S-240. A 4" stabilization slab will be placed between the concrete substructures and the soil foundation.

f. Project Feature 19-6' Dia. Pipe Siphon. – The substructures for this proposed feature will be 16 inch diameter steel pipe piles located at the intake end of the siphon which will provide a support system for the 6' diameter pipes, and 16 inch dia. steel pipe piles located at the riverward end of the excavated inlet channel which will support a protective dolphin and floating boom system. The support system for the 6' diameter pipes, and the protective dolphins will be supported with both vertical and battered pipe piles. The pile tip elevation of the vertical pipe piles for the 6' dia. pipe support system will be El.-90.0, and the pile tip elevation for the battered pipe piles will be El.-85.0. The pile tip elevation of the vertical pipe piles for the protective dolphins will be El.-80.0, and the pile tip elevation for the battered pipe piles will be El.-85.0. It is assumed the bedding system for the 6' diameter pipe will be determined at a later design stage. Location and pile tip elevations for the pipe piling is shown on drawing S-250.

g. Project Feature 30-6' Dia. Pipe Siphon. – The substructures for this proposed feature will be 16 inch diameter steel pipe piles located at the intake end of the siphon, which will provide a support system for the 6' diameter pipes, and 16 inch dia. steel pipe piles located at the riverward end of the excavated inlet channel which will support a protective dolphin and floating boom system. The support system for the 6' diameter pipes, and the protective dolphins will be supported with both vertical and battered pipe piles. The pile tip elevation of the vertical pipe piles for the 6' dia. pipe support system will be El.-90.0, and the pile tip elevation for the battered pipe piles will be El.-85.0. The pile tip elevation of the vertical pipe piles for the protective dolphins will be El.-80.0, and the pile tip elevation for the battered pipe piles will be El.-85.0. It is assumed the bedding system for the 6' diameter pipe will be determined at a later design stage. Location and pile tip elevations for the pipe piling is shown on drawing S-260.

L8.2 STRUCTURAL DESIGN FOR DIVERSION FACILITY

L8.2.1 General

The general physical configuration of structures for this proposed diversion project were based on a variety of considerations, among them hydraulic requirements, similar structures performing the same function, and utilizing existing designs from other projects. All concrete structures will be reinforced and cast-in-place. Concrete and structural steel member sizes were assumed based on similar structures of equivalent size with similar loadings, therefore, no stress analyses were performed in this design phase.

L8.2.2 Description of Structural Features

a. Project Feature 3-15'x15' Gated Box Culverts. – The proposed structures at this location will be a series of reinforced cast-in-place concrete box culverts constructed monolithically in conjunction with inflow, roller gate, bulkhead, and T-wall monoliths. These structures will be located under an existing earth levee. There will be three box culvert barrels, each 15 feet high and 15 feet wide (inside dimensions). The flow line elevation inside the barrels will be El.-15.0. The box culverts base slab will be 4.0 feet thick, the top slab will be 3.0 feet thick, the interior vertical walls will be 2.5 feet thick, and the exterior vertical walls will be 3.0 feet thick. The length of the box culverts will be 160.0 feet. The concrete inflow monoliths on the upstream end of the structure will be comprised of a 4.0 foot thick base slab and two 3.0 foot thick vertical guidewalls providing a length of 150.0 feet. The upstream end of the inflow monoliths will flare from 56.0 to 96.0 feet in width. The roller gate monolith will be 59.0 feet long and 56.0 feet wide. The concrete bulkhead monolith on the downstream end of the structure will also be comprised of a 4.0 foot thick base slab and two 3.0 foot thick vertical guidewalls providing a length of 95.0 feet and a width of 56.0 feet. The concrete T-walls which retain the earth embankment, will be located at the downstream end of the bulkhead monolith, on both sides of the channel. Two T-walls will be located on each side of the channel, and oriented 55 degrees from the centerline of the channel. Each T-wall will be 36.0 feet long, with a top of stem elevation of El.+6.0. All the T-wall bases will be 3.0 feet thick, and the vertical stem thicknesses will vary. The foundation elevation of the T-walls nearest the bulkhead monolith will be El.-23.0, and the remaining T-walls will be founded at El.-15.0. The inflow channel bottom will be El.-16.0, with a width of 96.0 feet and side slopes of 1 vert. on 3 horiz. The outflow channel bottom will transition from El.-16.0 at the bulkhead monolith to El.-20.0, 100.0 feet from the concrete structure with a width of 50.0 feet and side slopes of 1 vert. on 3 horz. Vertical slots and structural steel roller guides will be provided in the concrete walls at each end of the barrels for the placement of a bulkhead, when required. A 15 foot high and 15 foot wide fabricated structural steel roller gate will be located at the upstream end of each barrel. A flush bottom closure for the gates will be accomplished by providing a steel sill beam assembly at El. -15.0. Vertical slots will be provided in the concrete sidewalls for the installation of structural steel roller guides. A concrete platform will be located at El.+17.5 to support the roller gate operators. A machinery building will be located adjacent to the support platform, also at El.+17.5. A 2.0 foot thick vertical concrete seepage cut-off wall extending from the top of the box culverts toEl.+13.0 will be located on the roller gate monolith near the centerline of the earth levee. A 17.0 foot wide and 34.0 foot long timber pile supported concrete bulkhead storage slab will be located on the landside of the levee.

b. Project Feature 10-15'x15' Gated Box Culverts. – The proposed structures at this location will be a series of reinforced cast-in-place concrete box culverts constructed monolithically in conjunction with inflow, roller gate, bulkhead, and T-wall monoliths. These structures will be located under an existing earth levee. There will be ten box culvert barrels, each 15 feet high and 15 feet wide (inside dimensions). The flow line elevation inside the barrels will be El.-15.0. The box culverts base slab will be 4.0 feet thick, the top slab will be 3.0 feet thick, the interior vertical walls will be 2.5 feet thick, and the exterior vertical walls will be 3.0 feet thick. The length of the box culverts will be 160.0 feet. The concrete inflow monoliths on the upstream end of the structure will be comprised of a 4.0 foot thick base slab and two 3.0 foot thick vertical guidewalls providing a length of 150.0 feet. The upstream end of the inflow monoliths will flare from 178.5 to 218.5 feet in width. The roller gate monolith will be 59.0 feet long and 178.5 feet wide. The concrete bulkhead monolith on the downstream end of the structure will also be comprised of a 4.0 foot thick base slab and two 3.0 foot thick vertical guidewalls providing a length of 95.0 feet and a width of 178.5 feet. The concrete T-walls which retain the earth embankment, will be located at the downstream end of the bulkhead monolith, on both sides of the channel. Two T-walls will be located on each side of the channel, and oriented 55 degrees from the centerline of the channel. Each T-wall will be 36.0 feet long, with a top of stem elevation of El.+6.0. All the T-wall bases will be 3.0 feet thick, and the vertical stem thicknesses will vary. The foundation elevation of the T-walls nearest the bulkhead monolith will be El.-23.0, and the remaining T-walls will be founded at El.-15.0. The inflow channel bottom will be El.-16.0, with a width of 218.5 feet and side slopes of 1 vert. on 3 horiz. The outflow channel bottom will transition from El.-16.0 at the bulkhead monolith to El.-20.0, 100.0 feet from the concrete structure with a width of 172.5 feet and side slopes of 1 vert. on 3 horz. Vertical slots and structural steel roller guides will be provided in the concrete walls at each end of the barrels for the placement of a bulkhead, when required. A 15 foot high and 15 foot wide structural steel roller gate will be located at the upstream end of each barrel. A flush bottom closure for the gates will be accomplished by providing a steel sill beam assembly at El.-15.0. Vertical slots will be provided in the concrete sidewalls for the installation of structural steel roller guides. A concrete platform will be located at El.+17.5 to support the roller gate operators. A machinery building will be located adjacent to the support platform, also at El.+17.5. A 2.0 foot thick vertical concrete seepage cut-off wall extending from the top of the box culverts toEl.+13.0 will be located on the roller gate monolith near the centerline of the earth levee. A 17.0 foot wide and 34.0 foot long timber pile supported concrete bulkhead storage slab will be located on the landside of the levee.

c. Project Feature 4,000' Gated Weir. - The proposed structure at this location will be a reinforced cast-in-place concrete fresh water diversion control structure incorporating vertical lift gates, a rail mounted gantry crane and crane bridge, and a highway vehicle bridge. The 3.5 thick substructure base slab will be founded at El.-5.5, extend 4,007.0 feet, and will be parallel to the vehicle, and gantry crane bridges. The upstream end of the base slab will include an elevated spillway with a top elevation of El.+8.0. The

remaining portion of the base slab will serve as a stilling basin with a top of slab elevation of El.-2.0. The stilling basin will include two rows of baffle blocks located near the mid point of the stilling basin. The top elevation of the baffle blocks will be El.+3.0. Concrete divider walls will be located parallel to flow at 22.0 feet on center to form 182 gate bays, which will contain the vertical lift gates. The divider walls will be 3.0 feet thick and are approx. 45.0 feet long. The divider walls will also provide a support foundation for the vehicle, and gantry crane bridges. The bridges will extend 43.5 feet beyond each end of the substructure for a total length of 4094.0 feet. The gantry crane bridge will be located toward the upstream end of the structure, above the spillway, with a top elevation of El.+20.0. The gantry crane bridge will be constructed of 4.0 feet deep reinforced cast-in-place T-beams. A steel crane rail will be installed on each T-beam. The highway vehicle bridge will provide two 12.0 foot driving lanes, with a top of deck elevation of El.+19.0 and total bridge width of 28.0 feet. The bridge deck and supporting beams will be reinforced cast-in-place concrete. The top elevation of the divider walls supporting the bridge beams will be El.+15.5. The vertical orientation of the lift gates will be made possible with the use of the gantry crane. When the lift gates are in their lowest position they will rest on the spillway at El.+8.0, and the top of the gates will be at El.+15.0. When the gates are at their highest position the bottom of the gate will be at El.+16.0, and the top of the gates will be at El.+23.0. The lift gates will be fabricated from structural steel and utilize steel rollers. Vertical slots will be provided in the concrete divider walls for the structural steel lift gate guides. Also, provisions will be made for installation of dogging devices in the divider walls in order to retain the lift gates in an open position.

d. Project Feature 3,000’ Gated Weir. - The proposed structure at this location will be a reinforced cast-in-place concrete fresh water diversion control structure incorporating vertical lift gates, a rail mounted gantry crane and crane bridge, and a highway vehicle bridge. The 3.5 thick substructure base slab will be founded at El.-5.5, extend 2.995.0 feet, and will be parallel to the vehicle, and gantry crane bridges. The upstream end of the base slab will include an elevated spillway with a top elevation of El.+8.0. The remaining portion of the base slab will serve as a stilling basin with a top of slab elevation of El.-2.0. The stilling basin will include two rows of baffle blocks located near the mid point of the stilling basin. The top elevation of the baffle blocks will be El.+3.0. Concrete divider walls will be located parallel to flow at 22.0 feet on center to form 136 gate bays, which will contain the vertical lift gates. The divider walls will be 3.0 feet thick and are approx. 45.0 feet long. The divider walls will also provide a support foundation for the vehicle, and gantry crane bridges. The bridges will extend 43.5 feet beyond each end of the substructure for a total length of 3,082.0 feet. The gantry crane bridge will be located toward the upstream end of the structure, above the spillway, with a top elevation of El.+20.0. The gantry crane bridge will be constructed of 4.0 feet deep reinforced cast-in-place T-beams. A steel crane rail will be installed on each T-beam. The highway vehicle bridge will provide two 12.0 foot driving lanes, with a top of deck elevation of El.+19.0 and total bridge width of 28.0 feet. The bridge deck and supporting beams will be reinforced cast-in-place concrete. The top elevation of the divider walls supporting the bridge beams will be El.+15.5. The vertical orientation of the lift gates will be made possible with the use of the gantry crane.

When the lift gates are in their lowest position they will rest on the spillway at El.+8.0, and the top of the gates will be at El.+15.0. When the gates are at their highest position the bottom of the gate will be at El.+16.0, and the top of the gates will be at El.+23.0. The lift gates will be fabricated from structural steel and utilize steel rollers. Vertical slots will be provided in the concrete divider walls for the structural steel lift gate guides. Also, provisions will be made for installation of dogging devices in the divider walls in order to retain the lift gates in an open position.

e. Project Feature 2,000' Gated Weir. - The proposed structure at this location will be a reinforced cast-in-place concrete fresh water diversion control structure incorporating vertical lift gates, a rail mounted gantry crane and crane bridge, and a highway vehicle bridge. The 3.5 thick substructure base slab will be founded at El.-5.5, extend 2.005.0 feet, and will be parallel to the vehicle, and gantry crane bridges. The upstream end of the base slab will include an elevated spillway with a top elevation of El.+8.0. The remaining portion of the base slab will serve as a stilling basin with a top of slab elevation of El.-2.0. The stilling basin will include two rows of baffle blocks located near the mid point of the stilling basin. The top elevation of the baffle blocks will be El.+3.0. Concrete divider walls will be located parallel to flow at 22.0 feet on center to form 91 gate bays, which will contain the vertical lift gates. The divider walls will be 3.0 feet thick and are approx. 45.0 feet long. The divider walls will also provide a support foundation for the vehicle, and gantry crane bridges. The bridges will extend 43.5 feet beyond each end of the substructure for a total length of 2,092.0 feet. The gantry crane bridge will be located toward the upstream end of the structure, above the spillway, with a top elevation of El.+20.0. The gantry crane bridge will be constructed of 4.0 feet deep reinforced cast-in-place T-beams. A steel crane rail will be installed on each T-beam. The highway vehicle bridge will provide two 12.0 foot driving lanes, with a top of deck elevation of El.+19.0 and total bridge width of 28.0 feet. The bridge deck and supporting beams will be reinforced cast-in-place concrete. The top elevation of the divider walls supporting the bridge beams will be El.+15.5. The vertical orientation of the lift gates will be made possible with the use of the gantry crane. When the lift gates are in their lowest position they will rest on the spillway at El.+8.0, and the top of the gates will be at El.+15.0. When the gates are at their highest position the bottom of the gate will be at El.+16.0, and the top of the gates will be at El.+23.0. The lift gates will be fabricated from structural steel and utilize steel rollers. Vertical slots will be provided in the concrete divider walls for the structural steel lift gate guides. Also, provisions will be made for installation of dogging devices in the divider walls in order to retain the lift gates in an open position.

f. Project Feature 19-6' Dia. Pipe Siphons. - The proposed fresh water diversion control structure at this location will be comprised of multiple components. The major component of this structure will be 19-6' dia. steel discharge pipes spaced at 10.0 feet on center, and will transport water over an existing levee. The approx. elevation of the top of the levee is El.+15.0. The pipes will be soil founded at various elevations on the landside of the levee. The pipes on the riverside of the levee at the water intake point will be supported with a pile founded structural steel component. The discharge pipe support structure will be located approx. 90.0 feet riverward from the centerline of the

existing levee. An inlet channel will be excavated between the waterway and the pipe support structure. The flow line elevation of the discharge pipes at the support structure will be El.-10.0. The inlet end of the discharge pipes will be fabricated as a horizontal line with a bottom elevation of El.-12.5. The pipe support structure will be supported with 16 inch dia. steel pipe piles placed in pairs between the discharge pipes. The riverward pile will be placed vertical, and the landward pile will be battered toward the levee. The support structure will be constructed of various sized structural steel members fastened to 24 inch dia. steel pipe sleeves. The pipe sleeves will be fastened over the end of the pipe piles. The pipe piles located at each end of the support structure will be battered either upstream or downstream depending on the location. Another component of this structure will be a system comprised of dolphins and floating booms, designed to restrain or deflect floating debris at the riverward end of the excavated inlet channel. A total of seven dolphins will be required and spaced at approximately 40.0 feet on center. Each dolphin will be attached to a cluster of three 16 inch dia. steel pipe piles. Two of the piles adjacent to the floating boom will be oriented in a vertical position, the third pile will be battered away from the boom. The top elevation of the vertical piles will be El.+14.0, and the top elevation of the battered piles will be El.+10.0. The upper portion of the dolphins will be a system constructed of structural steel members fastened to 24 inch dia. steel pipe sleeves. The pipe sleeves will be fastened over the end of the pipe piles. A floating boom placed horizontally will extend between every two dolphins. The booms will be constructed of watertight 24 inch steel pipe filled with foam, and fastened to the dolphins in a manner to allow the booms to rise and fall with the surrounding water elevation changes. A platform will be provided on top of two dolphins to support solar powered lanterns and storage batteries. The elevation of the top of the platform will be El.+12.5. One lantern will be located at each end of the dolphin group.

g. Project Feature 30-6’ Dia. Pipe Siphons. - The proposed fresh water diversion control structure at this location will be comprised of multiple components. The major component of this structure will be 19-6’ dia. steel discharge pipes spaced at 10.0 feet on center, and will transport water over an existing levee. The approx. elevation of the top of the levee is El.+15.0. The pipes will be soil founded at various elevations on the landside of the levee. The pipes on the riverside of the levee at the water intake point will be supported with a pile founded structural steel component. The discharge pipe support structure will be located approx. 90.0 feet riverward from the centerline of the existing levee. An inlet channel will be excavated between the waterway and the pipe support structure. The flow line elevation of the discharge pipes at the support structure will be El.-10.0. The inlet end of the discharge pipes will be fabricated as a horizontal line with a bottom elevation of El.-12.5. The pipe support structure will be supported with 16 inch dia. steel pipe piles placed in pairs between the discharge pipes. The riverward pile will be placed vertical, and the landward pile will be battered toward the levee. The support structure will be constructed of various sized structural steel members fastened to 24 inch dia. steel pipe sleeves. The pipe sleeves will be fastened over the end of the pipe piles. The pipe piles located at each end of the support structure will be battered either upstream or downstream depending on the location. Another component of this structure will be a system comprised of dolphins and floating booms,

designed to restrain or deflect floating debris at the riverward end of the excavated inlet channel. A total of ten dolphins will be required and spaced at approximately 40.0 feet on center. Each dolphin will be attached to a cluster of three 16 inch dia. steel pipe piles. Two of the piles adjacent to the floating boom will be oriented in a vertical position, the third pile will be battered away from the boom. The top elevation of the vertical piles will be El.+14.0, and the top elevation of the battered piles will be El.+10.0. The upper portion of the dolphins will be a system constructed of structural steel members fastened to 24 inch dia. steel pipe sleeves. The pipe sleeves will be fastened over the end of the pipe piles. A floating boom placed horizontally will extend between every two dolphins. The booms will be constructed of watertight 24 inch steel pipe filled with foam, and fastened to the dolphins in a manner to allow the booms to rise and fall with the surrounding water elevation changes. A platform will be provided on top of three dolphins to support solar powered lanterns and storage batteries. The elevation of the top of the platforms will be El.+12.5. One lantern will be located at each end of the dolphin group, and one at the mid-point.

L9. Electrical and Mechanical Requirements

L9.1 ELECTRICAL SOURCES AND SUPPLY REQUIREMENTS

L9.1.1 General

Development of this proposed diversion project will require various proposed structural features to accomplish the intended purpose. All the structural features will require either a single or multiple type of electrical power source depending on the operational requirements at each site. The ability to furnish electrical power to each structural feature from an off site location has not been determined at this time, and will be investigated in another design stage. The possible electrical requirements at each feature site have been presented below.

L9.1.2 Electrical Requirements Per Site

a. Project Feature 3-15'x15' Gated Box Culverts. – An electrical power supply will be required to operate the roller gate operators. Whether the operators will be electrically or hydraulically operated has not been determined at this time. In either case an electrical power source will be required for the operator motors, or for the electrical motors driving the hydraulic pumps for the operators. In addition, a power source will be required for the machinery building lighting, and switchboard equipment in the building.

b. Project Feature 10-15'x15' Gated Box Culverts. – An electrical power supply will be required to operate the roller gate operators. Whether the operators will be electrically or hydraulically operated has not been determined at this time. In either case an electrical power source will be required for the operator motors, or for the electrical motors driving the hydraulic pumps for the operators. In addition, a power source will be required for the machinery building lighting, and switchboard equipment in the building.

c. Project Feature 4,000' Gated Weir. – An electrical power supply will be required to operate the movable gantry crane. The power supply will operate the drive motors which move the crane, the lifting hoist motors which position the lift gates, the jib crane motor, and the motor which operates the clamshell bucket.

d. Project Feature 3,000' Gated Weir. – An electrical power supply will be required to operate the movable gantry crane. The power supply will operate the drive motors which move the crane, the lifting hoist motors which position the lift gates, the jib crane motor, and the motor which operates the clamshell bucket.

e. Project Feature 2,000' Gated Weir. – An electrical power supply will be required to operate the movable gantry crane. The power supply will operate the drive motors which move the crane, the lifting hoist motors which position the lift gates, the jib crane motor, and the motor which operates the clamshell bucket.

f. Project Feature 19-6' Dia. Pipe Siphon. – Operation of the siphon will not require an electrical power source. In the event a decision is made, at a later date, to provide exterior lighting or a lighted maintenance building, an electrical power source may be required.

g. Project Feature 30-6' Dia. Pipe Siphon. – Operation of the siphon will not require an electrical power source. In the event a decision is made, at a later date, to provide exterior lighting or a lighted maintenance building, an electrical power source may be required.

h. Electric Power Source(s). – Electric power source(s) can be either commercial utility electric power or diesel engine generators. Location of commercial utility power and the cost to supply this power will be compared to the cost of a diesel engine generator set, including estimated O&M costs to determine the recommended source of the required electrical power.

L9.2 SOLAR POWER SUPPLY SYSTEMS

L9.2.1 General

The only project features that would incorporate a solar power system will be the two siphon structures mentioned above. The siphon features will include protective dolphins placed in the waterway. Warning lanterns will be mounted on top of the dolphins and powered with electrical storage batteries which will be charged with solar panels. Exterior lighting and a maintenance building are not proposed to be included in this project at this time, but in the event they are included, solar power may be provided in lieu of extending a conventional power supply to the sites.

L9.3 ELECTRICAL AND MECHANICAL DESIGN FOR DIVERSION FACILITY

L9.3.1 General

The size and type of electrical and mechanical components for the project features were selected based on a variety of considerations, among them hydraulic requirements, similar features performing the same function, and utilizing existing designs from other projects.

L9.3.2 Electrical/Mechanical Requirements Per Site

a. Project Feature 3-15'x15' Gated Box Culverts. – Regulation of flow thru the culverts will be controlled with the use of three 15'x15' fabricated structural steel roller gates. The gates will be raised/lowered with the use of a gate hoist supplied by a known and acceptable gate manufacturer. Selection of either electric motor operated or hydraulically operated gate hoists will be determined in a later project design stage. Two fabricated structural steel bulkheads approximately 15 feet square will be provided and stored on site when not in use. The bulkheads will be fitted with rollers, and vertical steel roller guides will be cast in slots in the concrete walls.

b. Project Feature 10-15'x15' Gated Box Culverts. – Regulation of flow thru the culverts will be controlled with the use of ten 15'x15' fabricated structural steel roller gates. The gates will be raised/lowered with the use of a gate hoist supplied by a known and acceptable gate manufacturer. Selection of either electric motor operated or hydraulically operated gate hoists will be determined in a later project design stage. Two fabricated structural steel bulkheads approximately 15 feet square will be provided and stored on site when not in use. The bulkheads will be fitted with rollers, and vertical steel roller guides will be cast in slots in the concrete walls.

c. Project Feature 4,000' Gated Weir. – Regulation of flow thru the weir structure will be controlled by the operational use of one hundred eighty two fabricated structural steel vertical lift gates. The gates will be approx. 19.0 feet wide and 7.0 feet high. The gates will be fitted with steel rollers, and vertical steel roller guides will be cast in slots in the concrete divider walls. Dogging devices will be attached to the gates to lock them in a raised position. The gates will be raised with the use of a fabricated structural steel lifting beam, connected with steel cables to a movable rail mounted gantry crane. The crane size and lifting capacity to be determined during a later design phase. The gantry crane assembly will include a jib crane, and clamshell bucket suspended from a boom with a 180 degree swing capability.

d. Project Feature 3,000' Gated Weir. – Regulation of flow thru the weir structure will be controlled by the operational use of one hundred thirty eight fabricated structural steel vertical lift gates. The gates will be approx. 19.0 feet wide and 7.0 feet high. The gates will be fitted with steel rollers, and vertical steel roller guides will be cast in slots in the concrete divider walls. Dogging devices will be attached to the gates to lock them in a raised position. The gates will be raised with the use of a fabricated structural steel lifting beam, connected with steel cables to a movable rail mounted gantry crane. The crane size and lifting capacity to be determined during a later design phase. The gantry crane assembly will include a jib crane, and clamshell bucket suspended from a boom with a 180 degree swing capability.

e. Project Feature 2,000' Gated Weir. – Regulation of flow thru the weir structure will be controlled by the operational use of ninety one fabricated structural steel vertical lift gates. The gates will be approx. 19.0 feet wide and 7.0 feet high. The gates will be fitted with steel rollers, and vertical steel roller guides will be cast in slots in the concrete divider walls. Dogging devices will be attached to the gates to lock them in a raised position. The gates will be raised with the use of a fabricated structural steel lifting beam, connected with steel cables to a movable rail mounted gantry crane. The crane size and lifting capacity to be determined during a later design phase. The gantry crane assembly will include a jib crane, and clamshell bucket suspended from a boom with a 180 degree swing capability.

L10. Construction Procedures

The MRT levee protects the project area from Mississippi River floods. A temporary levee will be in place, with the appropriate level of protection, when the levee is breached for construction to protect the evacuation route. Appropriate erosion control measures will be in place for the duration of the construction.

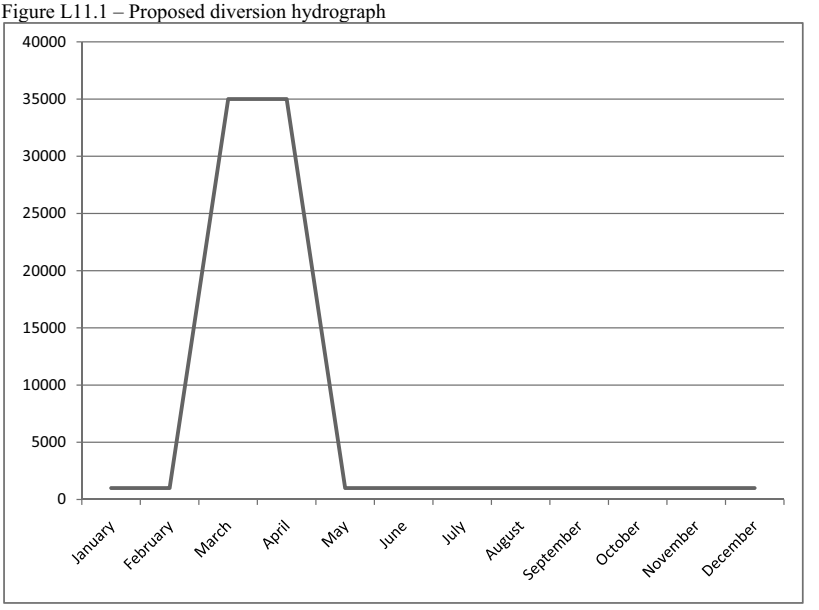
Highway 39 is the emergency evacuation route for areas south of the diversion site. Continued access to the project area during construction will be necessary to ensure the population will not be isolated. Temporary detours of Highway 39 will be constructed, with appropriate safety measures in place. Secondary road detours will be made to allow local residents access to their property during the construction of the project.

L11. Operations and Maintenance

L11.1 Operations

Operations for the diversion are yet to be determined. It is assumed that there will be some type of seasonal pulse in the spring of the year lasting from possibly two weeks to three months depending on conditions. For this pulse, water will be gradually introduced so as to minimize scour without affecting the sediment load. The current proposed operations are to have a March and April pulse of the maximum amount of water possible (up to 35,000cfs). Figure L11.1 shows the proposed hydrograph of the diversion structure.

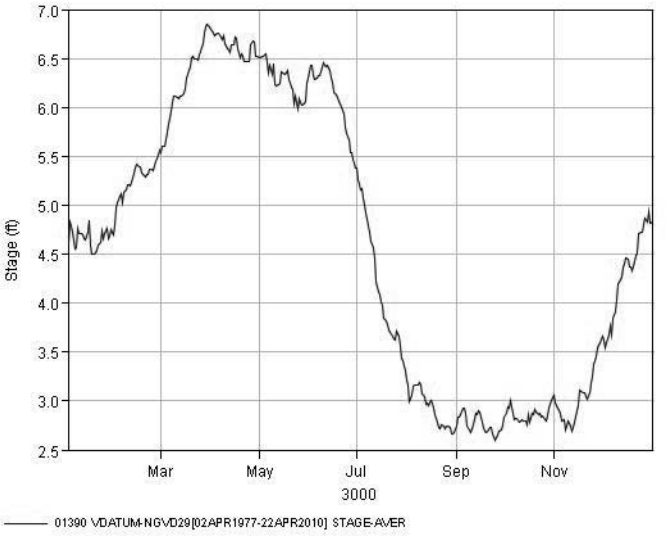
Figure L11.1 – Proposed diversion hydrograph



The operation of this structure will be closely tied to the operation of the Caernarvon Diversion as well other diversions along the Mississippi River. Interrelated operations between these different diversions are critical to provide benefits to the different coastal marshes and not create undesired impacts to the Mississippi River such as induced shoaling.

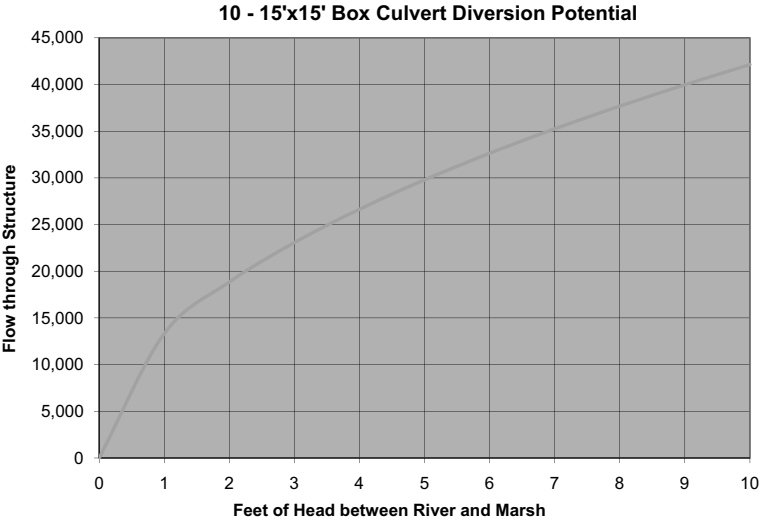
The diversion will be driven based off of the head differential between the Mississippi River and the coastal marsh where we are diverting water. The outfall of the diversion is in an estuary and assumed to have an average stage equal to sea level (0.00 NAD88) throughout the course of the year. Therefore, the river stage will typically be the head that the diversion can utilize. Figure 11.2 shows the average stage of the river at the Alliance, LA gage. The Alliance, LA gage is approximately 5 miles upstream from the proposed diversion site and is assumed to have the same stage. Figure 11.3 shows the rating curve for the 10 – 15'x15' Box Culvert Diversion.

Figure 11.2 – Average Mississippi River stage at Alliance, LA



3675

Figure 11.3 – Diversion Rating Curve



For more information operations of the diversion, please consult chapter 3.0 Plan Formulation of the White Ditch Feasibility Study.

L11.2 Maintenance

With the proposed diversion there will be needs for channel maintenance dredging, removal of sediment buildup in box culverts and sluice gate maintenance. It is estimated that there will need to be significant channel dredging every 10 years on the proposed channel enhancement features. Sediment removed from box culverts and dredged from channels shall be placed in sediment deficient areas near the dredge site. It is also assumed that there will be annual maintenance and lubrication needs provided to the sluice gates.

L12. Cost Estimates

L12.1 Basis of Cost Estimate

An initial array of alternatives was developed by the PDT. The initial array of alternatives included at Location 2 are:

- Alternative 2A: 30 pipe siphon with a 5,000 cfs outfall capacity
- Alternative 2B: 3 box culverts with a 5,000 cfs outfall capacity

- Alternative 2C: 30 pipe siphon with a 10,000 cfs outfall capacity
- Alternative 2D: 3 box culverts with a 10,000 cfs outfall capacity
- Alternative 2E: 10 box culverts with a 15,000 cfs outfall capacity
- Alternative 2F: 10 box culverts with a 35,000 cfs outfall capacity

The initial array of alternatives include at Location 3 are:

- Alternative 3A: 30 pipe siphon with a 5,000 cfs outfall capacity
- Alternative 3B: 3 box culverts with a 5,000 cfs outfall capacity
- Alternative 3C: 30 pipe siphon with a 10,000 cfs outfall capacity
- Alternative 3D: 3 box culverts with a 10,000 cfs outfall capacity
- Alternative 3E: 10 box culverts with a 15,000 cfs outfall capacity
- Alternative 3F: 10 box culverts with a 35,000 cfs outfall capacity

Each alternative consists of a structure paired with an appropriately sized outfall channel to convey a desired flow of fresh water and sediment into the weakened marsh area.

The preliminary cost estimates for the initial array of alternatives are unit price estimates based on preliminary design and associated quantity take-offs with price data from recent bid results, historical costs, and the expertise of the district's cost estimators and engineers. Appropriate contingencies are applied. The price level for these cost estimates is November 2009. The cost estimates for the initial array of alternatives can be found in Annex 3.

The final array of alternatives included four alternatives at Location 3. The alternatives were selected from the initial array of alternatives and had to meet the project goals outlined in the main report. The final alternatives chosen are:

- Alternative 3B: 3 box culverts with a 5,000 cfs outfall capacity
- Alternative 3D: 3 box culverts with a 10,000 cfs outfall capacity
- Alternative 3E: 10 box culverts with a 15,000 cfs outfall capacity
- Alternative 3F: 10 box culverts with a 35,000 cfs outfall capacity

The preliminary cost estimates for the final array of alternatives are also based on further refined preliminary design and associated quantity take-offs with price data from recent bid results, historical costs, and the expertise of the district's cost estimators and engineers. Appropriate contingencies are applied. The price level for these cost estimates is December 2009. The cost estimates for the final array of alternatives can be found in Annex 3. In addition to the four final alternatives, the cost estimates for the siphons at Location 3 were included. These estimates were included for quantity clarification purposes only.

L12.2 DETAILED ESTIMATE

The tentatively selected plan for the White Ditch Marsh Restoration project is Alternative 3F, 10 each, sized 15 feet x 15 feet box culverts, with an outfall capacity of 35,000 cfs. The selected plan involves excavating a section of levee and road to construct the 10 box culvert structure, replacing the levee and road on top of the structure, and excavating an outfall channel system to

convey 35,000 cfs of fresh water and sediment to the damaged marsh. The structure also has ten sluice gates with hydraulic operators that will be used to regulate the flow of fresh water and sediment through the structure.

The preferred alternative cost estimate is a detailed estimate based on the expertise of the district's cost estimators and engineers. The cost estimate for the recommended plan was prepared utilizing the MCACES software. The MCACES estimate is included in Annex 3. The estimated costs were based upon an analysis of each line item evaluating quantity, production rate, and time, together with the appropriate equipment, labor, and material costs. Appropriate contingencies are applied. The price level for this cost estimate is January 2010.

The detailed estimate meets the requirements and recommendations of the following documents and sources:

- ER 1110-2-1150, Engineering and Design for Civil Works Projects.
- ER 1110-2-1302, Civil Works Cost Engineering.
- ETL 1110-2-573, Construction Cost Estimating Guide for Civil Works.

The detailed estimate assumes that the marsh and main outfall excavation will be completed by two small dredges and the side berms will be formed by several amphibious excavators. The detailed estimate also assumes that all construction elements associated with the box culvert will be completed on land.

Planning, Engineering and Design costs and Construction Management costs are included in the detailed estimates. These costs are calculated as a percentage rate of the construction cost. The rates are 17.5% for planning, engineering and design, which includes engineering and design during construction, and 10% for construction management. The planning, engineering, and design rate was calculated based on percentages for Engineering, Project Management, Estimating, Construction, and Planning & Environmental Compliance. The construction management rate is based on average expenditures for construction management.

A plan construction schedule was developed based on the production rates used in the detailed estimate and the expertise of the district's cost estimators and engineers. The plan construction schedule was used in the Cost and Schedule Risk Analysis discussed below. The anticipated construction duration based on the plan schedule is four years and one month. The plan construction schedule is included in Annex 3.

The Total Project Cost table was developed based on the detailed estimate, the completed cost and schedule risk analysis, and the civil works work breakdown structure (CWWBS) elements included in the detailed estimate. Those elements are:

- 01 LANDS AND DAMAGES
- 02 RELOCATIONS
- 15 FLOODWAY CONTROLS AND DIVERSION STRUCTURES
- 30 PLANNING, ENGINEERING & DESIGN
- 31 CONSTRUCTION MANAGEMENT

The Total Project Cost table shows the effective price level for the detailed estimate of January 2010, the Budget Year effective price level of October 2010, and the Fully Funded Project Cost with a construction midpoint date of April 2014. Escalation for the price level years is based on the Army Corps of Engineers Engineering Manual (EM) 1110-2-1304 Civil Works Construction Cost Index System (CWCCIS) revised 30 September 2009. The Total Project Cost table is included in Annex 3.

L12.3 Contingencies

Contingencies are based on a Cost Rick Analysis using Crystal Ball software. Results of this analysis are discussed in the Risk Analysis Section below.

L12.4 Risk Analysis

A cost risk analysis was performed for this project in accordance with ER 1110-2-1302 paragraph 7.3.2 and ER 1110-2-1302, appendix B, paragraph 4. The results of the cost risk analysis are shown in the Project Cost and Schedule Risk Analysis Report included in Annex 3.

ANNEX 1

Quantifying Benefits of Freshwater Flow Diversions to Coastal Marshes

Quantifying Benefits of Freshwater Flow Diversion to Coastal Marshes: Theory[a] and Applications[b]

S. Kyle McKay[1], J. Craig Fischenich[2], S. Jarrell Smith[3], and Ronald Paille[4]

[1]U.S. Army Engineer Research and Development Center (ERDC)
Environmental Laboratory
187 Oglethorpe Ave. Apt. B
Athens, Georgia, 30606
Email: Kyle.McKay@usace.army.mil

[2]U.S. Army Engineer Research and Development Center (ERDC)
Environmental Laboratory
3909 Halls Ferry Rd.
Vicksburg, Mississippi, 39180
Email: Craig.J.Fischenich@usace.army.mil

[3]U.S. Army Engineer Research and Development Center (ERDC)
Coastal and Hydraulics Laboratory
3909 Halls Ferry Rd.
Vicksburg, Mississippi, 39180
Email: Jarrell.Smith@usace.army.mil

[4]U.S. Fish and Wildlife Service
646 Cajundome Boulevard, Suite 400
Lafayette, Louisiana 70506
Email: Ronald_Paille@fws.gov

Keywords: wetland, Louisiana, accretion, uncertainty, organic, inorganic, coastal restoration, operation,

Abstract

The combination of relative sea level rise and river/marsh disconnection has created a deficit of available soil and accompanying land loss in a large portion of coastal Louisiana. The U.S. Congress recently charged the U.S. Army Corps of Engineers, State of Louisiana, and other federal and local agencies with restoring the coastal wetlands of Louisiana and Mississippi. Many alternative combinations of restoration measures have been proposed, and assessment of the advantages and disadvantages of these efforts must be made to determine the optimal design. One technique being applied for coastal restoration is the reconnection of rivers to coastal marshes through flow diversions.

---

[a] Based on material from McKay, S.K., J.C. Fischenich, and S.J. Smith. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. I: Theory." In draft for submission to Ecological Engineering.
[b] Based on material from McKay, S.K., J.C. Fischenich, and R. Paille. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. II: Application to Louisiana Coastal Protection and Restoration." In draft for submission to Ecological Engineering.

Freshwater flow diversions offer significant nutrient and sediment inputs to marshes that induce both organic and inorganic accumulation of soil. Boustany (2007) presented a screening level model for assessing both the nutrient and sediment benefits of flow diversion over long time scales. This paper has presented the adaptation of Boustany's (2007) model to include daily variation in sediment processes in order to optimize diversion structure design and operation. The model was verified using an existing diversion to prove the ability of the model to track land evolution associated with flow diversion. This paper also demonstrates the application of the model to diversion operational and structural optimization.

Introduction

In the fall of 2005, Hurricanes Katrina and Rita awakened the United States public to the natural protection that coastal wetlands provide in reducing of the effects of hurricanes on coastal communities. In response to these catastrophic events, the U.S. Congress directed the U.S. Army Corps of Engineers (USACE) to "conduct a comprehensive hurricane protection analysis and design…to develop and present a full range of flood control, coastal restoration, and hurricane protection measures" (USACE, 2006). This paper focuses on interagency efforts to assess and weigh benefits of coastal restoration via freshwater flow diversion. The paper will focus on the development and adaptation of a screening level model to quantify the benefits of flow diversion to coastal marshes and will describe the assessment of various diversion operational and structural scenarios.

Coastal Marsh Accretion and Flow Diversion

The tidal marshes of coastal Louisiana are receding at alarming rates as high as 115 km^2/yr (Barras et al., 1994). Submergence of these valuable ecological assets (Figure 1) was once counteracted by vertical accretion due to the addition of freshwater, nutrient, and mineral inputs from riverine environments; however, eustatic sea level rise (ESLR) and basin subsidence now exceed the current rate of vertical accretion, and coastal marshes have been disconnected from their freshwater and sediment sources, distributary channels of the Mississippi and Atchafalya Rivers. ESLR has been attributed to global increase in ocean volume and has been estimated as 1.0-2.4 mm/yr (Church et al., 2001). Subsidence of the Mississippi delta has been attributed to multiple factors, namely: regional isostasy, faulting, sediment consolidation, and soil dewatering (Dokka et al., 2006). Previous researchers identified other potential sources of subsidence as groundwater and petroleum extraction (Morton et al., 2002); however, Dokka et al. (2006) renounce these hypotheses as unlikely due to the relative lack of groundwater extraction from the highly saltwater intruded groundwater table of most of southern Louisiana and the lack of coincidence between petroleum extraction and subsidence. The synergy of ESLR and basin subsidence has created an apparent local change in sea level known as Relative Sea Level Rise (RSLR) that has been measured in the Mississippi Delta at rates as high as 10 mm/yr (Snedden et al., 2007).

In addition to RSLR, the disconnection of coastal marshes from their sediment and nutrient source is equally disconcerting. Over geologic time scales, large-scale delta lobe switching has lead to alternating episodes of delta building and redistribution of sediment

and nutrients throughout the coastal plain (Coleman, 1988; Coleman et al., 1998); however, in the last two centuries, the Mississippi River has been controlled by levees and other structures in order to maintain a consistent navigation channel for commerce and protect infrastructure against floods (Coleman et al., 1998; Parker et al., 2006). Presently, much of the sediment and nutrient load of the Mississippi River is discharged directly into the northern Gulf of Mexico through the birdsfoot delta, providing little benefit to protective delta building and contributing to an increasing zone of hypoxia near the river mouth (Mitsch et al., 2001). In addition to problems associated with fate of river sediment and nutrients, this disconnection starves coastal wetlands of historic nutrient and sediment inputs necessary for marsh sustainment. Although the relative importance of this multitude of factors has yet to be rigorously quantified throughout the Louisiana coastal plain, the combination of RSLR and river/marsh disconnection has led to high land loss rates and conversion of many freshwater marshes to shallow saltwater bays.

In recent years, freshwater flow diversions from river sources to coastal marshes have been offered as a tool for combating RSLR and disconnection of rivers and wetlands. In these diversions, river water is released into marshes to simulate flooding of a river onto its floodplain and increase hydrologic connectivity. Potential benefits have been observed from pulsing diversion discharges to simulate natural flood regimes (Day et al., 2003; Reyes et al., 2003; Snedden et al., 2007). Many studies have also shown that flow diversion is a plausible remedy to reconnect rivers to tidal marshes and deltas and induce organic and inorganic deposition (Parker et al., 2006; Snedden et al., 2007). An ancillary benefit of these flow diversions is potentially reduction of the nutrient loading to the Gulf of Mexico with associated reduction in the hypoxic zone (Lane et al., 1999; Mitsch et al., 2001).

Vertical accretion of marshes has been identified as highly dependent upon both inorganic and organic accumulation (Figure 2; Delaune et al., 1981; Nyman et al., 1993; Day et al., 1995; Reed, 1995; Foote and Reynolds, 1997; Nyman et al., 2006; Morris, 2007). Often accretion is only accounted for through sedimentation (e.g. Parker et al., 2006); however locations have been identified that depend more upon organic inputs than sediment inputs (Nyman et al., 2006). The characteristics of the receiving marsh and associated hydrologic connectivity are likely to influence whether inorganic or organic inputs control (Boustany, 2007). For instance, if a region is initially unvegetated, sediment inputs will be necessary to establish a soil platform for dense vegetative growth; however, once vegetation is well established, the vegetative inputs are likely to dominate while at the same time inducing higher retention of sediment in the process. This complex feedback system necessitates the inclusion of both inorganic (sediment) and organic (vegetative) inputs to any calculation of vertical accretion (Reed, 1995).

Vegetative accumulation in coastal marshes involves a delicate balance of above and belowground plant productivity (Gosselink, 1984; Edwards and Mills, 2005), salinity (Visser et al., 2004), nutrient availability (Delaune et al., 2005), flood frequency (Nyman et al., 2006), vegetation type (Gosselink, 1984), and seasonality (Visser et al., 2004), among other factors. Freshwater reintroduction has been shown to increase nutrient

inputs to coastal marshes (Lane et al., 1999) and stimulate growth in these ecosystems (Cardoch et al., 2002), further causing vegetative inputs to contribute to accretion. In coastal Louisiana most marshes are nutrient limited (Nyman et al., 1990; Delaune et al., 2005), so the introduction of limiting nutrients such as nitrogen and phosphorous from flow diversion is a topic of great importance when considering flow diversion alternatives and benefits (Lane et al., 1999; Hyfield, 2004; Hyfield, 2008); however, excessive nutrient loading to coastal wetlands could potentially induce harmful water quality effects such as eutrophication (Delaune et al., 2005) or stimulation of invasive plant species (Carter and Bernard, 2007), so diversion of flow to coastal wetlands must be carefully balanced and planned.

The accretion of sediment on coastal marshes and deltas has also been studied extensively (Stumpf, 1983; Wang, 1997; Rybczyk and Cahoon, 2002; Reyes et al., 2003; Parker et al., 2006; Snedden et al., 2007). Relevant sedimentation processes have been identified as sediment loading from floods/diversions (Reed, 1995; Parker et al., 2006), sediment settling properties (Stumpf, 1983; Soulsby, 1997; Winterwerp and van Kesteren, 2004), tidal erosion (Stumpf, 1983; Wang et al., 1997), wind and storm induced erosion and deposition (Wang, 1997), sediment export through canals and bayous (Wang, 1997; Baustian and Turner, 2006), and vegetation induced settling (Gleason et al., 1979; Stumpf, 1983; Reed, 1995; Leonard and Luther, 1995).

Although flow diversions have proved useful for combating coastal land loss, the optimization of flow diversion locations and operation has been difficult due to the complexity in data needs of a coupled ecological and hydrodynamic model (Reyes et al., 2003; Delaune et al., 2003; Snedden et al., 2007). These complexities encourage the development of a simple, screening-level model that includes the effects of vegetation and sediment dynamics and allows for straightforward examination and optimization of flow diversion feasibility and operational benefits.

Boustany (2007) Landscape Evolution Model

Boustany (2007) developed a composite nutrient and sediment model to assess the feasibility of flow diversions and screen diversion alternatives under the Coastal Wetland Planning, Protection, and Restoration Act (CWPPRA; Boustany, Personal Communication). This model, herein referred to as the Boustany Model (BM), presents all benefits of flow diversion in terms of marsh area by assuming all nutrient and sediment benefits additive to the existing area and land change rate:

$$A_{i+1} = A_i + \delta_{nut} A_i + A_{sed}$$

Equation 1

Where A_i is the marsh area at time i, δ_{nut} is the fractional change in land area due to RSLR and river-marsh disconnection (value may be positive or negative) that has been adjusted to account for the benefits associated with nutrient addition, and A_{sed} is the area benefit of sediment addition.

The BM was developed to compare long term relative benefits of many flow diversion locations and was implemented with an annual time step to provide quick estimates of the potential benefits of diversions. The BM is sufficient for quick estimation of flow

diversion benefits and initial screening of alternatives, but the LACPR program required greater temporal resolution in order to assess not only the relative benefits of diversion locations, but also the effects of diversion structure type, diversion operational regimes, and hydrologic variability. Ideally a detailed two- or three-dimensional model coupling nutrient and sediment processes would be used to account for the complex mechanisms governing coastal marsh accretion (Reyes et al., 2000; Dortch et al., 2007); however, the vast number of alternatives and short time scale of the LACPR report to Congress precluded development of such models for every alternative and marsh. As such, the BM was adapted to include processes deemed most critical to LACPR alternatives analysis. The following sections provide further details of the nutrient and sediment models implemented in the landscape evolution calculations, but the two major adaptations of the BM were:

- High temporal variability in sediment processes encouraged the refinement of the temporal resolution of the sediment model to include daily impacts of the diversion on the marsh.
- In order to maintain model simplicity, the BM required estimation of a number of parameters to account for nutrient and sediment processes (e.g. sediment retention and average annual suspended sediment concentration). The adaptation of the model has also included the calculation of many of these inputs in order to account for temporal variance, reduce data requirements, and minimize potential input errors.

Nutrient Benefits

Nutrient addition to coastal marshes has proven to be a source of vegetation stimulation and strengthening and biomass creation (Deegan et al., 2007). Boustany (2007) proposes a model that accounts for the ability of nutrients to stimulate vegetation to better resist erosional processes. This model determines the percent of the vegetated area that is strengthened from nutrient addition. This parameter is found by examining the annual nutrient requirements of the marsh relative to the nutrients loaded to the marsh.

The nutrients required by the marsh for vegetative growth are assumed to be the mass of the nutrients held in plant biomass. This quantity may be assessed by examining the rate of biomass production (annual primary productivity, P_r) and the percent of biomass containing these nutrients (γ). Since most Louisiana coastal marshes are nitrogen or phosphorous limited, Boustany proposes that the total concentration of nitrogen and phosphorous (*TNP*) be used to account for nutrient benefits.

$$LR_{req} = P_r \gamma_{TNP}$$

Equation 2

Where LR_{req} is the marsh required nutrient loading rate [$ML^{-2}T^{-1}$], P_r is primary productivity [$ML^{-2}T^{-1}$], and γ_{TNP} is the percent of plant biomass containing nitrogen and phosphorous [1].

The nutrient loading rate of the diversion to plant biomass, LR_{div}, may be calculated from the volumetric discharge of water to the marsh from the diversion, Q_{div} [L^3T^{-1}], the

concentration of nutrients in the source water, C_{source} [ML^{-3}], the retention rate of nutrients in plant biomass, R_{nut} [1], and the vegetated marsh area, A_{veg} [L^2].

$$LR_{div} = \frac{Q_{div} C_{source}}{A_{veg}} R_{nut}$$

Equation 3

In addition to nutrient loading from the diversion, there is ambient nutrient loading to the marsh from other ongoing processes (e.g. atmospheric deposition, stormwater runoff, current plant decomposition, denitrification, etc.). These processes will be accounted for by a loading rate for background sources, $LR_{background}$. The net loading of nutrients to the marsh, LR_{net}, is therefore the sum of the background and diversion loading rates.

$$LR_{net} = LR_{div} + LR_{background}$$

Equation 4

From knowledge of the loading rates applied, LR_{net}, and required, LR_{req}, one may obtain the fraction of wetlands sustained by nutrient addition, E_s.

$$E_s = \frac{LR_{net}}{LR_{req}}$$

Equation 5

In this model, nutrients are assumed to be unable to freely construct land; however, they can reduce the loss rate by strengthening vegetated areas against erosion. This assumption produces conservative estimates of the organically-induced benefits of the diversion. For instance, in an environment with a low land loss rate, according to the model, the diversion could potentially reduce the land loss to zero; however, no land gain would be associated with organic inputs. The percentage of wetland sustained by nutrient addition serves as a reduction ratio to the land loss rate in the form of Equation 6.

$$\delta_{nut} = \begin{cases} \delta(1 - E_s) & For E_s < 1 \\ 0 & For E_s \geq 1 \end{cases}$$

Equation 6

Where δ is the land change rate prior to the diversion and δ_{nut} is the nutrient adjusted land change rate.

Sediment Benefits

The accumulation of diverted sediments is determined by a sediment budgeting model utilizing the input concentration of sediment from the source water and calculated hydrodynamics of the system to determine the quantity of diverted sediment retained in the marsh. As previously specified, the BM implemented sedimentation calculations on an annual timescale, and while this assumption is reasonable for preliminary screening of alternatives, further refinement is necessary for more detailed analyses of flow diversion benefits. The sediment model implemented herein relies on calculation of sediment inputs and sediment settling theory on a daily timescale over a single representative year and reapplies that year throughout the proposed project life cycle.

Sediment Input

In order to minimize costs and maximize benefits of flow diversion in coastal Louisiana, diversion structures often withdraw water from one of the region's major rivers (e.g.

Mississippi, Atchafalya, Calcasieu). These rivers are located throughout the coastal plain, carry large water and sediment loads, and serve as a virtually infinite source of diversion resources.

River discharge and suspended sediment concentration have often been shown to be positively correlated (Mossa, 1996; Snedden et al., 2007). The relationship between discharge and sediment load may be determined by analytical and partially analytical models (e.g. Meyer-Peter Muller, Einstein, Yang; Richardson et al., 2001) or by empirical models for a given set of observed discharge and sediment concentration values (Mossa, 1996; Snedden et al., 2007). In coastal Louisiana, there exists enough recorded sediment discharge data to generate empirical models of sediment concentration for some of the major rivers of the region. For this analysis, a power function was found to provide enough resolution in sediment concentration variation (Equation 7). Table 1 presents a number of sediment ratings of this form for coastal Louisiana.

$$Q_{s,river} = a_1 Q_{river}^{\ a_2}$$

Equation 7

Where $Q_{s,river}$ is sediment load (ton/da), Q_{river} is river discharge (cfs), a_1 is a dimensional coefficient, and a_2 is a dimensionless coefficient. From this sediment rating, flow-averaged suspended sediment concentration of the river, C_{river}, may be calculated $\left(C_{river} = Q_{s,river} / Q_{river} \right)$ and transformed to the desired units.

Regardless of the model defining this relationship, the sediment concentration has been shown to be highly dependent upon discharge; therefore, in order to capture the temporal variance in sediment discharge through a diversion, the sediment concentration must vary with river discharge at an appropriate time scale (Snedden et al., 2007). For the purposes of this analysis, daily variation in discharge provides sufficient temporal resolution for accurate calculation of sediment loading to marshes by diversions.

One of the purposes for adapting the BM is the desire to examine relative diversion structure operation. In order to do this, daily estimates of diversion discharge are also required. These daily diversion discharges, Q_{div}, are combined with the daily predictions of river suspended sediment concentration, C_{river}, to determine the mass loading rate of sediment to the marsh, $Q_{s,div}$ (Equation 8). This increase in temporal resolution allows for examination of diversion discharge operation such that sediment benefits may be maximized by coinciding diversion discharges with periods of high river suspended sediment concentration.

$$Q_{s,div} = Q_{div} C_{river}$$

Equation 8

Sediment Retention

After sediment laden water has been diverted to a coastal wetland, a portion of the sediment load is expected to settle from suspension and deposit. Sediment that remains in suspension is then subject to being transported outside the system boundaries. Sediment retention defines the fraction of diverted sediments retained within the coastal wetland.

Retention is dependent upon system properties such as: wetland geometry, diversion discharge, tidal velocities (Stumpf, 1983), wind and storm events (Wang, 1997), settling velocity of diverted sediments (Soulsby, 1997; Winterwerp and van Kesteren, 2004), vegetation coverage (Stumpf, 1983), and canal-induced sediment import/export (Wang, 1997). The approach taken by Boustany (2007) is to apply retention factors estimated for other sites (e.g. Wax Lake Outlet) or allow the analyst to choose a retention factor based on knowledge of the receiving area and best professional judgment. Building upon the suggestion of Stumpf (1983), an alternative to this approach is to use a simple calculation which includes effects of wetland geometry, sediment properties, and flow hydrodynamics at the site. The effects of vegetation and channels are ignored in this analysis in order to maintain model simplicity; however, vegetation would likely increase roughness, reduce turbulence, and induce greater sediment deposition leading to conservatively low estimates of sediment retention, while the influence of channels may serve as pathways to sediment export and thus produce non-conservatively high estimates of sediment retention.

Consider suspended sediments in a water body. The time required for a given particle to settle from the water surface to the bed is given as:

$$T = \frac{H}{W_{s,eff}}$$

Equation 9

Where T is the time required for sediment to completely settle, H is the local depth, and $W_{s,eff}$ is the effective settling velocity of a specific sediment class.

As the particle settles, it is also transported by tidal and diversion currents, so the distance traveled by the particle is:

$$X = U_{div} T = U_{div} \frac{H}{W_{s,eff}}$$

Equation 10

Where U is the diversion induced mean velocity. As the averaging timescale of the model is greater than the tidal period and net tidal flow is zero, Equation 10 neglects the influence of tidal velocities, and the net displacement of water within the marsh is described by the diversion flow.

For this analysis the wetland is assumed to have rectangular planform and cross-sectional geometries described by the average length (L), width (B), and depth (H). The fraction of sediment retained in the wetland then becomes a function of wetland length relative to transport distance prior to full deposition of the sediment fraction in question (Stumpf, 1983). If all diverted sediment is retained within the system, the retention factor is 1. Since this analysis takes a macroscopic view of the total sediment retained in the system and location of deposit is not considered, the retention factor becomes 1 if the length of the wetland is greater than the transport length, and the retention of a given sediment particle class, R_j, may be expressed as:

$$R_j = \min\left(\frac{L}{X}, 1\right)$$

Equation 11

Due to variation in fall velocity with sediment size, coarse particles may be retained while fines are flushed from the system; therefore, the combined retention of the entire grain size distribution must be made. Retention over all sediment classes may be expressed as:

$$R_T = \sum R_j f_j$$

Equation 12

Where R_T is the combined total retention factor and f_j is the mass fraction associated with each sediment class.

Fall Velocity

A key element of the sediment budgeting model presented is the calculation of the effective fall velocity of a given sediment size class, which is a function of the fall velocity of that sediment in a static body of water, W_s, and the turbulence of the flow. Fall velocity of sediment is dependent upon both sediment properties (shape, size, density, concentration, ability to flocculate) and fluid properties (viscosity, density, temperature, salinity). In the natural environment, turbulence is generated by flow over the sediment bed. The presence of turbulence acts to vertically mix suspended sediments, which reduces the effective settling velocity of suspended particles. The steady-state vertical flux balance at a point in the water column is given by:

$$W_s C + K_z \frac{dC}{dz} = 0$$

Equation 13

Where C is the suspended sediment concentration, K_z is the vertical diffusivity, and z is the vertical distance from the bed.

For the purposes of this tool to estimate retention, it is convenient to combine the terms in Equation 13 to define an effective settling velocity (Equation 14).

$$W_{s,eff} C = W_s C + K_z \frac{dC}{dz}$$

Equation 14

Vertical diffusivity varies with turbulent intensity and height above the bed. Rouse proposes that diffusivity varies parabolically with height above the bed in the form (Richardson et al., 2001):

$$K_z = \kappa u_* z \left(1 - \frac{z}{H}\right)$$

Equation 15

Where κ is the von Karman constant (~0.4) and u_* is the total friction velocity (a measure of turbulent intensity).

Given the sediment flux balance in Equation 13, the vertical concentration profile is:

$$C = C_a \left(\frac{z}{z_a} \frac{H - z_a}{H - z}\right)^{-b}$$

Equation 16

Where b is the Rouse parameter $\left(b = {W_s}/{\kappa u_*}\right)$ and z_a is a reference height above the bed with a known sediment condition, C_a.

The turbulent shear velocity is estimated from the depth-averaged velocity by the logarithmic boundary layer (law of the wall) (Kundu, 1990).

$$u_* = \frac{U\kappa}{\ln\left(\frac{H/3}{z_0}\right)}$$

Equation 17

Where U is the daily mean wetland velocity with both tidal and diversion related components and z_0 is the hydraulic roughness length.

For the diurnal tidal cycle of coastal Louisiana, the tide is assumed to have approximately sinusoidal periodicity. The mean instantaneous wetland velocity can then be determined by considering both tidal and diversion components (Figure 3).

$$U_i = U_{div} + U_{\max,tide}\sin\omega = \frac{Q_{div}}{HB} + U_{\max,tide}\sin\omega$$

Equation 18

Where U_i is the instantaneous mean velocity with tidal and diversion components and $U_{max,tide}$ is the maximum tidal velocity (or tidal amplitude), and ω is tide phase.

For the use in the flow diversion model, the velocity is integrated over the tidal cycle (0 to 2π) to obtain the daily mean velocity, U.

$$U = \frac{1}{2\pi}\left\{U_{div}\left(2\omega_1 - \omega_0 - \omega_2\right) + U_{\max,tide}\left(\cos\left(\omega_2\right) - 2\cos\left(\omega_1\right) + \cos\left(\omega_0\right)\right)\right\}$$

Equation 19

Where ω_0 is the tide phase at zero up-crossing $\left(\omega_0 = \sin^{-1}\left({-U_{div}}/{U_{\max,tide}}\right)\right)$, ω_1 is the tide phase at zero down-crossing $\left(\omega_1 = \pi - \omega_0\right)$, and ω_2 is the completed tidal phase $\left(\omega_2 = \omega_0 + 2\pi\right)$ (Figure 3).

In order to estimate the shear velocity, the hydraulic roughness must also be estimated from local sediment grain size, form roughness, and vegetative coverage. In this analysis, a lumped parameter accounting for both grain size and form roughness is implemented based on marsh surface character (Table 2). Vegetative roughness is incredibly important in coastal marshes where emergent plants are encountered throughout the marsh, and although basing this parameter on bed material ignores the effects of vegetation, this will provide an estimate of sediment settling in open water and will therefore provide conservative estimates of settling in vegetated or partially vegetated marsh.

Combining Equation 13 – Equation 17, one may obtain an expression for the effective settling velocity of sediment in coastal marshes.

$$W_{s,eff} = W_s - bK_z\left(\frac{H - z_a}{z_a}\right)^{-b}\left(\frac{z}{H - z}\right)^{-b-1}\left(\frac{H}{(H - z)^2}\right)$$

Equation 20

For incorporation into the flow diversion model, vertical mixing has been computed at a height above the bed equal to 1/10 of water depth $\left(z = H/10\right)$ and z_a is approximated as 1/100 of the depth $\left(z_a = H/100\right)$. These values provide an estimate of the settling velocity of particles very near the bed that are assumed to settle. Insertion of these relations into Equation 20 yields:

$$W_{s,eff} = W_s - bK_z(99)^{-b}\left(\frac{1}{9}\right)^{-b-1}\left(\frac{0.81}{H}\right)$$

Equation 21

Where $K_z = 0.009\kappa u_* H$.

Net Sediment Benefit

By accounting for sediment loading to the marsh and sediment retention within the marsh, the mass loading rate of sediment retained in the marsh may be determined by:

$$Q_{s,net} = Q_{s,div} R_T$$

Equation 22

Where $Q_{s,net}$ is the net mass loading rate of sediment to the marsh.

This loading rate may then be used to calculate the net aerial sediment benefit due to flow diversion, A_{sed}, for a given time period.

$$A_{sed} = \frac{Q_{s,net}\, dt}{H\rho_{bd}}$$

Equation 23

Where dt is the time step (da) and ρ_{bd} is the average bulk density of the receiving area.

Bulk density in coastal marshes varies significantly with depth due to sediment consolidation. For our analysis, we assumed that the bulk density was a depth averaged value based on the depth of marsh being filled with sediment (i.e. flow depth, H). Bulk density profiles were obtained from literature (Nyman et al., 1990; Nyman et al., 1993; Delaune et al., 2003) and available data (Michael Channel, personal communication).

Application: Caernarvon Diversion and Breton Sound Estuary

In order to verify the ability of the model to account for landscape evolution due to flow diversion, the model was applied to an existing diversion structure and marsh, the Caernarvon Diversion to Upper Breton Sound Estuary (Figure 4). The Caernarvon Diversion is located on the east bank of the Mississippi River at river mile 81.5 (131.2 km) (approximately 12.5 river miles (20.1 km) downstream of New Orleans) and

discharges Mississippi River water into Breton Sound through five 15-ft (4.57-m) box culverts with vertical lift gates (Lane et al., 1999; Snedden et al., 2007). The diversion was constructed between 1988 and 1991 and opened for operation in August of 1991 with goals of reducing the salinity in Breton Sound for commercial shell fisheries. An ancillary benefit of the diversion has been sediment and nutrient loading to the marsh and corresponding reduction in land loss (Snedden et al., 2007).

Upper Breton Sound is approximately 231 mi^2 (599 km^2) in area with a length of 18.8 mi (30.2 km) and a width of 12.3 mi (19.8 km). This estuary was historically an intermediate marsh, but due to RSLR and river/marsh disconnection, marsh salinity elevated to brackish conditions before the diversion became operational (Carter and Bernard, 2007). The current marsh is dominated by brackish species (e.g. *S. patens*) near the diversion and saline marsh species (e.g. *S. alterniflora*) far from the diversion (Snedden et al., 2007).

Breton Sound is hydrologically isolated from surrounding marshes by levees on both the eastern and western borders; therefore accounting for inflows and outflows to the marsh is relatively straightforward with water budgets for Upper Breton Sound revealing major hydrologic processes to be precipitation, evaporation, and freshwater diversion. Groundwater and stormwater inflows have been shown to be relatively small compared to precipitation and diversion (Hyfield, 2004).

In order to maximize the retention time of diverted water and induce desirable sediment settling and nutrient uptake, the State of Louisiana has initiated outfall management for the Caernarvon Diversion. Management actions have included restoration and backfilling of man-made canals, installation of control structures throughout the marsh (Carter and Bernard, 2007), and operational adjustment to test theories of marsh sedimentation processes (Snedden et al., 2007).

Snedden et al. (2007) have shown that a large majority (nearly 99%) of Caernarvon's discharge flows downmarsh through two major flow routes for low discharges. These authors indicate that below 3500 cfs, the diverted waters remain almost entirely in these canals. When diversion discharge exceeds this threshold value, diverted waters appear to exceed canal banks and flow over the marsh as sheet flow (Snedden et al., 2007). This indicates that large pulses of discharge may be more effective in distributing sediments throughout the estuary. These authors also applied a local river sediment rating based on near-surface suspended sediment concentrations of the Mississippi River approximately 5 mi (8 km) downstream of the Caernarvon structure at Belle Chase, Louisiana. By examining sediment loading rates through the diversion, these authors concluded that pulsing of discharges in phase with high river sediment concentrations not only induces sheet flow over the marsh, but also has the ability to load much greater quantities of sediment to the marsh (Snedden et al., 2007).

The Caernarvon Diversion provides an excellent test case for the model developed herein due to the variable discharge inputs and extensive knowledge of current system processes. Table 3 presents the inputs to the model for the Caernarvon Diversion and

Breton Sound. Many of these inputs have a significant amount of variability and have been presented with standard deviations in order to provide the reader with a scale of parameter uncertainty. When data was not available, parameters and ranges were estimated by best professional judgment. Since many of the input parameters contain a significant amount of uncertainty and forecasting land evolution in such a complex system is difficult, model uncertainty has been characterized by a Monte Carlo risk analysis. In this analysis, parameter uncertainty was estimated and assumed normal about the mean. Random errors were then introduced in each parameter for 10,000 calculations. Model results were computed with each set of randomly induced errors, and the range of area predictions was analyzed to determine 90% confidence intervals.

In order to apply the model to Breton Sound, the diversion and river hydrographs must be estimated to indicate marsh nutrient and sediment availability. The river hydrograph may be estimated by using a representative water year or by averaging flows for many years and determining mean daily discharges over a period of record. The diversion hydrograph may be estimated by applying historic operational records, assuming an input hydrograph, testing various operational theories (e.g. pulses timed with river discharge), or linking the discharge to the diversion structure type (e.g. diversion discharge dependence upon river stage using a weir equation). A sample representative diversion and river hydrograph are displayed (Figure 5) for operation of the Caernarvon structure in 1994. Both the diversion and river hydrographs for this year output very near average annual discharge volumes and the peak magnitudes of the hydrographs were well represented; therefore, for this analysis, the diversion and river hydrographs were assumed to be that of the 1994 calendar year for each year of the simulation.

Figure 6 presents the evolution of land area within Upper Breton Sound from before the diversion was opened (1 November 1990) until the end of 2006 (31 December 2006). This figure shows the observed values of marsh area along with estimates by the current model with associated parameter uncertainty alongside the Boustany Model. The estimated future without project (FWOP) is presented to provide the reader with the magnitude of marsh area benefit the Caernarvon Diversion is providing Breton Sound. Vertical lines indicate the beginning of diversion operation and hurricanes making landfall in Louisiana. It is clear that hurricanes create significant perturbations to the system; however, hurricanes may provide both import and export to a given marsh depending upon the location of landfall and are, for the purpose of this screening level model, assumed to create no net import or export of sediment over a long planning horizon.

In addition to model verification at Caernarvon, readers may be interested in the benefits provided by nutrient and sediment components separately; therefore Figure 7 presents the model predictions with nutrient only and sediment only scenarios for the Caernarvon Diversion application.

Optimization of Implemented Diversion

The focus of LACPR has been the analysis of alternatives and the decision support framework associated with choosing diversion sites and quantities. The land evolution

model has been applied as tool for assisting in this framework and has provided relative benefits of various flow diversion sites and scenarios. The utility of the tool, however, has not yet been fully exploited. Following the narrowing of alternatives, the land evolution model may then be used in the initial optimization of the selected diversions by examining different operational and structural scenarios. This type of analysis has not yet been conducted for each of the alternatives of the LACPR, but this section provides a sample of how these analyses might be conducted for a given diversion site. The model will be applied to an existing diversion (Caernarvon) to assess the land gain benefits of six operational and five structural scenarios with near equal annual discharge volumes.

As previously stated, the Caernarvon Diversion discharges Mississippi River water to Upper Breton Sound through five 15 ft box culverts with vertical lift gates which can be used to control diversion discharges to the marsh. For this analysis the diversion is merely used to demonstrate the ability of the land evolution model to provide relative benefits of different operational and structural conditions. Table 3 provides the model inputs used for these optimization exercises. For these analyses, the 1994 Mississippi River hydrograph was found to be representative of the average annual discharge volume, peak magnitude, and seasonality of flow in the river and has been used throughout the duration of the model simulations in these exercises.

Operational Optimization of Gate Structures

The continuous hydrographic inputs of the model provide a tool for optimizing gate-type diversion operation to obtain the greatest land evolution benefits. In this section, the model will be applied to demonstrate the operational benefits for the six approximately equal-volume discharge scenarios that follow (Figure 8). These annual hydrographs were chosen based on previous research indicating that pulsing and timing of diversions may be critical to land evolution (Day et al., 2003; Snedden et al., 2007).

1. Historic operation based on 2003 operational conditions (a “pulsed” diversion year with a large portion of the annual sediment load derived from two two-week pulses)
2. Simulated operation with a large pulse of one-month duration timed *in phase* with high river sediment discharges
3. Simulated operation with a large pulse of one-month duration timed *out of phase* with high river sediment discharges
4. Simulated operation with a small pulse of six-month duration timed *in phase* with high river sediment discharges
5. Simulated operation with a small pulse of six-month duration timed *out of phase* with high river sediment discharges
6. Constant diversion discharge

Each of the annual hydrographs was input to the model, and land evolution estimates were made for a 50 year time period starting at the arbitrary starting date of January 1, 2001 (Figure 9). These results indicate that, for the inputs considered, the magnitude and timing of the diversion discharges is critical to suppression of the land loss rate. Therefore, for this hypothetical diversion scenario at Caernarvon, the diversion of flows

could be altered to be in phase with high river sediment discharges and should occur from later winter to early summer (February – June). These periods of high sediment discharge may not, however, align with other project goals of a given diversion (e.g. reduction of salinity for maintenance of commercial fisheries). This analysis indicates a time period over which the greatest land evolution benefits may be obtained, and diversion operation may be optimized within that timeframe to include multiple project goals.

Structure Selection

Not only will operational considerations impact diversion benefits, but structure type will also have a drastic impact on the selection and operation of a given diversion. For instance, a gate-type structure (such as the one at Caernarvon) may be controlled to achieve the desired water and sediment discharges, but the cost and maintenance may be high. Whereas a broad-crested weir may have low cost, but control of diversion discharges is relatively minimal. A siphon is a third common diversion structure that may require significant maintenance and operational effort, but the suspended sediment concentration of the diverted water may be higher and the size gradation of the sediment diverted may be significantly larger inducing more land gain on both accounts. This section will demonstrate the ability of the model to assess land evolution by applying the model to the Caernarvon Diversion for the following five hypothetical structural scenarios:

1. Gate structure with pulsed operation based on the 2003 hydrograph
2. 100-ft wide broad-crested weir
3. 200-ft wide broad-crested weir structure
4. 1 – 15 ft siphon with a single short duration (113 day) discharge event
5. 1 – 6 ft siphon with continuous operation throughout the year

The weir structures have been assumed to behave as theoretical broad-crested weirs (Equation 24) and the discharge was determined based on the Mississippi River stage for the representative hydrograph (1994). The weir elevations were adjusted to produce annual discharge volumes approximately equal to the average annual diversion discharge volume from 1991-2006.

$$Q_{div} = C_{weir} B_{weir} \left(z_{river} - z_{weir} \right)^{3/2}$$

Equation 24

Where C_{weir} is a weir coefficient (~4.37 $ft^{0.5}/s$), B_{weir} is the width of the weir (ft), z_{river} is the elevation of the river for a given flow rate (ft), z_{weir} is the elevation of the weir (ft) (White, 2003).

In order to calculate the discharge of the diversion by siphoning, Bernoulli's equation was implemented (Equation 25). Frictional losses in the pipe were assumed negligible due to the qualitative nature of this analysis. As with the weir, the marsh elevation was optimized to produce annual discharge volumes approximately equal to the average annual diversion discharge volume from 1991-2006. Figure 10 presents diversion discharge hydrographs for the five scenarios considered.

$$Q_{div} = V_{siphon} A_{siphon} = \sqrt{2g\left(z_{river} - z_{marsh}\right)}\left(\frac{\pi d^2}{4}\right)$$

Equation 25

Where z_{marsh} is the elevation of the marsh and d is the pipe diameter.

The land evolution model was applied using these annual diversion hydrographs and the parameters from the Caernarvon Diversion (Table 3). The only alteration of the Caernarvon model inputs was the sediment rating curve and size fraction applied to the siphon calculations. A weir or gate structure diverts surface waters of the Mississippi River to the marsh, and the Belle Chase surface sediment rating presented in Table 1 was determined as such (Snedden et al., 2007), but a siphon could draw water from lower in the water column, producing a larger sediment concentration and a more coarse sediment size fraction. As such, the total sediment rating at Belle Chase was applied with an assumed size fraction distribution based on the observed fraction of silt and clay (f_{sand} = 0.12, f_{silt} = 0.44, f_{clay} = 0.44, f_{floc} = 0.3).

As evident by the land evolution calculations (Figure 11), the benefits of flow diversion are extremely sensitive to the size fraction and concentration of the river water diverted. Therefore, the choice of structure type from a land evolution perspective is overwhelmingly in favor of siphons which divert higher concentrations of coarser sediment. However, logistical difficulties associated with operation and maintenance of a siphon (e.g. maintaining head differential, priming the siphon, air intrusion) may eliminate this structure type from consideration in many instances. It is also important to note that the results presented herein likely offer overly optimistic benefits of siphon structures due to the exclusion of friction in the siphon and the use of the total suspended sediment rating at Belle Chase. Although the siphon will be able to draw water from lower in the Mississippi River water column than a gate or weir, in order to maintain appropriate pressure differential for flow to the marsh, the siphon inlet will likely be required to draw in the upper half of the water column where suspended sediment concentrations are lower. The land evolution benefits of a siphon may also be overshadowed by other project objectives which may be detrimentally impacted by high turbidity or suspended sediment concentrations, such as fisheries production and marsh vegetation stimulation.

Summary of Diversion Optimization

The purpose of this exercise was not to identify an operational condition or structural alternative that is ideal for all flow diversions in coastal Louisiana, but was instead to demonstrate the land evolution model's ability to maximize land gain benefits for various operational and structural alternatives. Land gain (or suppression of land loss) is often not the only objective in the large-scale, long-term projects of the LACPR, and many other factors may be included in the selection of a diversion operational or structural scheme, some of which include:

- Cost of diversion with both structural and operation/maintenance components
- Desire to control diversion releases
- Commercial fisheries impacts
- Public recreational land use patterns

Conclusions

This paper has presented the adaptation of a model for quantifying flow diversion benefits and demonstrated the model's ability to estimate the relative benefits of various flow diversion locations, structures, and operational regimes; however, the model results are limited due to the exclusion of a variety of important system processes. Some of the major assumptions and limitations of the model were:

- Benefits of flow diversion are independent (in reality the benefits are likely non-linearly coupled due to vegetation inducing sediment deposition and sedimentation increasing suitable habitat for vegetation)
- Nutrients serve as a reduction in land loss, not a source of land gain benefits (Deposition of particulate organic matter neglected)
- Spatial uniformity - vegetation, roughness, bulk density, and other parameters are highly heterogeneous in coastal marshes
- Temporal resolution is only represented intra-annually, not contiuously
- Rectangular wetland geometry
- No vegetative component to settling/roughness
- Organic accumulation is not considered as a function of time even through biomass production is highly seasonal
- No habitat switching with time
- Canals are not accounted for as a sediment loss mechanism
- Sheetflow was assumed for all diversion flow rates
- No sediment resuspension due to rainfall, tidal flows, waves, or hurricanes
- Uniform distribution of sedimentation.
- Nutrient recycling neglected

Although these assumptions significantly limit the model's ability to quantify the benefits of flow diversion, approximations had to be made due to the time and resource constraints under which the model was developed. Further refinement of model processes and algorithms are recommended and should address the above limitations specifically focusing on the following:

- Temporal distribution of nutrient benefits to account for seasonality and storage
- Nutrients as a source of benefit, not just a source of loss reduction. Refer to the organic accumulation models of Blum et al. (1978), Mitsch and Reeder (1991), and Reyes et al. (2000) for examples of organic benefit frameworks
- Nutrient retention calculations inclusive of marsh nutrient cycling processes (e.g. denitrification, burial)
- Division of nutrients – nutrients should be divided into individual components (e.g. nitrogen and phosphorous) due to marsh limitation to a single nutrient
- Salinity is roughly covered in the model by the adjustment of bulk density and primary productivity, but the parameter is not explicitly covered and habitat switching is not tracked
- Spatial complexity/geometry improvements
- Inclusion of coastal currents and erosion, major storm events, and wind erosion
- Better methods of accounting for hydraulic resistance

Acknowledgements

This effort was developed and funded under the Louisiana Coastal Protection and Restoration (LACPR) Program of the U.S. Army Corps of Engineers. The authors would like to acknowledge the LACPR Habitat Evaluation Team (HET), and their extensive technical guidance of the development of the technology presented herein. In particular, Ronald Paille and Tamieka Armstrong provided critical feedback on formulation and application of the model. Ron Boustany provided the basis for the nutrient model presented herein and the authors are grateful for his willingness to assist in this effort. Gregg Snedden, Joann Mossa, Robert Lane, and Mike Channell all provided valuable data and knowledge resources throughout the development of this model.

References

Barras, J.A., P.E. Bourgeois, and L.R. Handley. (1994). "Land Loss in coastal Louisiana 1956-1990." *Open File Report 94-01*. National Biological Survey, National Wetlands Research Center, Lafayette, Louisiana.

Baustian, J.J. and R.E. Turner. (2006). "Restoration Success of Backfilling Canals in Coastal Louisiana Marshes." *Restoration Ecology*. Society for Ecological Restoration International, Vol. 14 (4).

Blum, U., E.D. Seneca, and L.M. Stroud. (1978). "Photosynthesis and Respiration of *Spartina* and *Juncus* Salt Marshes in North Carolina: Some Models." *Estuaries*. Estuarine Research Federation, Vol. 1 (4), pp. 228-238.

Boustany, R.G. (2007). "A Method of Estimating the Benefit of Freshwater Introduction into Coastal Wetland Ecosystems: Nutrient and Sediment Analysis." *April 2007 Draft Report*, USDA-NRCS, Lafayette, LA.

Cardoch, L., J.W. Day, C. Ibanez. (2002). "Net Primary Productivity as an Indicator of Sustainability in the Ebro and Mississippi Deltas." *Ecological Applications*. Ecological Society of America, Vol. 12 (4), pp. 1044-1055.

Carter, B.S. and T. Bernard. (2007). "2004 Operations, Maintenance, and Monitoring Report for Caernarvon Diversion Outfall Management." Louisiana Department of Natural Resources Coastal Restoration Division and Coastal Engineering Division, New Orleans, Louisiana.

Church, J.A., J.M. Gregory, P. Huybrechts, M. Kuhn, K. Lambeck, M.T. Nhuan, D. Qin, and P.L. Woodworth. (2001). "Changes in Sea Level." In: *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Eds. Houghton, J.T.,Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson. Cambridge University Press, New York, NY, 881pp.

Coleman, J.M. (1988). "Dynamics Changes and Processes in the Mississippi River Delta." *Geological Society of America Bulletin*. Geological Society of America, Vol. 100, pp. 999-1015.

Coleman, J.M., H.H. Roberts, and G.W. Stone. (1998). "Mississippi River Delta: an Overview." *Journal of Coastal Research*. Vol. 14 (3), pp. 698-716.

Day, J.W., D. Pont, P.F. Hensel, and C. Ibanez. (1995). "Impacts of Sea-Level Rise on Deltas in the Gulf of Mexico and Mediterranean: The Importance of Pulsing Events to Sustainability." *Estuaries*. Estuarine Research Federation, Vol. 18 (4), pp. 636-647.

Day, J.W. et al. (2003). "Pulses: The Importance of Pulsed Physical Events for Louisiana Floodplains and Watershed Management." *Proceedings of the First Interagency Conference on Research in the Watersheds*. USDA-ARS, Benson, AZ.

Deegan, L.A., et al. (2007). "Susceptibility of Salt Marshes to Nutrient Enrichment and Predator Removal." *Ecological Applications*. Ecological Society of America, Vol. 17 (5), pp. S42-S63.

Delaune, R.D. and S.R. Pezeshiki. (2003). "The Role of Soil Organic Carbon in Maintaining Surface Elevation in Rapidly Subsiding U.S. Gulf of Mexico Coastal Marshes." *Water, Air, and Soil Pollution*. Kluwer Academic, Vol. 3, pp. 167-179.

Delaune, R.D., S.R. Pezeshki, and A. Jugsujinda. (2005). "Impact of Mississippi River Freshwater Reintroduction on *Spartina patens* Marshes: Responses to Nutrient Input and Lowering of Salinity." *Wetlands*. Society of Wetland Scientists, Vol. 25 (1).

Delaune, R.D., C.N. Reddy, and W.H. Patrick. (1981). "Accumulation of Plant Nutrients and Heavy Metals through Sedimentation Processes and Accretion in a Louisiana Salt Marsh." *Estuaries*. Estuarine Research Federation, Vol. 4 (4).

Delaune, R.D., A. Jugsujinda, G.W. Peterson, and W.H. Patrick. (2003). "Impact of Mississippi River Freshwater Reintroduction on Enhancing Marsh Accretionary Processes in a Louisiana Estuary." *Estuarine, Coastal, and Shelf Science*. Elsevier, Vol. 58, pp. 653-662.

Delaune, R.D., A. Jugsujinda, J.L. West, C.B. Johnson, and M. Kongchum.. (2005). "A Screening of the Capacity of Louisiana Freshwater Wetlands to Process Nitrate in Diverted Mississippi River Water." *Ecological Engineering*. Elsevier, Vol. 25, pp. 315-321.

Dokka, R.K., G.F. Sella, and T.H. Dixon. (2006). "Tectonic Control of Subsidence and Southward Displacement of Southeast Louisiana with Respect to Stable North America." *Geophysical Research Letters*. AGU, Vol. 33.

Dortch, M.S., M. Zakikhani, M.R. Noel, and S.C. Kim. (2007). "Application of a Water Quality Model to Mississippi Sound to Evaluate Impacts of Freshwater Diversion." *ERDC/EL TR07-20*. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi.

Edwards, K.R. and K.P. Mills. (2005). "Aboveground and Belowground Productivity of *Spartina Alterniflora* (Smooth Cordgrass) in Natural and Created Louisiana Salt Marshes." *Estuaries*. Estuarine Research Federation, Vol. 28 (2), pp. .

Foote, A.L. and K.A. Reynolds. (1997). "Decomposition of Saltmeadow Cordgrass (*Spartina patens*) in Louisiana Coastal Marshes." *Estuaries*. Estuarine Research Federation, Vol. 20 (3), pp. 579-588.

Gleason, M.L., D.A. Elmer, N.C. Pien and J.S. Fisher. (1979). "Effects of Stem Density upon Sediment Retention by Salt Marsh Cordgrss, *Spartina Alterniflora* Loisel." *Esturaies*. Estuarine Research Federation, Vol. 2 (4), pp. 271-273.

Gosselink, J.G. (1984). "The Ecology of Delta Marshes of Coastal Louisiana: A Community Profile." *FWS/OBS-84109*. USFWS, Washington, D.C.

Hyfield, E.C.G. (2004). "Freshwater and Nutrient Inputs to a Mississippi River Deltaic Estuary with River Reintroduction." Master's Thesis, Louisiana State University.

Hyfield, E.C.G., J.W. Day, J.E. Cable, and D. Justic. (2008). "The Impacts of Re-Introducing Mississippi River Water on the Hydrologic Budget and Nutrient Inputs of a Deltaic Estuary." *Ecological Engineering*. Elsevier, Vol. 32, pp. 347-359.

Kundu, P.K. (1990). Fluid Mechanics. Academic Press, San Diego.

Lane, R.R., J.W. Day, and B. Thibodeaux. (1999). "Water Quality Analysis of a Freshwater Diversion at Caernarvon, Louisiana." *Estuaries*. Estuarine Research Federation, Vol. 22 (2A), pp. 327-336.

Leonard, L.A. and M.E. Luther. (1995). "Flow Hydrodynamics in Tidal Marsh Canopies." *Limnology and Oceanography*. American Society of Limnology and Oceanography, Vol. 40 (8), pp. 1474-1484.

McKay, S.K., J.C. Fischenich, and S.J. Smith. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. I: Theory." In draft for submission to *Ecological Engineering*. Elsevier.

McKay, S.K., J.C. Fischenich, and R. Paille. (2008). "Quantifying Benefits of Flow Diversion to Coastal Marshes. II: Application to Louisiana Coastal Protection and Restoration." In draft for submission to *Ecological Engineering*. Elsevier.

Mitsch, W.J. and B.C. Reeder. (1991). "Modelling Nutrient Retention of a Freshwater Coastal Wetland: Estimating the Roles of Primary Productivity, Sedimentation, Resuspension, and Hydrology." *Ecological Modelling*. Elsevier, Vol. 54, pp. 151-187.

Mitsch, W.J., J.W. Day, J.W. Gilliam, P.M. Groffman, D.L. Hey, G.W. Randall, and N. Wang. (2001). "Reducing Nitrogen Loading to the Gulf of Mexico from the Mississippi River Basin: Strategies to Counter a Persistent Ecological Problem." *Bioscience*. Bioscience, Vol. 51 (5), pp. 373.388.

Morris, J.T. (2007). "Ecological Engineering in Intertidal Saltmarshes." *Hydrobiologia*. Springer, Vol. 577, pp. 161-168.

Morton, R.A., N.A. Buster, and M.D. Krohn. (2002). "Surface Controls on historical Subsidence Rates and Associated Wetland Loss in South-Central Louisiana." *Transactions of the Gulf Coast Association of Geological Societies*. Vol. 52, pp. 767-778.

Mossa, J. (1996). "Sediment Dynamics in the Lowermost Mississippi River." *Engineering Geology*. Elsevier, Vol. 45, pp. 457-479.

Nyman, J.A., R.D. Delaune, and W.H. Patrick. (1990). "Wetland Soil Formation in the Rapidly Subsiding Mississippi River Deltaic Plain: Mineral and Organic Matter Relationships." *Estuarine, Coastal, and Shelf Science*. Academic Press, Vol. 31, pp.57-69.

Nyman, J.A., R.D. Delaune, H.H. Roberts, and W.H. Patrick. (1993). "Relationship between Vegetation and Soil Formation in a Rapidly Submerging Coastal Marsh." *Marine Ecology Progress Series*. Inter-Research, Vol. 96, pp.269-279.

Nyman, J.A., R.D. Delaune, S.R. Pezeshki, and W.H. Patrick. (1995). "Organic Matter Fluxes and Marsh Stability in a Rapidly Submerging Estuarine Marsh." *Estuaries*. Estuarine Research Federation, Vol. 18 (1B), pp. 207-218.

Nyman, J.A., R.J. Walters, R.D. Delaune, and W.H. Patrick. (2006). "Marsh Vertical Accretion Via Vegetative Growth." *Estuarine, Coastal, and Shelf Science*. Elsevier, Vol. 69, pp.370-380.

Parker, G., O. Sequeiros, and River Morphodynamics Class Spring, 2006. (2006). "Large Scale River Morphodynamics: Application to the Mississippi Delta." Proceedings River Flow 2006 Conference, Lisbon, Portugal, September 6-8, 2006, Balkema.

Reed, D.J. (1995). "The Response of Coastal Marshes to Sea-Level Rise: Survival or Submergence?." *Earth Surface Processes and Landforms*. John Wiley & Sons, Ltd., Vol. 20, pp. 39-48.

Reyes, E., M.L. White, J.F. Martin, G.P. Kemp, J.W. Day, and V. Aravamuthan. (2000). "Landscape Modeling of Coastal Habitat Change in the Mississippi Delta." *Ecology*. Ecological Society of America, Vol. 81(8), pp. 2331-2349.

Reyes, E., R. Lane, and J.W. Day. (2003). "Watershed Analysis of Pulsing Freshwater Events Using Landscape Modeling in Coastal Louisiana." *Proceedings of the First Interagency Conference on Research in the Watersheds*. USDA-ARS, Benson, AZ.

Richardson, E.V., D.B. Simons, and P.F. Lagasse. (2001). "River Engineering for Highway Encroachments: Highways in the River Environment." *FHWA-NHI-01-004-HDS-6*. FHWA, Washington, D.C.

Rybczyk, J.M. and D.R. Cahoon. (2002). "Estimating the Potential for Submergence for Two Wetlands in the Mississippi Delta." *Estuaries*. Estuarine Research Federation, Vol. 25 (5), pp. 985-998.

Snedden, G.A., J.E. Cable, C. Swarzenski, and E. Swenson. (2007). "Sediment Discharge into a Subsiding Louisiana Deltaic Estuary Through a Mississippi River Diversion." *Estuarine, Coastal, and Shelf Science*. Elsevier, Vol. 71, pp.181-193.

Soulsby, R.L. (1983). "The bottom boundary layer of shelf seas." In Physical Oceanography of Coastal and Shelf Seas, ed. B. Johns, pp. 189-266. Elsevier, Amsterdam.

Soulsby, R.L. (1997). "Dynamics of marine sands." Thomas Telford, London.

Stumpf, R.P. (1983). "The Process of Sedimentation on the Surface of a Salt Marsh." Estuarine, Coastal, and Shelf Science. Academic Press Inc., Vol. 17, pp. 495-508.

United States Army Corps of Engineers (USACE). (2006). "Louisiana Coastal Protection and Restoration: A Preliminary Technical Report to United States Congress." U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana.

Visser, J.M. et al. (2004). "Chapter C.9: Habitat Switching Module." In Louisiana Coastal Area (LCA) Ecosystem Restoration Study, Appendix C. U.S. Army Corps of Engineers, New Orleans, Louisiana.

Wang, F.C. (1997). "Dynamics of Intertidal Marshes near Shallow Estuaries in Louisiana." *Wetlands Ecology and Management*. Kluwer Academic, Vol. 5, pp.131-143.

White, F. M. (2003). Fluid Mechanics: Fifth Edition. McGraw-Hill, New York, New York.

Winterwep, J.C. and W.G.M. van Kesteren. (2004). Introduction to the Physics of Cohesive Sediment in the Marine Environment. Developments in Sedimentology Series No. 56 xiii, 446 pp. Elsevier, Amsterdam, The Netherlands.

Figures



Figure 1. Typical coastal Louisiana marsh community with a patchwork of dense vegetation and open water

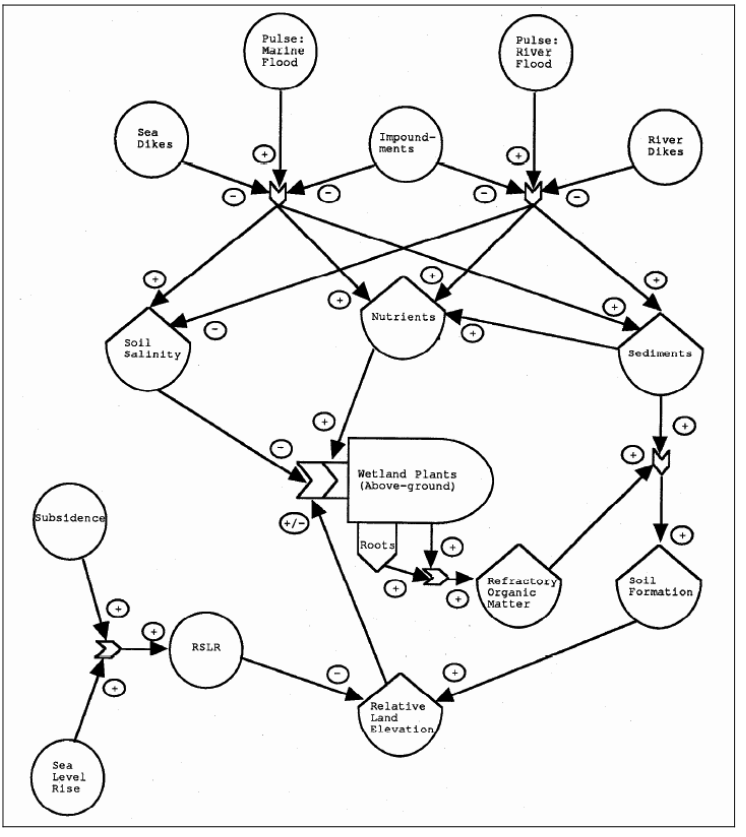


Figure 2. Conceptual model of coastal Louisiana marsh accretionary processes (from Day et al., 1995)

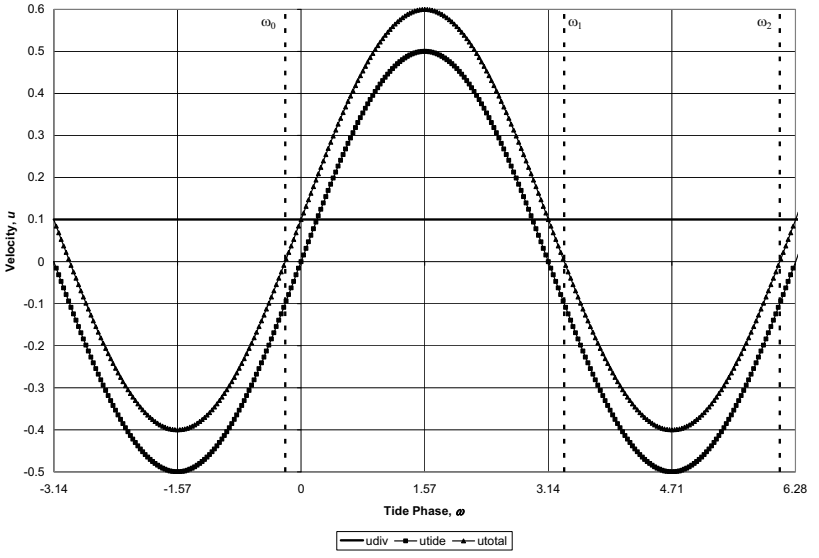


Figure 3. Wetland velocity with diversion and tidal components



Figure 4. Aerial view of Breton Sound displaying Caernarvon Diversion and project division areas for tracking land evolution. In this analysis only the following areas were considered to be directly influenced by the Caernarvon Diversion in order to maintain relative uniformity in conditions: Upper Reference Outfall East, Upper Project Outfall, Upper Reference West, Middle Reference West, and Middle Project Area.

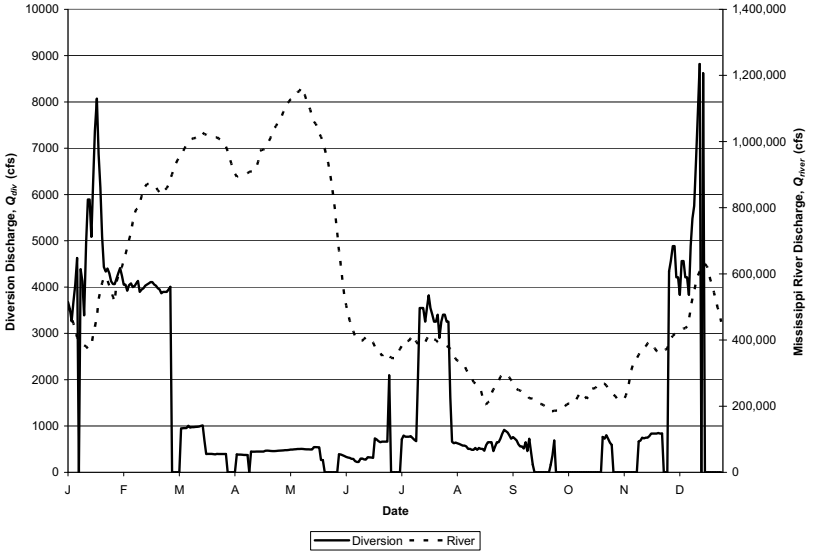


Figure 5. Representative diversion and river hydrographs for land evolution forecasting associated with the Caernarvon Diversion (1994 hydrographs)

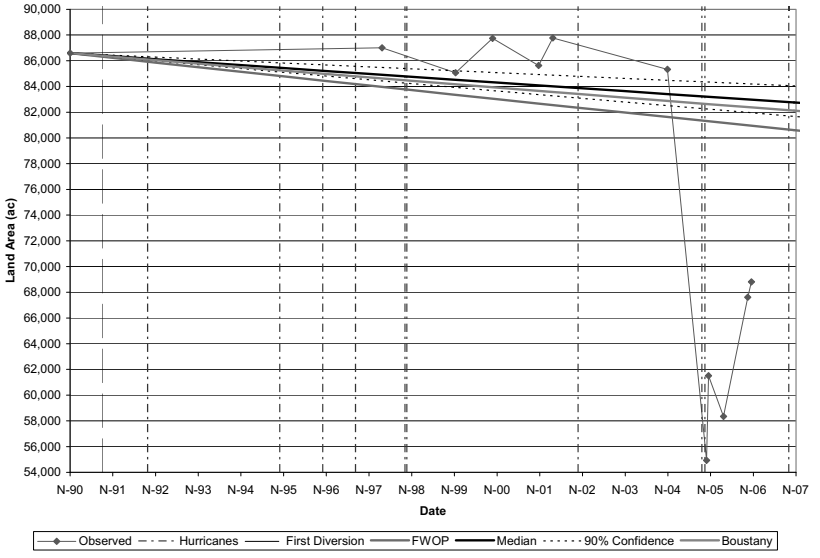


Figure 6. Marsh area prediction for the Caernarvon Diversion from 1990-2006 with observed acreages, model predictions with parameter uncertainty bounds, as well as the Boustany Model predictions

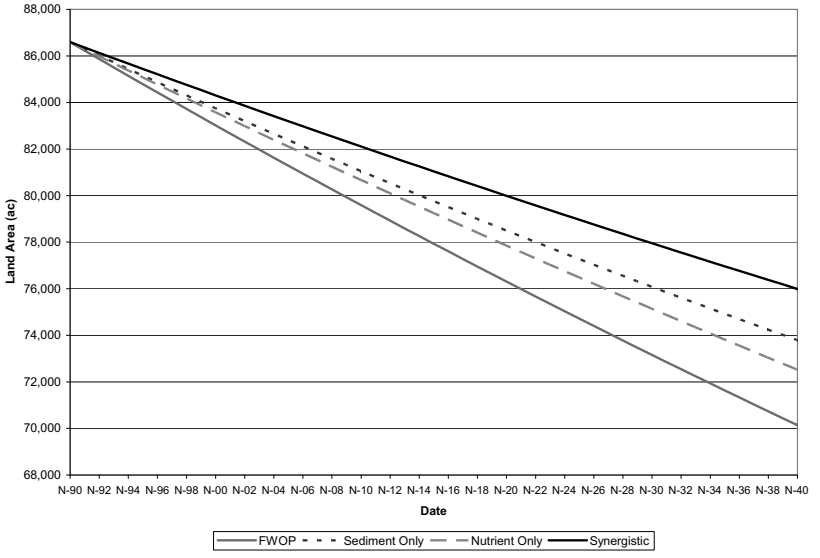


Figure 7. Marsh area prediction for the Caernarvon Diversion from 1990-2040 with isolated nutrient and sediment benefits

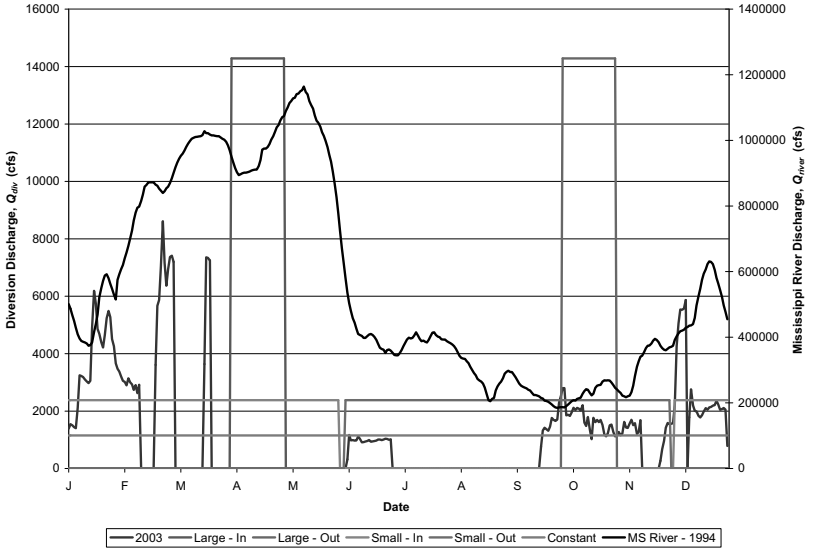


Figure 8. Hydrographs considered in Caernarvon Diversion operational optimization

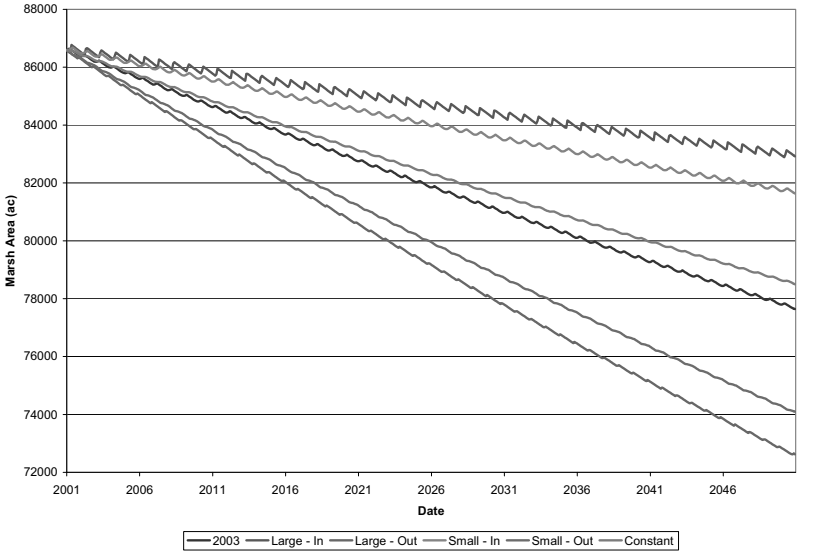


Figure 9. Land evolution predictions for multiple operational scenarios at the Caernarvon Diversion

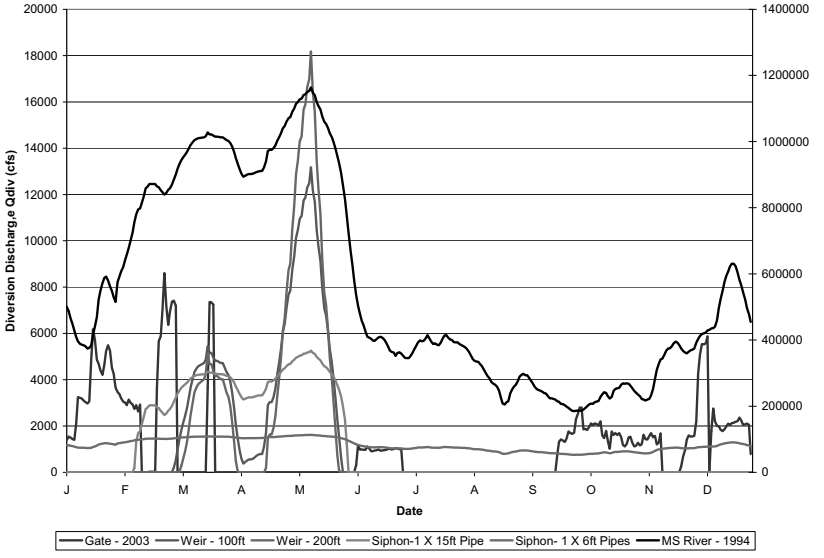


Figure 10. Calculated hydrographs for various structure types at the Caernarvon Diversion

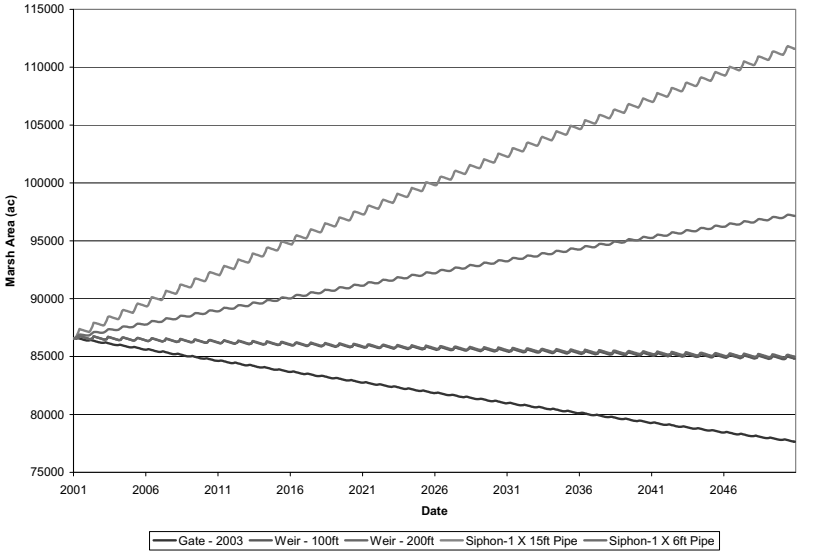


Figure 11. Land evolution predictions for various structure types at the Caernarvon Diversion

Tables

Table 1. Sediment Ratings for Rivers on the Louisiana Coastal Plain

River	Gauge Location	a_1	a_2	R^2
Mississippi	Belle Chase Surface*	3.205E-07	2.000	0.6648
	Belle Chase	1.237E-08	2.320	0.7302
	Tarbert - 1949-1975	1.192E-04	1.702	0.7945
	Tarbert - 1975-2007	7.096E-03	1.342	0.7689
	St. Francisville	6.501E-04	1.507	0.7357
Atchafalaya	Melville	4.941E-06	1.937	0.7764
	Simmesport	8.286E-04	1.563	0.8138

All ratings developed from suspended sediment concentrations and water discharges from USGS Website except "Belle Chase Surface"

*Surface concentrations of suspended sediment at Belle Chase and Tarbert's Landing Discharges (Snedden et al., 2007)

Table 2. Hydraulic roughness height as a function of bed material grain size

Channel Boundary	Roughness Height, z_0[1]		
	ft	mm	m
Mud	6.6E-04	0.2	2.0E-04
Mud/Sand	2.3E-03	0.7	7.0E-04
Silt/Sand	1.6E-04	0.05	5.0E-05
Sand (unrippled)	1.3E-03	0.4	4.0E-04
Sand (rippled)	2.0E-02	6	6.0E-03
Sand/Shell	9.8E-04	0.3	3.0E-04
Sand/Gravel	9.8E-04	0.3	3.0E-04
Mud/Sand/Gravel	9.8E-04	0.3	3.0E-04
Gravel	9.8E-03	3	3.0E-03

[1]Adapted from Soulsby (1983, Table 5.4)

Table 3. System properties and land evolution model parameters for the Caernarvon Diversion to Breton Sound Estuary

Parameter	Best Estimate	Approximate Standard Deviation
General System Properties		
Initial Land Area (ac)[#]	86,591	-
Project Area (ac)[#]	148,018	-
Average Water Depth, H (ft)[*]	3	0.5
Average Water Width, B (ft)	65,000[#]	1,000[*]
Maximum Tidal Velocity, $U_{tide,max}$ (ft/s)[*]	0.6	0.1
Roughness Height, z_o (ft)[*]	0.005	0.0005
Land Loss Rate (%/y)[1]	-0.42	0.042
Bulk Density, ρ_{bd} (g/cm^3)	0.26	-
Sediment Rating of Surface Concentrations of the Mississippi River at Belle Chase[2]		
Coefficient	3.205E-07	3.21E-08
Exponent	2.000	-
Size Fraction of Belle Chase Rating[2]		
Sand	0.01	0.0017
Silt	0.63	0.1050
Clay	0.36	-
Floc Fraction[*]	0.3	0.0667

1236

Parameter	Best Estimate	Approximate Standard Deviation
Approximate Fall Velocity[3] (m/s)		
Sand	1.00E-02	8.33E-04
Silt	3.00E-04	2.50E-05
Clay	7.00E-06	5.83E-07
Floc Fraction	2.00E-04	4.00E-05
Marsh Nutrient Requirements		
Plant Productivity Rate, P_r (g/m^2yr)[*]	4,150	415
Percent of N and P in Plant Biomass, γ_{TNP}(%)[4]	0.72	0.072[*]
Nutrient Loading to Marsh		
Background Concentration of N and P, $C_{background}$ (mg/L)[5]	0.34	0.034[*]
Sourcewater Concentration of N and P, C_{source} (mg/L)[#]	2.28	0.5[*]
Nutrient Retention, R_{nut} (%)[*]	50	10

[1]Land loss rate calculated from observed marsh acreage from 1978-1990

[2]Data for rating and size fraction from Snedden et al. (2007)

[3]Calculated from method of Soulsby (1997)

[4]Foote and Reynolds (1997)

[5]Hyfield (2004)

[#]Available data

[*]Best professional judgment

Symbols

b = Rouse parameter
d = Diameter of siphon
f_i = Sediment size fraction i
g = Acceleration due to gravity
u_* = Shear velocity
x = Longitudinal or down-marsh coordinate
y = Horizontal or cross-marsh coordinate
z = Vertical coordinate
z_0 = Hydraulic roughness length
z_a = Reference depth
z_{river} = River stage
z_{marsh} = Marsh Elevation
z_{weir} = Weir Elevation
A = Marsh area
A_{veg} = Vegetated area of receiving area
A_{nut} = Total aerial nutrient benefit from flow diversion
A_{sed} = Total aerial sediment benefit from flow diversion
A_{siphon} = Cross-sectional area of siphon
B = Average marsh width
B_{weir} = Weir width
C = Suspended sediment concentration
C_a = Suspended sediment concentration at reference elevation z_a
C_{river} = Suspended sediment concentration of river
C_{source} = Nutrient concentration of source water
C_{weir} = Theoretical weir coefficient
E_{sus} = Percent of wetland sustained by nutrient loading
H = Average marsh depth
K_z = Vertical diffusivity
L = Average marsh length
LR_{req} = Marsh required nutrient loading rate
LR_{div} = Loading rate of nutrients from the flow diversion
$LR_{background}$ = Background loading rate of nutrients from preexisting marsh sources
LR_{net} = Net loading rate of nutrients from diversion and background sources (=LR_{div} - $LR_{background}$)
P_r = Primary Production
Q_{div} = Volumetric water discharge through diversion
$Q_{s,river}$ = Sediment discharge of river
$Q_{s,div}$ = Sediment discharge of diversion
$Q_{s,net}$ = Rate of sediment discharged to and retained in marsh
R_i = Sediment retention of size fraction i
R_T = Total sediment retention factor
T = Time required for particle settling
U = Daily mean velocity with tidal and diversion related components
U_i = Instantaneous mean velocity with tidal and diversion related components

U_{div} = Diversion induced velocity (= Q_{div} / HB)
$U_{max,tide}$ = Maximum tidal velocity (tidal velocity amplitude)
V_{siphon} = Velocity of flow in siphon
W_s = Natural settling velocity
$W_{s,eff}$ = Effective settling velocity due to natural settling and turbulence
X = Transport distance of suspended sediment
δ = Land change rate (% / time)
δ_{nut} = Nutrient suppressed land change rate (% / time)
γ_{nut} = Percent of plant biomass made up of nutrients
κ = von Karman's constant (0.4)
ω = Tide phase
ω_0 = Tide phase of the up-crossing zero velocity
ω_1 = Tide phase of the down-crossing zero velocity (=$\omega_0 + \pi$)
$\omega_2 = \omega_0 + 2\pi$

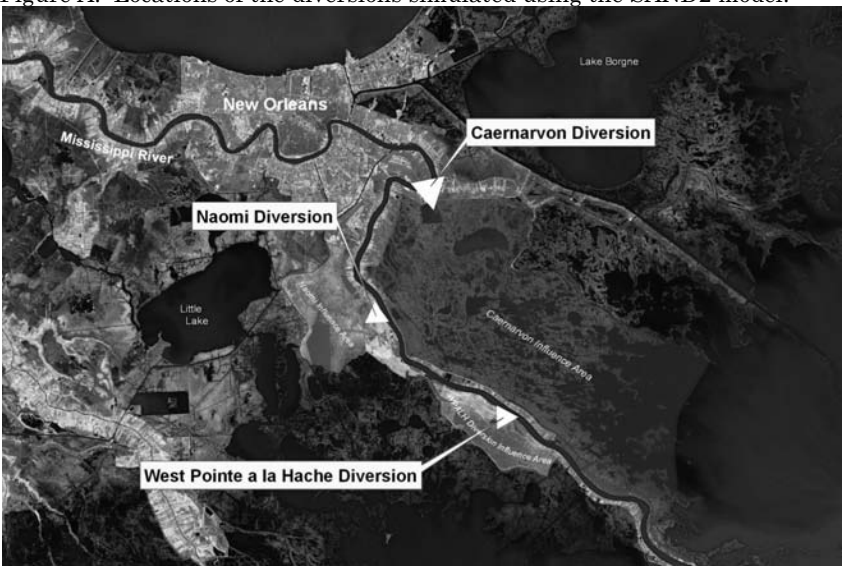
ANNEX 2

ERDC-SAND2 Model Verification

ERDC-SAND2 Model Verification

Verification of the SAND2 model was conducted by simulating the effects of the freshwater diversions (siphons) at Naomi and West Pointe a la Hache, both of which began operating in 1993 (Figure A), and the larger Caernarvon Freshwater Diversion Project, which began operating in 1991.

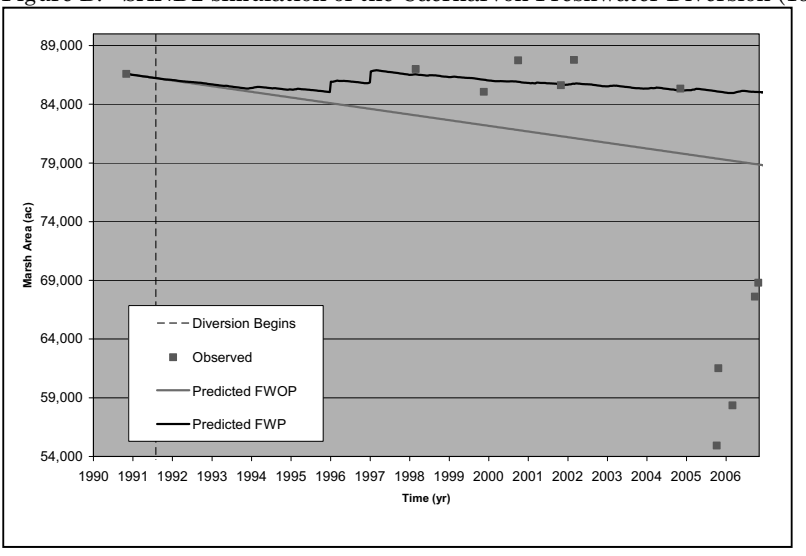
Figure A. Locations of the diversions simulated using the SAND2 model.



Daily discharge information from each of these diversions was used as input into the SAND2 model. Wetland acreages from the respective influence areas, from 1956 to 1990 were used to determine pre-diversion wetland loss rates. The SAND2 model was then used to predict post-operation wetland acreages. Those predicted acreages were then compared to post-operation observed wetland acreages to verify model results.

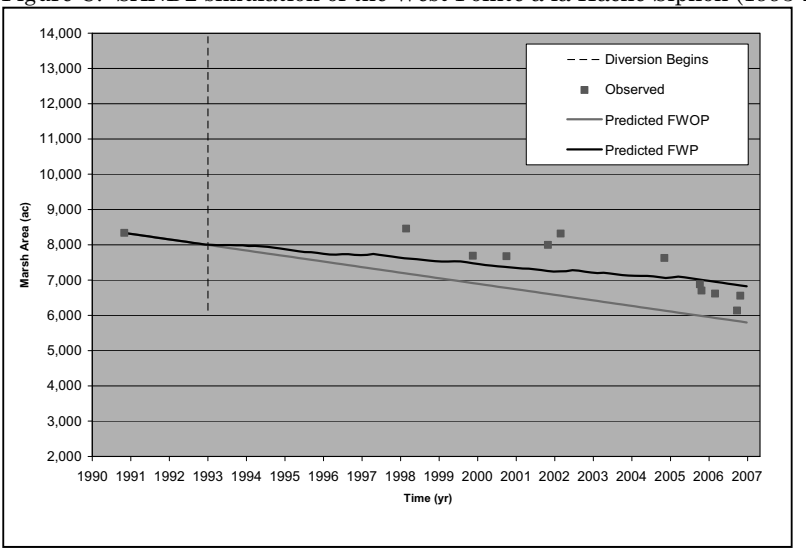
The SAND2 model did a reasonably good job forecasting Caernarvon benefits until 2005 when Hurricane Katrina caused severe marsh loss in the influence area. Because the model does not incorporate effects of major storm impacts, the model-predicted acreages differed dramatically from observed acreages following Katrina (Figure B).

Figure B. SAND2 simulation of the Caernarvon Freshwater Diversion (1991-2006).



Compared to the 8,000 cubic feet per second (cfs) design maximum discharge for the Caernarvon Diversion structure, the maximum discharge of the 2 siphons is roughly 2,000 cfs. Although the SAND2 model did a fairly good job predicting the effects of the West Pointe a la Hache Siphon (Figure C), the predicted results tended to underestimate actual observed wetland acreages.

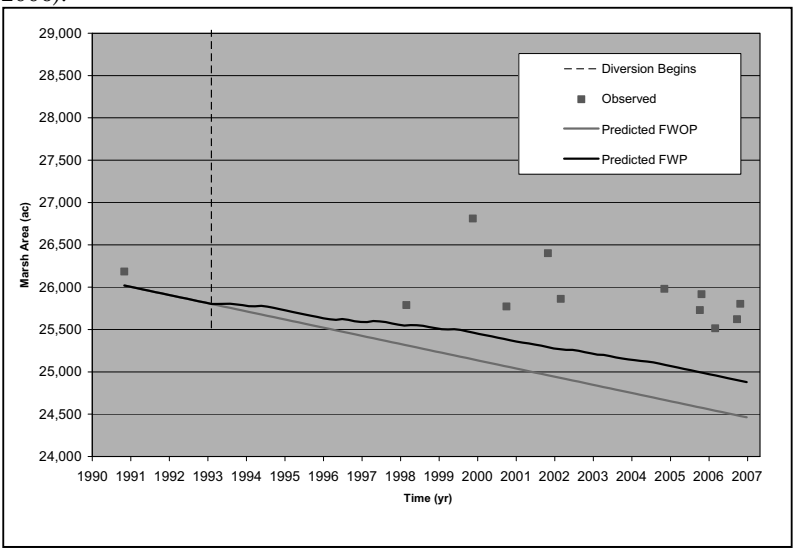
Figure C. SAND2 simulation of the West Pointe a la Hache Siphon (1993-2007).



Likewise, the SAND2 results also underestimated wetland acreage in the area influenced by the Naomi Freshwater Diversion Siphon (Figure D). The underestimate for the Naomi Siphon may be related in part to the large and relatively deep open water included within the siphon's influence area. Exclusion of this area, or a reduction in the influence area size, may have improved the accuracy of model results. This issue highlights the influence of project area selection on model results. Ideally, a hydrologic model or other systematic method to determining the project area (diversion influence area) is needed to achieve the best model results. Unfortunately, there was not sufficient time to conduct model runs to determine the potential ARTM diversion influence areas for each freshwater introduction measure. Instead, influence area polygons were determined using best professional judgment.

The SAND2 verification work, and other work with the SAND2 model indicates that it is most applicable in interior marsh systems. When applied to open bays or large lakes, it appears to substantially overestimate land-building. This may be related to resuspension and export of deposited sediments, a process that the model does not address. The ARTM measures, however, are all generally interior locations which are handled well by the SAND2 model. Unfortunately, no examples of freshwater introductions without sediment are available to verify the application of the SAND2 model for nutrient-only situations.

Figure D. SAND2 simulation of the Naomi Freshwater Diversion Siphon (1993-2006).



ANNEX 3

MCASES Cost Analysis

For Internal Use Only

FINAL REPORT

USACE WHITE DITCH EVALUATION AND DESIGN

HYDRODYNAMIC AND SALINITY TRANSPORT MODELING

Prepared for
USACE

June 4, 2010

URS Corporation
1625 Summit Lake Drive, Ste. 200
Tallahassee, FL 32317

Table of Contents

Section 1 Introduction **1-1**

Section 2 Background Data **2-1**

2.1 Bathymetry 2-1
2.2 Tide Stage 2-1
2.3 Meteorological Data 2-1
2.4 Salinity 2-2
2.5 Caernarvon Flows 2-2
2.6 Bathymetric Survey Data 2-3
2.7 URS Field Investigation 2-3
2.7.1 Water Level 2-3
2.7.2 Salinity 2-3

Section 3 Conceptual Models **3-1**

Section 4 Modeling Approach **4-1**

4.1 Model Selection 4-1
4.2 Model Domain and Grid Generation 4-2
4.3 Boundary Conditions 4-4

Section 5 Model Calibration **5-1**

Section 6 Alternatives Simulations **6-1**

6.1 Alternatives Analysis 6-1
6.2 Preliminary Evaluation/Initial Screening 6-1
6.3 Sea Level Rise Simulations 6-2
6.4 Long Term Simulations at Location 3 6-2

Section 7 Conclusions **7-1**

Section 8 References **8-1**

Tables

Table A Grid Configurations and Flow Capacities
Table B No Project Simulations Boundary Conditions
Table C Sea Level Rise Scenarios
Table D Boundary Condition Inputs for Long-Term Simulations at Location 3
Table E Time Period and Naming Convention for Long-term Simulations at Location 3

Figures

Figure 1 Study Area
Figure 2 Alternative Locations
Figure 3 Existing DEM and Contour Data
Figure 4 Station Locations
Figure 5 Sample Tide Record
Figure 6 Monthly Average Tide Stage at the Bay Gardene Station for Period 2000-2009
Figure 7 Wind and Rainfall Station Locations
Figure 8 Pilot East 2008 Wind Rose
Figure 9 Belle Chasse Rainfall Data
Figure 10a Monthly Average Salinity at the Bay Gardene Station for Year 2009
Figure 10b SONRIS Salinity Data
Figure 11 Seasonal Flows from Caernarvon Freshwater Diversion
Figure 12 Transect Locations
Figure 13 Sample of the Surveyed Cross-Sections
Figure 14 Sample of the Surveyed Cross-Sections
Figure 15 Salinity and Velocity Sampling Stations
Figure 16 Additional URS Field Locations
Figure 17 Measured Stage Data
Figure 18 Salinity Sampling Results
Figure 19 Model Domain
Figure 20 Water Polygon Data from the LA GIS Digital Map Compilation DVD
Figure 21 USGS Water Area Changes Study Results
Figure 22a Final Polygon Set

Figure 22b Final Polygon Set in White Ditch Study Area
Figure 23 Survey Data Distribution
Figure 24 Effective Depths and Locations from Cross-Section Transect Data
Figure 25 Template of Water Body Depths
Figure 26 Scatter Set Used for Grid Generation
Figure 27 Enlarged Portion of Point Grid Data
Figure 28 Final Grid and Grid Information
Figure 29 Depth Contours
Figure 30 Grid Cell Resolution in area of interest (top) and showing number of cells in canals and rivers (right)
Figure 31 Grid with Boundary Cellstring Locations
Figure 32 Boundary Input Data
Figure 33 Sensitivity of the Tide Calibration to the Datum Shifts in the Bay Gardene Stage Data
Figure 34 Final Stage Calibration
Figure 35 Typical Response of Salinity During a Calibration Simulation
Figure 36 Final Salinity Calibration
Figure 37 Location 2
Figure 38 Location 3
Figure 39 Location 2 5000 cfs Capacity Cross-Sections
Figure 40a Location 3 5000 cfs Capacity Cross-Sections
Figure 40b Location 3 5000 cfs Capacity Cross-Sections
Figure 40c Location 3 5000 cfs Capacity Cross-Sections
Figure 41 35,000 cfs Capacity Alternative 2 Depth Contours
Figure 42 35,000 cfs Capacity Alternative 3 Depth Contours
Figure 43 Sequence of Salinity Distributions at Location 2 with 35,000 cfs Capacity Grid.
Figure 44 Sequence of Salinity Distributions at Location 3 with 35,000 cfs Capacity Grid.
Figure 45 Time-averaged Salinities for Final 7 days of the Simulation at Location 2.
Figure 46 Time-averaged Water Depths for Final 7 days of the Simulation at Location 2.
Figure 47a Salinity Time Series Results at Points throughout the White Ditch Area
Figure 47b Salinity Time Series Results at Points throughout the White Ditch Area

Figure 48 Final Week Salinity Simulation Results from the 35,000 cfs Capacity at Location 3 Summer Simulation at Maximum Flow

Appendices

Appendix A Discussion of Bay Gardene Tide Gage Datum

SECTIONONE Introduction

The White Ditch project area is located in the Breton Sound estuary and covers the area extending north and south from just south of Belair, Louisiana to the coastline of Louisiana and extending east and west from the Mississippi River to the Oak River. This area extends about 50 km in the NW-SE directions and about 30 km in the SW-NE direction. Subsidence, erosion, channelization, saltwater intrusion, storm damage and the absence of fresh water, sediments and nutrients from the Mississippi River have all caused significant adverse impacts to the White Ditch project area resulting in extensive wetland loss and ecosystem degradation. There is an existing siphon at the mouth of White Ditch that was built in 1963 and has not been in operation since 1991, except for two brief episodes.

The absence of a supply of fresh water, sediment, and nutrients has caused the marsh to degrade. This degradation coupled with the subsidence and a sea level rise rate of approximately 1.04 cm per year has led to an increase in saltwater intrusion. The additional influx of saltwater from the Gulf of Mexico through the vast canal network in the project area has further damaged the marsh vegetation. In August and September of 2005 Louisiana was hit by hurricanes Katrina and Rita. These hurricanes brought high winds and high tidal surges and destroyed thousands of acres of already weakened marsh. In September of 2008 hurricanes Ike and Gustav also hit the Gulf coast. While they did not make direct landfall in the project area, the tidal surges from these storms caused the loss of additional marsh acreage.

The White Ditch area is part of the Breton Sound estuary system. Breton Sound estuary is located in southern Louisiana, between Breton Sound Bay and approximately the last 85 miles of the Mississippi River before it discharges into the Gulf of Mexico. The estuary consists of about 430 square miles (1,100 km2) of fresh and brackish coastal wetlands that are made up of shallow water ponds, lakes, bays, and a man-made canal system (Figure 1). The major rivers in the estuary are the Oak River (also known as River aux Chenes) and Bayou Terra aux Boeufs. The larger water bodies are Big Mar, Lake Leary, Spanish Lake, Grand Lake, and Little Lake.

On the northern edge of Breton Sound estuary is the Caernarvon freshwater diversion structure. It is located on the east bank of a Mississippi River oxbow at river mile 81.5. The diversion structure began operating in 1991 as a means for establishing optimal salinity conditions for oyster production, and can also be used to prevent saltwater intrusion during storms or droughts.

The USACE is investigating alternative designs for a fresh water diversion from the Mississippi River to the White Ditch project area. Two alternative locations (Locations 2 and 3) are proposed for the diversion near White Ditch and are shown in Figure 2. Location 2 uses a modification of the existing siphon at White Ditch. Location 3 is located farther to the south. At both alternative locations, different channel depths and widths are considered for different peak diversion flow rates, ranging from 5,000 to 100,000 cfs. Location 2 also includes culverts located throughout the modified channels to provide connectivity with the marsh areas.

The alternatives are evaluated in terms of their impact on water depths and salinities throughout the study area. A hydrodynamic and salinity model has been developed to quantify the impacts of each alternative and evaluate the effects of diversion flow operations on the water depth and salinity. The results of the hydrodynamic and salinity model simulations were post-processed and used as input for the Wetland Value Assessment model to quantify the environmental benefits of the diversion. In addition to assessing environmental benefits such as the impacts on plant and animal communities in the project area, the stage data was also used to estimate potential flooding impacts for each alternative.

SECTIONONE Introduction

This report describes the hydrodynamic and salinity modeling analyses used to evaluate alternative designs and flow rates. The application of the wetland value assessment and other analyses were conducted by the USACE and are reported separately.

There were a number of existing data sets available to support the configuration, calibration and application of the hydrodynamic and salinity transport model. In addition to the existing data sets, a bathymetric survey and a field measurement program were conducted prior to the modeling analysis in order to provide site-specific data. Each of these data sets is briefly described below.

2.1 BATHYMETRY

There was sparse existing data within the coverage area, and the resolution and precision of any available data was insufficient for model use. Digital Elevation Model (DEM) and contoured elevation coverages were available at http://atlas.lsu.edu/rasterdown.htm for portions of the modeled area (Figure 3), however the elevation values available in these datasets did not contain the resolution necessary for use in the model.

2.2 TIDE STAGE

Real-time tide data were downloaded from http://waterdata.usgs.gov/nwis for three U.S. Geological Survey (USGS) stations. Station locations include: Northeast Bay Gardene (Station ID: 7374527), Black Bay near Snake Island (Station ID: 7374526) and Cow Bell at American Bay (Station ID: 73745258). Tide data were also obtained from http://tidesonline.nos.noaa.gov/ for the National Oceanic and Atmospheric Administration (NOAA) Station Pilot East (Station ID: 8761305). Station locations are shown in Figure 4. Time series plots of sample portions of the tide data are shown in Figure 5.

A review of the tide gages revealed that there were no suitable gage locations in the proximity of the White Ditch area. The closest gages were Cow Bell at American Bay and Northeast Bay Gardene. Data from the Bay Gardene station was chosen for use in the modeling analysis since it provided the widest date range of available data with the fewest data gaps.

A plot of the monthly average water elevations for the period 2000-2009 for the Bay Gardene station is shown in Figure 6. The data show that the stage tends to be higher in the fall, which corresponds to the period when the winds are predominantly from the Southeast.

2.3 METEOROLOGICAL DATA

Wind data are available from various stations in the project area. The wind data were collected by NOAA from 1999 through 2009 (http://www.ncdc.noaa.gov/oa/ncdc.html). Louisiana wind station locations include: Grand Isle (Station Number 8762417), Pilot East (Station Number 8760922) and Shell Beach (Station Number 8761305). The locations of these stations are shown in Figure 7. Hourly data was available from the Pilot East station and was downloaded for the time period of 3/25/2004 through 7/23/2009. A wind rose based on data collected at the Pilot East station during the year 2008 is shown in Figure 8.

Rainfall data were obtained from the NOAA Port Sulfer Station (Station 167471) and from a Belle Chasse station. Station Locations are shown in Figure 7. The data included a daily sum of rainfall in inches for 1/1/2004 through 8/27/2009 for Port Sulfur and 9/28/2006 through 8/20/2009 for Belle Chasse. Annual and seasonal rainfall patterns are shown in Figure 9 for the Belle Chasse data set.

There were no daily evaporation data available from stations near the project area. In order to provide some information for evaporation rates, data in the literature was reviewed. A study conducted by Cooke et al. (2008) provided measured data at a variety of stations in Louisiana. The nearest station for which summer evaporation rates were available was Houma. The data indicate some daily fluctuations do occur, ranging between 2 and 8 mm/day, with an average rate on the order of 5 mm/day.

2.4 SALINITY

Salinity data are available from the USGS and were obtained from the website: http://waterdata.usgs.gov. Data from three Louisiana stations including Northeast Bay Gardene (Station ID 7374527), Black Bay near Snake Island (Station ID 7374526), and Cow Bell at American Bay (Station ID 73745258) were obtained. The station locations are shown in Figure 4. The monthly average salinities for 2009 for the Bay Gardene station are shown in Figure 10a.

Another salinity data set was available from Strategic Online Natural Resources Information System (SONRIS). This data set included hourly or monthly salinity measurements and stations were located throughout the Breton Sound with varying periods of record). Station locations are shown in Figure 10b, and average, max and minimum salinity values at stations with sufficient data are shown in the table in Figure 10b. The average salinity is lowest in the spring and is controlled by Freshwater from the Caernarvon Diversion and the Mississippi River, which are the two freshwater sources for this area.

2.5 CAERNARVON FLOWS

On the northern edge of Breton Sound estuary is the Caernarvon freshwater diversion structure. It is located on the east bank of a Mississippi River oxbow at river mile 81.5. The diversion structure began operating in 1991 as a means for establishing optimal salinity conditions for oyster production, and can also be used to prevent saltwater intrusion during storms or droughts. The 23-meter-wide structure has the capacity to divert up to about 8,000 cfs (226 m^3/s) of Mississippi River water into the Breton Sound estuary, and has been managed at many different discharge rates since its commencement.

The US Army Corps of Engineers (USACE), New Orleans District, manages the Caernarvon Freshwater Diversion Project and provided daily flow data in cfs from 1992 through 2009. The seasonal flows from the diversion are shown in Figure 11.

Based on discussions with local land managers, it is believed that the flow from the diversion followed two dominant paths form the diversion. The main one is to the south through the Bayou Mandeville area. The second one is directed to the west, through the Delacroix Canal, and ultimately merges with the Oaks River. It is believed that about 20 to 30 percent of the diversion flows went through the western path until Hurricane Katrina impacted the area. After Katrina, many of the smaller channels to the west were clogged with debris, and it is believed that only 5 to 10 percent of the diversion flow now flows westward.

2.6 BATHYMETRIC SURVEY DATA

The USACE conducted a bathymetric survey of the White Ditch area to support both the modeling analysis and the alternative designs. The survey transects are shown in Figure 12. The surveyed cross-sections are shown in a sequence of plots in Figures 13 and 14. These data provide information on the channel depths and widths, the lake depths, elevations of ridges bounding the channels as well as the characteristics of the inter-tidal and land areas.

2.7 URS FIELD INVESTIGATION

The White Ditch field investigation was conducted from July 20 through July 23, 2009 to collect necessary calibration data for the CMS-Flow hydrodynamic model of the study area. The field investigation was conducted by two crews of URS field staff operating from airboats hired for the project. The field crews were accompanied by William Terry of the U.S. Army Corps of Engineers (USACE) St. Louis District Office for most of the field investigation. A detailed report of the field program, its implementation and an analysis of the data were provided to the USACE as a deliverable on 9/28/2009 (URS, 2009). The two data sets explicitly used in the modeling analysis, the water elevations and the salinity data, are summarized here.

The study area and sampling stations are shown in Figure 15. Measurements of flow velocity, temperature, salinity and turbidity were collected periodically between July 21 and 23, 2009 at the primary stations (N1, N2, N3, S1, S2, and S3). Water level measurements were collected at stations N3 and S3 from July 20 to July 23, 2009 using temporary staff gauges and recording pressure transducers that were installed at these locations.

Less frequent flow velocity, temperature and salinity measurements were collected at the secondary locations (Oak River Channel, N4, N5, N6, S4, S5, S6, S7, S8, S9, S10, and S11). Water depth measurements were collected at each of the primary and secondary locations, and at additional field locations (S12-S33) shown on Figure 16.

2.7.1 Water Level

Staff gauges and recording pressure transducers were installed at locations S3 and N3 to measure water level fluctuations within the study area. The transducers used were Micro-Diver Dataloggers (Model DI601) manufactured by the Schlumberger Corporation. The data loggers were initially programmed to collect pressure measurements every five minutes in the units of feet of water. The sample interval was changed to 30 seconds after approximately 24 hours.

Staff gauges constructed of 1-inch diameter PVC pipe were also installed at locations S3 and N3. Periodic measurements of the water level at each staff gauge were recorded. The measured stage data collected at the two stations are shown in Figure 17. When compared to the tides at the Bay Gardene Station, it is evident that there is a significant loss of tidal amplitude as the tides propagate into the White Ditch area.

2.7.2 Salinity

Salinity data (as well as temperature and turbidity measurements) were collected at each primary location and other select locations (shown on Figure 15) using a HydroLab Quanta system. The median, maximum and minimum salinity at each station are shown in Figure 18. The SONRIS

salinity data are also shown in Figure 10b, and although the data represent different time periods, they show a general trend in the salinity patterns. The trends show a basic low to high salinity gradient from offshore to the NW as well as a high to low gradient from the east bank of the Mississippi River to the NE. The general gradients, even those in the White Ditch area, point towards the Caernarvon Diversion, indicating that it is a significant source of freshwater in the area.

Salinity measurements were also made at surface and bottom – the data indicate a very minor difference between top and bottom – less than 0.5 ppt.

SECTION THREE Conceptual Models

A conceptual model for the analysis has been developed based on the project goals and the data summary. The key points considered in developing the conceptual model are discussed below:

- The area of interest is large with a network of inter-connecting channels and lakes with varying widths and depths. The land elevations and tide ranges indicate that the tidal flows will be contained to the channels during lower tide stages but may inundate the land segments during higher tide stages.
- The proposed Alternatives include relatively high flow rates, up to 100,000 cfs that will likely flood the land areas, at least in the vicinity of the discharge.
- The salinities are controlled by rainfall and evaporation and freshwater from the Caernarvon Diversion and the Mississippi River. The effects of the Mississippi river are inherent in the salinity data at the USGS gages near the southern extent of the study area.
- Salinity transport in the White Ditch area will also be affected by wind driven circulation.
- The time scale for salinity to reach steady state is relatively large for ambient conditions (including Caernarvon), on the order of one month but will be shorter for high-flow White Ditch diversions
- The proposed Alternatives include culverts to route freshwater to the White Ditch area and therefore these structures will require representation in the modeling analysis.
- The salinity data available from the field study indicate that there is very little vertical stratification, indicating the depth-averaged modeling is suitable

The components of the conceptual model that were developed based on the above considerations are described below:

- The model boundaries should extend from the Mississippi River levees from the northwest and southwest to the Mississippi River-Gulf Outlet (MRGO) channel to the northeast and to the general vicinity of the Bay Gardene USGS station to the southeast. This domain includes the majority of the area influenced by the Caernarvon Diversion, which is important to properly represent its influence on the White Ditch area.
- The details of the intricate network of channels will need resolution in the model grid. The most detailed resolution should focus on White Ditch area but at least include large conveyance channels in the area to the east of the Oak River. This component will require grid cell dimension on the order of 10 to 30 meters in the White Ditch area.
- The model needs to include a simulation of tides, winds, diversion discharges, rainfall and evaporation and salinity transport.
- The simulations will require the representation of significant wetting and drying of land segments throughout the area, especially during larger White Ditch diversion flows
- The modeling analysis needs to represent the location and conveyance of culverts on the flow
- A 2D depth-average model is suitable for the analysis

4.1 MODEL SELECTION

A number of hydraulic models were considered for use in simulating the White Ditch diversion alternatives. The candidate models are listed below and organized into finite element and finite volume categories. In general, the finite element models have unstructured meshing capabilities that allow for the efficient detailed resolution of small features, However, they are difficult to implement in projects with large areas of wetting and drying, often requiring excessive bathymetric and topographic smoothing to achieve a stable solution.

finite element models

ADCIRC – unstructured mesh
no salinity, poor wetting and drying

FESWMS – unstructured mesh,
no salinity, poor wetting and drying

RMA2 – unstructured mesh, salinity transport
poor wetting and drying

finite volume models

CMS– salinity transport, good wetting and drying
rectilinear mesh

EFDC – salinity transport, good wetting and drying
curvilinear mesh

FVCOM – unstructured mesh, good wetting and drying
commercial availability

POM– salinity transport, good wetting and drying
curvilinear mesh

The finite difference models typically will not have any stability problems when considering wetting and drying, but often do not have the benefits of unstructured meshes since they typically use rectilinear or curvilinear structured meshes. The FVCOM model is unique in that it is a finite volume model that uses an unstructured mesh and therefore can realize the mesh generation benefits often associated with finite elements. However, the model is relatively new and limited to research applications. Non-research applications are occurring but model documentation and general industrial familiarity with the model are not mature. The remaining three finite volume models (CMS, EFDC and POM) all have similar capabilities and are suitable for the project.

Of those three, CMS is supported by the USACE and therefore was selected for the project. CMS-Flow is a process-based 2D depth-averaged hydrodynamic, sediment transport and morphology model developed by the USACE for application in and around inlets and channels. It is accessible via the Surfacewater Modeling System (SMS) graphical user interface (Militello, 2004; Buttolph, 2006).

4.2 MODEL DOMAIN AND GRID GENERATION

The model domain is shown in Figure 19. The domain includes all of the white ditch area as well as an extensive portion of Breton Sound. A primary reason for including the larger portion of Breton Sound was the potential influence of the diversion peak flows on the east of the Oaks River. Also, the channels providing flow pathways from the Caernarvon Diversion to the White Ditch area required inclusion since the Caernarvon Diversion flows provided a significant portion of the freshwater to the White Ditch area (the other freshwater source being rainfall).

To provide bathymetric data for the model grid, a project-specific bathymetric and topographic data set was developed. This data was then used to set the bottom elevation of the cells in the model grid. Initial experiments with the model indicated that the grid resolution in the White Ditch area would need to be on the order of 10 to 30 meters. This level of resolution would provide sufficient resolution of the channel features but allow for reasonable simulation times on high-end workstations. Therefore, the bathymetric and topographic data should have a minimum resolution of 10 meters in the White Ditch area.

The area bathymetry and topography were developed from existing bathymetric data, land/water boundary data and results from the project field survey. It was determined early in the bathymetric data development that existing bathymetric data were limited to areas above MSL and sets did not provide sufficient precision or resolution for direct use in the grid generation. Therefore the following approach was used to develop the bathymetric and topographic data set.

1. Acquire the most recent land/water boundary data
2. Update the land/water boundary data for Post Katrina conditions
3. Divide the land/water boundaries into small polygons representing channels, lakes, land segments and other features
4. Assign depth/elevation to each polygon
5. Convert the polygons to a 10 meter grid and export
6. Import the 10 meter grid into SMS and use to populate the CMS grid

Several datasets of land and water polygons were obtained for use in developing the bathymetric dataset; one from the Louisiana GIS Digital Map Compilation DVD (2007) and one from the ESRI Streetmap dataset. The land/water polygon data from the LA GIS Digital Map Compilation DVD was used to start the bathymetric data processing. This polygon data represents pre-Katrina conditions and is shown in Figure 20 overlaying post-Katrina aerial images. It is clear that there were some significant changes in the land mass as a result of Katrina in the White Ditch area, especially in the NW region. These changes were confirmed in a USGS study, the results of which are shown in Figure 21. Therefore, in order to update the land/water polygons, polygons from the ESRI dataset were merged with the LA GIS data and subsequently modified to best reflect the post-Katrina conditions. Additional digitizing was conducted so that the final set of polygons reflected the land and water boundaries as depicted in the most current aerial photography available for the area. Additional reviews of the polygon data set indicated that not all of the canals in the study area were completely represented in the processing up to this point. Canals not represented were digitized and canal water body connections that were inaccurate were modified. The final set of polygons is shown in Figures 22a and 22b.

The next step is to assign depth values to each of the polygons in the data set. As pointed out in Section 2, there was no comprehensive bathymetric data set available. In order to assign depths, information from the project bathymetric survey and NOAA nautical chart data were used. The first step was to set the land elevation. For this purpose, all of the survey data was pooled and sorted to identify the distribution and range. The distribution of the data is shown in Figure 23. There is a distinctive break in the distribution at elevation 0 ft (NAVD 88) that is likely representative of MSL, where the channel and lake banks are steepest. Assuming that most of the inter-tidal zones and land segments lie at or above 0 ft elevation, the data was filtered to eliminate values below 0 feet, and then resorted. The results are also shown in Figure 23, and indicate that the median land elevation is 1 foot NAVD 88. This value was adopted as the land elevation and all land polygons were assigned a depth of one foot.

In order to assign depth values to the canals and lakes, the survey data transects were processed and used to develop a suitable average depth for each cross-section. Each transect cross-section was clipped so that the only the portion below MSL remained. Then the hydraulic radius of the cross-section was calculated. Then the cross-section effective depth was calculated so that it would yield the same hydraulic radius as the original cross-section. This value was then assigned to the center point of the cross-section transect and used to assign depth values in the canal and lake polygons. The effective depths and their locations, as obtained by this procedure, are shown in Figure 24. The effective depth data did not provide sufficient information to assign depths to all canal and lake polygons. Therefore a generalized template for canal and lake depths was developed and used to assign the depths to the remaining polygons. A review of Figure 24 indicates that there is a general increase in the canal and lake depths from the NW to the SE. A template, shown in Figure 25, was developed using this trend.

After completing the depth assignments to each polygon, the depth data were interpolated from the polygons to a point grid. The point grid consisted of 10 m spacing in the White Ditch area and expanded to 50 m spacing to the east of the Oak River and to the SE. The 50 m resolution was necessary to keep the file size manageable and still provide sufficient resolution of key features. A view of the bathymetric data as reflected by the point grid is shown in Figure 26. An enlarged portion of the point grid data is shown in Figure 27, where the points are color coded by the assigned depths.

The point grid bathymetry dataset was imported into SMS, triangulated, and the depths were interpolated on to the CMS grid. Based on trials in the focus area near White Ditch, a 20 meter resolution was determined to be optimal for areas in the vicinity of the proposed diversion.

The grid was designed with 20 meter spacing in the White Ditch area with the cell spacing expanding to the SE and SW. In these regions of grid expansion, the grid was allowed to increase to a maximum grid cell size of 500 meters in order to keep the number of cells as low as possible and help manage simulation run time while still providing detailed resolution in the White Ditch study area. The final grid is shown in Figure 28. The green cells are ‘inactive’ and represent areas protected by levees or that are above 4 feet elevation. These cells are not used in the model simulations and are a by-product of the inherent CMS rectangular grid structure. A QAQC process was performed in order to ensure canal connections and other components necessary for accurate flow simulation were correctly implemented. Cell properties were adjusted manually where appropriate. The final grid contains 866,791 active cells in 992 Columns and 569 Rows. The bathymetry as represented in the final grid is shown in Figures 29 and 30. After some initial testing, a time step of 1.5 seconds was found to provide numerically

stable solutions, and the model simulations (including salinity transport) were determined to take about two days (48 hours) in order to simulate a one month period on an HP Workstation Z400 with an Intel 2.93 Ghz Xeon Quad processor and 8gb DD3 SDRam.

4.3 BOUNDARY CONDITIONS

The boundary conditions required for the White Ditch model simulations included:

1. Offshore tide elevation
2. Offshore salinity values
3. Flow boundaries (flow rate and salinity)
4. Rainfall and Evaporation
5. Wind Forcing

The location of each boundary application (for White Ditch location 3) is shown in Figure 31. Note that during the model calibration, it was found that the salinity calibration was sensitive to both the total flow rate from the Caernarvon Diversion as well as the split between the amounts assumed to flow through the Delacroix Canal to the west and the through Bayou Mandeville to the south. Therefore, the grid was modified slightly in the region of the Caernarvon Diversion so that the flow splits could be assigned directly.

The hydrodynamic and salinity calibration were conducted simultaneously. This was necessary because it was learned in the preliminary salinity calibration simulations that the salinity calibration was sensitive to the total flow and flow split assumed for the Caernarvon Diversion. Since these flow rates may influence the tidal response in the white ditch area, it was necessary to conduct the hydrodynamic and salinity calibration simultaneously.

The hydrodynamic calibration period was selected to coincide with the period for which the stage data was available from the project field program, namely the four day period July 20 through July 24th. Preliminary testing with the model indicated that the tidal flows required a relatively short spin-up period, on the order of one-week, but it was found that the salinity simulations required a much longer spin-up period.

The salinity calibration focused on the same period for data comparison, July 20th through July 24th, for which salinity data was available from the project field program. After some preliminary testing with the model, it was found that a two-month spin-up was required to eliminate the effects of the initial conditions on the solution.

For the calibration simulation, the model was configured with measured wind, tide, rainfall, evaporation, salinity and Caernarvon flow data corresponding to the calibration period. For the evaporation, the average value of 5 mm/day adopted from the Cooke et al. (2008) study was used. The tide, wind and Caernarvon flow data are shown in Figure32. For the Caernarvon diversion flows, freshwater was assumed, and the corresponding salinity was assigned a value of zero. The initial salinity in the grid domain was set to 7.0 ppt which was an approximate average value of the calibration data.

The key calibration parameters are:

1. Bottom Fiction (Manning's n)
2. Lateral Dispersion
3. Fresh Water flow and flow split from Caernarvon

The calibration simulations indicated that the hydrodynamic calibration was most sensitive to the bottom friction, with a minor sensitivity to the Carnarvon flow splits. The salinity calibration was most sensitive to the Caernarvon Diversion flow rate and flow split, with a lower level of sensitivity to the lateral dispersion.

An initial range for the lateral dispersion was obtained by considering the length scales of the water bodies in the White Ditch area and the length-scale dependent dispersion values from data summarized by Fischer (1979). For this analysis, a length scale was developed by taking the square-root of the area of each of the polygons used to represent each water body and then selecting the median value. The median value is approximately 300 meters, for which the associated dispersion coefficient is 10 m^2/s.

During some initial sensitivity simulations, it was found that the stage calibration was difficult to obtain using a reasonable range of values to the friction and dispersion parameters. Eventually, the difficulty was traced to the gage Datum of the Bay Gardene stage data used as a boundary condition on the southeast boundary of the grid. After some investigation and discussions with USGS staff familiar with the gage it was determined that there was some uncertainty in the gage datum, and therefore an adjustment to the gage data was developed. More details of the investigation are discussed in Appendix A. The adjustment to the gage data consisted of a shift in

the stage that was based on some sensitivity of the calibration to the measured stage data. Figure 33 shows the results of the sensitivity analysis for the cases of no shift, a 0.5 foot shift and a one foot shift in the Bay Gardene stage data. For the 0.5 and 1.0 shifts, the simulated response shows a much smaller tide range. This is caused by the inundation of the land segments when the water elevations are higher. The inundation dampens the tide signal causing the lower tide range. The 1.0 shift for the Bay Gardene data was adopted for the modeling calibration and all subsequent alternatives analysis simulations.

The rational for adjusting the Carnarvon total flow is that the model grid domain does not contain the entire area influenced by the diversion flow. Therefore, only a portion of the flow actually drains through the region covered by the model grid. The remaining portion of the flow drains towards the MRGO channel that is not represented in the model grid. Thus, it is appropriate to reduce the Carnarvon flow rates so that they better represent the flow entering the area covered by the model gird. The "best" reduction level was determined via the salinity calibration.

It was also found that the salinity calibration was sensitive, albeit to a smaller degree, to the assumed split of the Caernarvon flow to the west and the south. As discussed in Section 2, historically the portion flowing to the west, directly towards the White Ditch area, was about 20 to 30 percent. However, it is believed by local land managers that after Hurricane Katrina, the percentage flowing directly to the west is lower, due to blockage of many of the smaller canals, and is currently about 5 to 10 percent.

After assigning the dispersion value, a sequence of final calibration simulations were completed in which the bottom friction and the total flow and flow split for the Caernarvon were systematically altered. The final calibration was obtained with the following parameter values:

- Manning's n: 0.021
- Dispersion Coefficient: 10 m^2/s
- Amount of Measured Caernarvon Flow applied: 58.2%
- Amount of Applied Caernarvon Flow directed to the west: 5%

The final stage calibration is shown in Figure 34. The simulated stage calibration indicates that the model represents the measured tide amplitude reduction and phase shifts at stations S3 and N3. A typical time series of the salinity response in the White Ditch area is shown in Figure 35. The decrease in the salinity values for all but the most offshore station from the initial conditions and the asymptotic characteristic of the final values are evident in the time series data. The values for station 39 increase, because it is closest to the offshore boundary and less influenced by the freshwater flow from the Caernarvon diversion. The influence of the tidal excursion is also most evident at this station.

The final salinity calibration results are shown in Figure 36 and represent the time-averaged salinity values over the last four days of the simulation, which correspond to the time period of the measured values obtained during the project field program. The spatial gradients and the actual salinity levels are well represented in the simulated results. The largest discrepancy occurs in the southern station (Simulated Salinity Point 37) where the model results slightly under-predict the salinity levels.

6.1 ALTERNATIVES ANALYSIS

The calibrated CMS hydrodynamic and salinity transport model was configured to simulate the impacts of 12 alternative diversion designs. The alternatives are located in either of two locations referred to as Location 2 and Location 3 as indicated in Figure 2. The USACE initially considered another location (Location 1) but that location was discarded and not considered for modeling evaluation.

The alternative design at Location 2 is connected to the Mississippi River with a box culvert and consists of two main outfall channels and three distribution channels, as indicated in Figure 37. Culverts are distributed along the channels to enhance the connectivity to the wetlands, and plugs are placed at some junctures to control the flow. There is a short final outfall channel connecting the second main outfall channel and the Oak River

The configuration for Location 3 is shown in Figure 38. At this location, there is one main outfall channel connected to a second channel with a natural alignment. Ridges align the channels and some plugs are included.

At each alternative location, six design diversion flow rates were considered. For each flow rate a different channel cross-sectional area was used and therefore a flow-specific model grid was configured for each of the six different flow capacities at each of the two locations (for a total of 12 grids). Flow capacities for the twelve unique grid configurations are shown in Table A.

For each alternative location and flow rate, the channels were represented in the model grid by adjusting the grid cell elevations within the footprint of each channel. Examples of cross-sections for the 5000 cfs capacity flow rate at Location 2 are shown in Figure 39 and shown for the 5000 cfs capacity flow rate at Location 3 in Figures 40a – 40c. In general the cross-section widths and depths increased as the design flow rates increased. An example of the 35,000 cfs flow-rate grid at Location 2 is shown in Figure 41. The corresponding grid for the 35,000 cfs flow-rate grid is shown in Figure 42.

The boundary conditions locations and implementation for these alternatives grids were identical to those used in the model calibration grid (i.e. existing conditions grid) except for the addition of the White Ditch diversion flow. A flow rate boundary condition cell string was created at the beginning of the main diversion channel for application of the diversion flow rate in the model simulations.

The evaluation of the alternatives was implemented in three phases:

1. Preliminary Evaluation/Initial Screening
2. Sea-level Rise Simulations
3. Long-term Simulations of the 35,000 cfs Flow Rate at Location 3

Each of these evaluations is described below.

6.2 PRELIMINARY EVALUATION/INITIAL SCREENING

A preliminary evaluation of the alternatives was conducted with a 29 day simulation. These simulations provided evaluations of the impact of the diversion flow on water elevations and salinity levels through-out the White Ditch area. For these simulations, the Caernarvon

Diversion flow was set to 8000 cfs and the water elevations for the Bay Gardene station for the period of July 2009 were used at the offshore boundary.

Instantaneous plots of the salinity distribution during the start-up of the diversions are shown in Figure 43 for Location 2 and in Figure 44 for Location 3. The freshwater flow through the diversion channels and culverts into the wetlands is evident in the sequence of plots.

As the simulations were completed, the model results were processed and delivered to the USACE for subsequent analysis. The main post-processing for these simulations were maps of the time-averaged salinity and water depth over the last week of simulation, during which conditions were quasi-steady, and varying only due to tidal effects. An example of the average salinity conditions for Location 2 35,000 flow-rate design conditions is shown in Figure 45. The corresponding plot of the time-average water depths is shown in Figure 46.

6.3 SEA LEVEL RISE SIMULATIONS

Twelve 90-day sea-level rise simulations were configured and are described in Table B. For these simulations, the existing no project conditions were used and there was no flow simulated from White Ditch. As indicated in Table B, both the Caernarvon flow rate and tide (sea) level were varied. Each sea-level rise was implemented by adding the rise to the water elevation time series used at the offshore boundary condition. The water elevations for the Bay Gardene station for the period of June through August were used for these simulations. Details of the sea-level rise scenarios designated in Table B are listed in Table C.

6.4 LONG TERM SIMULATIONS AT LOCATION 3

Seven additional alternatives were completed using the 35000 cfs capacity grid at Location 3. Three simulations represented a 90 day period using the Bay Gardene water elevation data for June – August, 2009 at the offshore boundary conditions. The diversion flows were steady at 10000, 15000, and then 35000 cfs, respectively. The flow at the Caernarvon Diversion was 1200 cfs. The results of these simulations were delivered to the USACE for further evaluation.

The remaining four simulations were 17 months long and were completed using the Location 3 35000 cfs flow capacity model grid. These model runs simulated conditions beginning during a Spring season and continuing through the Summer of the following year. Flow rates at both the White Ditch diversion and the Caernarvon diversion were varied throughout the simulation period. The flow conditions for each scenario are shown in Table D.

The 17 months of simulation time was divided into eight consecutive simulations. The first seven (a through g) each simulated two months time and the eighth simulation (h) simulated the final three-month period. The labels a through h at the top of Table D indicates the simulation period. For simulations 1 and 2, the simulations were started at period d, using the solutions at the end of the previous 90 day simulations.

Tide inputs for these long term simulations were taken from measured data at Bay Gardene Station for the entire year 2009. Data from March through December 2009 were used for the initial ten months of simulation, and then data from January through July 2009 were used during the last seven months of simulation.

Time series plots of salinity at seven observation locations within the model grid are shown for simulation 3 in Figure 47a and simulation 4 in Figure 47b. The impact of the high White Ditch Diversion flow rates during period a and f and g are very evident in the time series and the response time of the salinity levels in the White Ditch area can be inferred from these time series. A plot of the time-averaged salinity over the final three months of simulation period (Simulation 3h) for long-term Simulation 3 is shown in Figure 48.

SECTIONSEVEN Conclusions

The CMS Flow model was successfully configured and calibrated for the White Ditch area for simulations of tide, flow and salinity. The model was subsequently used to evaluate various alternative designs and operational scenarios for the White Ditch diversion.

During the calibration and implementation of the CMS Flow model, a number of assumptions and data limitations were identified that were required in order to complete the modeling analysis within the project schedule. In anticipation of a need for additional modeling analysis, it is recommended that additional data collection be completed to reduce the number of assumptions and limitations. The data categories are:

1. Additional bathymetric and topographic data
2. Additional water level and salinity data
3. Flow measurements geared towards verifying westward flow patterns from the Caernarvon Diversion
4. Better understanding of rainfall and evaporation runoff from the land segments

Each of these topics is discussed below.

Bathymetric and topographic data

The original survey data focused on the areas adjacent to the proposed diversion. Scheduling considerations and access rights prevent survey data collection from areas to the northwest, southeast and across the Oaks River area. Aerial images since the impact of Hurricane Katrina have provided suitable data for delineating the dense network of canals, streams and lakes, but the water depths and land elevations are not well documented. For the development of the existing model, assumptions for the water depths and land elevations were made based on the spatial patterns derived from the available project surveys. It is recommended that additional data, similar to the survey data collected as part of this project, also be collected. The ridge along the Oaks River north and south of the previous survey area should also be surveyed, as this is an important feature in the project area, controlling flows from the project area into the Oaks River.

Another area for survey data collection is along the canals that connect the Caernarvon Diversion to the Oaks River. During the model calibration it was found that Caernarvon Diversion flow westward to the Oaks River area had a strong impact on the salinity in the project area. Thus, an improved delineation of the flow-ways would enhance the reliability of the model.

Additional Water Level and Salinity Data

The model calibration data set consisted of a few days of continuous water elevations at two stations in the central area of the project. Salinity data consisted of point measurements at about eight stations around the central project area. Although this data set did provide reasonable constraints of water elevation and salinity, a more rigorous model calibration could be made if continuous water elevation and salinity data could be obtained. It is recommended that continuous monitoring of water elevation and salinity be made at stations spanning the entire project area, and in the vicinity of the flow-ways connecting the Caernarvon Diversion flows to the Oaks River. At least three stations would be located in the projected area, one each in the north, central and southern portion of the project area. An additional station should be located east of the Oaks River, in one of the major flow-ways connecting the Caernarvon Diversion flows to the Oaks River. Measurements should be made for at least two weeks (a complete spring-neap tide cycle), and preferably over a month or more to collect data under a larger

variety of conditions. Consideration should be given to collecting data during high and low Caernarvon Diversion flows.

The need for sensor maintenance during deployment in a marine environment should be considered in identifying station locations.

All water elevation sensors should be surveyed so that they can be referenced to the same vertical datum of the bathymetric and topographic survey data.

Flow measurements for verifying westward flow patterns from the Caernarvon Diversion

During the model calibration, it was found that the simulated salinities in the project area were sensitive to assumptions as to the total amount of Caernarvon Diversion flow that traveled westward and south-westward towards the Oaks River and project area. At that time, only antidotal estimates of the flow rates were available, mainly from observations of persons familiar with the area. Thus, additional data collection to establish the flow rates would be very useful in enhancing the model calibration. Flow measurements should be made at 2 to 5 stations in flow-ways connecting the Caernarvon Diversion to the Oaks River. Measurements should be made every 1 to 2 hours over a 24-hour period. (or 12-hour period if access is not feasible at night). At least one set of flow measurements should be collected during a spring tide and one during a neap tide.

Better understanding of rainfall and evaporation runoff from the land segments

Another model parameter that affected the salinity in the project area was the rainfall and evaporation rates. During the model calibration, assumption of the rainfall water balance (evaporation, direct run-off and infiltration and groundwater discharge) had to be made. It is recommended that two or three pressure gages be installed in shallow wells to provide continuous water table surface elevation and salinity data during the same period that the continuous surface water measurements are being recorded. The well should be able to be installed using a hand auger due to the shallow depths. The pressure sensors should also be surveyed to provide the data referenced to the same vertical datum as the bathymetric and topographic data. The installation of automatic rainfall gages and pan evaporation measurement systems should considered at each of the well locations.

SECTIONEIGHT References

Buttolph, A. M.; Reed, C. W.; Kraus, N. C.; Ono, N.; Larson, M.; Camenen, B.; Hanson, H.; Wamsley, T. and Zundel, A. K., 2006. Two-Dimensional Depth-Averaged Circulation Model CMS-M2D: Version 3.0, Report 2, Sediment Transport and Morphology Change. Coastal and Hydraulics Laboratory Technical Report ERDC/CHL-TR-06-7. Vicksburg, MS: US Army Engineer Research and Development Center.

Cooke, William H. III, Katarzna Grala, Charles L. Wax, A Method for Estimating Pan Evaporation for Inland and Coastal Regions of the Southeastern U.S. , Southeastern geographer, 48(2) 2008: pp. 149–171.

Fischer, H., List, J., Koh, R., Imberger, J., Brooks, N., Mixing in Inland and Coastal Waters, (Academic Press, Inc., Orlando) 1979.

Militello, A., Reed, C.W., Zundel, A.K., and Kraus, N.C. 2004. Two-Dimensional Depth-Averaged Circulation Model M2D: Version 2.0, Report 1, Technical Documentation and User's Guide, ERDC/CHL TR-04-2, U.S. Army Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

URS, White Ditch Filed Program Results, 2009, Submitted to the USACE.

TABLES

Table A. Grid Configurations and Flow Capacities.

	Flow Rate (cfs)
Location 2	5,000 cfs
	10,000 cfs
	15,000 cfs
	35,000 cfs
	70,000 cfs
	100,000 cfs
Location 3	5,000 cfs
	10,000 cfs
	15,000 cfs
	35,000 cfs
	70,000 cfs
	100,000 cfs

Table B. No Project Simulations Boundary Conditions.

Simulation ID	Caernarvon Flow (cfs)	Sea Level Rise Scenario
2000	8,000	2009 Low
2500	2,800	2009 Low
3000	200	2009 Low
3500	8,000	2065 Low
4000	2,800	2065 Low
4500	200	2065 Low
5000	8,000	2065 Moderate
5500	2,800	2065 Moderate
6000	200	2065 Moderate
6500	8,000	2065 High
7000	2,800	2065 High
7500	200	2065 High

Table C. Sea Level Rise Scenarios.

Scenario			
Year	**Low feet**	**Intermediate feet**	**High feet**
2009	0	0	0
2015	0.2	0.2	0.3
2020	0.3	0.4	0.5
2025	0.5	0.6	0.8
2030	0.7	0.8	1.1
2035	0.8	1	1.4
2040	1	1.2	1.8
2045	1.2	1.4	2.1
2050	1.3	1.6	2.5
2055	1.5	1.8	2.9
2060	1.7	2.1	3.3
2065	1.8	2.3	3.7

Table D. Boundary Condition Inputs for Long-Term Simulations at Location 3.

Simulation	Model Run By	Flow Input Location	a		b		c		d		e		f		g		h		
			March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
Simulation 1	USACE	White Ditch							1000	1000	1000	1000	1000	1000	1000	35000	1000	1000	1000
		Caernarvon							500	450	750	1750	2600	3000	2000	1500	1050	950	1000
Simulation 2	USACE	White Ditch							0	0	0	0	0	0	0	35000	0	0	0
		Caernarvon							500	450	750	1750	2600	3000	2000	1500	1050	950	1000
Simulation 3	URS	White Ditch	35000	0	0	0	0	0	0	0	0	0	15000	20000	35000	0	0	0	0
		Caernarvon	2000	1500	1050	950	1000	650	500	450	750	1750	500	500	500	1500	1050	950	1000
Simulation 4	URS	White Ditch	35000	1000	1000	1000	1000	1000	1000	1000	1000	1000	15000	20000	35000	1000	1000	1000	1000
		Caernarvon	2000	1500	1050	950	1000	650	500	450	750	1750	500	500	500	1500	1050	950	1000

Table E. Time Period and Naming Convention for Long-term Simulations at Location 3.

	Total Hours	Begin Month	End Month
SIM 3a, 4a	1464	March	April
SIM 3b, 4b	1464	May	June
SIM 3c, 4c	1488	July	August
SIM 1d, 2d, 3d, 4d	1464	September	October
SIM 1e, 2e, 3e, 4e	1464	November	December
SIM 1f, 2f, 3f, 4f	1416	January	February
SIM 1g, 2g, 3g, 4g	1464	March	April
SIM 1h, 2h, 3h, 4h	2208	May	July

FIGURES

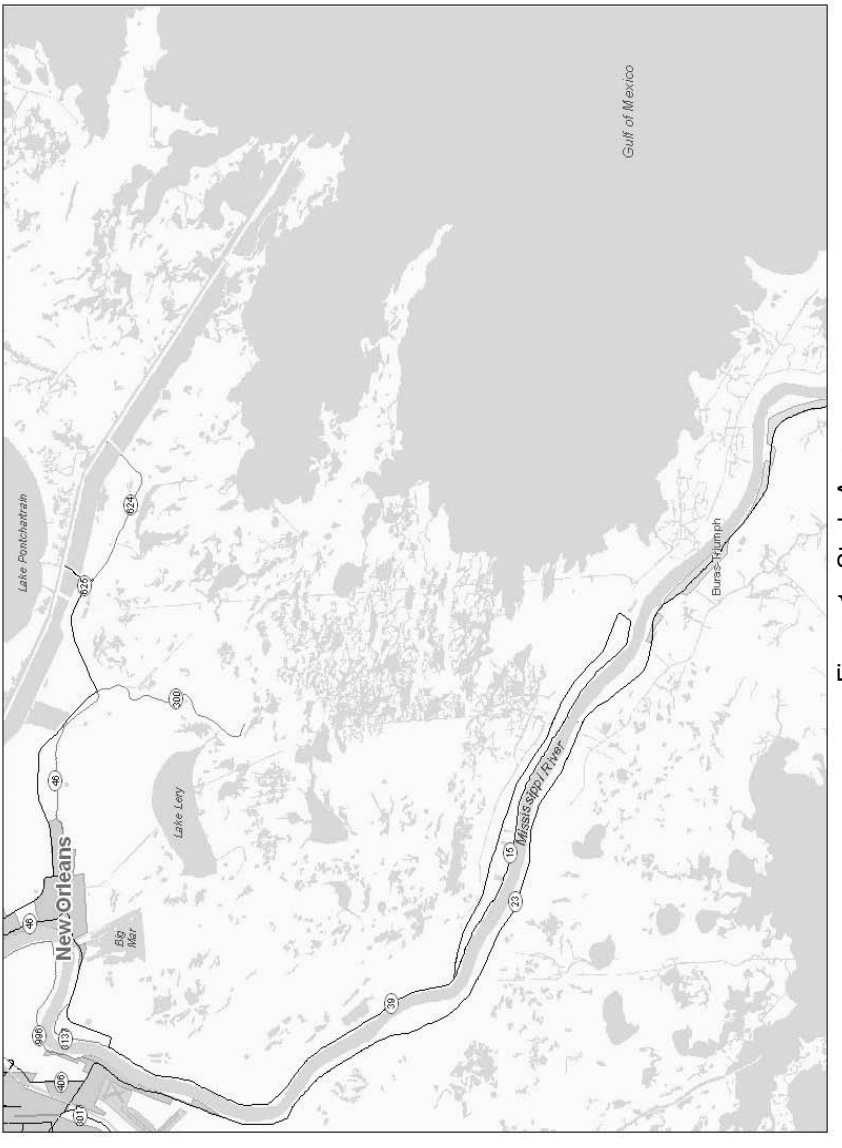


Figure 1. Study Area.



Figure 2. Alternative Locations.

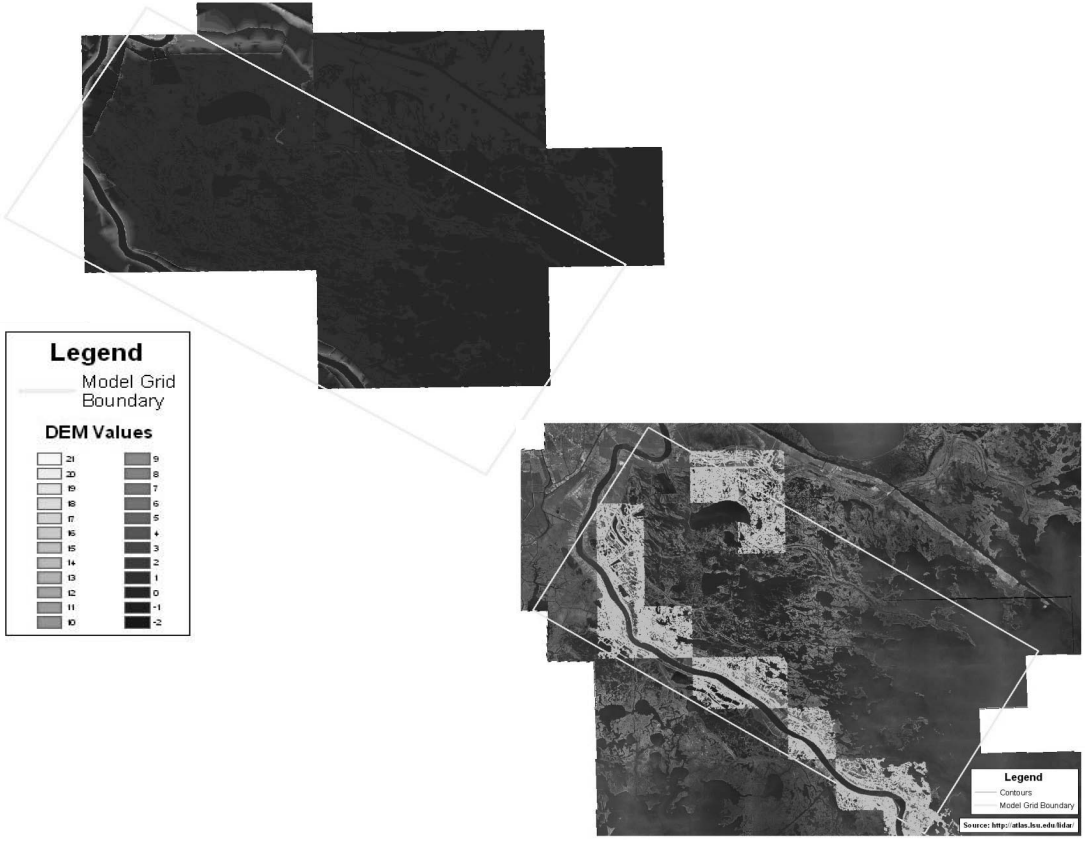


Figure 3. Existing DEM and Contour Data.

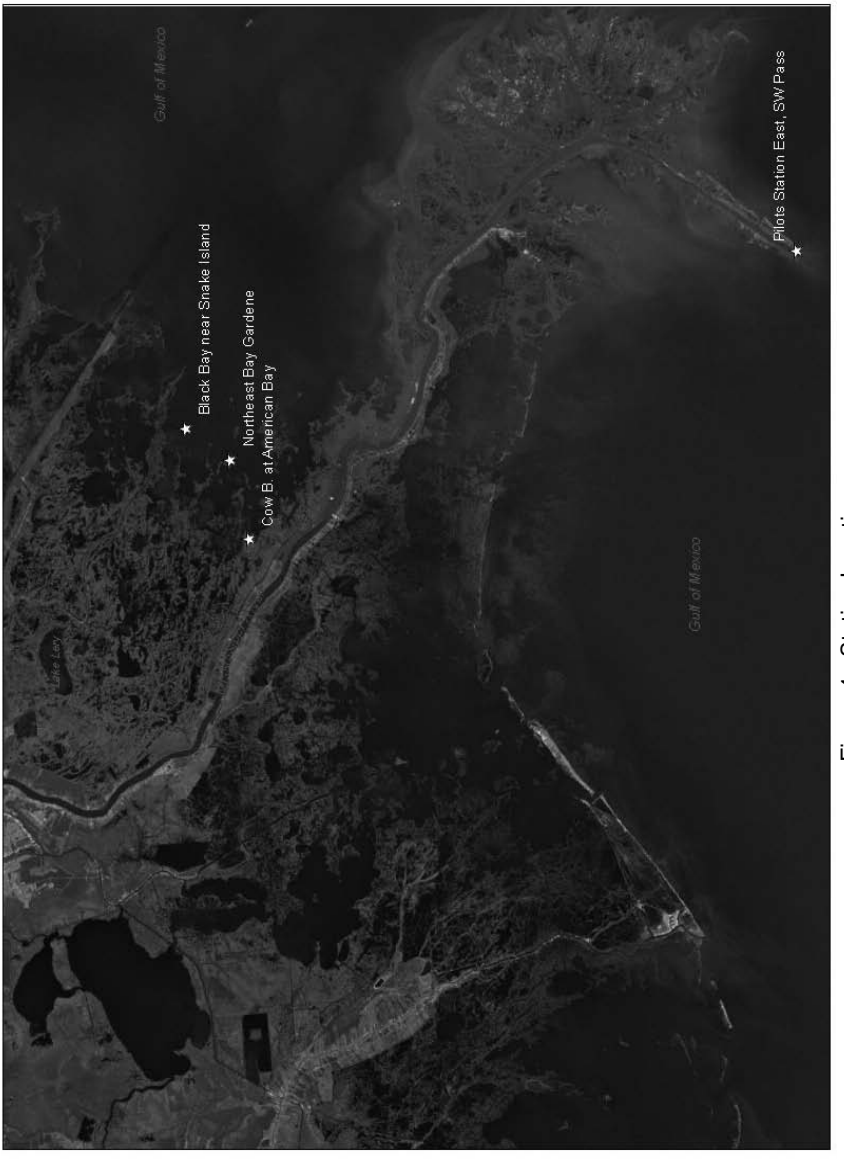


Figure 4. Station Locations.

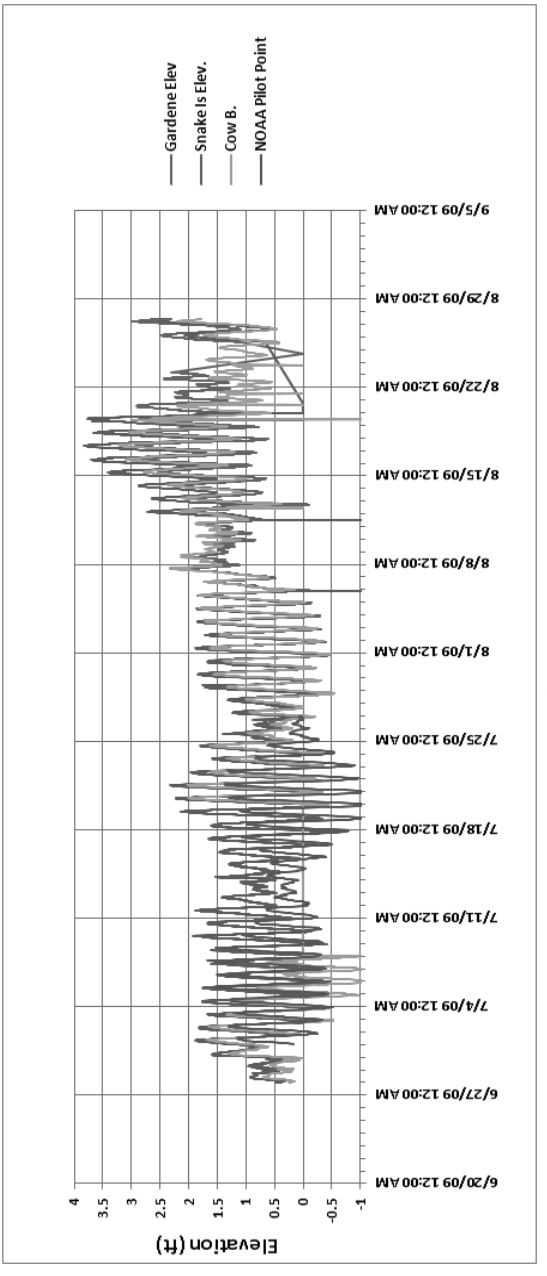


Figure 5. Sample Tide Record.

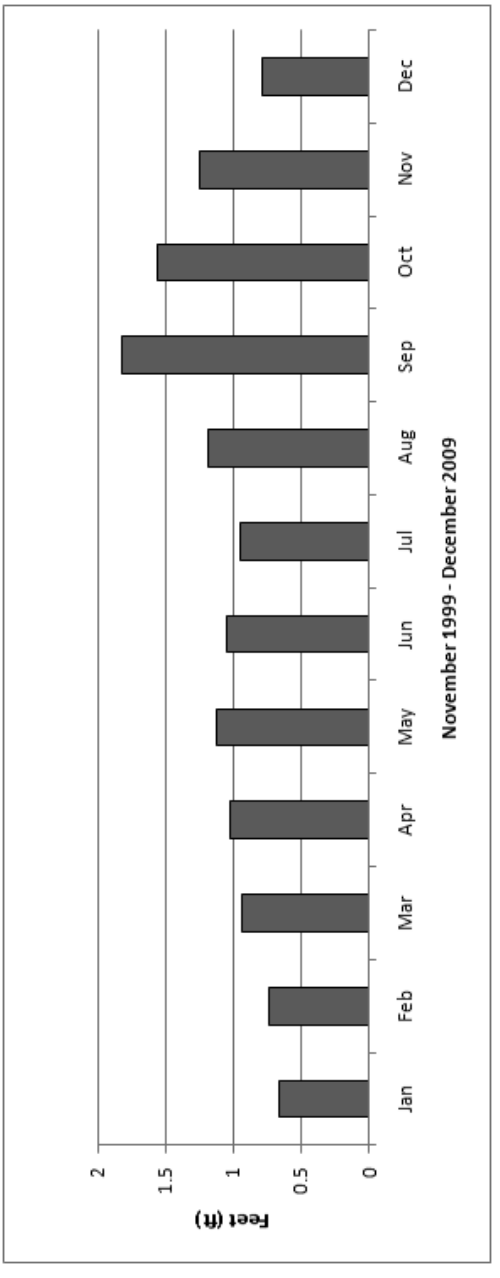


Figure 6. Monthly Average Tide Stage at the Bay Gardene Station for Period 2000–2009.

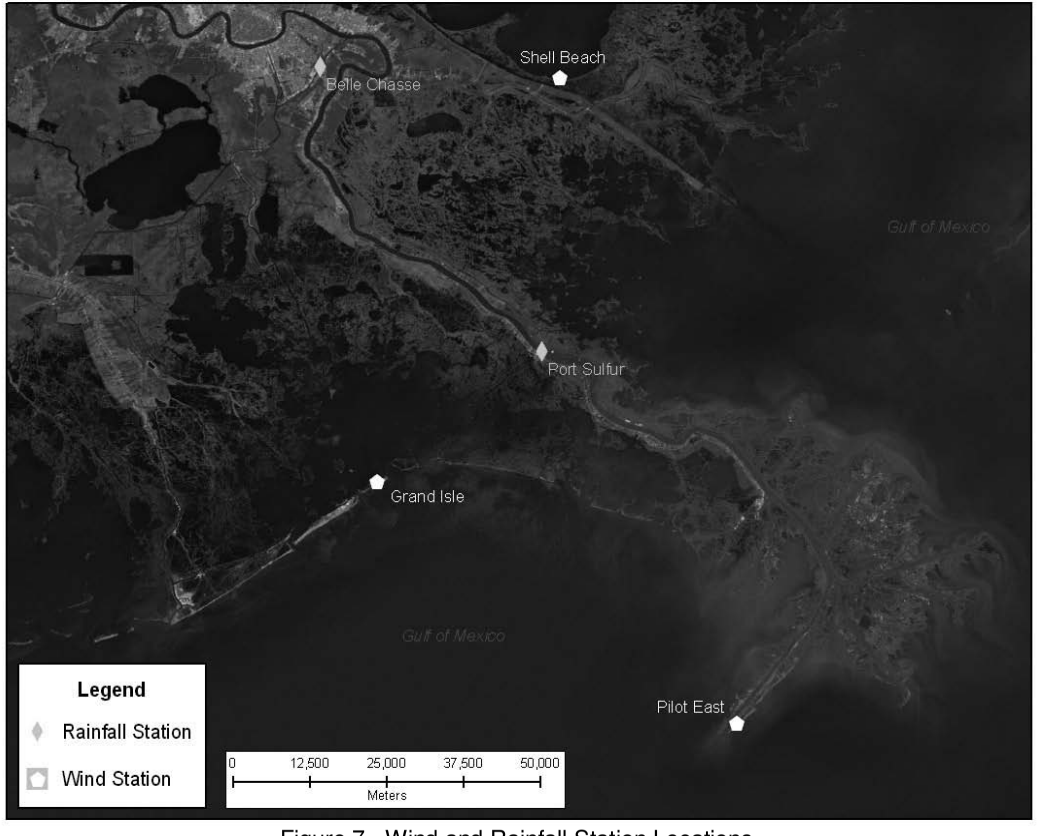


Figure 7. Wind and Rainfall Station Locations.

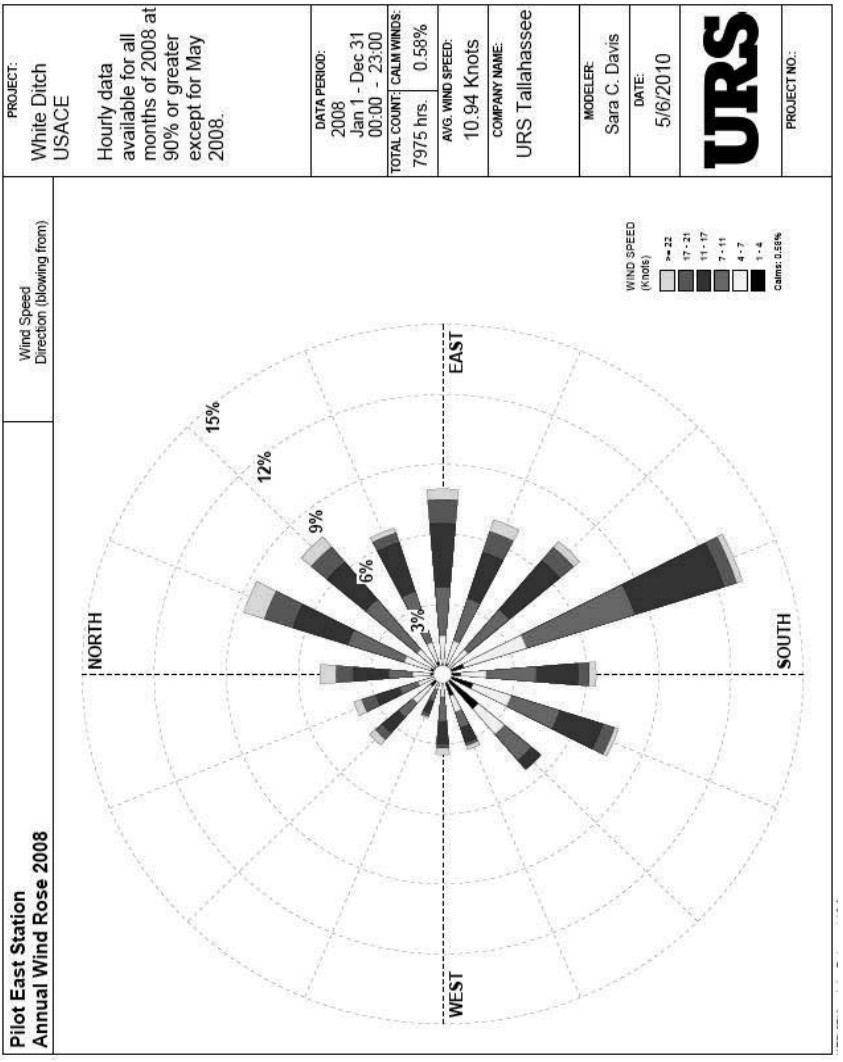


Figure 8. Pilot East 2008 Wind Rose.

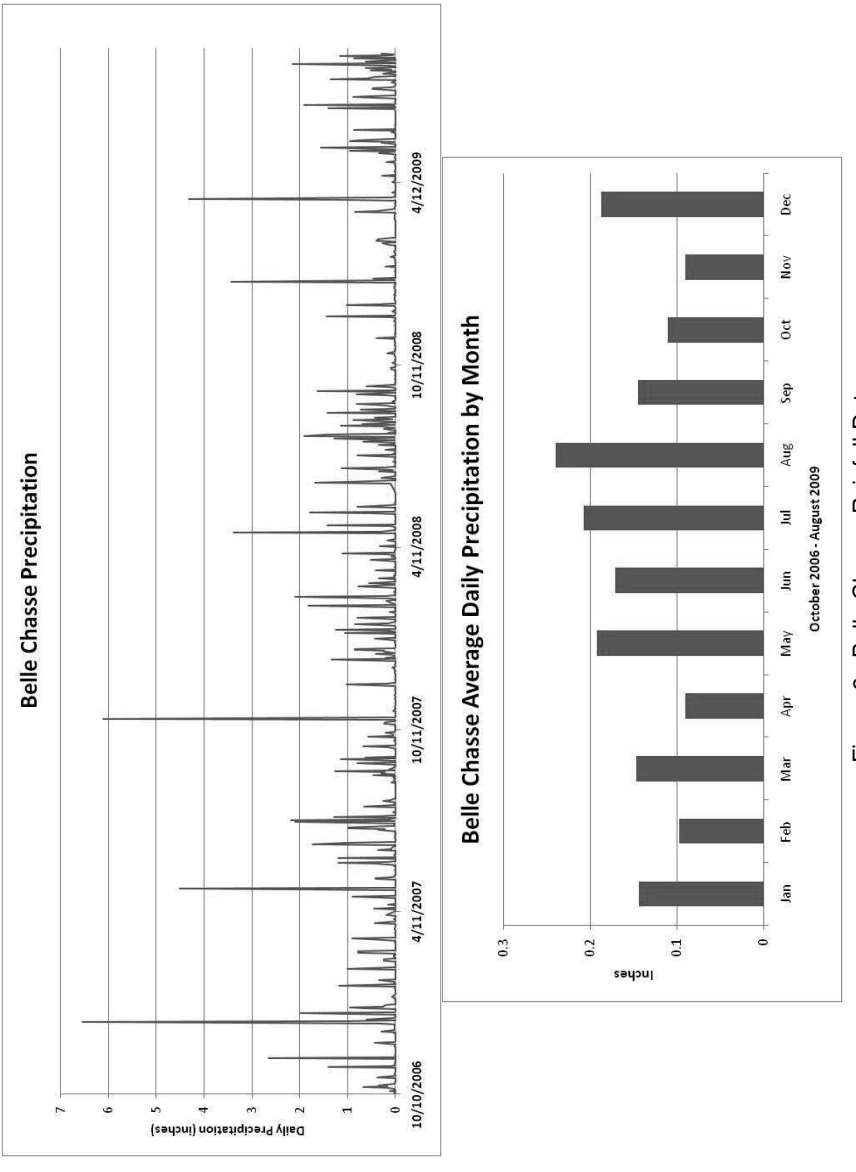


Figure 9. Belle Chasse Rainfall Data.

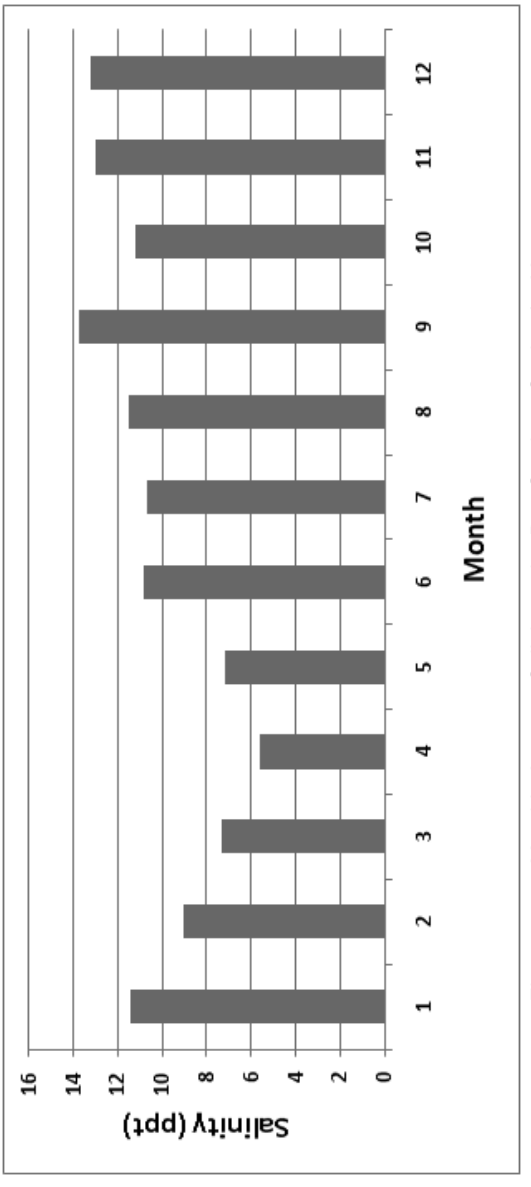
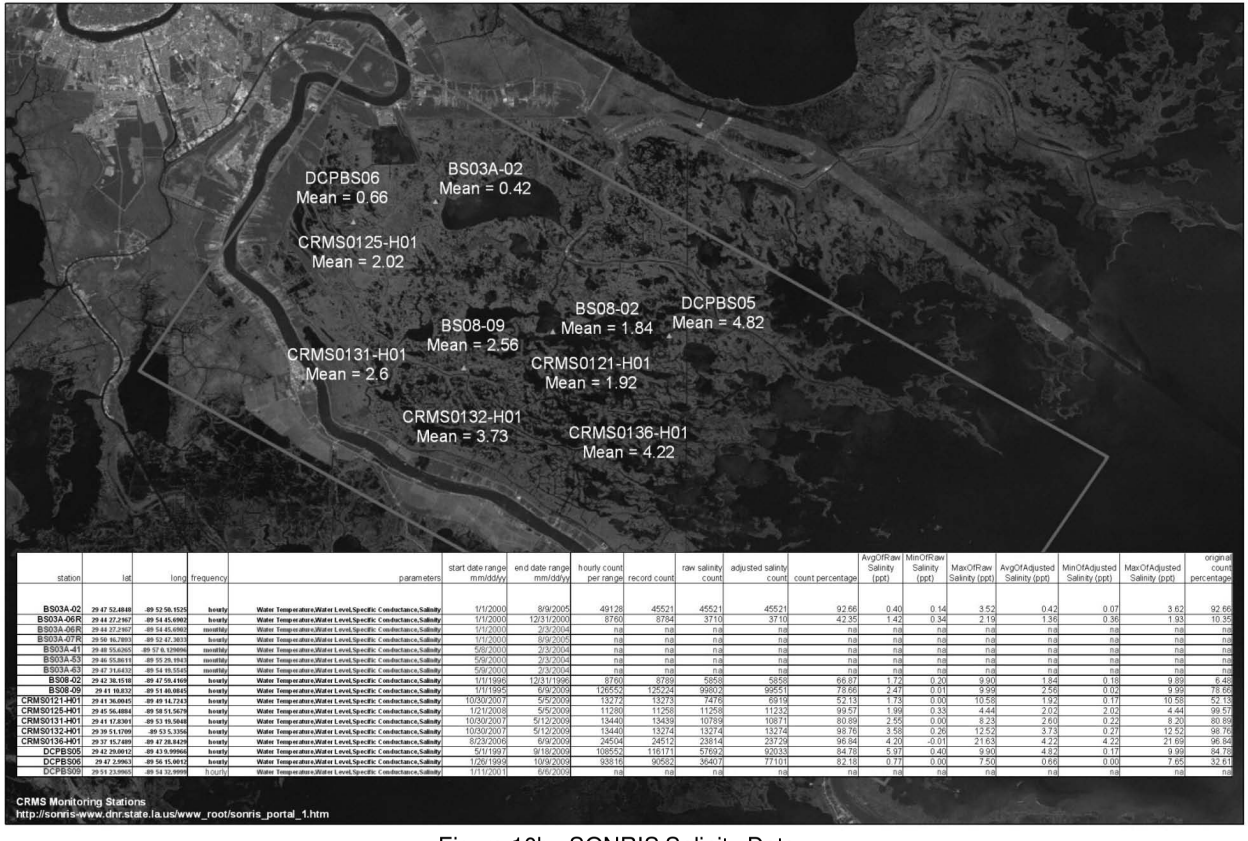


Figure 10a. Monthly Average Salinity at the Bay Gardene Station for Year 2009.



station	lat	long	frequency	parameters	start date range mm/dd/yy	end date range mm/dd/yy	hourly count per range	record count	raw salinity count	adjusted salinity count	count percentage	AvgOfRaw Salinity (ppt)	MinOfRaw Salinity (ppt)	MaxOfRaw Salinity (ppt)	AvgOfAdjusted Salinity (ppt)	MinOfAdjusted Salinity (ppt)	MaxOfAdjusted Salinity (ppt)	original count percentage
BS03A-02	29 47 52.4840	-89 52 50.1525	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/2000	8/9/2005	49128	45521	45521	45521	92.66	0.40	0.14	3.52	0.42	0.07	3.62	92.66
BS03A-06R	29 44 27.2167	-89 54 45.6902	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/2000	12/31/2000	8760	8784	3710	3710	42.35	1.42	0.34	2.19	1.36	0.36	1.93	10.35
BS03A-06R	29 44 27.2167	-89 54 45.6902	monthly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/2003	2/3/2004	na	na	na	na	na	na	na	na	na	na	na	na
BS03A-07R	29 50 16.7893	-89 52 47.3833	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/2000	8/9/2005	na	na	na	na	na	na	na	na	na	na	na	na
BS03A-41	29 48 55.6265	-89 57 0.129096	monthly	Water Temperature,Water Level,Specific Conductance,Salinity	5/8/2003	2/3/2004	na	na	na	na	na	na	na	na	na	na	na	na
BS03A-63	29 46 55.8619	-89 55 29.1943	monthly	Water Temperature,Water Level,Specific Conductance,Salinity	5/9/2003	2/3/2004	na	na	na	na	na	na	na	na	na	na	na	na
BS03A-63	29 47 31.6432	-89 54 19.5545	monthly	Water Temperature,Water Level,Specific Conductance,Salinity	5/9/2003	2/3/2004	na	na	na	na	na	na	na	na	na	na	na	na
BS08-02	29 42 38.1518	-89 47 59.4169	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/1999	12/31/1999	8760	8789	5858	5858	66.87	1.72	0.20	9.90	1.84	0.18	9.89	6.48
BS08-09	29 41 10.832	-89 51 40.0845	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/1/1995	6/9/2009	126552	125224	99802	99551	78.66	2.47	0.01	9.99	2.56	0.02	9.99	78.66
CRMS0121-H01	29 41 36.0045	-89 49 14.7243	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	10/30/2007	5/5/2009	13272	13273	7476	6919	52.13	1.73	0.00	10.58	1.92	0.17	10.58	52.13
CRMS0125-H01	29 45 56.4884	-89 50 51.5679	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/21/2008	5/5/2009	11280	11258	11258	11232	99.57	1.99	0.33	4.44	2.02	2.02	4.44	99.57
CRMS0131-H01	29 41 17.8301	-89 53 19.5048	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	10/30/2007	5/12/2009	13440	13439	10789	10871	80.89	2.55	0.00	8.23	2.60	0.22	8.20	80.89
CRMS0132-H01	29 39 51.1709	-89 53 5.3356	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	10/30/2007	5/12/2009	13440	13274	13274	13274	98.76	3.58	0.26	12.52	3.73	0.27	12.52	98.76
CRMS0136-H01	29 37 15.7489	-89 47 28.8429	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	8/23/2006	6/9/2009	24504	24512	23814	23729	96.84	4.20	-0.01	21.63	4.22	4.22	21.69	96.84
DCPBS05	29 42 29.0012	-89 43 9.99966	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	5/1/1997	9/18/2009	108552	116171	57692	92033	84.78	5.97	0.40	9.90	4.82	0.17	9.99	84.78
DCPBS06	29 47 2.9963	-89 56 15.0012	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/26/1999	10/9/2009	93816	90582	36407	77101	82.18	0.77	0.00	7.50	0.66	0.00	7.65	32.61
DCPBS09	29 51 23.0665	-89 54 32.9999	hourly	Water Temperature,Water Level,Specific Conductance,Salinity	1/11/2001	6/5/2003	na	na	na	na	na	na	na	na	na	na	na	na

Figure 10b. SONRIS Salinity Data.

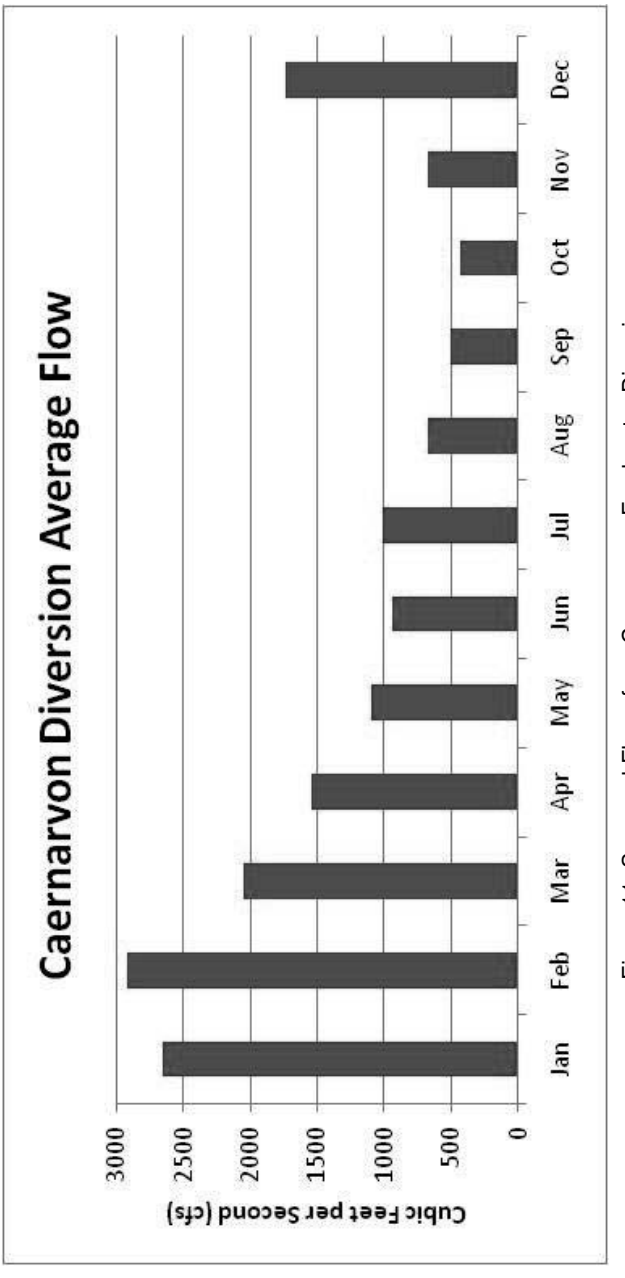


Figure 11. Seasonal Flows from Caernarvon Freshwater Diversion.

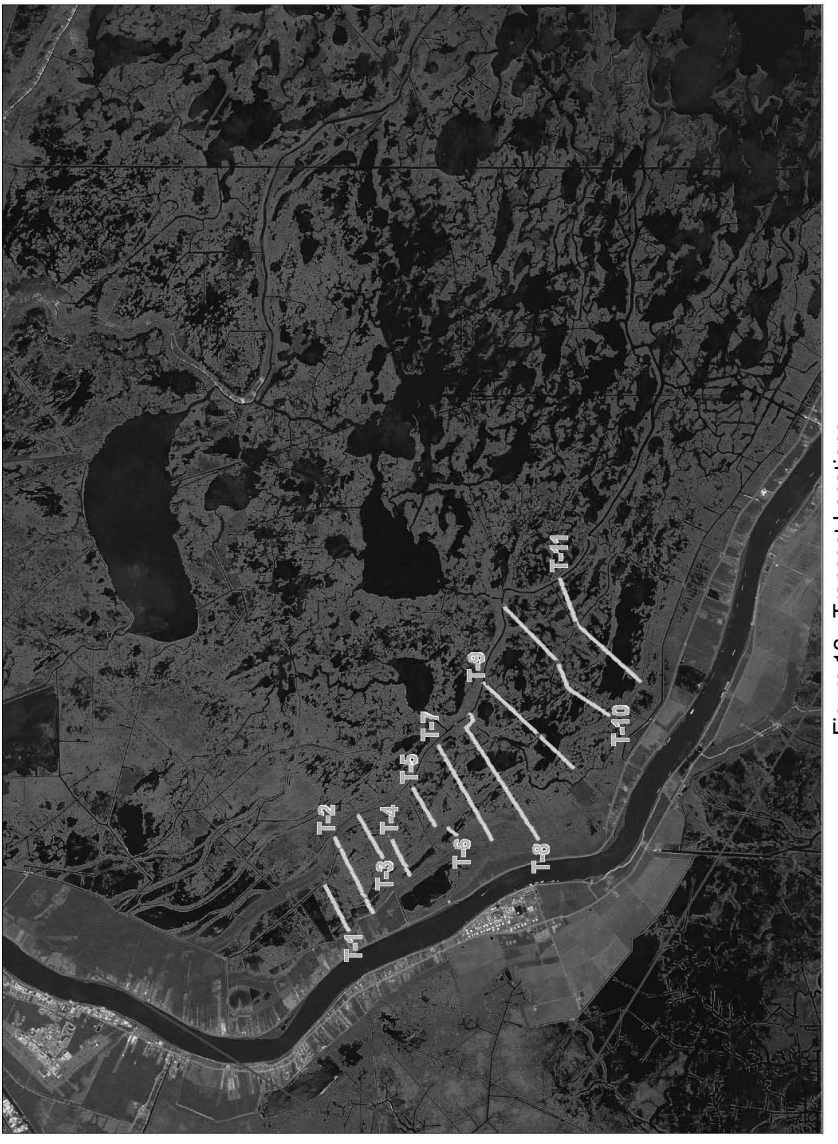


Figure 12. Transect Locations.



Figure 13. Sample of the Surveyed Cross-Sections.

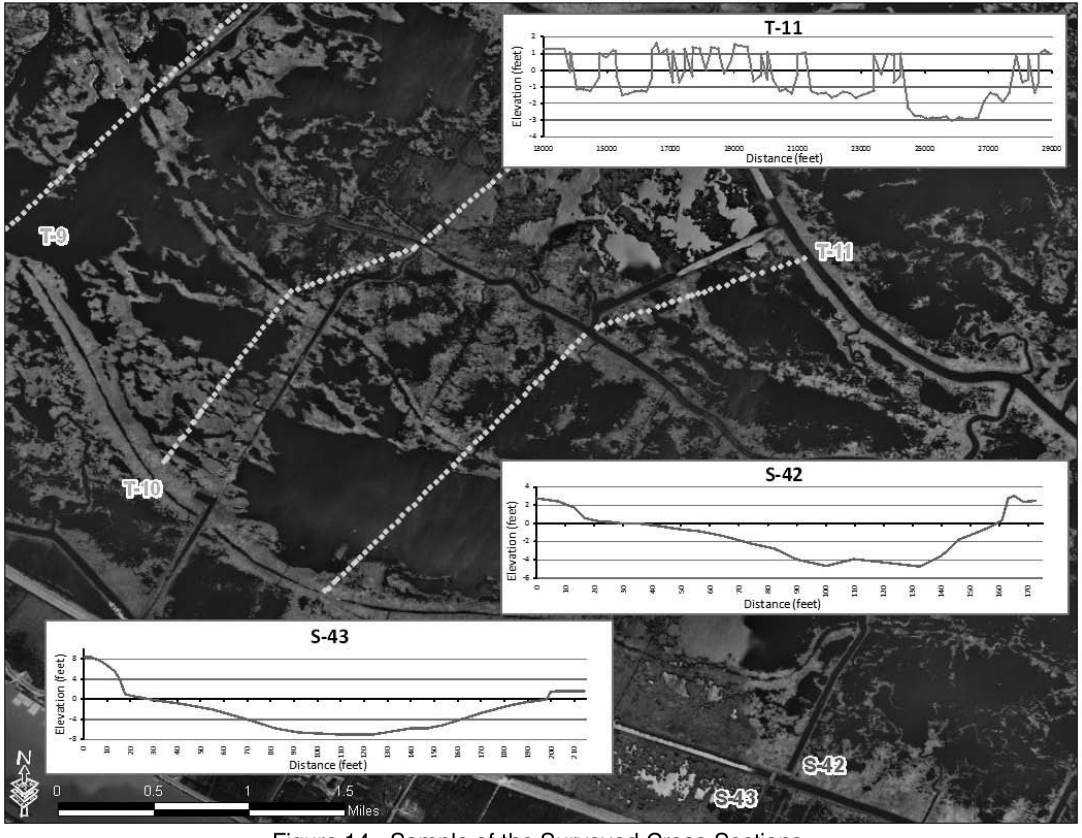


Figure 14. Sample of the Surveyed Cross-Sections.

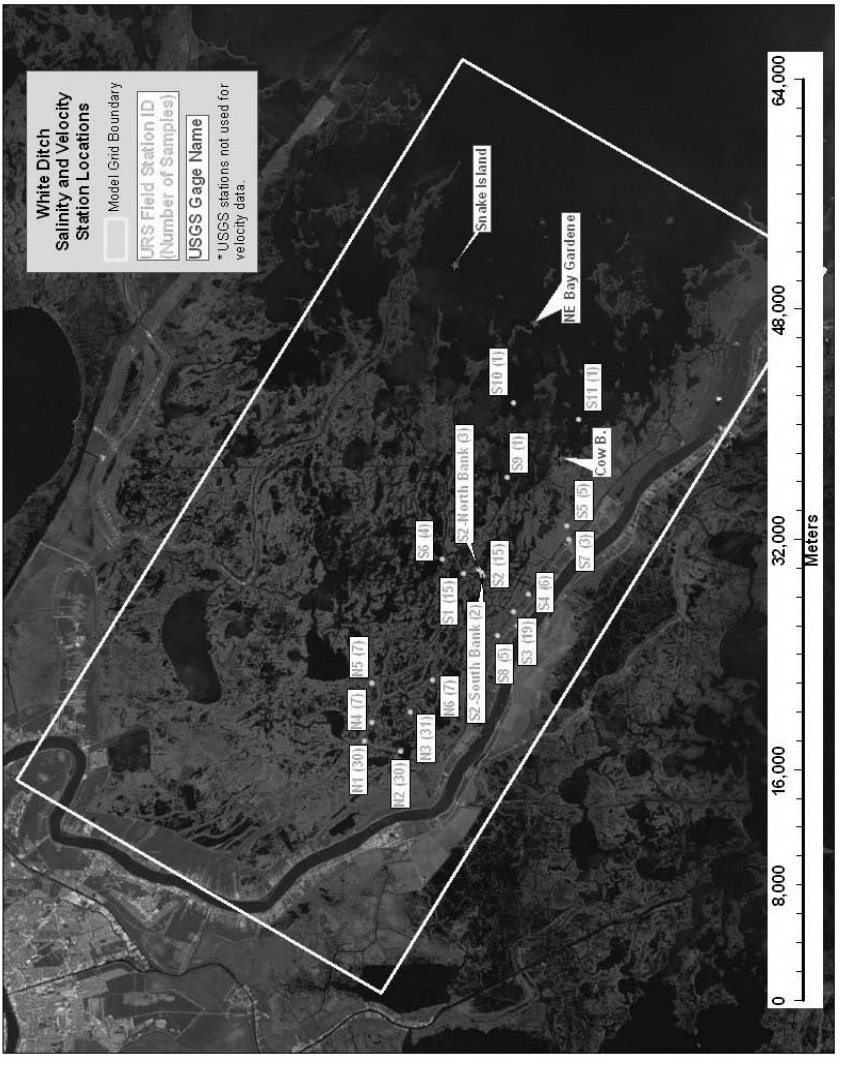


Figure 15. Salinity and Velocity Sampling Stations.

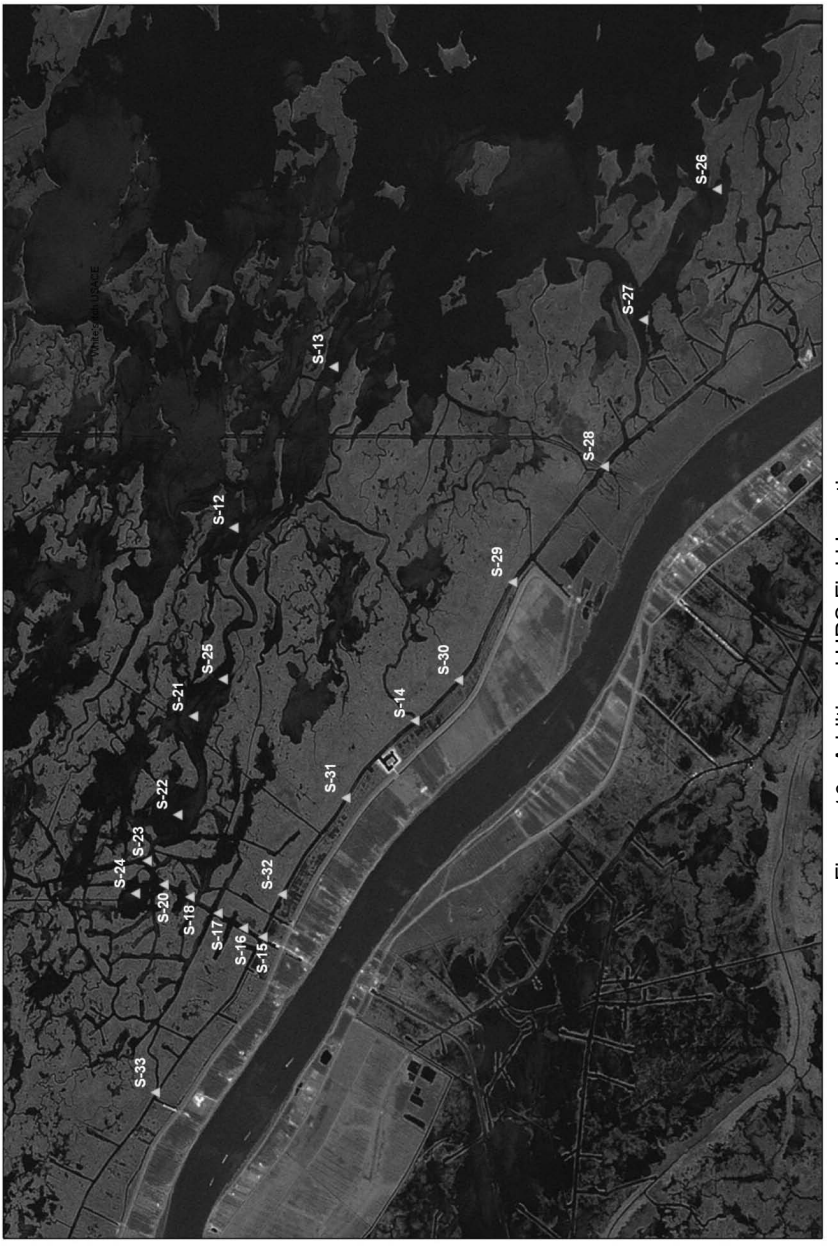


Figure 16. Additional URS Field Locations.

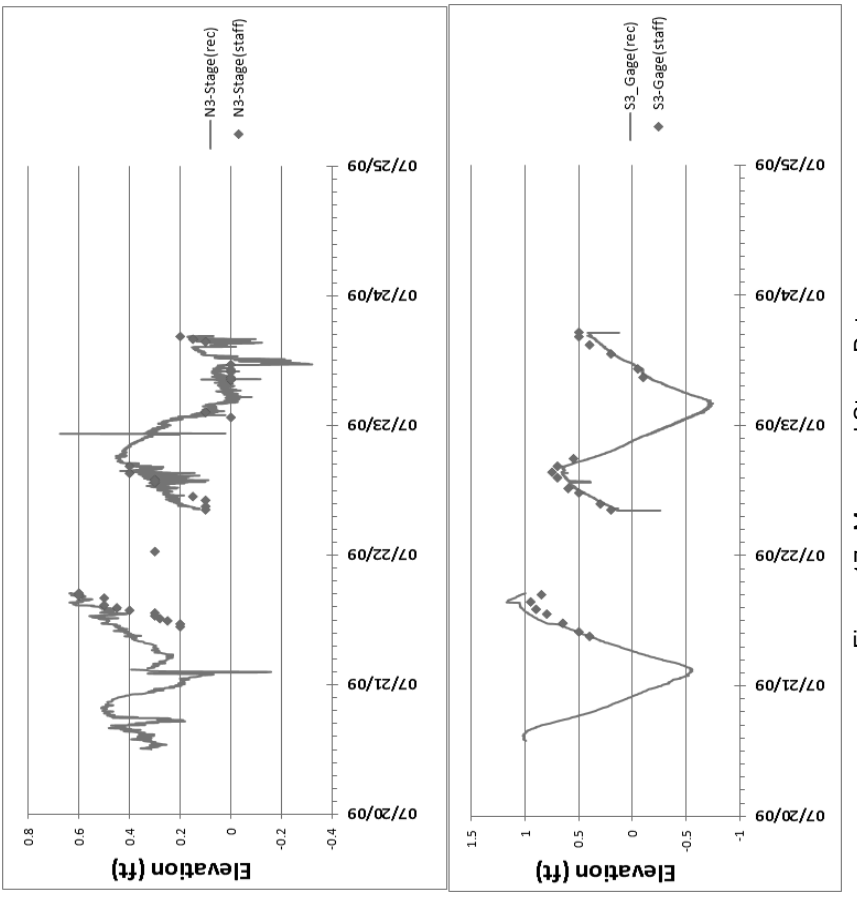


Figure 17. Measured Stage Data.

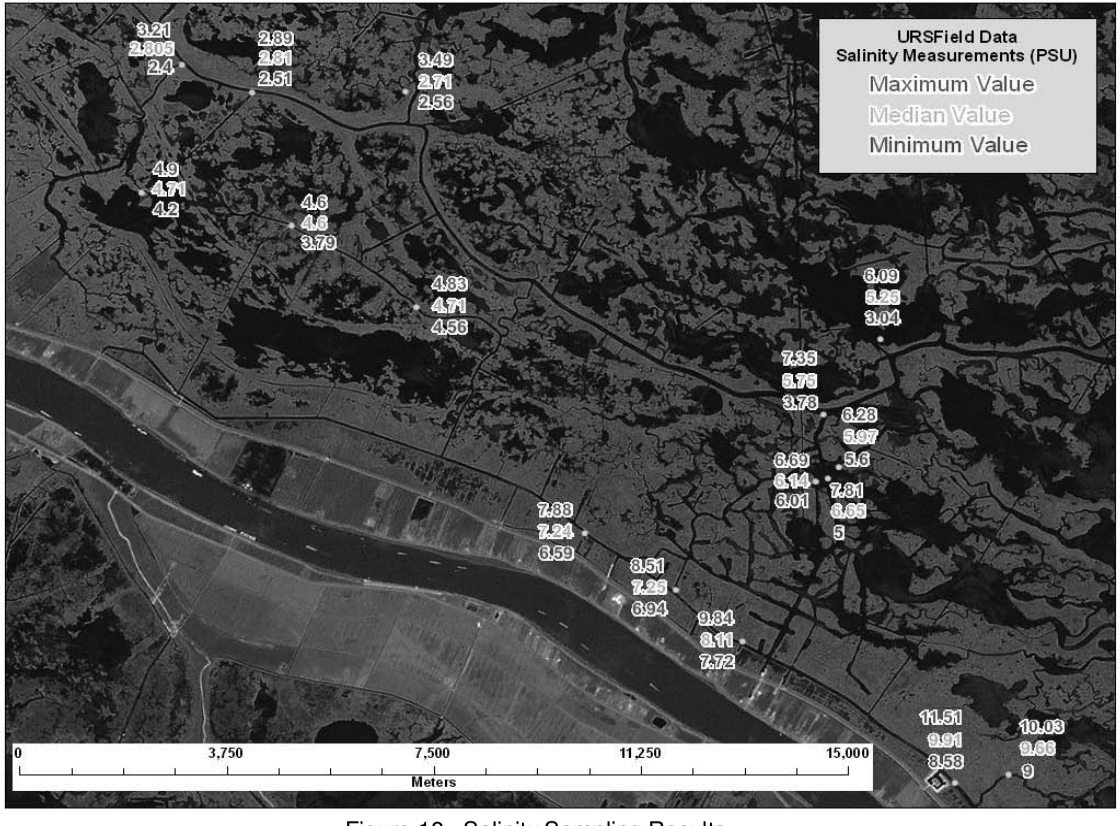


Figure 18. Salinity Sampling Results.

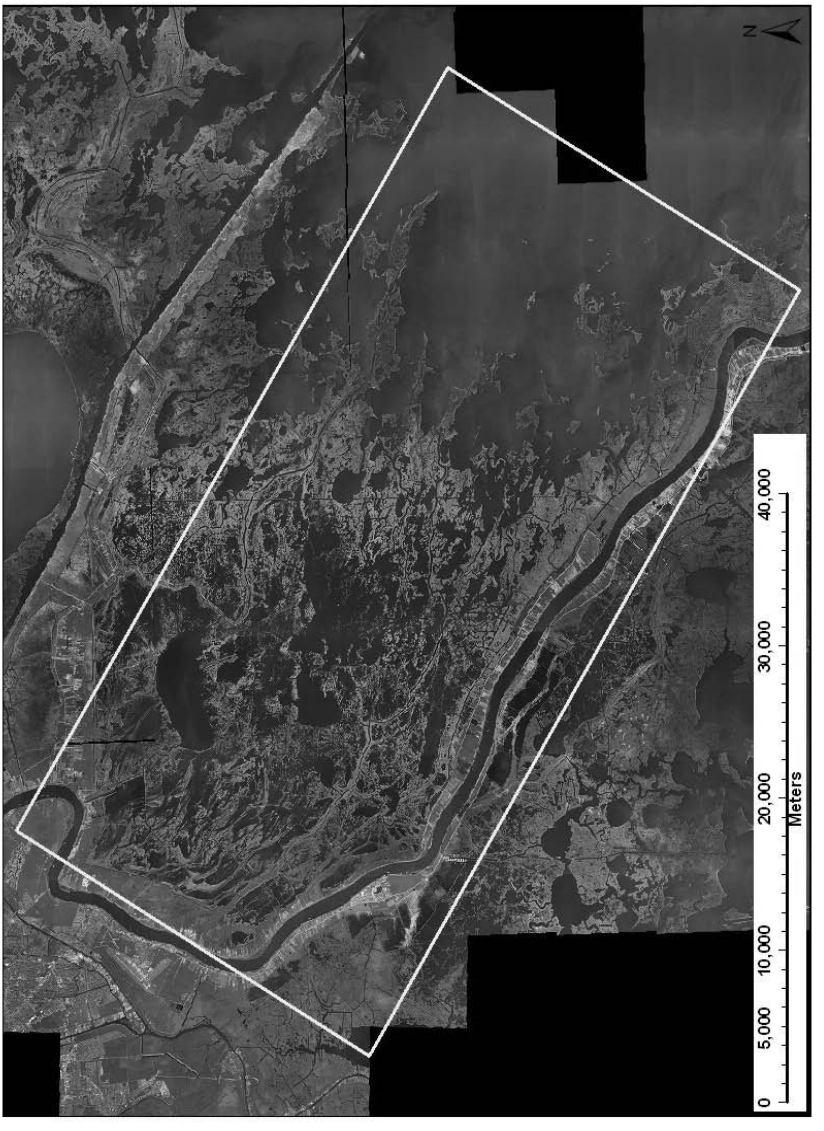


Figure 19. Model Domain.



Figure 20. Water Polygon Data from the LA GIS Digital Map Compilation DVD.

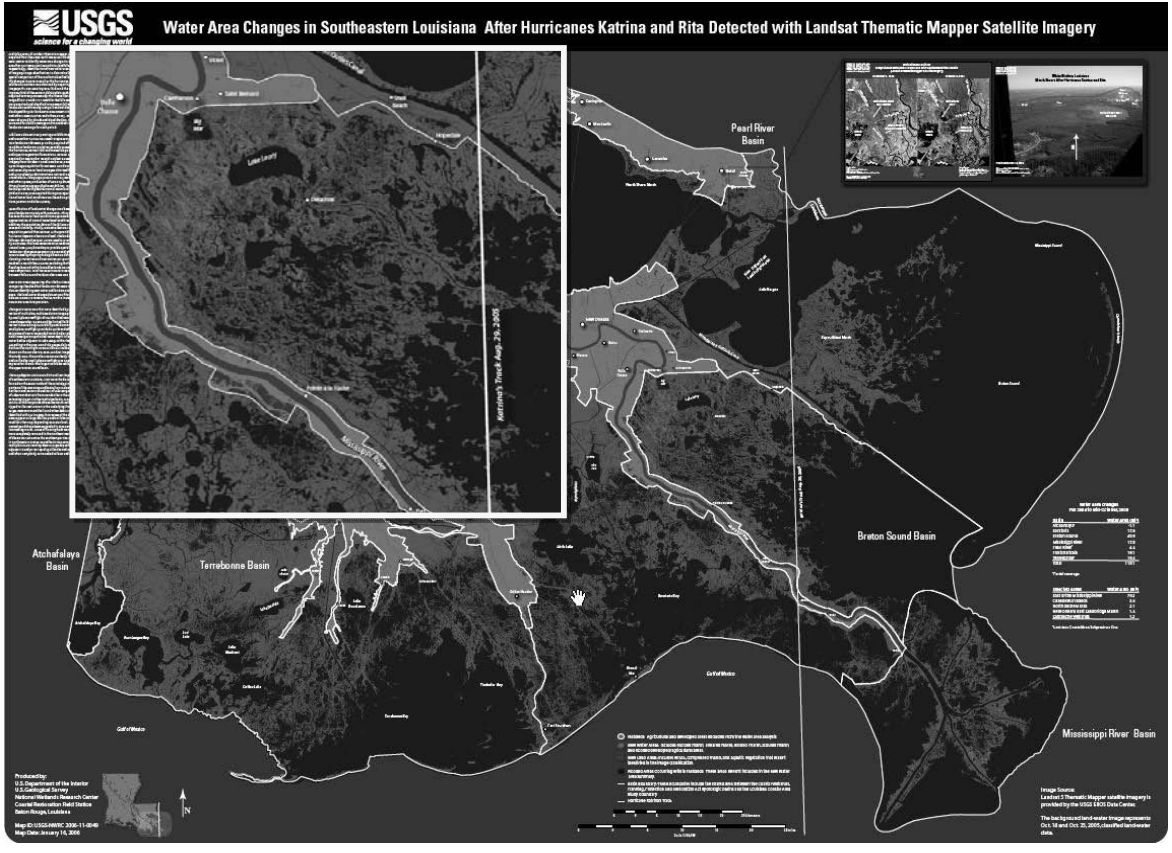


Figure 21. USGS Water Area Changes Study Results.

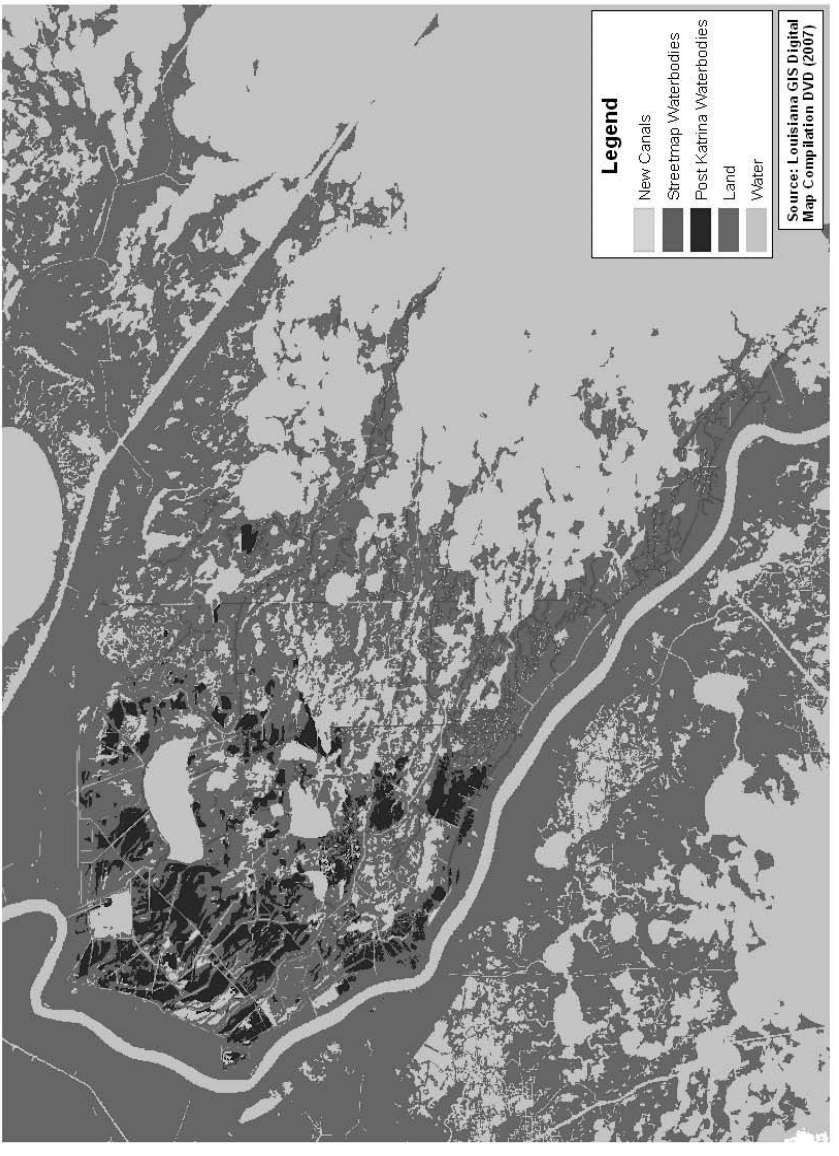


Figure 22a. Final Polygon Set.

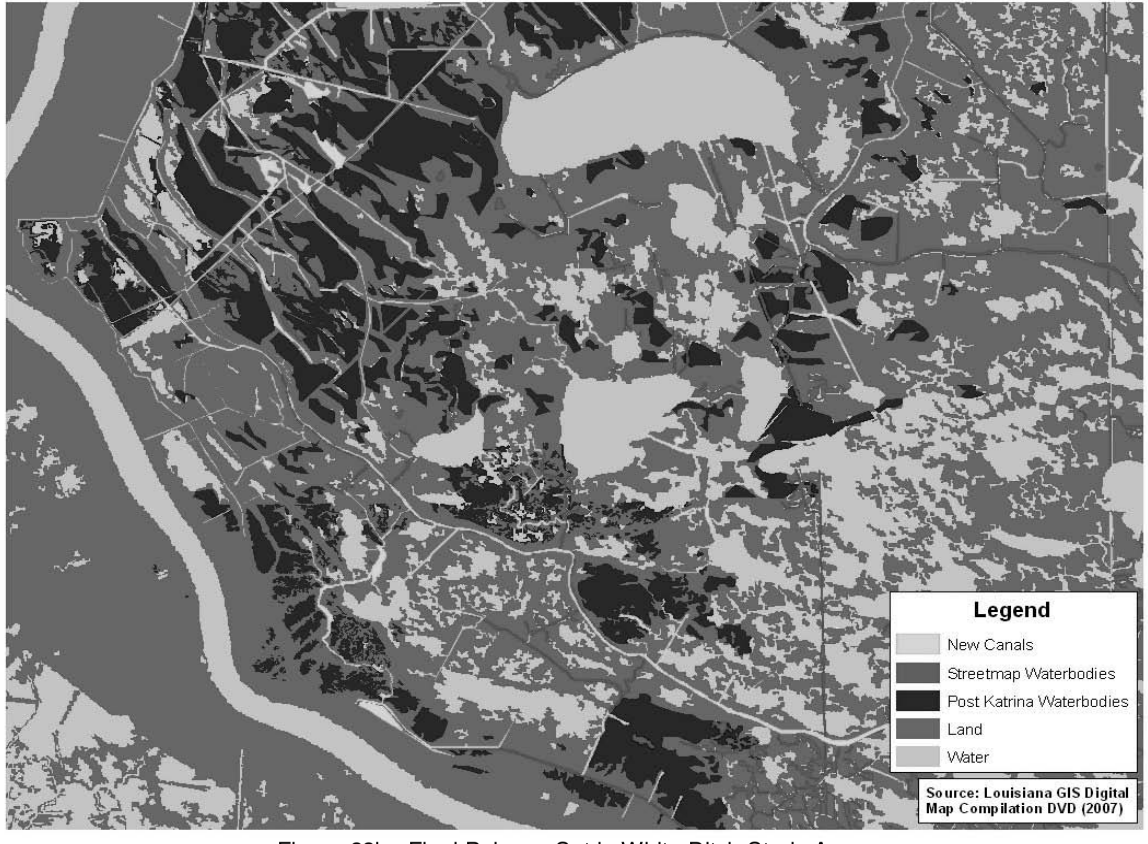


Figure 22b. Final Polygon Set in White Ditch Study Area.

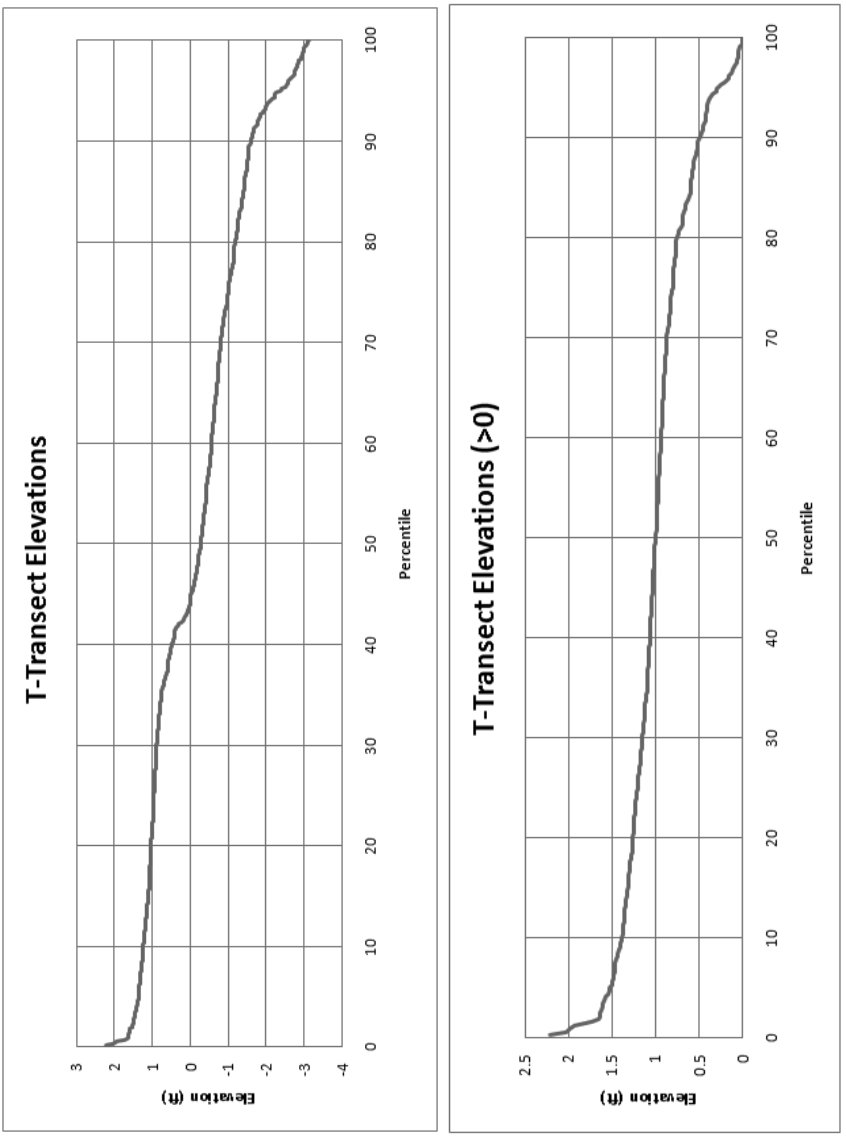


Figure 23. Survey Data Distribution.



Figure 24. Effective Depths and Locations from Cross-Section Transect Data.



Figure 25. Template of Water Body Depths.

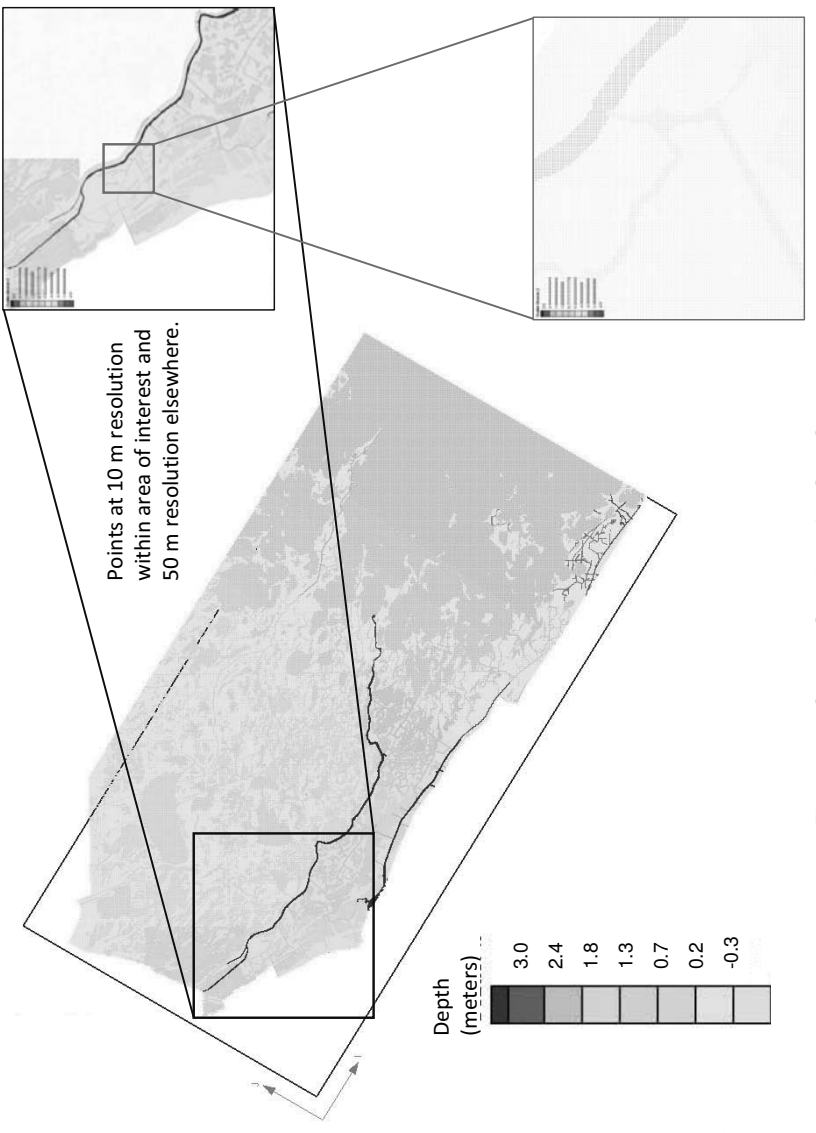


Figure 26. Scatter Set Used for Grid Generation.

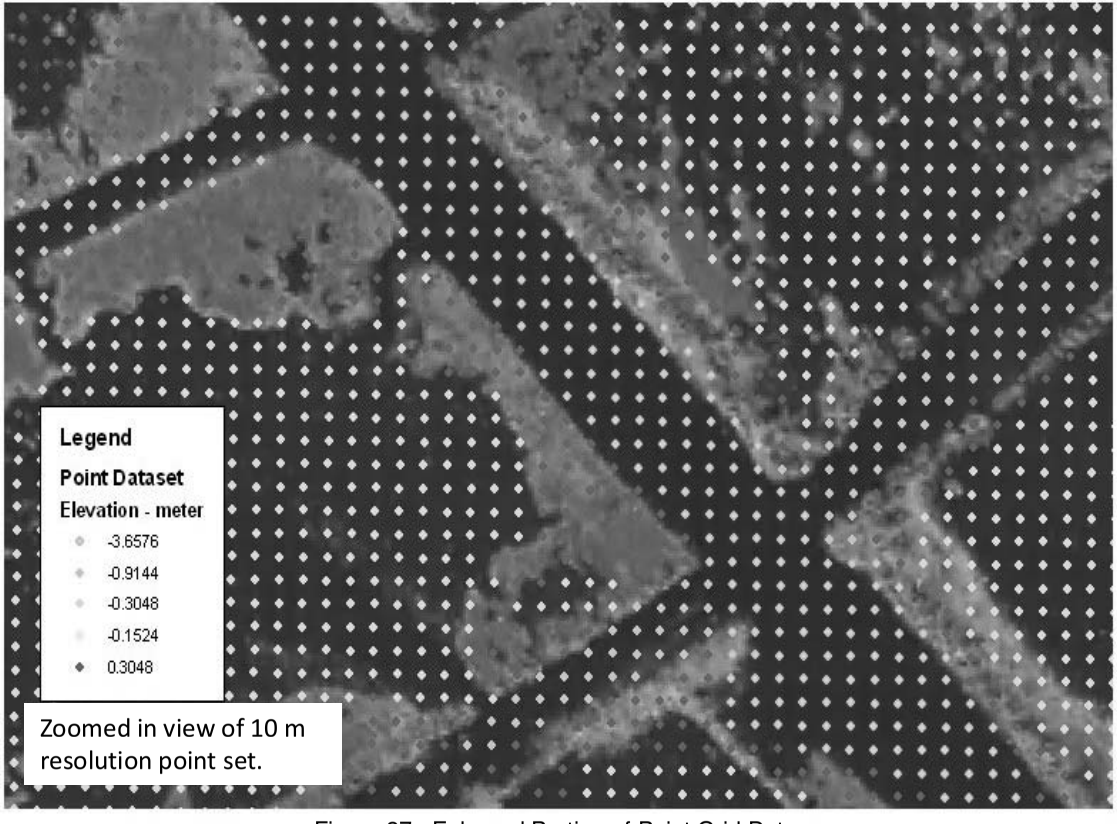
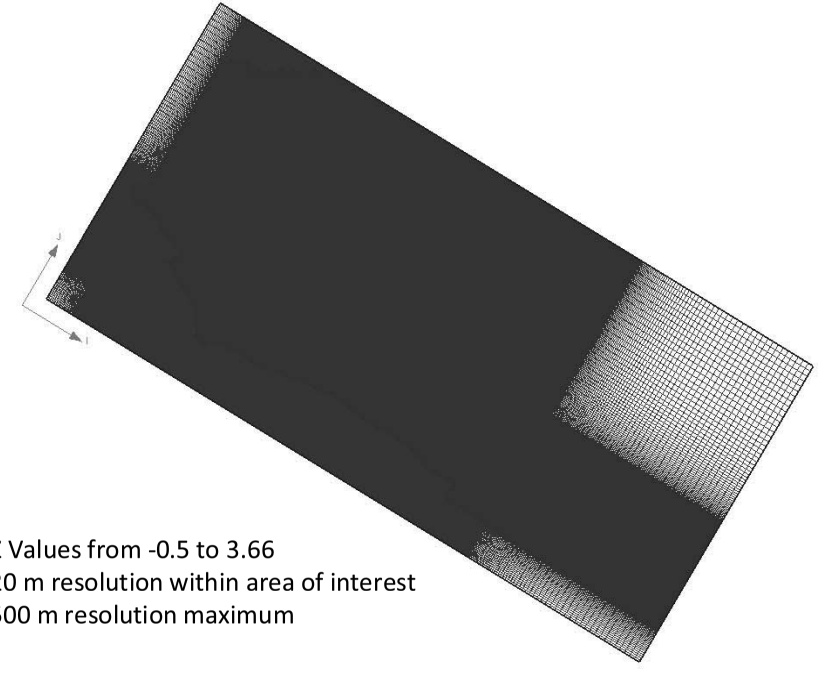


Figure 27. Enlarged Portion of Point Grid Data.

~ 57 Km in I direction	992 Columns
~ 26 Km in J direction	569 Rows
1,133,448 Total Cells	866,791 Ocean Cells



Z Values from -0.5 to 3.66
20 m resolution within area of interest
500 m resolution maximum

Figure 28. Final Grid and Grid Information.

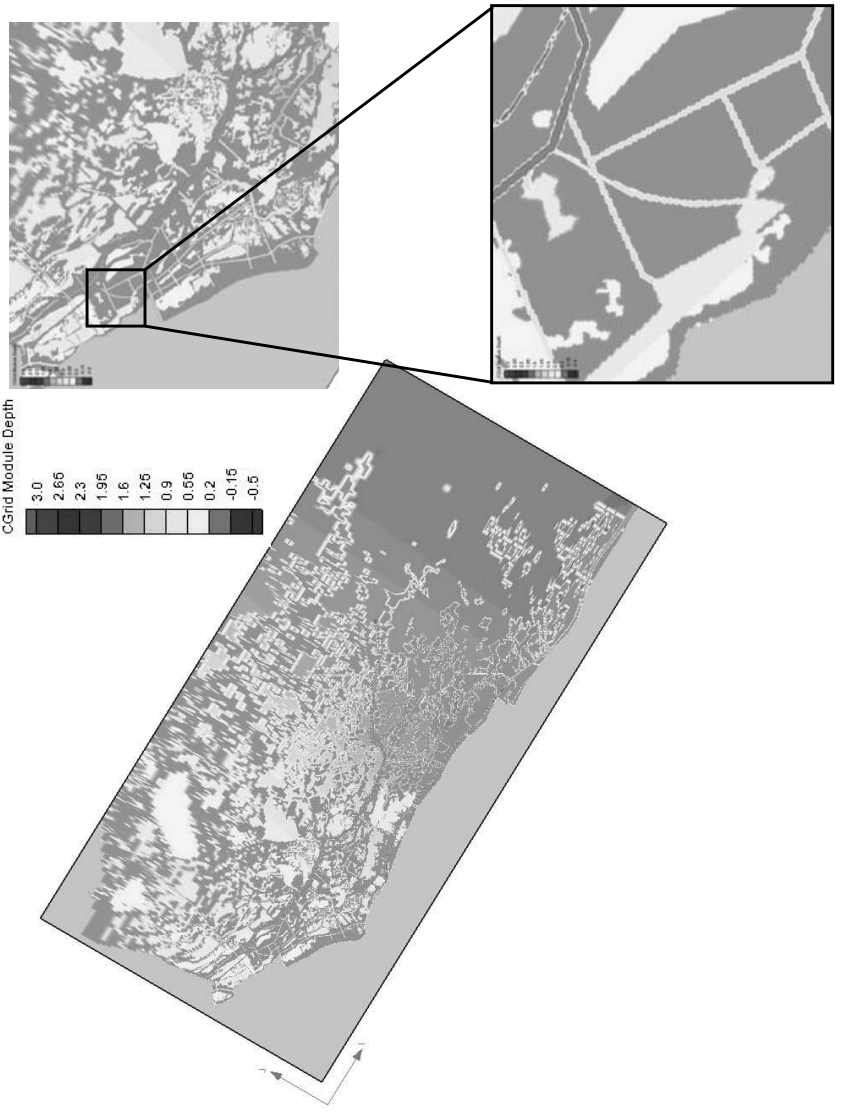


Figure 29. Depth Contours.

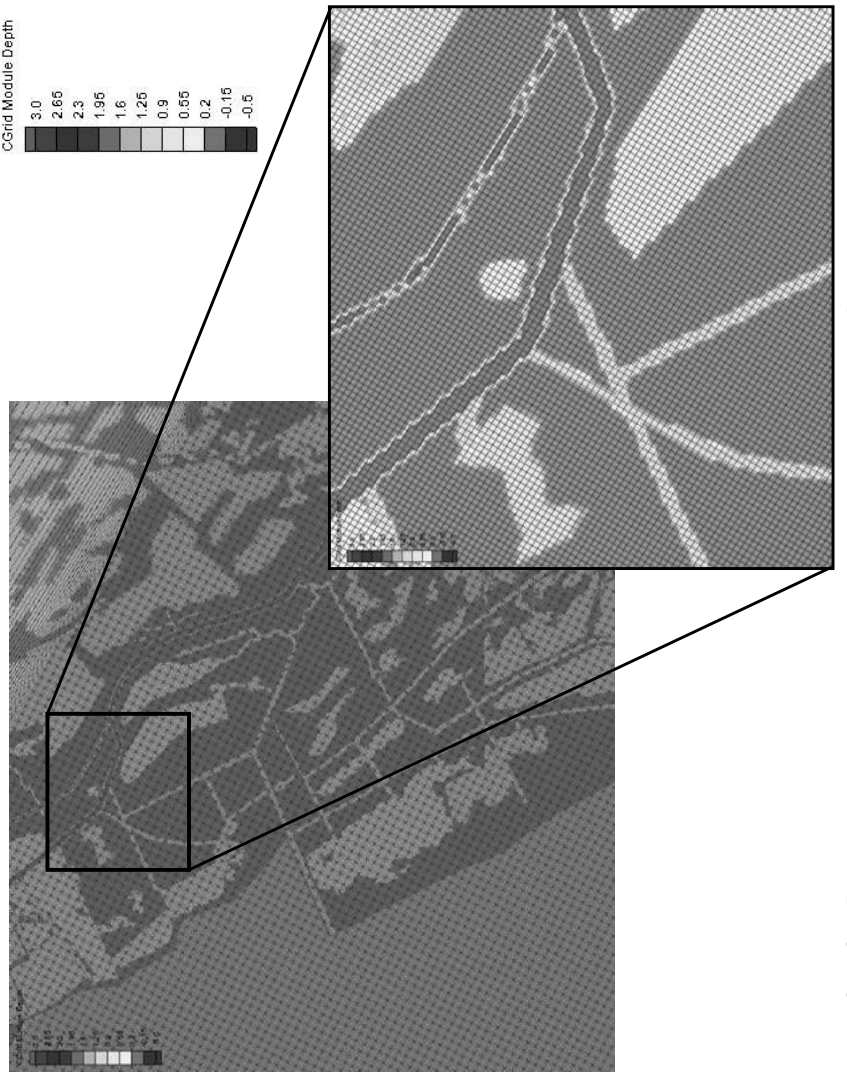


Figure 30. Grid Cell Resolution in area of interest (top) and showing number of cells in canals and rivers (right).

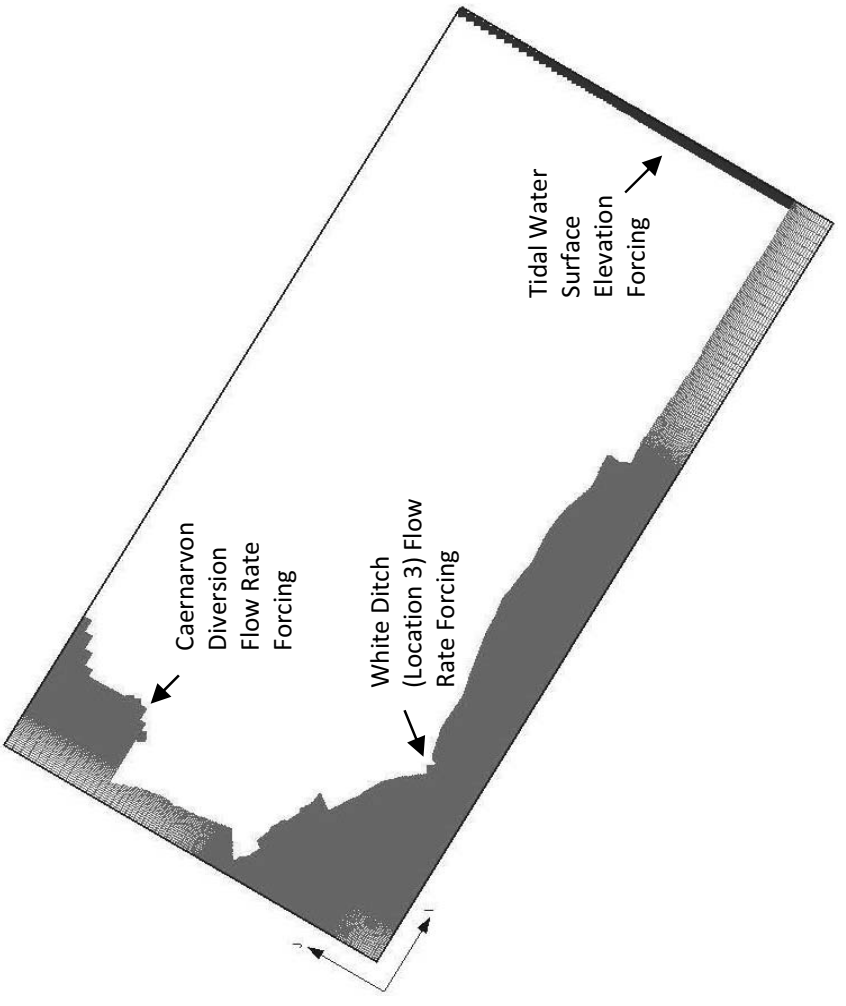


Figure 31. Grid with Boundary Cellstring Locations.

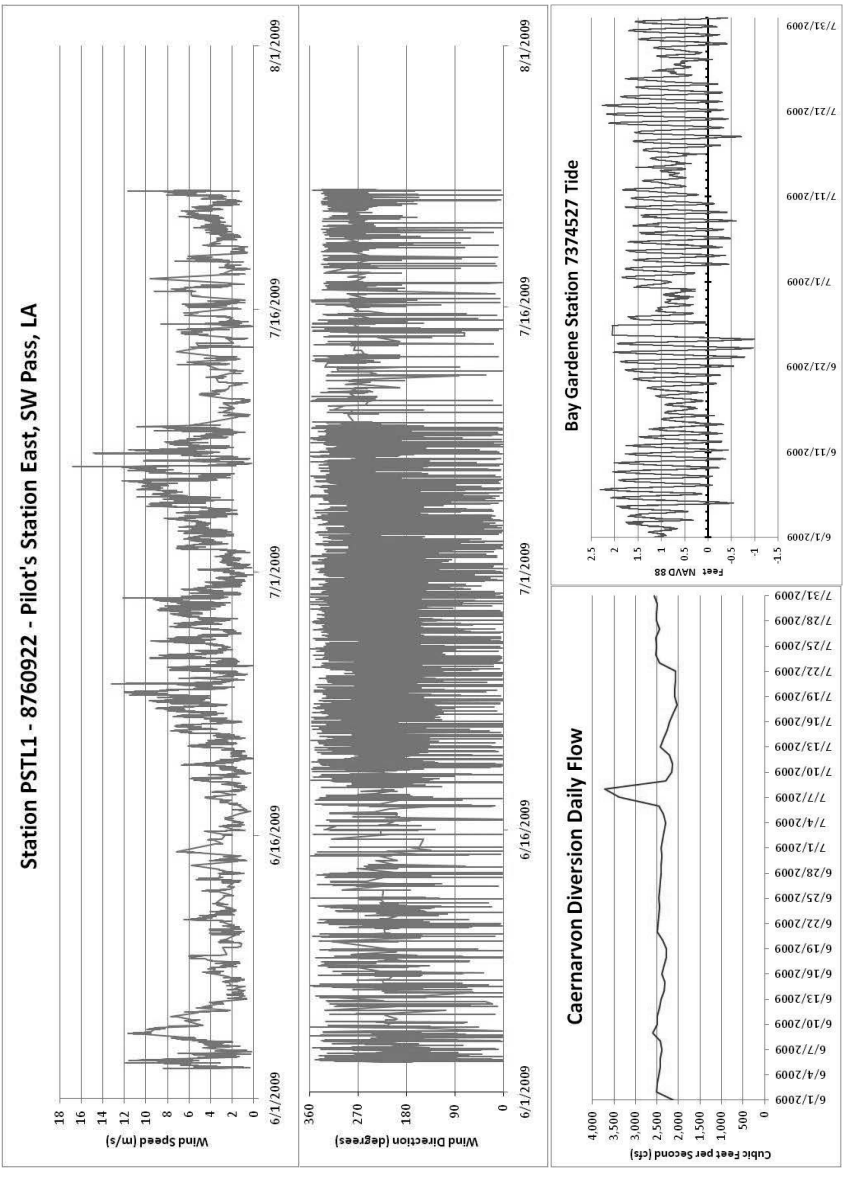


Figure 32. Boundary Input Data.

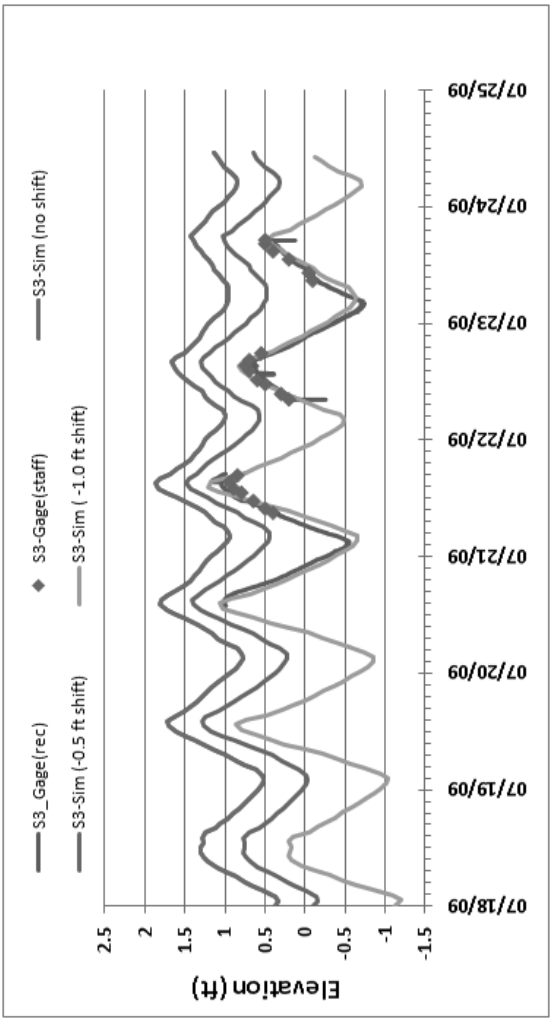


Figure 33. Sensitivity of the Tide Calibration to the Datum Shifts in the Bay Gardene Stage Data.

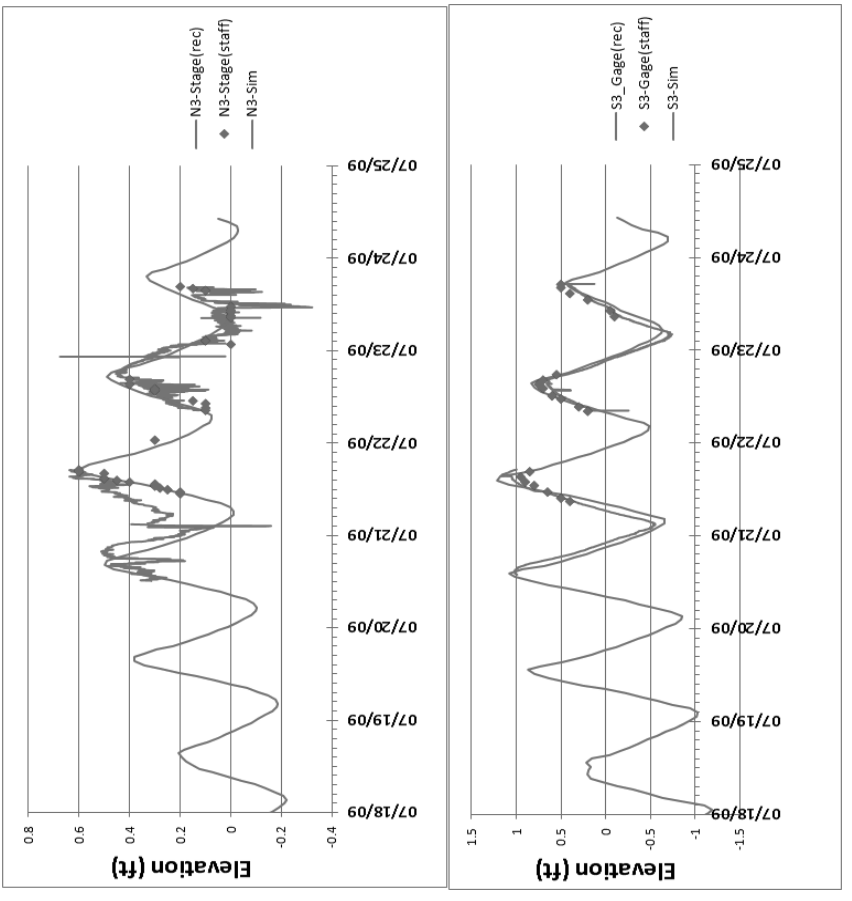


Figure 34. Final Stage Calibration.

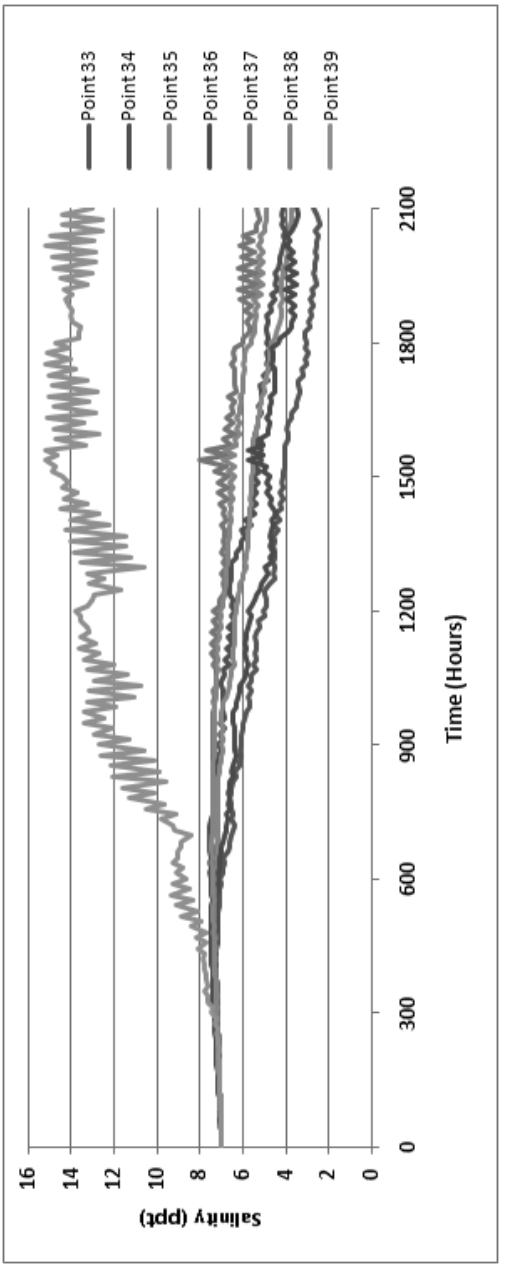


Figure 35. Typical Response of Salinity During a Calibration Simulation (Point locations are shown on Figure 36).

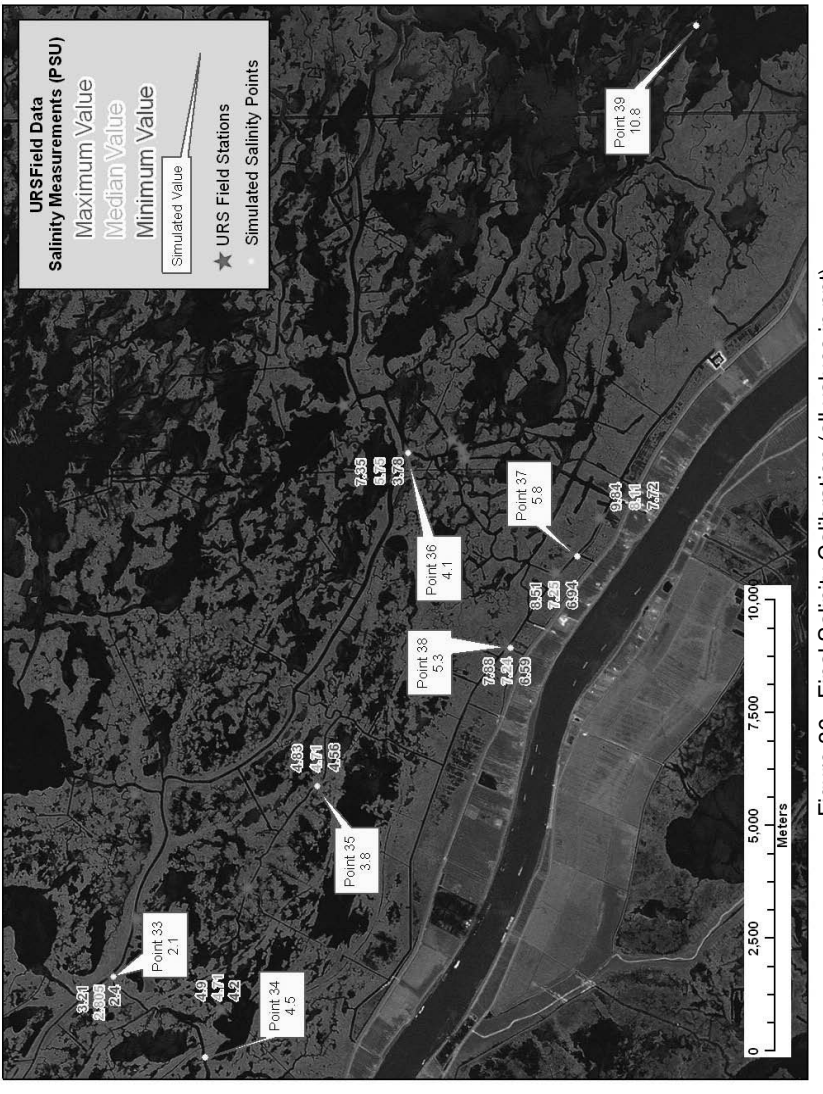


Figure 36. Final Salinity Calibration (all values in ppt).

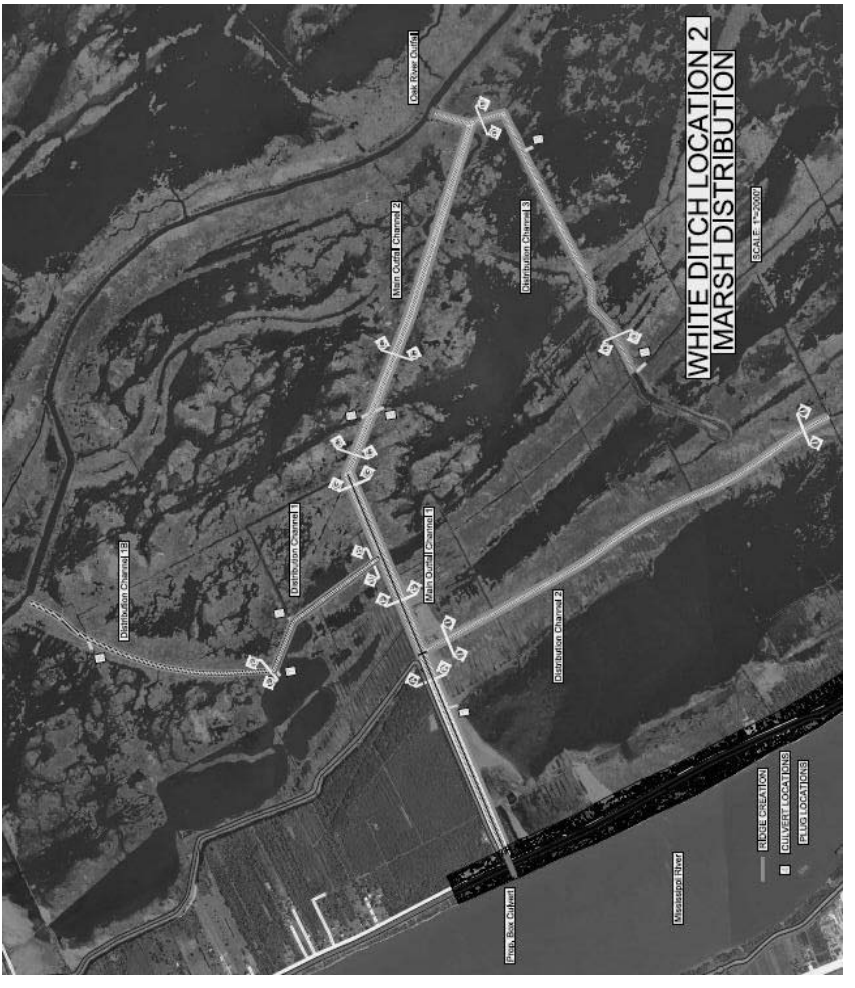


Figure 37. Location 2.

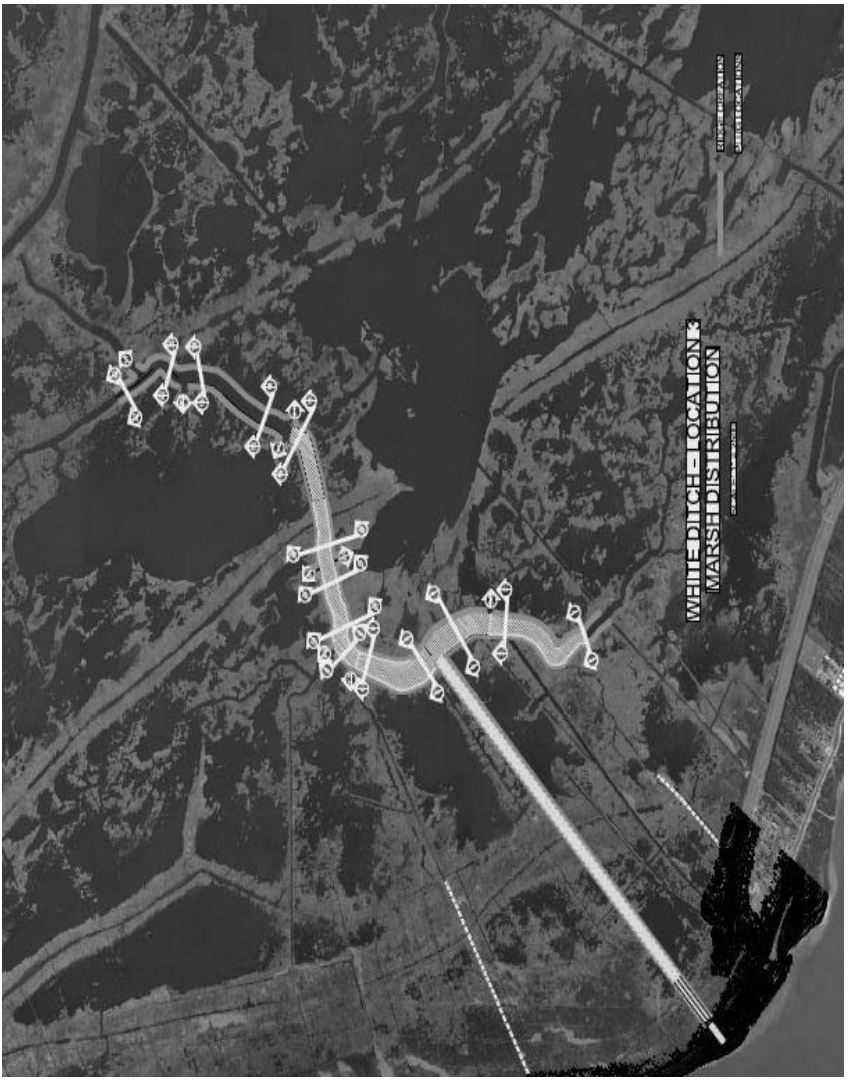


Figure 38. Location 3.

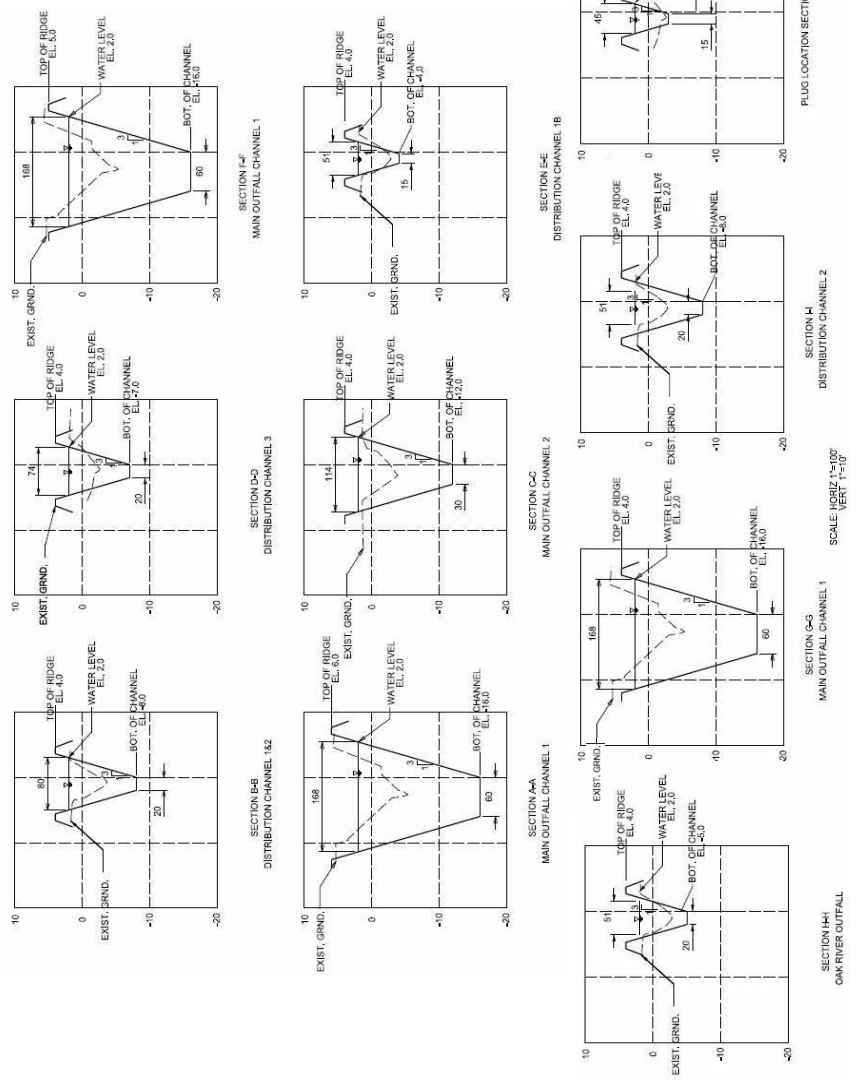


Figure 39. Location 2 5000 cfs Capacity Cross-Sections.

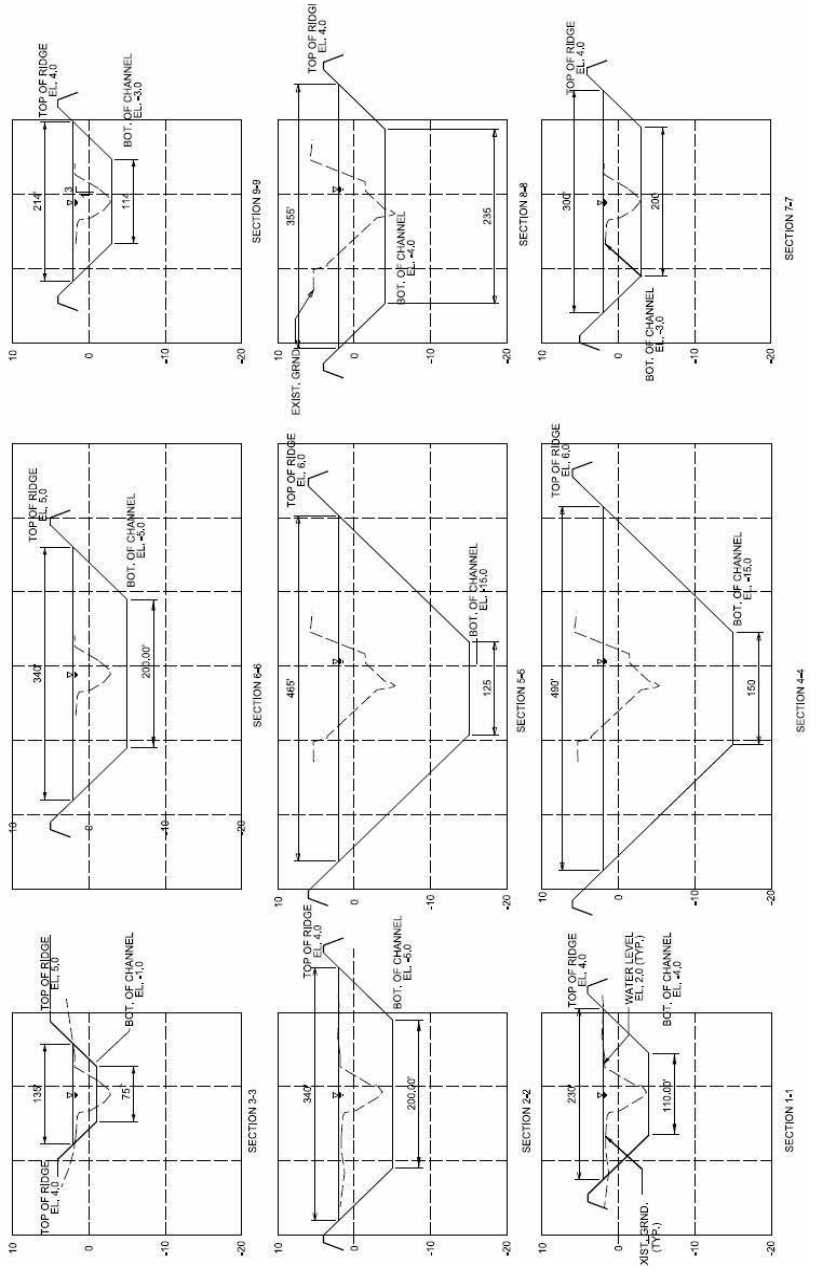


Figure 40a. Location 3 5000 cfs Capacity Cross-Sections.

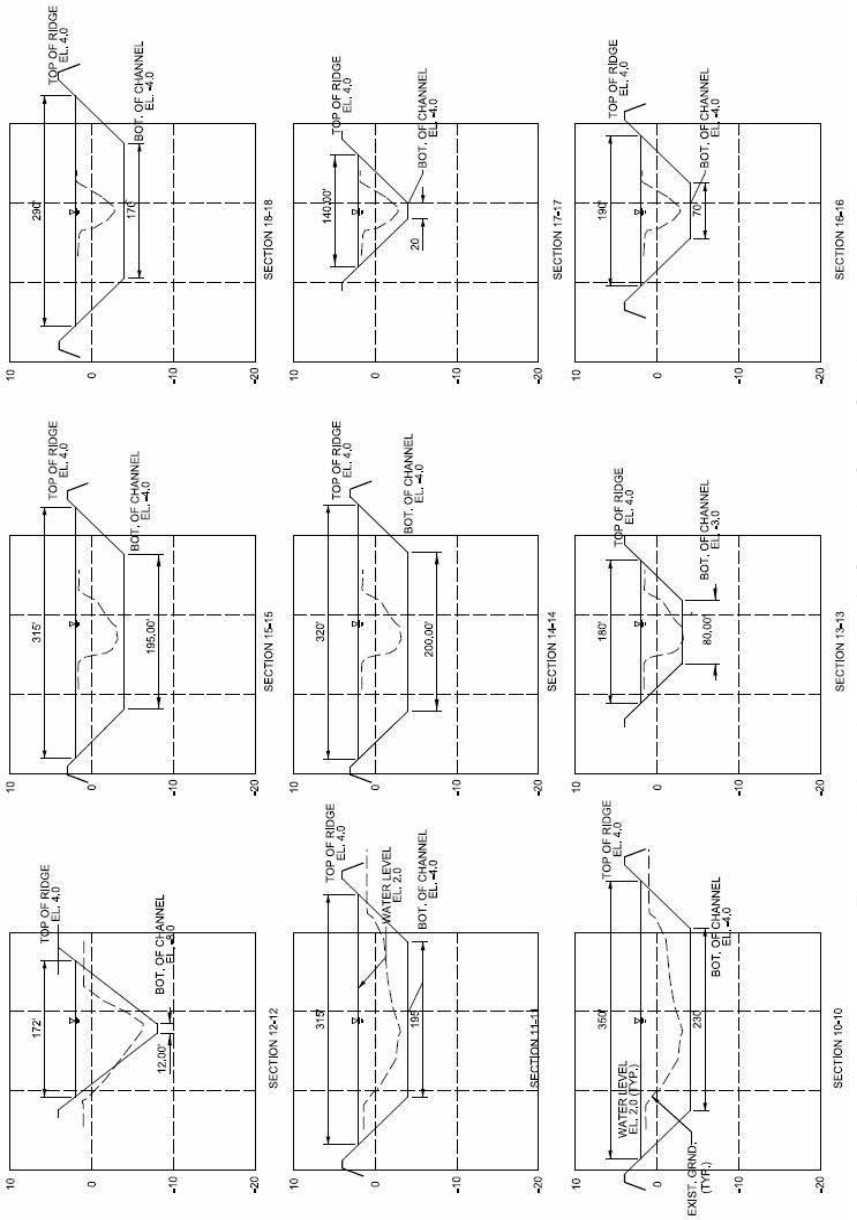


Figure 40b. Location 3 5000 cfs Capacity Cross-Sections.

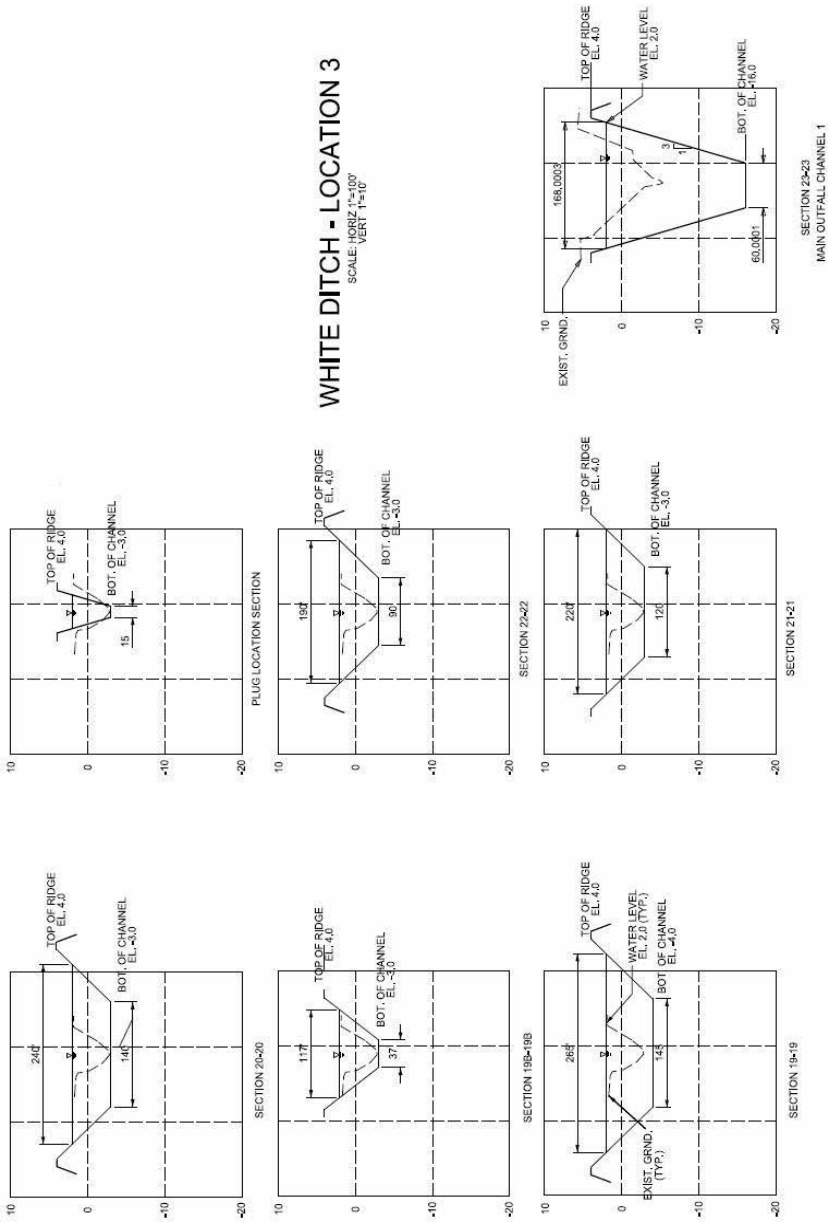


Figure 40c. Location 3 5000 cfs Capacity Cross-Sections.

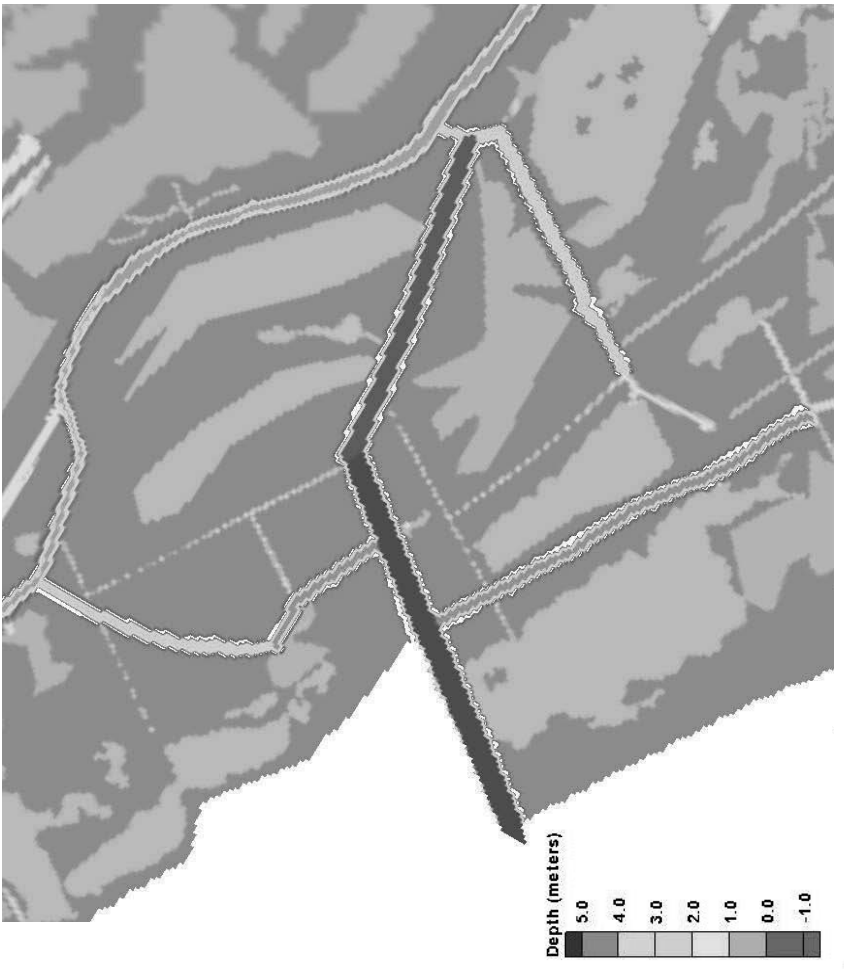


Figure 41. 35,000 cfs Capacity Alternative 2 Depth Contours.

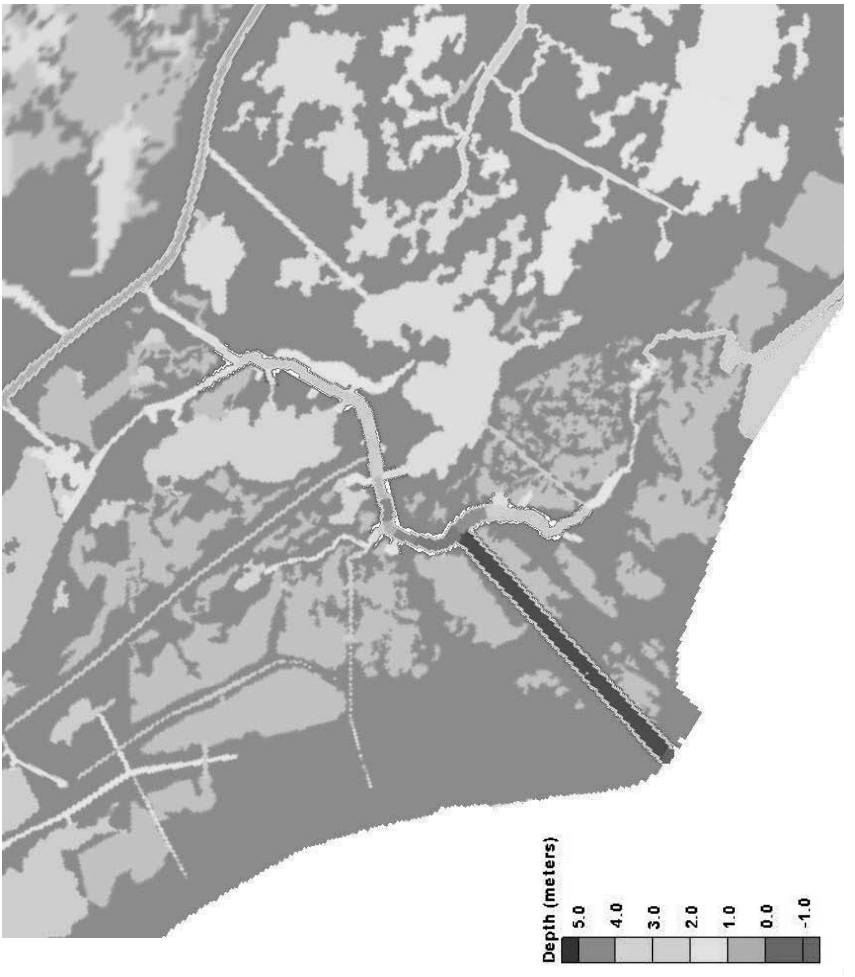


Figure 42. 35,000 cfs Capacity Alternative 3 Depth Contours.

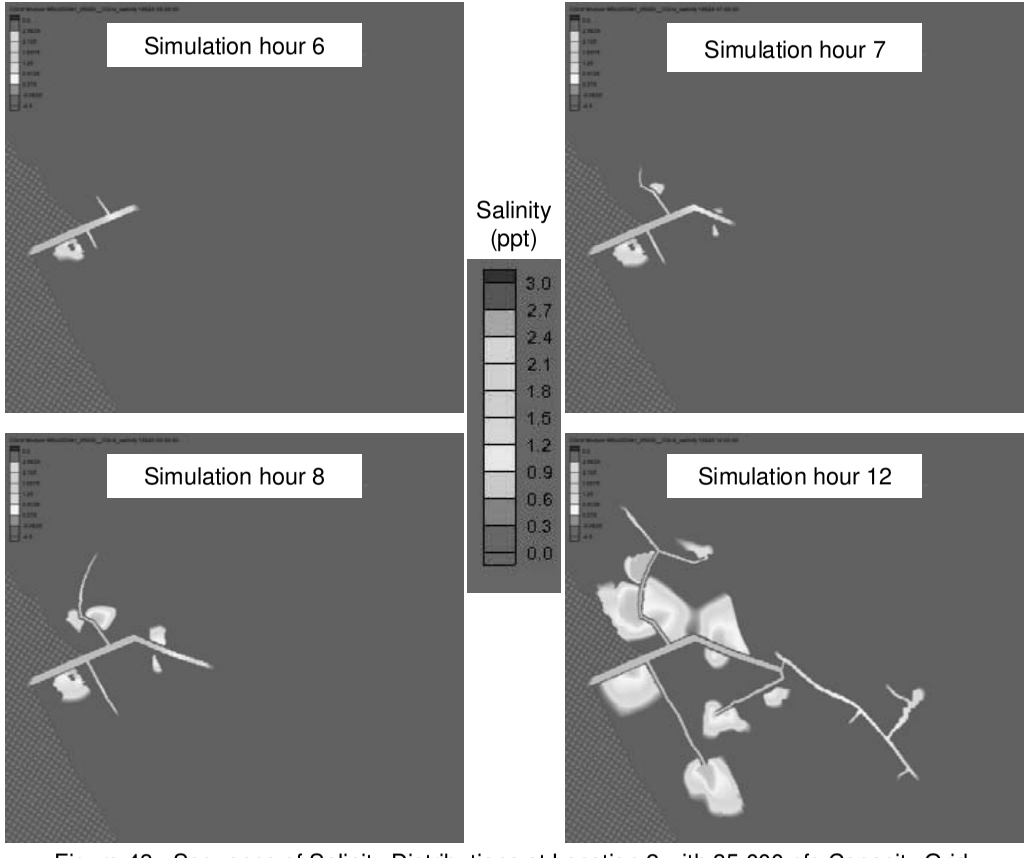


Figure 43. Sequence of Salinity Distributions at Location 2 with 35,000 cfs Capacity Grid.

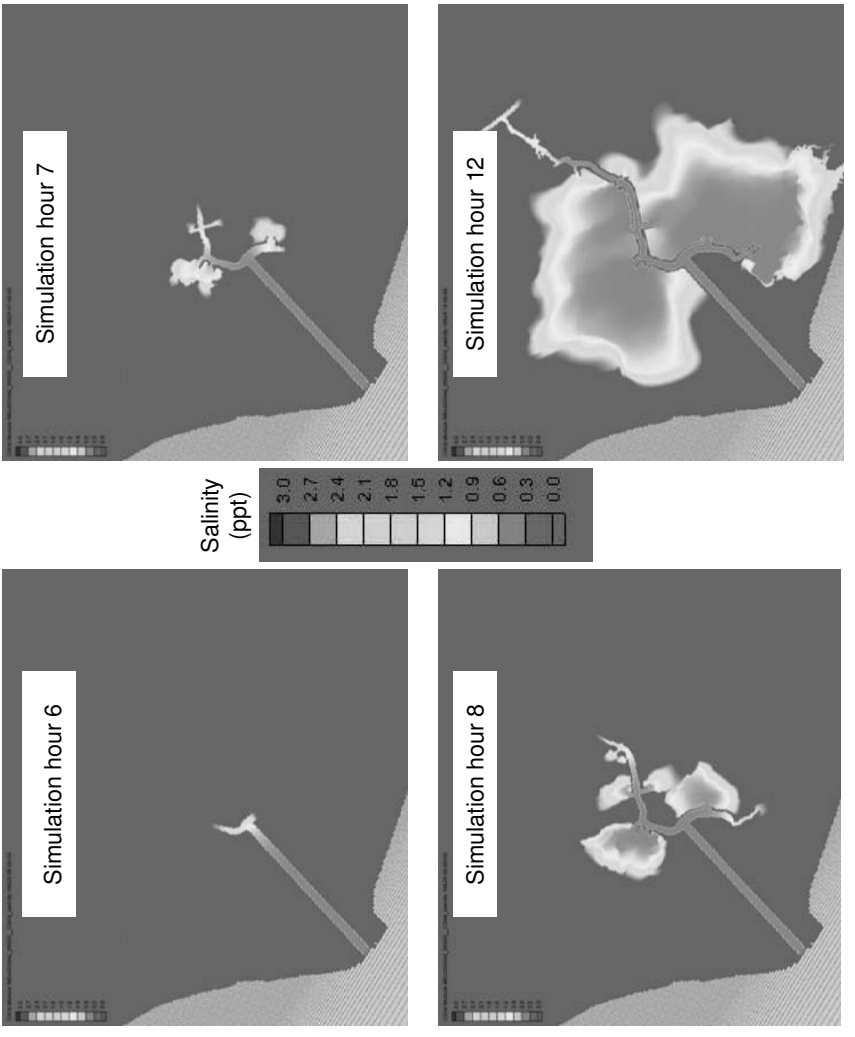


Figure 44. Sequence of Salinity Distributions at Location 3 with 35,000 cfs Capacity Grid.

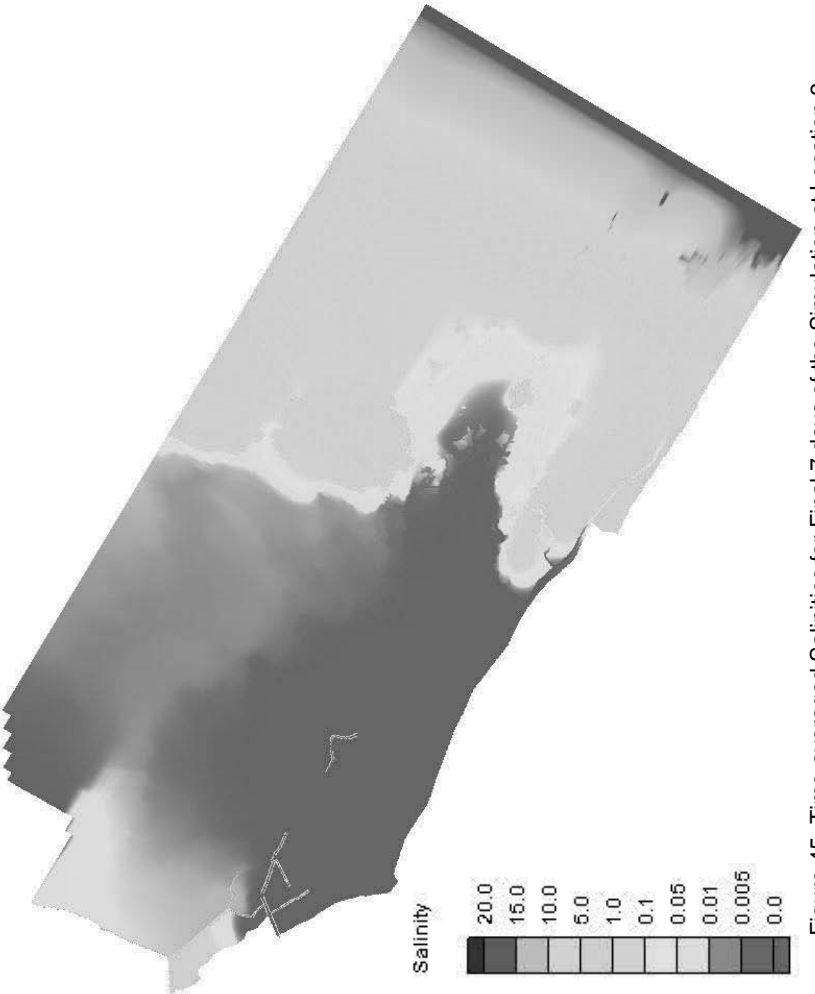


Figure 45. Time-averaged Salinities for Final 7 days of the Simulation at Location 2.

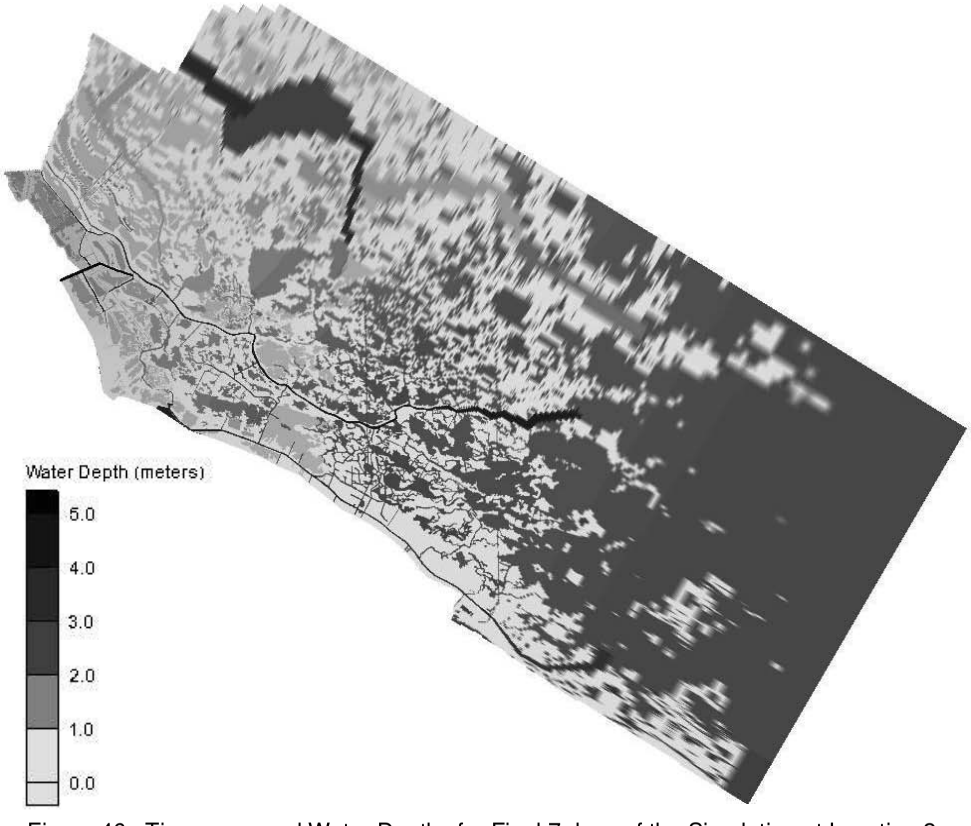


Figure 46. Time-averaged Water Depths for Final 7 days of the Simulation at Location 2.

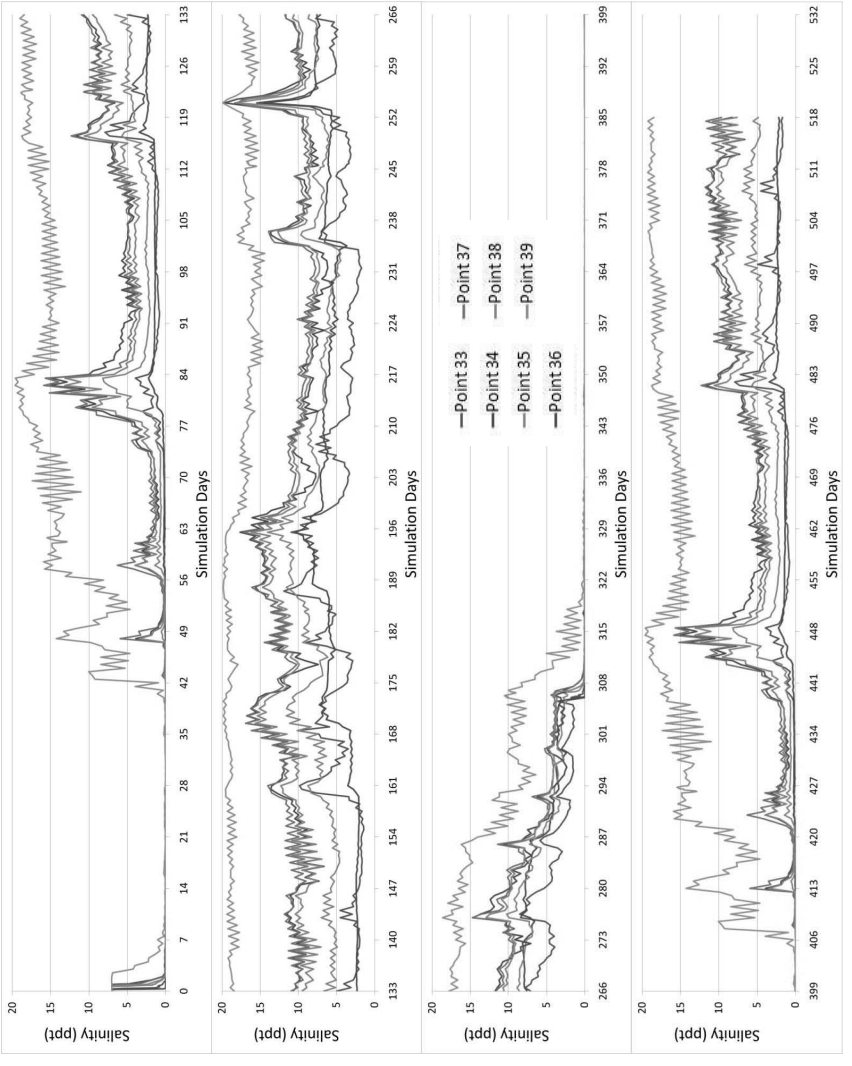


Figure 47a. Simulation 3 Salinity Time Series Results at Points throughout the White Ditch Area (Point Locations shown on Figure 36).

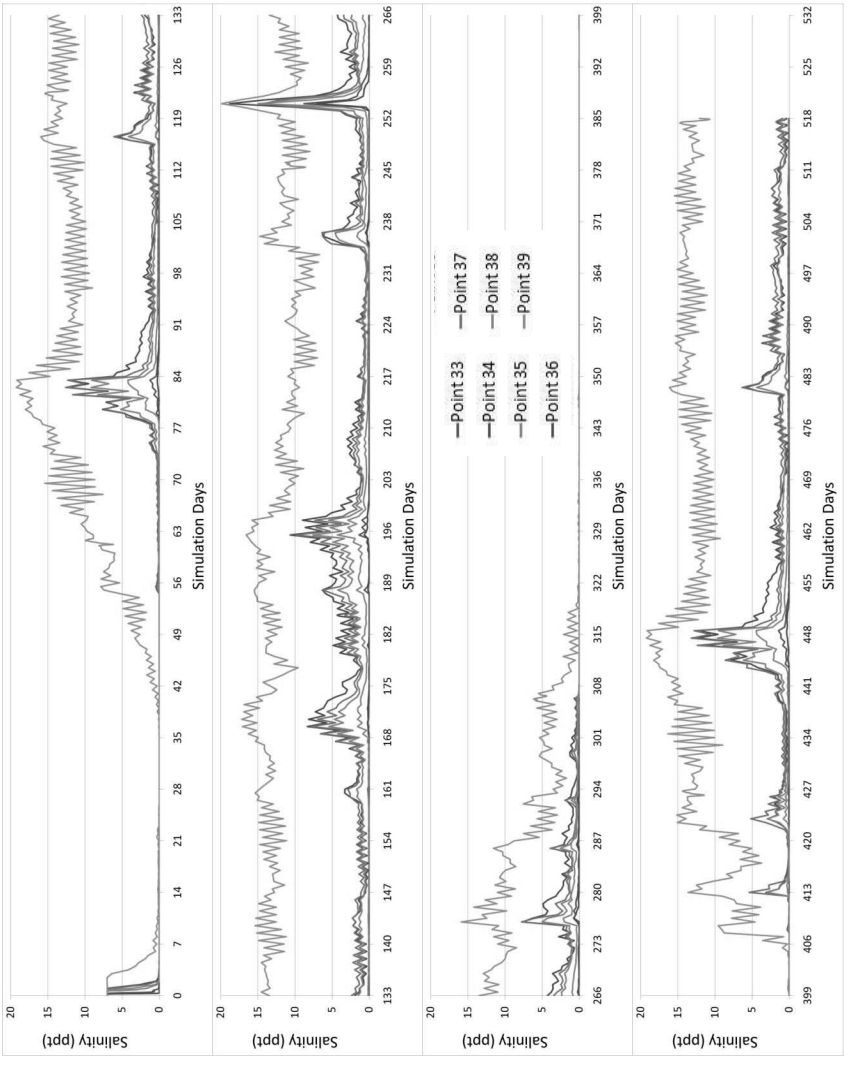


Figure 47b. Simulation 4 Salinity Time Series Results at Points throughout the White Ditch Area (Point Locations shown on Figure 36).

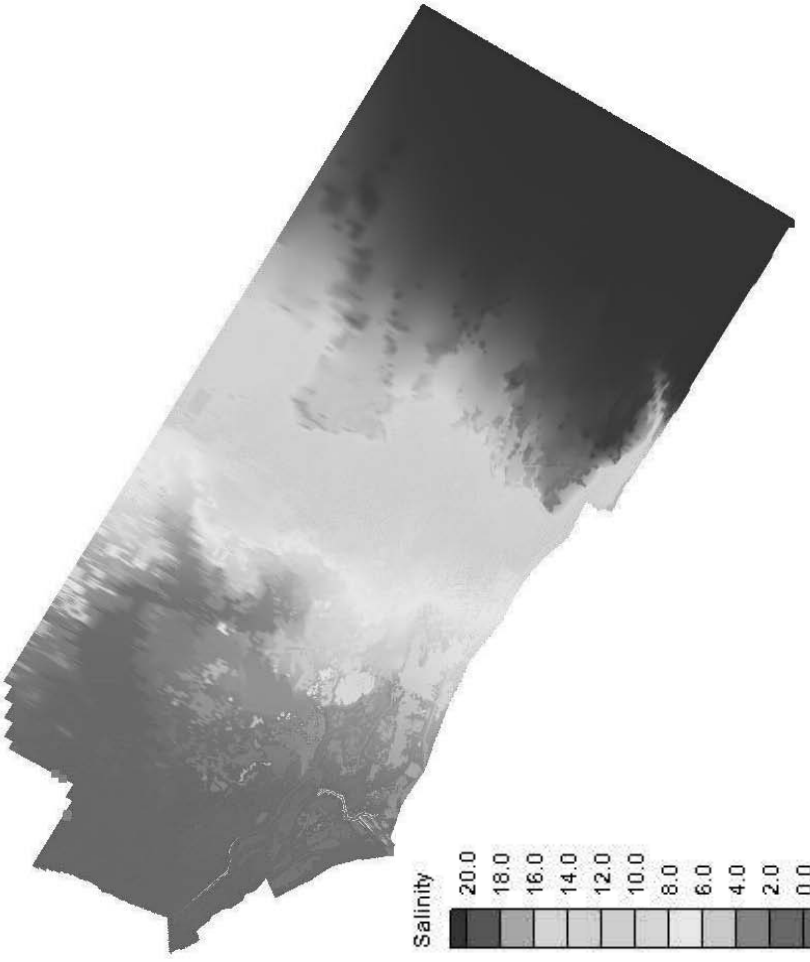


Figure 48. Time-averaged Salinity Distribution for Long-term Simulation 3.

Appendix A
Discussion of Bay Gardene Tide Gage Datum

The White Ditch hydrodynamic and salinity model developed by URS uses the USGS Bay Gardene tide data for the offshore water elevation boundary condition. During the model calibration it was not possible to obtain a tidal calibration to measured data in the White Ditch area without shifting the reported elevation of the tide data. The shift used was approximately 1 foot downward.

The Bay Gardene tide data is reported as NAVD 88 and the mean tide elevation for one or more year period is approximately one foot. The typical spring tide range is about 2 feet. The local survey data in the White Ditch are indicates that the median land elevation (based on numerous survey points on transects across the area) is about 1 foot. Thus during the rising tide, it is expected that the land will be inundated and during a falling tide the inundated areas would become dry. This was reproduced in the model simulations, but it causes a severe attenuation of the tide range in the White Ditch area, so much so that there was no possibility of matching the measured tide range in the area with adjustments to the friction or mixing parameters.

Local knowledge of the area, based on discussion with airboat operators who spend a significant amount of time in the area indicate that during normal tides the land areas do not become submerged, even at high tides. The only exception is during the month of September when high offshore water levels associate with predominant southeasterly winds causes a setup in the White Ditch area. In order to reconcile some of these findings an investigation of the tidal datum for the Bay Gardene gage was made. The findings of this investigation are summarized as follows:

- The USGS indicates that the gage was reset with the last year and there is larger than normal uncertainty in the accuracy of the gage datum (NAVD88)
- NOAA is not aware of or is not using the datum data that the USGS generated (no MSL to NAVD 88 info). NOAA has no published website Benchmark Page and they do not publish a NAVD to MSL conversion for the Bay Gardene gage.
- The NOAA VDATUM software quotes the uncertainty of datum conversions in the east Louisiana and Mississippi area as 17.1 cm (65% chance that actual area is below this level)
- Discussion with Garron Ross of USGS (referred to by Scott Beddingfield) indicates that there is a good degree of uncertainty in the tidal benchmark at Bay Gardene and that the USGS plans to re-survey it using a state-of-the-art GPS system in the near future, possibly publishing it in Summer 2010. The current gage was remounted about a year ago, and an expedient method of establishing the gage datum was used. Mr. Ross also pointed out that the Bay Gardene data of summer 2009 is still provisional, and noted that there was a sudden 0.5 foot shift in the data back in January.

These findings indicate that there is sufficient uncertainty in the Bay Gardene gage datum to allow for some adjustment of the stage levels in the modeling analysis.

Appendix M

Hazardous, Toxic, and Radioactive Waste Initial Assessment Documentation

A Summary of the HTRW Initial Assessment Documentation is listed below. Additional technical information and data is on file and available on request.

LCA White Ditch
Mississippi River Delta, Louisiana
HTRW Initial Assessment (IA) Documentation
Prepared by ARDL, Inc.
Revised 24 February 2010

8.0 ASSESSMENT FINDINGS

8.1 Summary of Results

ARIDL, Inc., has performed HTRW Initial Assessment documentation for the restoration project to implement a medium diversion at White Ditch in conformance with the scope and limitations of ASTM Practice 1527-05. Exceptions to or deletions from this practice are documented in Section 9.0 of this report. This assessment has revealed no evidence of Recognized Environmental Conditions in connection with the property, except for the following:

1. Oil/gas pipeline running through target area
2. Oil/gas wells within target boundary and adjoining properties
3. Presence of sunken boats in canals within target boundary
4. Presence of Petroleum Refining Facility on property within 1 mile of target area
5. Presence of ASTs on adjacent property
6. Maritime transportation traffic in nearby Mississippi River

8.2 Risk Assessment

The environmental professionals who have conducted the site visit and reviewed the results of the data collection effort have concluded that the following are "Recognized Environmental Conditions" which may have the following range of qualitative impacts on the soil and water resources on the subject properties. It is the responsibility of the user of this report, based on his or her risk tolerance, fiduciary responsibility or the applicable law, to determine the extent of further inquiry.

Recognized Environmental Condition	Potential Environmental Impact
Oil/gas pipeline within target area	Low to Moderate
Oil/gas wells within target area and adjacent property	Low to Moderate
Sunken boats in canals	Low
Presence of refinery within 1 mile of target area	Low to Moderate
ASTs on Adjacent property	Low
Maritime transportation traffic on Mississippi River	Low

8.3 Recommendations

Based upon the data reviewed and observations made within the immediate target area, no further environmental actions are warranted at this time. There was evidence of RECs within the target area as stated in Section 8.1.

According to information collected for this EA, the presence of at least one known pipeline is located within the project target area. A ConocoPhillips pipeline enters the target area from the west, trends to the northeast, and then turns due north towards Lake Borne. Other unreported pipelines are located within the target area, as evidenced by topographic map review and the presence of access canals. The reported oil/gas pipeline poses a low risk of environmental impact on the subject property, as long as the pipeline operates in a secure and environmentally compliant manner. Any reported incident would be required to be fully remediated by the responsible oil and gas well operators/owners as mandated by state and Federal regulations. No such incidents have been reported within or in close proximity to the project area.

The oil and gas wells pose a low risk of environmental impact on the subject property. Any reported incident would be required to be fully remediated by the responsible oil and gas well operators/owners as mandated by state and Federal regulations. No such incidents have been reported within or in close proximity to the project area.

The sunken boats present in the canals within the target property may have potential environmental impact due to the presence of unused or leaking diesel fuel on board. Any accidental release, leak, or rupture would be considered an REC. However, in the event that this should occur, the incident would be fully remediated by the responsible parties, Louisiana Department of Environmental Quality, or the U.S. Coast Guard, according to state and Federal regulations.

The ConocoPhillips refinery located west of the Mississippi River and west of the target areas may have potential environmental impact due to the presence of large capacity ASTs, treatment ponds and other known environmental waste streams. During the course of this BA, no major violations, environmental liens or pending litigation could be found concerning this facility. Although the ConocoPhillips refinery has the potential to be a major REC, research conducted for the purpose of this BA found the refinery to be operating in compliance with state and Federal guidelines. Any accidental release, leak, or rupture would be considered an REC. However, in the event that this should occur, the incident would be fully remediated by ConocoPhillips, other possible responsible parties, Louisiana Department of Environmental Quality, or the U.S. Coast Guard according to state and Federal regulations. Because of the potential for the ConocoPhillips refinery to be a future REC, this facility is considered to be a low to moderate risk.

Aboveground tanks can pose an environmental hazard due to possible leakage, spills or ruptures. The ASTs mentioned by individuals interviewed were also observed during the site visit at the pumping station off of Belair Pump Road. No containment structures were observed around the tanks; thus any leakage, spill or rupture could environmentally impact the surrounding area. Since the tanks appeared to be in proper working order and no spills had been reported, the assignment of low level impact was assigned to this REC.

The maritime barge traffic on the Mississippi River poses a low risk of environmental impact to the subject property. Any reported incident which may occur would be required to be fully remediated by the responsible barge line or U.S. Coast Guard, as mandated by state and Federal regulations.

9.0 LIMITATIONS AND DATA GAPS

9.1 Purpose

The purpose of this report was to assess the physical characteristics of the subject site with respect to the presence in the environment of hazardous waste or material, oil, or petroleum products according to ASTME 1527-05 and 1528.

No specific attempt was made to check on the compliance of present or past owners or operators of the site with Federal, state, or local laws and regulations, environmental or otherwise. Non-ASTM scope issues (i.e., asbestos, lead-based paint, etc.) were not addressed.

The scope of this assessment did not include any additional environmental investigation, which were not outlined herein, or any analysis for the presence or absence of hazardous or toxic materials in the soil, groundwater, surface water, air, in, on, under or above the subject tract.

Specifically, ARDL, Inc., does not and cannot represent that the site contains no hazardous waste or material, oil (including petroleum products), or other latent condition beyond that observed by ARDL, Inc., during its site assessment.

The observations described in this report were made under the conditions stated therein. The conclusions and data presented in the report were based solely upon the services of the time and budgetary constraints imposed by the client. Furthermore, such conclusions are based solely on the site condition, and the rules and regulations in effect, at the time of the study. The findings and conclusions stated herein must be considered not as scientific certainties, but rather as professional opinions regarding the limited data obtained during the course of the environmental site assessment. No other warranty, expressed or implied, is made.

In preparing this report, ARDL, Inc., relied on certain information provided by Federal, state or local officials and other parties referenced therein, and on information contained in the files of Federal, state or local agencies at the time of the site assessment. Although there may have been some degree of overlap in the information provided by these various sources, an attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this site assessment was not made.

Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the site or to structures on the site was unavailable or limited, ARDL, Inc., renders no opinion as to the presence of indirect evidence relating to hazardous waste or material, oil, or other petroleum products in that section of the site or structure. In addition, ARDL, Inc., renders no opinion as to the presence of hazardous waste or material, oil or other petroleum products or to the presence of indirect evidence relating to hazardous material, oil, or petroleum products where direct observation of the interior walls, roof, or ceiling of a structure on a site was obstructed by objects or coverings on or over these surfaces.

Unless otherwise specified in the report, ARDL, Inc., did not perform testing or analyses to determine the presence or concentration of asbestos, radon, formaldehyde, lead-based paint, lead in drinking water, electromagnetic fields (EMFs) or polychlorinated biphenyls (PCBs) at the site or in the environment at the site.

The ASTM standard requires that the history of the subject property be traced from the present back to when the property first contained structures or was used for residential, commercial, industrial or governmental purposes. This requires the investigator to review sources that are *publicly available, within a reasonable time and cost, reasonably ascertainable and considered practically reviewable*, as defined under the ASTM standard. In addition, these criteria are applied keeping in mind sources that are likely to provide information concerning possible recognized environmental conditions at the subject property. ARDL, Inc., has reviewed all sources of information that are considered to meet these criteria. in cases where history of the property is not traced to a prior or its first developed use, this condition is considered to be a *data gap*, and not an exception to the required scope of work.

In addition, the ASTM standard does not require a search interval of less than 5 years. This search interval is not guaranteed to identify all prior tenants or occupants of the subject property.

9.2 The Degree of Obviousness of the Presence or Likely Presence of Contamination

(a) Persons to whom this part is applicable per 40 CFR§312.1(b) and environmental professionals conducting an inquiry of a property on behalf of such persons must take into account the information collected under §312.23 through 312.30 (historical information, interviews, records search) in considering the degree of obviousness of the presence of releases or threatened releases at the subject property. (b) Persons to whom this part is applicable per §312.1(b) and environmental professionals conducting an inquiry of a property on behalf of such persons must take into account the information collected under §312.23 through 312.30 in considering the ability to detect contamination by appropriate investigation. The inquiry of the environmental professional should include an opinion regarding additional appropriate investigation, if any.

Environmental Recommendation for Further Action

Property Name and Address	Pertinent Information
White Ditch	Property has concerns as to the obvious presence or likely presence of contamination as a finding of this investigation.

This Phase I ESA did identify Recognized Environmental Conditions (RECs) associated with the Property.

9.3 Data Gaps

Data Gaps

Resource	Pertinent Information
Neighboring owners Interviews	Multiple attempts, no response within time constraints.
Owner interview	Multiple attempts, no response.
City directories	Property not listed.
Public Health Specialist, Plaquemines Parish, LA	Multiple attempts, no response within time constraints.
U.S. Department of Transportation, Pipelines Information	Multiple attempts, no response within time constraints.
Various Plaquemines Parish Agencies Information Request Form	Multiple attempts, no response within time constraints.
Purchase price comparison, if property was found to be environmentally impacted	Not supplied by User to the Environmental Professional. Property was not found to be environmentally impacted to an extent that the fair market value of the property would be adversely affected.

Appendix N

Qualitative Induced Shoaling Analysis

Appendix N
Induced Shoaling Analysis

The continuing loss of coastal wetlands in Louisiana has led to a call for more Mississippi River diversions of water, nutrients and sediment to at least offset the continuing losses, if not to regain some of the lost wetlands. Natural and man-made diversions have been in place for some time now, both upstream and downstream of the proposed site at RM 60 AHP. Several more are in the study and design stage. The diversion of significant quantities of river sediments and water typically leads to unintended consequences, in that the diverted water and sediment concentrations are not in the same proportion as in the river. The typical response is sedimentation and shoaling in the main river downstream of the diversion. In the receiving diversion channel, sedimentation or erosion could take place, depending on a variety of factors. Complex analytical or physical models are needed to gain insight into what the impacts of a diversion might be. However, such modeling has not yet been done for the White Ditch project.

The proposed White Ditch Diversion will be located on the inside of a bend in the river at about RM 60 AHP. This location currently exhibits shoaling and sand deposition tendencies. If the design of the diversion encourages the entrance of significant sand concentrations, downstream sand deposition could be minimal on a year-round basis in the Mississippi channel. Diverting significant amounts of sand is important in that deposition downstream of a diversion will consist primarily of sand particles, as silts and clays tend to stay in suspension until the velocity approaches zero.

The current operating plan for the White Ditch Diversion is limited to a diversion pulse of 35,000 cfs in March–April of each year, during the normal high flow period of the Mississippi River, and a diversion of 1,000 cfs the rest of the year. This flowrate may not be experienced over the full 60 day period. The proposed 35,000 cfs diversion will be the largest man-made diverted flow for wetland building on the Lower Mississippi River, but the one to two month duration will be a modifying factor. The diversion should approximate five percent or less of the main channel flow for most years. Although some deposition in the downstream channel will occur, the one to two month duration should result in minimal shoaling, especially in the navigation channel. Although the peak monthly sediment concentration normally occurs in March, the peak monthly water discharge occurs in April with high flows typically continuing into May and later. When the diversion is reduced to 1,000 cfs, some of this deposition will be re-suspended by the Mississippi flow and carried on downstream in the following months. On an annual basis, the net gain in downstream deposition could be minimal. Specific sediment transport studies for the White Ditch Diversion are required to better address the amount of deposition expected.

A brief review of available technical information along with a general literature search on diversions and sediment effects yielded little hard technical information on this subject. The greatest amount of this type effort has been performed by the Corps of Engineers over the past 20 years. White Ditch has not been addressed, but other, similar diversions may be reviewed for applicability to White Ditch. Past sediment transport studies on the impacts of diversions for the entire Lower Mississippi reach were described in a report by the Corps of Engineers[i] The study found that a diversion up to 15,000 cfs had no measurable impact on downstream deposition, so only the March–April diversion pulse would affect the Mississippi. The study utilized the

HEC-6[ii] computer program to evaluate the impacts of various actual and proposed diversions both upstream and downstream of New Orleans. The three potential future diversion sites and discharges examined for sedimentation impacts included: Fort Jackson (15,000 cfs), Bohemia (100,000 cfs) and Myrtle Grove (15,000 cfs). The latter is across the river from the location of White Ditch Diversion. Although Bohemia was only to be operated during a 3–4 year frequency flood or rarer, its operation resulted in the most deposition over a simulated 96 year period of record (75,000 cubic yards dredged annually). The total annual maximum increase from the three diversions was 105,000 cubic yards requiring dredging. The White Ditch Diversion dredging requirements should be a small fraction of this total. The study also found that deposition in the Pilottown anchorage caused by the diversions took many years to reach this location. The further upstream the diversion, the more years required to impact the Pilottown anchorage and adjacent areas. In addition, the study highlighted the importance of diverting a large amount of sand. If the diverted flow contained more than 50% of the river's normal sand concentration, channel changes near Head of Passes were small. If the sand concentration diverted was less than 50% of the normal river concentration, channel changes were significantly greater at Head of Passes.

An ongoing study of the impact of West Bay Diversion on downstream deposition in the anchorage area is in the draft phase. West Bay is a year-round flow diversion of 20,000 cfs just upstream of Head of Passes[iii], although flows approaching 30,000 cfs through the diversion have been recorded. Future increased diversions at West Bay could reach 50,000 cfs, although the Breaux Task Force has voted to close the project (possibly by the end of 2010) due to excessive shoaling downstream[iv]. A Corps draft report has concluded that West Bay is responsible for 15–55%[v] of the shoaling in the anchorage area near Head of Passes. As the White Ditch Diversion would only operate at flows in this range for one to two months of the year, the project would increase shoaling in the anchorage area by a fraction of West Bay totals, perhaps 2–10%. It would also take many years for the impact to reach Pilottown, since the White Ditch diversion is about 60 river miles upstream.

An additional consideration will be the sedimentation that may take place in interior distribution channels after the flow is diverted. The March discharge will be directed into marsh and open water areas and the portion of the diverted sediment load that is sand will settle quickly when the flow velocity decreases. If it is desired for the sand load to be carried well away from the diversion point, the diversion channel(s) must be carefully designed to maintain the velocity necessary to keep the sand load in suspension. Similarly, silts and clays will begin depositing as velocities approach zero, so the diversion channel design should minimize the creation of eddies or areas of low velocity.

---

[i] Corps of Engineers, July 2000. Mississippi River Sediment, Nutrient and Freshwater Redistribution Study, pp 147-151.
[ii] Corps of Engineers Hydrologic Engineering Center computer program HEC-6. Scour and Deposition in Rivers and Reservoirs, 1993
[iii] Louisiana Coastal Wetlands Conservation and Restoration Task Force, West Bay Sediment Diversion (MR-04), Project Status
[iv] New Orleans Times-Picayune, Jan 21, 2010
[v] New Orleans Times-Picayune, Dec 8, 2009