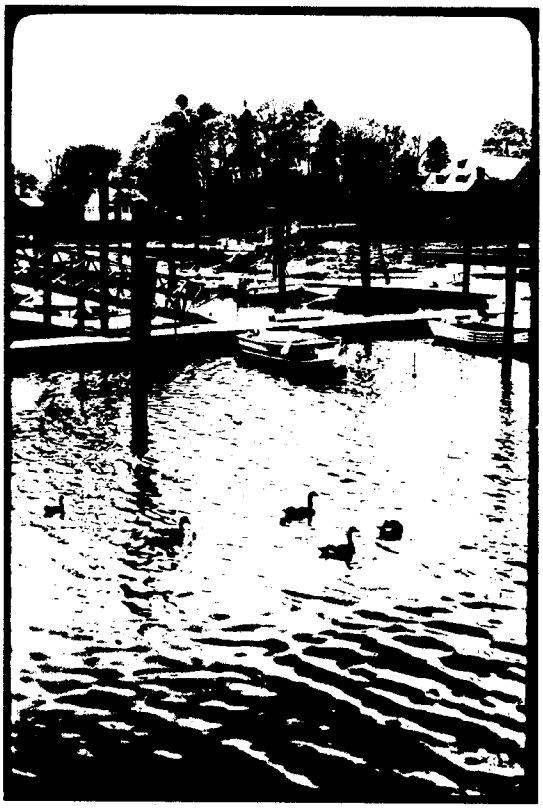
Connecticut Embayments Study

Department of Environmental Protection
State of Connecticut

Connecticut Coastal Zone Management Program

Phase II
Problem Response Options



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CONNECTICUT EMBAYMENTS STUDY

PHASE II - PROBLEM RESPONSE OPTIONS

Prepared for
The State of Connecticut
Department of Environmental Protection
Coastal Area Management Program

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SUMMARY

Under a contract to the Department of Environmental Protection, Anderson-Nichols was selected to perform an environmental reconnaissance study of the coastal embayments of the state. A composite list of embayments was prepared by the Coastal Areas Management (CAM) Office. The list excluded embayments with known, well-documented problems, and focused on embayments with little or no existing documentation of problems.

Each community bordering one of the problem embayments received a set of questionnaires concerning the current state and history of the embayment. Municipal officials were invited to identify and describe any known environmental problems in the area. The responses were supplemented with a literature review, visits to key federal and state agencies, and a historic air photo analysis. The air photo analysis extended from 1934 to the present, and was supplemented by our own oblique air photos of the coast. The information collected in these analyses was used to identify a number of embayments that appeared to have serious environmental concerns. The state reviewed this list and added several sites, bringing the total number of embayments on the list to 35.

Each of the communities containing one or more of the study embayments was contacted by staff from Anderson-Nichols. Meetings and field visits to each embayment were scheduled and executed, and involved most of the local planning, engineering, and environmental officials. Information on the problems, land use, local environment, and developmental history was reviewed and discussed. Field visits included key town officials, and focused on typical or critical problem sites around the embayment.

All of the above information was compiled and presented by community and embayment in the appended report. Sections of the report for each embayment include such topics as basin environment, land use, problem identification, and problem analysis.

Based on the project analysis, seven basic problem categories were established: siltation, erosion, eutrophication, wetlands loss, fish and shellfish loss, flow constriction, and water pollution. The severity, trend and causes of each problem were provided to express the overall environmental quality of each embayment (see Tables S1 and S2).

Following this categorization of problems, various structural and non-structural solutions were discussed and evaluted in the Phase II Report.

Table S.1

EMBAYMENT PROBLEM TYPE, SEVERITY, AND TREND

Name	Problem Type						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Wequetequock	-	2a	-	-	-	2b	1b
Quiambog	-	2a	3b	-	-	3b	-
West Cove	-	1b	-	-	-	-	2b
Palmer's Cove	-	3b	-	-	-	2b	1b
Mill Cove	-	2b	-	-	-	2a	2b
Poquetanuck	-	1b	1c	-	-	-	2b
Smith Cove	2b	1a	--	-	-	2c	1b
Keeney Cove	-	2b	-	-	-	2b	-
Smith's Cove	-	2a	3b	-	-	2c	2b
Niantic River	-	2a	-	-	-	2c	2b
Fourmile River	-	2a	3b	-	-	2a	3b
Middle Cove	2b	2b	-	-	-	2b	2b
Indiantown	3b	2b	-	-	-	3b	3a
Menunketesuck	2a	2a	-	-	-	2a	3b
West River	1a	1a	-	-	-	2b	1a
Little Harbor	-	1a	-	-	-	-	2b
E. Haven River	3b	2a	-	2b	-	2c	2c
Pattaconk	-	1b	-	-	-	3b	1b
Mill River	-	1b	1b	-	-	1b	2b
Gulf Pond	-	3a	-	-	-	2b	1b
Wepawaug	-	2b	-	-	-	2b	-
Marine Basin	-	3b	-	-	-	2a	-
Lewis Gut	-	-	-	1a	-	2a	2b
Frash Pond	-	3b	-	2a	2b	3b	1b
Ash Creek	-	-	-	-	-	2b	2b
Mill River	-	-	-	-	2b	1b	3b
Horse Tavern	-	-	-	2a	-	-	1a

Table S.1 (Continued)

EMBAYMENT PROBLEM TYPE, SEVERITY, AND TREND

Name	Problem Type						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Bermuda Lagoon	3a	-	-	-	2b	2b	-
Gray's Creek	-	2a	-	-	-	2b	-
Canfield Island	2a	2a	-	2a	-	-	-
Mill Pond	2a	1a	-	-	-	-	1b
Village Creek	-	2a	-	1a	-	-	-
Holly's Pond	-	-	-	-	-	2a	1b
Gorham's Pond	2a	-	-	-	-	-	2b
Byram Harbor	-	2b	-	3b	-	1c	-

Table Symbols

1 = Severe 2 = Moderate 3 = Minor

a = Conditions Worsening, b = Conditions Stable, c = Conditions Improving

Table S.2

EMBAYMENT PROBLEM CAUSES

Embayment	Problem						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Wequetequock	-	7,8	-	-	-	25,26,29	36
Quiambog	-	8,10	-	20	-	25,26,29	-
West Cove	-	11	-	-	-	-	38
Palmer's Cove	-	8	-	-	-	25,26,30	36,37
Mill Cove	-	7,8-	-	-	-	25	36,37
Poquetanuck	-	8	15	-	-	-	36
Smith Cove	2	9,8	-	-	-	25,28,32,33	36,37
Keeney Cove	-	8	-	-	-	25,26,32	-
Smith's Cove	-	8,12	15	-	-	25	44
Niantic River	-	8,9	-	-	-	25,26,32	36,37
Fourmile River	-	11	15	-	-	32	36,37
Middle Cove	4,5,6	10	-	-	-	26	44
Indiantown	6	7	-	-	-	25,26	45
Menunketesuck	2,4	11	-	-	-	25,26,31	37
West River	1	10,11	-	-	-	25,28	39
Little Harbor	-	11	-	-	-	-	38
E. Haven River	-	8,11	-	18	-	25,31,35	40
Pattaconk	-	8,14	-	-	-	25,26	36,37
Mill River	-	8,9	15	-	-	27,29,34	39,41
Gulf Pond	-	7	-	-	-	29	36,37
Wepawaug	-	8	-	-	-	26,29	-
Marine Basin	-	8,11	-	-	-	26,29,32	-
Lewis Gut	-	-	-	18	-	29,35	39

Table S.2 (continued)

EMBAYMENT PROBLEM CAUSES

Embayment	Problem						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Frash Pond	-	8	-	17	21,22	26	40
Ash Creek	-	-	-	-		27,29,30	39,40
Mill River	-	-	-	-	21	25,29,34	36,37,42
Horse Tavern	-	-	-	18	-	-	40
Bermuda Lagoon	-	-	-	16	23,24	25,26	-
Gray's Creek	-	8,9,10,11	-	-	-	27	-
Canfield Island	1	10,11	-	17,20	-	-	-
Mill Pond	1,2,3	7	-	-	-	-	43
Village Creek	-	8,11	-	17	-	-	-
Holly's Pond	-	-	-	-	-	26,29	42
Gorham's Pond	-	8,9	-	-	-	-	42
Byram Harbor	-	7,10	-	16,20	-	25,32	-

Table S.2 (continued)

Problem Cause Categories

Erosion
1. Wave Attack
2. Bank Undermining; Natural
3. Bank Undermining; Man-caused
4. Boat Wakes
5. Dredging Impacts
6. Wave Reflection

Siltation
7. Constriction
8. Upland Erosion
9. Bank Erosion
10. Current Transport
11. Wave Transport
12. Historic Land Use
13. Development
14. Deteriorating Bulkheads

Eutrophication
15. Water Pollution

Wetland Loss
16. Riverine Erosion
17. Filling
18. Tide Gates/Tidal Restrictions
19. Wake Erosion
20. Wave Attack

Fin/Shellfish Losses
21. Pollution
22. Tide Gates
23. Septic Failure
24. Natural Conditions

Pollution
25. Septic Failure
26. Residential Runoff
27. Urban Runoff
28. Agricultural Runoff
29. Point Discharge
30. Marina Spills
31. Boat Discharges
32. Leachate from Landfills
33. Fly Ash Erosion
34. Contaminated Bottom Sediment
35. Transport from Other Areas

Flow Constriction
36. Railroad Causeway
37. Bridge
38. Jetty/Groin
39. Natural Bar Formation
40. Tide Gates
41. Marsh Filling
42. Dam
43. Culvert
44. Natural
45. Filling

Coastal Embayments Study
Phase II Report

INTRODUCTION

The Phase I Report of this project provided a comprehensive environmental review of 35 coastal embayments along the Connecticut coast. The report provided a review of hydrologic, soils, vegetation, and marined conditions in an around each of the embayments, analyzed past changes in land use and environmental characteristics, and provided an identification of significant environmental problems present at each site. A review of the various problems present allowed the identification of seven major problme categories: erosion, siltation, eutrophication, wetland loss, fin and shellfish loss, pollution, and (flow) constriction. Although these categories do not explicitly cover every problem present in the studied embayments, they provide a fairly complete synthesis of embayment conditions for an overview. Tables 1 and 2, which were also presented in the Phase I Report, provide a listing of the problems found in each embayment, as well as the severity, trend, and suspected causes of each problem. The purpose of this report will be to provide one or more solutions to each embayment problem, as well as a preliminar overview of the environmental, aesthetic, and economic impacts of each option or set of options. Unit costs and conceptual designs have been provided in an appendix (Appendix 3), and these can be used for planning purposes where appropriate. The purpose of this is to identify practical and cost effective options which may be utilized to mitigate existing problems. These options are only a guide. In almost all cases, further analysis of specific problems, causes and solutions must be pursued before a final, enviromentally sound alternative, which is consistent with applicable, federal, state and local regulatory programs can be selected.

ENVIRONMENTAL MANAGEMENT RANGE OF CHOICE

Prior to the identification of potential problem solutions, the various problem cause categories listed in Table 2 were reviewed by planning and engineering staff. This review focusd on categorical problem solutions that were both structural and non-structural in nature. The staff review was supplemented by a literature review that spanned both the Phase I and Phase II Reports. Table 3 represents the results of that review. Solutions have been grouped into problem categories, and further grouped into structural and non-structural options. This listing is not intended to be a complete listing of all solutions that might be applied to a given problem, rather it was designed to identify feasible and cost effective solutions to the issues raised in the Phase I Report.

ENVIRONMENTAL MANAGEMENT RANGE OF CHOICE (Con't)

The listed options are also somewhat general in nature. For example, there may be 15 types of seawalls that could be applied to a given problem, but the final selection will rely on site-specific factors. Land Use Planning refers to a wide range of potential planning, zoning, and regulatory options that may be utilized by the community. The direction of each recommendation, however, is clear when related to a specific problem cause. For example, in an area where significant sedimentation is occurring due to development pressures, land use planning would imply planning and specification of suitable and unsuitable sites (slopes, soil erodibility, etc.) for certain uses.

PROPOSED RESPONSE OPTIONS FOR EMBAYMENT PROBLEMS

The following text uses the range of choices listed in Table 3 to develop potential solutions for the various embayment problems with a severity of ranking of moderate or severe. For each embayment, each problem category was reviewed, and one or more options were selected. In certain circumstances, more than one option was not feasible. For example, areas that are experiencing septic failures and are located on unsuitable soils cannot support septic systems, so some form of a sewage collection/treatment program has to be considered if the problem is to be solved. Individual systems can be operated, but only with a significant alteration of the soils around each residence. Since this is not cost-effective, a group system of some form would be required.

In other situations, only one option was evidently practical under existing enviromental and/or economic constraints. For example, many of the embayments experience constriction of flow and tidal exchange due to the railroad or highway causeways. In this circumstance, there is no feasible and cost-effective way to alter the causeway form. Reconstruction of a trestle, placement of culverts under the rail bed, etc. would cost millions of dollars for each embayment. Therefore a no-action option was recommended as the only viable approach.

Finally, there are problems that can be solved by two very different approaches. Marina siltation might be solved by various upstream/upslope soil management practices, or it might be solved by continuous dredging of the affected areas. In some of these cases, a more preferable option (under environmental, aesthetic, and economic criteria) was indicated by an asterisk. Because of their generally greater cost-effectiveness and applicability in the coastal zone, non-structural options were identified wherever possible.

The following text considers each embayment in general geographic order, starting in Stonington and moving west to Greenwich.

Table 1

EMBAYMENT PROBLEM TYPE, SEVERITY, AND TREND

Name	Problem Type						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Wequetequock	-	2a	-	-	-	2b	1b
Quiambog	-	2a	3b	-	-	3b	-
West Cove	-	1b	-	-	-	-	2b
Palmer's Cove	-	3b	-	-	-	2b	1b
Mill Cove	-	2b	-	-	-	2a	2b
Poquetanuck	-	1b	1c	-	-	-	2b
Smith Cove	2b	1a	--	-	-	2c	1b
Keeney Cove	-	2b	-	-	-	2b	-
Smith's Cove	-	2a	3b	-	-	2c	2b
Niantic River	-	2a	-	-	-	2c	2b
Fourmile River	-	2a	3b	-	-	2a	3b
Middle Cove	2b	2b	-	-	-	2b	2b
Indiantown	3b	2b	-	-	-	3b	3a
Menunketesuck	2a	2a	-	-	-	2a	3b
West River	1a	1a	-	-	-	2b	1a
Little Harbor	-	1a	-	-	-	-	2b
E. Haven River	3b	2a	-	2b	-	2c	2c
Pattaconck	-	1b	-	-	-	3b	1b
Mill River	-	1b	1b	-	-	1b	2b
Gulf Pond	-	3a	-	-	-	2b	1b
Wepawaug	-	2b	-	-	-	2b	-
Marine Basin	-	3b	-	-	-	2a	-
Lewis Gut	-	-	-	1a	-	2a	2b
Frash Pond	-	3b	-	2a	2b	3b	1b
Ash Creek	-	-	-	-	-	2b	2b
Mill River	-	-	-	-	2b	1b	3b
Horse Tavern	-	-	-	2a	-	-	1a

Table 1 (Continued)

EMBAYMENT PROBLEM TYPE, SEVERITY, AND TREND

Name	Problem Type						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Bermuda Lagoon	3a	-	-	-	2b	2b	-
Gray's Creek	-	2a	-	-	-	2b	-
Canfield Island	2a	2a	-	2a	-	-	-
Mill Pond	2a	1a	-	-	-	-	1b
Village Creek	-	2a	-	1a	-	-	-
Holly's Pond	-	-	-	-	-	2a	1b
Gorham's Pond	2a	-	-	-	-	-	2b
Byram Harbor	-	2b	-	3b	-	1c	-

Table Symbols

1 = Severe 2 = Moderate 3 = Minor

a = Conditions Worsening, b = Conditions Stable, c = Conditions Improving

Table 2

EMBAYMENT PROBLEM CAUSES

Embayment	Problem						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Wequetequock	-	7,8	-	-	-	25,26,29	36
Quiambog	-	8,10	-	20	-	25,26,29	-
West Cove	-	11	-	-	-	-	38
Palmer's Cove	-	8	-	-	-	25,26,30	36,37
Mill Cove	-	7,8-	-	-	-	25	36,37
Poquetanuck	-	8	15	-	-	-	36
Smith Cove	2	9,8	-	-	-	25,28,32,33	36,37
Keeney Cove	-	8	-	-	-	25,26,32	-
Smith's Cove	-	8,12	15	-	-	25	44
Niantic River	-	8,9	-	-	-	25,26,32	36,37
Fourmile River	-	11	15	-	-	32	36,37
Middle Cove	4,5,6	10	-	-	-	26	44
Indiantown	6	7	-	-	-	25,26	45
Menunketesuck	2,4	11	-	-	-	25,26,31	37
West River	1	10,11	-	-	-	25,28	39
Little Harbor	-	11	-	-	-	-	38
E. Haven River	-	8,11	-	18	-	25,31,35	40
Pattaconk	-	8,14	-	-	-	25,26	36,37
Mill River	-	8,9	15	-	-	27,29,34	39,41
Gulf Pond	-	7	-	-	-	29	36,37
Wepawaug	-	8	-	-	-	26,29	-
Marine Basin	-	8,11	-	-	-	26,29,32	-
Lewis Gut	-	-	-	18	-	29,35	39

Table 2 (continued)

EMBAYMENT PROBLEM CAUSES

Embayment	Problem						
	Erosion	Siltation	Eutrophication	Wetland Loss	Fin/Shellfish Loss	Pollution	Flow Constriction
Frash Pond	-	8	-	17	21,22	26	40
Ash Creek	-	-	-	-		27,29,30	39,40
Mill River	-	-	-	-	21	25,29,34	36,37,42
Horse Tavern	-	-	-	18	-	-	40
Bermuda Lagoon	-	-	-	16	23,24	25,26	-
Gray's Creek	-	8,9,10,11	-	-	-	27	-
Canfield Island	1	10,11	-	17,20	-	-	-
Mill Pond	1,2,3	7	-	-	-	-	43
Village Creek	-	8,11	-	17	-	-	-
Holly's Pond	-	-	-	-	-	26,29	42
Gorham's Pond	-	8,9	-	-	-	-	42
Byram Harbor	-	7,10	-	16,20	-	25,32	-

Table 2 (continued)

Problem Cause Categories

Erosion
1. Wave Attack
2. Bank Undermining; Natural
3. Bank Undermining; Man-caused
4. Boat Wakes
5. Dredging Impacts
6. Wave Reflection

Siltation
7. Constriction
8. Upland Erosion
9. Bank Erosion
10. Current Transport
11. Wave Transport
12. Earlier Land Use
13. Development
14. Deteriorating Bulkheads

Eutrophication
15. Water Pollution

Wetland Loss
16. Riverine Erosion
17. Filling
18. Tide Gates/Flushing Restrictions
19. Wake Erosion
20. Wave Attack

Fin/Shellfish Losses
21. Pollution
22. Tide Gates
23. Septic Failure
24. Natural Conditions

Pollution
25. Septic Failure
26. Residential Runoff
27. Urban Runoff
28. Agricultural Runoff
29. Point Discharge
30. Marina Spills
31. Boat Discharges
32. Leachate from Landfills
33. Fly Ash Erosion
34. Contaminated Bottom Sediment
35. Transport from Other Areas

Flow Constriction
36. Rail Road Causeway
37. Bridge
38. Jetty/Groin
39. Natural Bar Formation
40. Tide Gates
41. Marsh Filling
42. Dam
43. Culvert
44. Natural Form
45. Filling

Table 3 Coastal Environmental Management Options

The options listed below represent a range of feasible responses to the range of problems identified in the Phase I Report. It is not intended to identify all options, but to identify those options that address the issues and problems listed in the Phase I Report. Specific option selection is reviewed in later text.

Erosion Control Options

Structural	Non-Structural
Sea Walls	Establishing Vegetation in Affected Areas
Rip Rap	Beach/Shoreline Replenishment
Offshore Breakwaters	Boat-Wake Control
Groins	Dredging Regulation
Bulkheads	Shoreline Construction Regulation
	Shoreline Land Use Management

Siltation Control Options

Structural	Non-Structural
Dredging	Tide Gate Management
Removal of Tidal Restrictions	Land Use Management
Modification of Tidal Restrictions	Revegetation of Disturbed Areas
Dams	Construction Practice Control
Desilting Basins	Conservation/Education Programs
Surface Runoff Collection	
On-Site Sediment Control	
Flow Constriction of River Discharge	
Groins	

Wetland Loss

Structural	Non-Structural
Rip Rap	Access Control
Bulkheads	Boat-Wake Control
Boardwalks, Fencing	Regulatory Enforcement
Fill Removal/Revegetation	Revegetation
Tide Gate Removal	Tide Gate Management

Fin/Shellfish Losses

Structural	Non-Structural
Control Point Discharges	Regulate Point Discharges
Septic System Improvement	Improve Enforcement/Monitoring
Water Treatment System Improvement	Zoning/Enforcement
Water Aeration	Septic System Management
Removal of Tide Gates	Land Use Management
Self-Regulating Tide Gates	Tide Gate Management

Note: Control septic failure and non-point runoff to minimize shellfish bed damage

Table 3 continued

Pollution

Structural	Non-Structural
New Septic/Cesspool Systems	Water Conservation
Sewer System	Septic System Management
Treatment Plant	Septic System Installation Control
Upgrade Existing Systems	Zoning
Outfall Relocation	Land Use Conversion Control
Discharge Modification	Discharge Monitoring and Enforcement
Runoff Collection and Diversion	Building Regulations
Sewer System Separation	Spill Contingency Plans
Landfill Capping	Water Resources Protection Plan
Leachate Collection/Treatment	Site Plan Review
Marina Pump-Out Facility	Landfill Closure
Dredging	Operational Guidelines for Landfills
Sealing Embayment Bottom	Boat Discharge Enforcement
	Public Education
	Setback Limits
	Agricultural Activity Restrictions

Eutrophication (combination of pollution and siltation usually)

Structural	Non-Structural
Dredging	Pollution Control (see above)
Pollution Control (see above)	

Constrictions (Tidal Flow)

Structural	Non-Structural
Modify or Remove Causeways	Tide Gate Management
Dredging	Culvert Maintenance
Erosion Control to Restrict Bar Formation	
Remove or Upgrade Tide Gates	
Culvert Redesign	

Embayment Wequetequock Cove Community Stonington

Problems	Severity	Trend	Cause
Sedimentation	moderate	increasing	constriction, upland erosion
Constriction	severe	stable	RR causeway
Pollution	moderate	stable	septic failures, point discharge, non-point discharge

Problem: Sedimentation

Solutions:

landuse control enforcement
construction practice regulation

Benefits/Impacts:

Environmental - reduced sedimentation, reduced erosion, reduce non-point pollutant impacts

Aesthetic - improved residential landscape

Economic - greater construction costs

Problem: Constriction

Solutions:

no apparent cost effective solutions

Problem: Pollution

Solutions:

for most area soils, septic tanks should be replaced with a sewer system, (poor soil suitability) community or cluster sanitary systems (offsite)

Benefits/Impacts:

Environmental - construction impacts, improved water quality

Aesthetic - construction impacts, enhanced water recreation potential

Economic - system cost to individuals and/or the community

Embayment Quiambog Cove Community Stonington

Problems	Severity	Trend	Cause
Sedimentation	moderate	increasing	upland erosion, longshore transport
Wetland loss	minor	stable	wave erosion
Pollution	minor	stable	septic tanks, non-point runoff, filter backwash

Problem: Sedimentation

Solutions:

longshore transport is not mitigated in any cost-effective manner that is environmentally sound - no action recommended

revegetation of disturbed areas where possible

Benefits/Impacts:

Environmental - reduced siltation (somewhat), improved shellfish resources are possible

Aesthetic - enhanced landscape quality, enhanced water clarity

Economic - minor

Embayment West Cove Community Groton

Problems	Severity	Trend	Cause
Constriction	moderate	stable	jetty construction
Sedimentation	serious	stable	wave transport

Problem: Constriction - impacts a limited portion of the embayment

Solutions:

no cost effective options apparent

Problem: Sedimentation

Solutions:

dredging - the only apparent option other than no action

Benefits/Impacts:

Environmental - spoil disposal issues, disruption of shellfish beds, benthic organism disruption, pollutant release, potential greater boat impacts

Aesthetic - improved water use potentials

Economic - improved recreational traffic, continued maintenance dredging costs, continued marina operations

Embayment Palmers Cove Community Groton

Problems	Severity	Trend	Cause
Constriction	severe	stable	RR causeway, bridge
Sedimentation	moderate	stable	constriction, upstream erosion
Pollution	moderate	stable	septic tools, marina runoff, non-point residential runoff

Problem: Constriction

no apparent cost effective solutions - 3 bridge/causeway systems
reduce tidal exchange

Problem: Sedimentation

Solutions:

land use management
revegetation of disturbed areas
construction practice controls

Benefits/Impacts:

Environmental - reduced erosion, sedimentation, improved water quality

Aesthetic - improved water recreation opportunities, improved landscaping

Economic - reductions in road undermining, reduced topsoil loss, increased developmental costs

Problem: Pollution

Solutions:

local septic or sewage system construction
discharge monitoring and enforcement
septic systems installation control

Benefits/Impacts:

Environmental - improved water quality, improved shellfish quality

Aesthetic - improved water recreation potentials

Economic - referendum/bond costs to raise money, disruption of local traffic/revenue flows

Embayment Mill Cove Community Ledyard

Problems	Severity	Trend	Cause
Constriction	moderate	stable	RR causeway, bridge
Sedimentation	moderate	stable	constriction, upstream erosion
Pollution	moderate	increasing	septic tank failure

Problem: Constriction

No cost effective solution found

Problem: Sedimentation - primarily from natural causes

Solutions:

revegetation of exposed soil slopes
soil conservation practices
dredging

Benefits/Impacts:

Environmental - revegetation/conservation; improved water quality, reduced erosion dredging; spoil disposal impacts

Aesthetics - improved recreational potential

Economic - improved marina traffic, cost of maintenance dredging

Problem: Pollution

Solutions:

sewage collection/treatment (or small scale package treatment systems)
septic system installation and management controls

Benefits/Impacts:

Environmental - improved water quality, reduced eutrophic conditions

Aesthetics - reduced odors from leachate breakout and anaerobic sediments, improved visual quality of water, enhanced water recreation potential

Economic - systems cost to individuals and/or community, enhanced waterfront property value

Embayment Poquetanuck Cove Community Ledyard

Problems	Severity	Trend	Cause
Constriction	moderate	stable	RR causeway
Sedimentation	minor	stable	upstream erosion
Eutrophication	minor	improving	non-point runoff

Problem: Constriction

No cost effective options apparent - railroad bridge/causeway reduces tidal flow

Embayment Smith Cove Community Waterford

Problems	Severity	Trend	Cause
Siltation	severe	increasing	bank erosion, upland erosion
Erosion	moderate	stable	bank erosion
Constriction	severe	stable	RR causeway, bridge
Pollution	moderate	decreasing	failing septic systems, fly ash, agricultural runoff

Problem: Siltation - primarily due to natural bank erosion, erosion of silt loams in drainage basin and soil loss from agriculture; sewer construction along banks

Solutions:

erosion control techniques (below)
dredging

Benefits/Impacts:

Environmental - erosion control impacts, reduced erosion (below); dredge spoil disposal impacts

Aesthetic - improved recreation potential

Economic - cost of maintenance dredging, enhanced residential land values

Problem: Erosion - primarily due to development-related impacts and natural bank erosion

Solutions:

bulkhead areas of chronic high erosion where possible
revegetate soil slopes where not oversteepened
land use management
construction practice control

Benefits/Impacts:

Environmental - reduced sediment loading, environmentally compatible natural soil loss controls, reduced water turbidity

Aesthetic - improved residential landscape, minimical visual impacts

Economic - maintenance of valuable agricultural lands, cost of structural improvements

Problem: Constriction

No cost-effective options apparent: bridges reduce tidal exchange

Problem: Pollution

Solutions:

sewer construction (underway)
control leachate from fly ash land fills
regulation of agricultural activities (feed lots, chemical wastes)
land use control
construction practice regulation
revegetation of disturbed areas

Smith Cove, Waterford (continued)

Benefits/Impacts:

Environmental - improved water quality, sewer construction impacts

Aesthetic - enhanced water recreation potential, construction impacts

Economic - system cost of individuals and/or the community, fly ash leachate control costs

Embayment Keeney Cove Community Waterford

Problems	Severity	Trend	Cause
Siltation	moderate	stable	upstream erosion
Pollution	moderate	stable	landfill leachate, septic failure, surface runoff

Problem: Siltation -- erosion from natural slopes, minor human disturbance

Solutions:

continued land use management
revegetation of disturbed areas
avoid encroachment of fill in the floodplain

Benefits/Impacts:

Environmental - reduced erosion and siltation; less turbid aquatic environment may impact Niantic shellfish beds

Aesthetic - greater water clarity for recreation, less chance of obnoxious odors from anaerobic sediments

Economic - reduced loss of valuable top soils, reduced potential impact to valuable shellfish beds

Problem: Pollution

Solutions:

install sanitary waste collection/treatment system
landfill managament program
partial landfill capping
install swale drainage systems and retention basins where feasible

Benefits/Impacts:

Environmental - improved water quality, sewer construction impacts

Aesthetic - sewer construction impacts, enhanced water recreation potential

Economic - system cost to individuals and/or the community, landfill capping costs, potential increased landfilling costs for users/community, swale and retention basin construction costs

Embayment Smith's Cove Community East Lyme

Problems	Severity	Trend	Cause
Sedimentation	moderate	increasing	earlier upstream development, upslope erosion
Pollution	moderate	improving	failing septic systems
Constriction	moderate	stable	natural mouth configuration
Eutrophication	minor	stable	

Problem: Sedimentation - sediment transport from Niantic system; erosion from upland construction activities

Solutions:

dredging
on-site sediment control
construction practice control

Benefits/Impacts:

Environmental - reduced erosion, improved tidal exchange, water quality dredging spoil disposal impacts

Aesthetics - improved land cover appearance, improved water recreation potential

Economic - dredging costs, construction costs for land stabilization, improve navigation and mooring space

Problem: Pollution - from non-point sources

Solutions:

Summer homes converted to year-round use should have adequate waste disposal facilities; poor soil conditions and high-density development indicate a need for sewer system or community waste treatment facility; boat pump-out facilities should be available at local marina

Benefits/Impacts:

Environmental - improved water quality, shellfish resources; sewer construction impacts

Aesthetic - construction impacts; improved recreational potential

Economic - system improvement costs to individual homeowner/boaters and/or the community

Problem: Constriction (natural origin)

Solutions:

No apparent cost effective solutions

Embayment Niantic River Community East Lyme

Problems	Severity	Trend	Cause
Siltation	moderate	increasing	upland erosion, bank erosion
Pollution	moderate	improving	septic failure, residential runoff
Eutrophication	minor	stable	see pollution
Constriction	moderate	stable	RR Causeway, bridge

Problem: Siltation - upland erosion, sediment transport

Solutions:

surface run-off collection
dredging may be the only practical solution, but may be prohibitively expensive

Benefits/Impacts:

Environmental - dredge spoil disposal; disruption of shellfish beds; limited improvement of flushing and circulation

Aesthetic - improve recreational boating opportunities; beach replenishment from clean dredge spoils

Economic - dredging costs

Problem: Pollution - from non-point sources

Solutions:

sewer system or local wastewater collection system for areas with soils poorly suited for individual septic systems; town sewer system

management or replacement of failing systems in areas of soils with adequate renovation capabilities; increase system setback distance from river (zoning); provide boat pump-out facilities at local marina

Benefits/Impacts:

Environmental - improved water quality, shellfish resources; sewer system construction impacts

Aesthetic - construction impacts, improved recreational potential

Economic - wastewater collection and/or treatment improvement costs to individual home owners, boaters, marina operators, and/or the community

Niantic River, East Lyme (Continued)

Problem: Circulation

Solutions:

no apparent cost-effective solutions. Embayment constrictions are fixed by a manmade causeway, railroad bridge and highway bridge. The causeway was constructed on a barrier spit that created some restriction of flow exchange.

Embayment Fourmile River Community East Lyme

Problems	Severity	Trend	Cause
Siltation	moderate	increasing	Long Island Sound Transport
Pollution	moderate	increasing	landfill leachate
Constriction	moderate	increasing	

Problem: Siltation - source is Long Island Sound

Solutions:

dredging is the only apparent (althouth not necessarily cost effective) solution
railroad bridge creates settling basin for sediment

Benefits/Impacts:

Environmental - dredge spoil disposal/construction impacts; improve tidal flushing and circulation; loss of shellfish resources

Aesthetic - improved navigation for recreational boaters

Economic - dredging costs

Problem: Pollution

Solutions:

eliminate sewage treatment plant located outside embayment (Bride Brook) which is source of shellfish contamination problem; eliminate upstream pollution from residential development and landfill leachate. Further study is needed of impacts associated with the landfill.

Problem: Constriction

Solutions:

no apparent cost effective solution for the problem which is caused by a railroad causeway and bridge

Embayment Middle Cove Community Essex

Problems	Severity	Trend	Cause
Constriction	moderate	stable	natural configuration
Sedimentation	moderate	stable	transport from the Connecticut River
Erosion	moderate	stable	boat wakes, dredging impacts, wave reflection
Pollution	moderate	stable	storm sewer outfall, possible sanitary sewage outfalls pollution impacts magnified by restricted flushing

Problem: Constriction

No cost effective solution found other than the periodic maintenance dredging as currently practiced (see "Sedimentation" below)

Problem: Sedimentation -- deposition of Connecticut River sediment

Solution:

*Continue maintenance dredging program

Benefits/Impacts:

Environmental - some improvement in flushing and circulation, dredge spoil disposal impacts

Aesthetic - improved capacity to boating recreation

Economic - continued viability of marina site; dredging costs

Problem: Erosion

Solution:

reduce boat wakes
avoid dredging navigational channels close to eroding, unstabilized shorelines
stabilize shorelines where channels must be located in close proximity

Benefits/Impacts:

Environmental - reduced turbidity and increased aquatic productivity, potential loss of intertidal habitat where shore stabilization conducted, reduced loss of sensitive coastal habitat

Aesthetic - increased water clarity, enhanced recreational potential

Economic - stabilization costs, reduced costs from reduced demand for dredging

Middle Cove (continued)

Problem: Pollution -- may be caused, in part, by old sanitary sewage outfalls and leachate contamination

Solution:

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*sewage collection/treatment or innovative off-site cluster septic systems
septic system installation/ management controls

Benefits/Impacts:

Environmental - improved water quality, sewer construction impacts

Aesthetic - enhanced water recreation potential

Economic - system costs to individuals and/or community

Embayment Pattaconk Creek Community Chester

Problems	Severity	Trend	Cause
Constriction	major	stable	R.R. causeway, bridge
Siltation	major	stable	upland erosion, riverine deposits deteriorating bulkheads
Pollution	minor	stable	septic failures, stormwater runoff

Problem: Constriction

No cost effective solution found

Problem: Siltation

Solutions:

revegetate exposed soil slopes
*repair deteriorating bulkheads
stabilize excavated boat slip lagoons
*dredging
develop soil conservation management program
reduce boat wakes

Benefits/Impacts:

Environmental - shore stabilization eliminates valuable intertidal habitat, dredge spoil disposal impacts, reduced turbidity enhances aquatic productivity, reduced BOD and nutrient loading, improved mixing and water circulation

Aesthetic - increased water clarity, reduced opportunity for obnoxious odors form anaerobic sediments, enhanced recreational boating potential, improved residential landscape

Economic - dredging costs, shore stabilization costs, continued viability of marina site, reduced loss of valuable topsoil

Embayment Indiantown Harbor Community Old Saybrook

Problems	Severity	Trend	Cause
Constriction	minor	increasing	breakwater construction, filling
Sedimentation	moderate	stable	constriction
Erosion	minor	stable	caused by breakwater, natural process
Pollution	minor	stable	residential runoff, septic failure

Problem: Sedimentation

Solution:

monitor impacts of 1981 jetty extension on sedimentation rates and patterns
dredge marina channel if necessary

Benefits/Impacts:

Environmental - potential for improved tidal flushing, dredge spoil disposal impacts

Aesthetic - enhanced opportunity for boating recreation, clean dredge spoil of appropriate grain size may be used to nourish eroding beaches

Economic - dredging costs

Embayment Menunketesuck Community Westbrook

Problems	Severity	Trend	Cause
Erosion	moderate	increasing	bank erosion, boat wakes
Siltation	moderate	increasing	Long Island Sound transport
Pollution	moderate	increasing	septic failures, boat discharges, residential runoff
Constriction	minor	stable	

Problem: Erosion

Solutions:

control boat wakes
no solution to erosion of bank due to natural change of river channel
no cost effective structural solutions

Benefits/Impacts:

Environmental - reduction of marsh loss due to boat control

Aesthetic - improvement of marshland quality, wildlife habitat

Economic - cost of enforcement of boat speed controls

Problem: Siltation - (maintenance of marinas)

maintenance dredging of marina areas is most effective solution; on-site sediment control for dredge spoil containment areas

Benefits/Impacts:

Environmental - dredging impacts; dredge spoil disposal impacts

Aesthetic - dredge spoil impacts; improved recreational boating opportunities

Economic - dredging costs; spoil containment costs

Problem: Pollution

Solutions:

control housing conversions
septic system improvements/maintenance
sewer or off-site cluster system

Benefits/Impacts:

Environmental - improved water quality; sewer and/or septic system construction impacts

Aesthetic - little significant impact

Economic - costs associated with boat pump-out facilities to boat owner and marina operators; costs of sewer and/or septic system improvements

Embayment West River Community Guilford

Problems	Severity	Trend	Cause
Erosion	severe	increasing	wave erosion
Siltation	severe	increasing	Long Island Sound transport
Pollution	moderate	stable	septic tank failures, agricultural runoff
Constriction	moderate	increasing	natural bar formation

Problem: Erosion

Solutions:

beach/shoreline replenishment (temporary action)
no cost effective structural option apparent

Benefits/Impacts:

Environmental - reduction in erosion of silty material; loss of shellfish beds; stabilize wetland areas

Aesthetic - little visual impact; improve recreational opportunities

Economic - cost of construction may be possible to tie-in with nearby dredging if clean material available

Problem: Siltation - predominant source Long Island Sound sediment

Solutions:

dredging
removal of flow constrictions (oyster bar, large rocks)
channelize river flow to improve flushing
dredge spoil containment

Benefits/Impacts:

Environmental - improved circulation/flushing; loss of shellfish beds; dredging impacts; wetland loss

Aesthetic - alteration of riverbank; improve navigation recreation potential; dredging/spoil disposal impacts; possible beach replenishment if clean material

Economic - increased commerical coating revenues, costs of dredging and/or channel improvements

West River, Guilford (continued)

Problem: Pollution - bacterial contamination

Solutions:

boat pump-out facilities
agricultural practice control/guidelines (wastes, fertilizers, pesticides)
septic system maintenance/improvements
off-site community wastewater collection systems
sewer system

Benefits/Impacts:

Environmental - improved water quality; septic system improvement and/or sewer system construction impacts improve shellfish resources

Aesthetic - little visual impact; some recreational improvement; construction impacts

Economic - costs of septic system improvements, sewer system or community system; loss of agricultural (orchard) crops; costs associated with boat pump-out facilities to boat owners/marina operators

Problem: Constriction

Solutions:

dredging (bar formation)
remove rock obstruction in channel

Benefits/Impacts:

Environmental - improved tidal flushing, sediment control; loss of shellfish resources; dredging impacts

Aesthetic - improved water quality, less turbidity better flushing; improved navigation recreation potential

Economic - costs of dredging and obstruction removal; increased revenues from increased boat traffic at marinas

Embayment Little Harbor Community Guilford

Problems	Severity	Trend	Cause
Siltation	severe	increasing	wave transport over groins
Constriction	moderate	stable	groin construction

Problem: Siltation

Solutions:

dredging
remove rock groins
floating tire breakwater failed, other structural measures deemed not cost effective

Benefits/Impacts:

Environmental - dredging and dredge spoil disposal impacts; improved shellfish habitat; reduction in turbidity; improved flushing

Aesthetic - improved water quality; improved recreational opportunities

Economic - dredging costs; construction costs

Problem: Constriction (due to groin construction)

Solutions:

No apparent solution

Embayment East Haven River Community Branford

Problems	Severity	Trend	Cause
Siltation	moderate	increasing	land development, wave transport
Pollution	moderate	decreasing	septic failure, boat discharge, transport from other harbors
Marsh Loss	moderate	stable	conversion, tide gates
Constriction	moderate	decreasing	tide gates

Problem: Siltation

Solutions:

construction practice controls
land cover management
tide gate removal
surface run-off collection
dredging (selective areas only)

Benefits/Impacts:

Environmental - decrease in sedimentation; improved water quality; improved shellfish habitat/marshland; dredging and dredging spoil disposal impacts

Aesthetic - improved marshland; improved recreational opportunities; construction impacts

Economic - construction/dredging costs; costs of surface run-off collection/detention facilities

Problem: Pollution

Solutions:

elimination of sewage discharges from treatment plants located outside of river system; improve septic systems; boat pump-out facilities;

Benefits/Impacts:

Environmental - improved water quality; construction impacts; improved shellfish resources

Aesthetic - little visual change

Economic - construction costs; cost of pump facilities to boat owners/marina operators; revenues from shellfish harvests, especially oysters

Problem: Wetlands Loss

Solutions:

tide gate removal

East Haven River, Branford (continued)

Benefits/Impacts:

Environmental - improved flushing, tidal circulation; increased flood hazard; reduction in fire hazard; improved shellfish resources

Aesthetic - improved saltmarsh habitat; improved recreational opportunities; visual enhancement

Economic - costs of regulatory enforcement; increased flood risks; shellfish revenues

Problem: Constriction

Solutions:

remove tide gates
no solution for highway (Rt. 146) bridge

Benefits/Impacts:

(See wetlands loss)

Embayment Mill River Community New Haven

Problems	Severity	Trend	Cause
Constriction	moderate	stable	marsh filling, sedimentation
Sedimentation	severe	stable	upstream erosion, bank erosion
Pollution	severe	stable	point, non-point urban discharge, contaminated sediments
Eutrophication	severe	stable	point, non-point urban discharge, contaminated sediments

Problem: Constriction

No cost effective solution found

Problem: Sedimentation

Solutions:

*maintenance dredging
upstream soil erosion control
stormwater runoff retention basins
revegetate exposed soil slopes

Benefits/Impacts:

Environmental - dredging and spoil disposal impacts from toxic sediments, improved circulation and tidal flushing, reduced siltation, improved water quality from reduced BOD and nutrient loading

Aesthetic - long term reduction in obnoxious odors from anaerobic sediments
improvement in visual appearance of sediment basin

Economic - enhance the commercial viability of water-dependent water-front uses, provides for unimpeded use of cooling water at United Illuminating power plant, reduced loss of valuable top soils

Problem: Pollution

Solutions:

upgrade sewage collection and treatment
enforce NPDES Effluent Limitation Standards
implement industrial pretreatment program
develop stormwater detention standards for new development
provide stormwater detention basins for problem areas where feasible
inventory and phase out all illegal outfalls in the embayment basin

Benefits/Impacts:

Environmental - improved water quality, reduced degredation of New Haven Harbor, increased aquatic productivity

Mill River (continued)

Aesthetic - visual improvement in water quality, reduced odors from anaerobic bottom conditions

Economic - sewer system costs to users and/or city, costs of upgraded treatment to meet NPDES standards, costs for industrial pretreatment program, retention basin land acquisition and maintenance costs

Problem: Eutrophication

Solutions:

reduce BOD loading through upgraded industrial effluent standards
develop stormwater management program
upgrade existing sewer system

Benefits/Impacts:

Environmental - improved water quality, increased biological productivity
dredge spoil disposal impacts

Aesthetic - reduced potential for obnoxious odors, improvement in visual characteristics of water

Economic - dredging costs, land acquisition costs for detention basins, upgraded sewer system costs to users and/or community, cost to industry to upgrade BOD effluent standards

Embayment Gulf Pond Community Milford

Problems	Severity	Trend	Cause
Constriction	severe	stable	bridge
Sedimentation	minor	increasing	constriction
Pollution	moderate	stable	point discharge (wastewater treatment)

Problem: Constriction

No cost effective solution found

Problem: Pollution

Solutions:

upgrade existing sewer plant on Gulf Pond
consider relocating the existing sewer outfall outside embayment
expand sewer service area to include west shore of Gulf Pond
develop stormwater runoff management program

Benefits/Impacts:

Environmental - improved water quality, increased biological productivity

Aesthetic - enhanced water recreation, potential opportunity for shellfishing with improved water quality conditions

Economic - upgraded sewer system costs to users/community, costs to expand sewer system into state-recognized problem areas, costs to upgrade industrial treatment, costs to relocate sewer outfall outside the embayment, enhanced property value, commercial value of reintroduced shellfishing

Embayment Wepawaug Community Milford

Problems	Severity	Trend	Cause
Siltation	moderate	stable	construction-related erosion, upland development
Pollution	moderate	stable	point/non-point discharges

Problem: Siltation

Solutions:

develop soil loss construction standards
land use control enforcement
revegetate exposed slopes
stabilize erosion-prone embayment and stream banks
dredging

Benefits/Impacts:

Environmental - reduced sedimentation, reduced erosion, reduced non-point pollution impacts, reduced turbidity, reduced biological oxygen demand, increased biological productivity, increased circulation and tidal flushing, dredge spoil disposal impacts

Aesthetic - improved visual appearance, reduced odors, enhanced opportunity for water recreation, improved residential landscape

Economic - dredging costs, stabilization costs, reduced loss of valuable top soils

Problem: Pollution

Solutions:

upgrade or phase out sewer plant on Wepawang River/Milford Harbor
reduce soil erosion (see "Siltation" above)

Benefits/Impacts:

Environmental - improved water quality, increased aquatic productivity dredge spoil disposal impacts, increased circulation and flushing

Aesthetic - reduced odors, more pleasant visual appearance, enhanced water recreation potential

Economic - sewer system upgrading costs to users and community, dredging costs

Embayment Marine Basin Community Stratford

Problems	Severity	Trend	Cause
Siltation	minor	stable	landfill erosion, wave/current transport
Pollution	moderate	increasing	point, non-point runoff, landfill leachate

Problem: Pollution

Solutions:

review NPDES permits of upstream industries
*landfill management program
partial landfill capping

Benefits/Impacts:

Environmental - improved water quality, increased aquatic productivity, reduced hazard of serious contamination

Aesthetic - enhanced recreational use, improved visual appearance

Economic - costs of upgrading industrial treatment, costs of capping and properly managing landfill

Embayment Lewis Gut Community Stratford

Problems	Severity	Trend	Cause
Constriction	moderate	stable	natural deposition
Pollution	moderate	increasing	transport from other harbors, fuel spills
Wetland Loss	severe	increasing	tidal gates

Problem: Constriction

Solutions:

implement tide gate management program

Benefits/Impacts:

Environmental - improved water circulation and tidal flushing, increased aquatic productivity, decreased impact of Bridgeport Harbor's degraded water quality on embayment

Aesthetic - separates part of Long Beach Park from mainland thus reducing some beach recreation potential, enhanced water recreation potential, increased potential to reestablish shellfishing

Economic - cost of excavation, reverses federal commitment to share stabilization along Long Beach using groins, increased value of commercial shellfishing

Problem: Pollution

Solutions:

improve circulation and tidal flushing (see "Constriction" above)
oil and gasoline spill prevention plan for Johnson Creek

review NPDES effleunt standards of Bridgeport and Stratford industries
discourage disposal of contaminated dredge/spoils in embayment

Benefits/Impacts:

Environmental - improved water quality, increased aquatic productivity

Aesthetic - enhanced water recreation use

Economic - excavation costs, increased value as commercial shellfishing

Lewis Gut (continued)

Problem: Wetland Loss

Solutions:

discourage mosquito ditching of wetlands to preserve unique quality of marsh
implement tide gate management program
control roadway runoff and embankment erosion

Benefits/Impacts:

Environmental - maintains valuable wildlife habitat, provides flood storage capacity, helps maintain biological productivity of embayment, maintains estuarine water quality

Aesthetic - maintains recreational opportunities, protects visual beauty of marsh

Economic - provides inexpensive water quality maintenance, enhances local property value, provides low cost recreational opportunities to community, deprives industry of access to inexpensive land for industrial development, provides inexpensive flood buffer system

Embayment Frash Pond Community Stratford

Problems	Severity	Trend	Cause
Tidal Constriction	severe	stable	tidal gates
Fish Kills	moderate	stable	constriction, pollution inputs
Siltation	minor	increasing	upland erosion
Water Pollution	minor	stable	surface runoff, constriction

Problem: Tidal Constriction

Solution:

tide gate management program or replace with self regulating tide gates

Benefits/Impacts:

Environmental - improved water quality, enhanced value as a spawning area, additional increased aquatic productivity, improved tidal flushing

Aesthetic - enhanced water recreation use

Economic - possible replacement of existing tide gates (depends on management flexibility permitted by existing design)

Problem: Fish Kills

Solutions:

tide gate management (see "Tidal Constriction" above)

Embayment Ash Creek Community Fairfield

Problems	Severity	Trend	Cause
Constriction	moderate	stable	natural bar formation, tide gates
Pollution	moderate	stable	point, non-point discharge, marina runoff

Problem: Constriction

Solutions:

dredging

Benefits/Impacts:

Environmental - improved tidal flushing, improved water quality, improved aquatic productivity, dredge spoil disposal impacts potential increased soil erosion and wetland loss

Aesthetic - enhanced water recreation use, improved boating access

Economic - continued viability of town marina

Problem: Pollution

Solutions:

develop stormwater management program emphasizing use of swales and retention basins for surface runoff
develop tide gate management encouraging gates that will enhance flushing or removal
develop fuel discharge monitoring and enforcement program for public marina
construct boat holding tank pump-out facility for marina

Benefits/Impacts:

Environmental - improved water quality, increased aquatic productivity potential reopening of condemned shellfish beds

Aesthetic - enhanced water recreation use, improved visual character of water

Economic - enhanced waterfront property value, potential increased commercial value of shellfishery

Embayment Mill River Community Fairfield

Problems	Severity	Trend	Cause
Constriction	minor	stable	dam, bridge, R.R. causeway
Pollution	severe	stable	septic failure, point discharge, bottom contamination
Shell/Fin Fish Losses	moderate	stable	point discharge

Problem: Pollution

Solutions:

develop management program for lead contaminated sediment
monitor effluent from ESB industrial outfalls

*expand sewer service area to include state-recognized problem areas (or rely on small-scale innovative alternatives)
upgrade existing sewage treatment facilities
*develop stormwater management program emphasizing use of swales and retention ponds for surface runoff where feasible

Benefits/Impacts:

Environemntal - eventual containment and mitigation of lead contamination, restoration of aquatic ecosystem

Aesthetic - enhanced water recreation use and enjoyment
reduced anxiety about fate of lead contamination

Economic - significant cleanup and containment costs, costs of sewer service area expansion to users and community

Problem: Shellfish/Fin Fish Losses

Solutions:

construct fish ladders on existing dams and mill ponds
expand sewage treatment service area and develop program for stormwater management (see "Pollution" above)

Benefits/Impacts:

Environmental - improved fisheries resources, improved water quality, enhanced aquatic productivity

Aesthetic - restored recreational shellfishing, improved water recreation opprotunities

Economic - cost of fish ladder construction, commercial value of restored shellfishery and fin fishery

Embayment Horse Tavern Creek Community Fairfield

Problems	Severity	Trend	Cause
Constriction	severe	increasing	tidal gates
Wetland Loss	moderate	increasing	tidal gates

Problem: Constriction

Solutions:

develop tide gate management program

Benefits/Impacts:

Environmental - improved tidal flushing and circulation, improved aquatic productivity

Aesthetic - enhanced recreational value

Economic - possible cost of tide gate replacement

Problem: Wetland Loss (Degradation)

Solutions:

develop tide gate management program (see "Constriction" above)

Embayment Bermuda Lagoon Community Westport

Problems	Severity	Trend	Cause
Wetland Loss	minor	increasing	natural erosion
Pollution	moderate	stable	septic leakage, stormwater runoff
Fin/Shellfish Losses	moderate	stable	low D.O., constriction, water temperature

Problem: Pollution

Solutions:

sewage collection/treatment (or small-scale innovative alternative)
septic system installation and management controls
develop stormwater management program

Benefits/Impacts:

Environmental - improved water quality

Aesthetic - improved water recreational potential

Economic - cost of uprgraded treatment systems to users and community

Problem: Finfish/Shellfish Loss

Solutions:

minimize septic tank leachate and surface runoff contamination by upgrading existing systems and controlling runoff (see "Pollution" above).

Embayment Gray's Creek Community Westport

Problems	Severity	Trend	Cause
Siltation	minor	stable	bank erosion, stormwater runoff
Pollution	moderate	stable	stormwater outfall

Problem: Pollution

Solutions:

Develop stormwater management program, encouraging use of swales and surface runoff retention ponds. Develop construction standards that encourage on-site infiltration of stormwater

Benefits/Impacts:

Environmental - improved water quality, increased biological productivity

Aesthetic - reduced opportunity for odors, increased water recreation opportunities

Economic - land acquisition costs for stormwater detention ponds

Embayment Canfield Island Community Norwalk

Problems	Severity	Trend	Cause
Sedimentation	moderate	increasing	Natural deposition of eroded marsh sediments
Erosion	moderate	increasing	wave erosion of marsh, boating
Wetland Loss	moderate	increasing	wave erosion, waste dumping, boat wakes, heavy marsh use by pedestrians/ hunters

Problem: Sedimentation

Solutions:

erosion control (see below), dredging (for navigation only) most likely not cost effective

Benefits/Impacts:

Environmental - dredging and dredge spoil disposal impacts; shellfish loss; bottom disturbance

Aesthetic - construction impacts; dredge spoil disposal

Economic - dredging costs

Problem: Erosion

Solutions:

boat wake control/enforcement
no cost-effective structural option is apparent to eliminate erosion from wave action

Benefits/Impacts:

Environmental - improved wetland habitat; reduction of marsh loss

Aesthetic - improved marshland; wildlife habitat; visual improvement

Economic - cost of boat wake control/enforcement actions

Problem: Wetland Loss

Solutions:

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access control
boat wake (erosion) control

Benefits/Impacts:

Environmental - improved wetlands habitat; reduced erosion and siltation

Aesthetic - improved marshland; enhanced visual quality; improved wildlife habitat

Economic - costs of fill removal/marsh restoration; regulatory control costs

Embayment Mill Pond Community Norwalk

Problems	Severity	Trend	Cause
Constriction	severe	stable	culvert design
Siltation	severe	increasing	culvert design
Erosion	moderate	increasing	bank erosion

Problem: Constriction

Solutions:

Increase dimensions of Seaview Avenue culvert

Benefits/Impacts:

Environmental - improved tidal flushing, improved water quality, increased aquatic productivity, improved wildlife habitat

Aesthetic - reduced odors from anaerobic sediments, increased water recreation opportunities

Economic - costs of installing new culvert

Problem: Siltation

Solutions:

control erosion of banks
revegetate exposed soil slopes
develop stormwater management plan emphasizing use of swales and retention basins for runoff
dredging

Benefits/Impacts:

Environmental - improved water quality, decreased siltation, increased aquatic productivity, reduced erosion, dredge spoil disposal impacts

Aesthetic - reduced odors from sediments, increased water recreation opportunities, increased water clarity

Economic - acquisition costs for detention basins, minimize loss of valuable topsoils, cost of dredging

Problem: Erosion

Solutions:

develop stormwater management program (see "Siltation" above)
control erosion of embayment banks
revegetate exposed soil slopes
develop soil conservation program for upstream section of drainage basin

Mill Pond (continued)

Benefits/Impacts:

Environmental - reduced erosion, reduced siltation, reduced turbidity in embayment, increased aquatic productivity

Aesthetic - increased water clarity, improved water recreation potential

Economic - reduced loss of valuable topsoil

Embayment Village Creek Community Norwalk

Problems	Severity	Trend	Cause
Siltation	moderate	increasing	upland erosion, transport from Long Island Sound
Wetland Loss	severe	increasing	historic and recent filling

Problem: Siltation

Solutions:

periodic maintenance dredging

Benefits/Impacts:

Environmental - dredge spoil disposal

Aesthetic - improved boating access

Economic - cost of dredging, enhanced property value

Problem: Wetland Loss

Solutions:

regular monitoring of illegal encroachment and filling of wetlands

Benefits/Impacts:

Environmental - maintenance of wildlife habitat, natural flood storage areas and natural water quality buffer system

Aesthetic - maintain visual quality of estuarine landscape

Economic - inexpensive natural buffer for water quality maintenance and aquatic productivity, reduced opportunity for industrial, commerical and residential development of wetlands

Embayment Holly Pond Community Darien

Problems	Severity	Trend	Cause
Pollution	moderate	increasing	non-point runoff, point discharges
Constriction	severe	stable	dam

Problem: Pollution

Solutions:

develop stormwater management program emphasizing use of swales and retention ponds for surface runoff
develop construction performance standards to minimize areal coverage of impervious surfaces
expand sewer system to include recognized problem areas
review compliance of upstream industries with their NPDES permit conditions

upgrade sewer overflow systems where feasible

Benefits/Impacts:

Environmental - improved water quality, increased aquatic productivity, reduced erosion, reduced siltation

Aesthetic - improved water recreation potential, restoration of recreational shellfishery, reduced potential for obnoxious odors

Economic - land acquisition costs for detention ponds, sewer system upgrading costs to users and community, costs of upgrading sewer overflow systems

Problem: Constriction

No cost effective solution found

Embayment Gorhams Pond Community Darien

Problems	Severity	Trend	Cause
Constriction	moderate	stable	dam
Sedimentation	moderate	increasing	upland/bank erosion

Problem: Constriction

No cost effective solution found

Problem: Sedimentation

Solutions:

develop soil conservation program for drainage basin
dredge dammed millponds
encourage use of swales and surface runoff detention ponds where appropriate
soil stabilization performance standards as part of City construction code

Benefits/Impacts:

Environmental - reduced soil erosion, reduced sedimentation, improved aquatic productivity, improved water quality
dredge disposal impacts

Aesthetic - improved landscape design, increased pond clarity, reduced incidence of obnoxious odors, improved water recreation potential

Economic - land acquisition costs for retention ponds, dredging costs

Embayment Byram Harbor Community Greenwich

Problems	Severity	Trend	Cause
Pollution	moderate	improving	septic tank failure (sewer construction underway)
Wetland Loss	minor	stable	erosion, mostly natural
Siltation	moderate	stable	constriction

Problem: Pollution

Solutions:

expand sewer service to include identified problem areas (currently underway)
septic tank siting and develop performance standards
develop septic tank monitoring program
develop stormwater management program, emphasizing use of swales and detention ponds for surface runoff
monitor Toms Brook for potential landfill leachate contamination

Benefits/Impacts:

Environmental - improved water quality, reduced erosion and sedimentation

Aesthetic - reduced incidence of beach closings from bacterial contamination

Economic - sewer system costs to users and community, land acquisition costs for detention ponds, septic tanks upgrading costs, enhanced waterfront land values

Problem: Siltation

Solutions:

develop stormwater management program (see "Pollution" above)
periodic maintenance dredging

Benefits/Impacts:

Environmental - improved tidal circulation and flushing, some reduction in siltation, dredge spoil disposal impacts

Aesthetic - improved boating access, enhanced water recreation potential

Economic - dredging costs, land acquisition costs for detention ponds

APPENDIX I

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APPENDIX II

SELECTION OF EMBAYMENTS FOR STUDY

APPENDIX II

This Appendix reviews the embayments surveyed during the detailed screening outlined in Chapter I. Each embayment falls into one of two groups: those embayments selected for detailed study, and those embayments deleted. A third category was included for state modification of the existing lists. A more detailed explanation of categories follows:

Category I - Areas which warrant further study

These embayments include areas with significant singular problems such as direct source pollution or areas which are experiencing a noticeable deterioration of environmental quality in a number of problem areas; i.e. poor circulation, recent fish kills or noticeable recent increase in sedimentation or erosion rates. This category also includes those areas where town responses were vague and our review suggested significant problems do, or may exist.

Category II - Areas to be deleted from further study

The 34 embayments in this category were deleted for a variety of reasons which are listed below.

a) Town response indicated no problems exist.

b) Town and our review indicated only minor or no significant problems exist.

c) Problems which exist relate to historical, long-term, or naturally existing conditions or actions.

d) Singular problems which are under study by the town, or for which corrective actions have been instigated.

Each embayment decision is reviewed in the following pages.

CATEGORY I EMBAYMENTS

SUMMARY LIST OF EMBAYMENTS WHICH WARRANT FURTHER STUDY

LOCATION

EMBAYMENT NAME — COMMENT

A. STONINGTON

1. Wequetequock Cove - Moderate to severe problems in all problem areas; poor circulation; pollution from various sources; siltation; erosion and fish losses.

B. GROTON

2. West Cove - Severe siltation and circulation problems, eutrophication reported. Heavy marina use.

3. Palmer's Cove - Moderate problems in several areas. Significant sedimentation problems at mouth and turnover problems. Open shellfish harvest area.

D. WATERFORD

1. Smith's Cove - Severe siltation, pollution and circulation problems identified. Pollution problem from landfill is recent occurrence.

H. ESSEX

1. Middle Cove - Areas of new construction located on highly-developed shoreline. Marina development. Poorer circulation than in North and South Coves. Potential problem area.

I. OLD SAYBROOK

1. Indiantown Harbor - Significant sedimentation problems, poor circulation and eutrophication reported. Heavy marine use.

J. WESTBROOK

1. Patchogue River - Newly occurring problems of pollution and sedimentation. New marina development. Possible problem area.

2. Menunketesuck River - New areas of major dredging 1970-1980. Newly developed problems relating to siltation erosion and pollution reported.

K. GUILFORD

3. West River - Mixture of problems exist. Severe siltation, erosion as well as pollution and circulation problems reported.

4. Little Harbor - Severe siltation and extreme wave action due to long southerly fetch. Town constructed floating tire breakwater, which failed.

L. BRANFORD

2. East Haven River - Moderate siltation and pollution problems. Agricultural runoff, shellfish harvest areas.

M. CHESTER

1. Pattaconk Creek - Siltation problems in newly-dredged areas. Pollution problem from marinas and road salts. Unknown problems in several areas.

N. NEW HAVEN

1. Mill River - Severe pollution problems due to multiple industrial outfalls. Fully-urbanized area.

R. MILFORD

1. Gulf Pond - Severe siltation and poor circulation in pond. Moderate erosion and pollution problems reported. Land use is a mix of residential/industrial.

2. Wepawaug River - Severe siltation and pollution problems identified. Agricultural runoff and industrial pollution. Several unknown problem areas.

S. STRATFORD

1. Marine Basin - Severe siltation, pollution and shellfish losses reported. Landfill and dumping in area.

2. Lewis Gut - Flow restrictions and severe pollution problems evident. Eutrophication and shellfish/finfish losses reported.

U. FAIRFIELD

1. Ash Creek - Major pollution problems exist, poor tidal flushing.

2. Mill River - Major pollution problems (lead) exist. Area is silting up, some filling.

4. Mill Pond - Severe circulation and fish loss problems of recent occurrence.

5. Horse Tavern Creek - Severe circulation, fish and saltmarsh losses of recent occurrence.

V. WESTPORT

1. Bermuda Lagoon - Problems in several areas of recent occurrence reported (some confusion as to location and physical description of lagoon by town).

2. Gray Creek - A mixture of problems from minor to severe. Recent severe siltation problem.

W. NORWALK

1. Canfield Island - Moderate to severe problems reported in several areas. Loss of saltmarsh due to dumping and filling.

4. Mill Pond - Mixture of moderate problems in several areas. Recent siltation problems.

5. Village Creek - Significant water pollution problems. Extensive urban runoff impacts (junk yard). Moderate problems in other areas.

X. DARIEN

2. Holly Pond - Severe pollution problems, poor circulation. Shellfish losses and saltmarsh losses.

3. Gorham's Pond - Severe siltation problem and non-point pollution from agricultural lands reported. Town wants dredging.

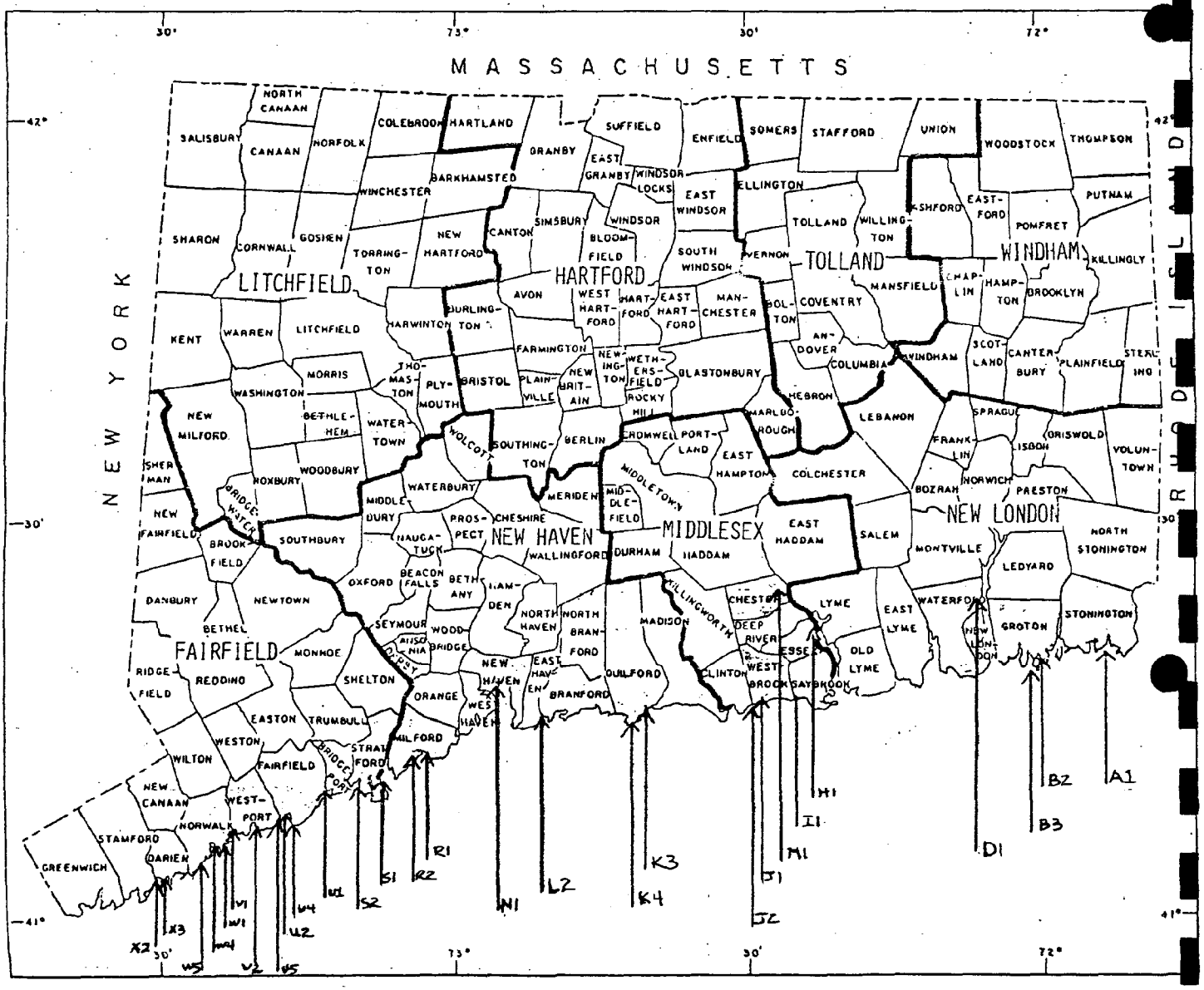

FIGURE 1. DISTRIBUTION OF STUDY AREAS

CATEGORY II EMBAYMENTS

SUMMARY LIST OF EMBAYMENTS DELETED FROM FURTHER STUDY

LOCATION

EMBAYMENT NAME — COMMENT

A. STONINGTON

2. Lord's Point Cove - Minor visible problems; singular moderate problem relating to septic system failures which town is aware of, good flushing and circulation characteristics.

3. Quiambog Cove - Minor erosion and pollution problems indicated; natural siltation problem, town wants dredging, recreational fishing, no marinas.

B. GROTON

1. Bebe Cove - Moderate problems relate to historical conditions, poor circulation due to railroad. Closed to shellfishing since 1948. No change in problems unless a major land change is made, such as removal of railway embankment.

4. Bennett's Cove - Long-term historical problems (100+ years) very small area classified by shellfish commissioner as "dead area".

5. Pine Island Bay - Significant levels of sedimentation due to natural process. Breech of barrier spit in 1938 hurricane and subsequent storms in 1954, 1960. Town reports DEP is currently involved in beach dune restoration for the area. Extensive shellfish beds.

6. Poquonnock Cove - See B.5 above. Part of same marine complex. Temporary pollution problem due to sewer pump station shutdown (town is correcting). Extensive shellfish beds.

7. Baker's Cove - See B.5 above. Closed to shellfishing since 1971 due to sewage discharge from airport. Town has proposal for airport to hook into new sewer lines.

D. WATERFORD

2. Goshen Cove - No problems were identified by town sedimenation problems at mouth due to natural process. Town has applied for funding to do a dredging study.

3. Keeney Cove - Severe pollution problems evident from septic tank leachate. Town is currently under study to eliminate the problem.

E. NORWICH

1. Yantic River - Only minor pollution problem indicated; problem has not changed in 10+ years.

F. EAST LYME

1. Smith's Cove)
2. Niantic River)
3. 4-Mile River) Town response indicated no problems exist at this time.
4. Pataquanset River)

H. ESSEX

2. North Cove - Only moderate siltation and erosion problems are indicated. Town reports that it is responding to problem through regulatory process. No structural measures are planned. Minor problems relating to high concentration of pleasure craft in marinas.

3. South Cove - See H.2 above. Only minor problems indicated.

K. GUILFORD

1. East River - Severe siltation and erosion problems indicated, but due solely to natural processes. Mouth was dredged by Army Corps of Engineers in 1958. Minor pollution (non-point) problem indicated.

2. Grass Island - See K.1 above. Part of same marine system.

L. BRANFORD

1. Stony Creek - Only problem indicated was pollution due to sewage discharge. Closed to shellfishing 1966.

3. Pages)
4. Lamphier) No significant problem apparent and reported by town.
5. Linsey)

O. HAMDEN

1. Mill River - No response from town forthcoming, area will be included in study of Mill River in New Haven.

R. MILFORD

3. Beard's Creek - Historical problems relating to pollution and sedimentation. Area is surrounded by residential development, no marinas, small waterbody.

S. STRATFORD

3. Mac's Harbor - No problems reported by town.

T. SHELTON

1. Far Mill River - No response from town forthcoming. No problems apparent.

U. FAIRFIELD

3. Pine Creek - Severe problems indicated for circulation, fish and saltmarsh losses. Town reports recently completed (1/81) $265,000 project to correct problems.

5. Turney Creek - Severe problems indicated for circulation, fish and saltmarsh losses. Town reports installation of self-regulating tide gates to correct the problems.

W. NORWALK

2. Charles Creek - Minor or no problems indicated. Minor problems relating to residential runoff and marina development. Good circulation.

3. Harbor View Wetlands - Only minor problems indicated, some filling (dumping) on wetlands. Town is aware of situation.

6. Wilson Cove - Only minor problems indicated, natural shoreline erosion occurring.

7. Five Mile River - Natural siltation and erosion occurring. River dredged in 1894, town wants to redredge. Good circulation, tidal flow.

8. Farm Creek - Only minor problems indicated for siltation and saltmarsh encroachment. No mooring areas. Open space acquisition has been proposed to protect area.

X. DARIEN

1. Scott Cove - No significant problems; some natural filling occurring. High productive saltmarsh in area.

Y. GREENWICH

1. Byram Harbor - Town reports no significant problems exist with the exception of loss of saltmarsh due to conversion to other uses. Urban runoff is major concern.

2. Greenwich Cove - Minor shoreline erosion problems, extensive tide flats. Pollution relating to sewage outfall and urban runoff reported existing for 70+ years.

3. Tomac Cove - Singular problem identified by town relates to urban runoff which reportedly has not changed for 25+ years.

CATEGORY III EMBAYMENTS

STATE REQUESTED MODIFICATIONS TO CATEGORIES I AND II

STONINGTON	-	Quiambog Cove
WATERFORD	-	Keeney Cove
EAST LYME	-	Smiths Cove
	-	Niantic River
	-	4 Mile River
	-	Pataquanset River
GREENWICH	-	Byram Harbor
LEDYARD	-	Mill Cove
	-	Poquetannuck Cove

STATE REQUESTED DELETION

WESTBROOK	-	Patchogue River

APPENDIX III

TYPICAL STRUCTURAL DESIGNS AND COSTS

APPENDIX III TYPICAL STRUCTURAL DESIGNS

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Figure III-2 Perforated Cassion
Figure III-3 Cellular Steel Sheet Pile
Figure III-4 Stone Asphalt
Figure III-5 Tribar Rubble-Mound
Figure III-6 Tetrapod Rubble-Mound

Jetties and Groins

Figure III-7 Cellular Sheet Steel Pile
Figure III-8 Dolos Rubble-Mound
Figure III-9 Quadripod Rubble-Mound
Figure III-10 Rubble-Mound Groin
Figure III-11 Prestressed Concrete Sheet-Pile Groin
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Figure III-30 Slide Gates, Medium Duty
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Figure III-33 Group Leaching System, Trench Type
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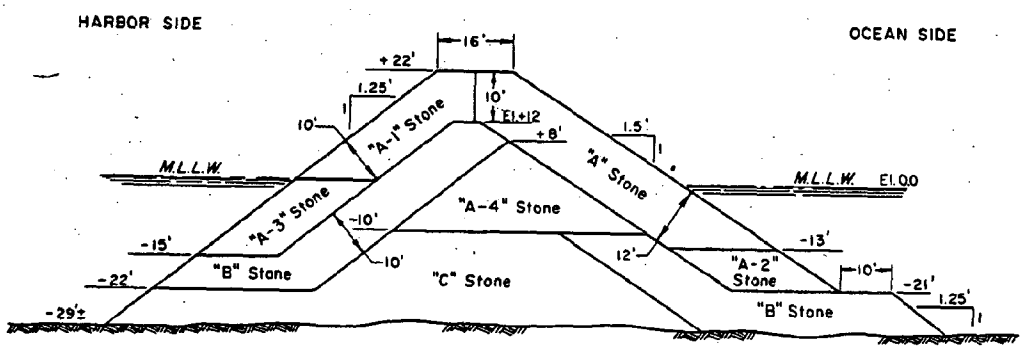
Unit Price Data (where appropriate)

Introduction

The following text represents a collection of conceptual or "typical" structural designs for the various structural options considered in the report. These designs are appropriate for general reference, but will vary on a site by site basis. The dimensions should be used as relative measures only, as requirements will vary.

General unit cost data have also been provided. These data are for general planning purposes, as costs may vary by an order of magnitude depending on site-specific conditions. More accurate data would require a design study.



"A" Stone — 16 tons or greater.

"A-1" Stone — 13 tons or greater.

"A-2" Stone — 8 tons or greater.

"A-3" Stone — 6 tons or greater.

"A-4" Stone — 500 lbs. to 8 tons.

"B" Stone — Core stone varies from quarry-run stone to pieces of 1 ton to 4 tons.

"C" Stone — Core stone varies from quarry-waste to pieces of 1,500 lbs. to 4 tons.

Figure III-1. Rubble-Mound Breakwater

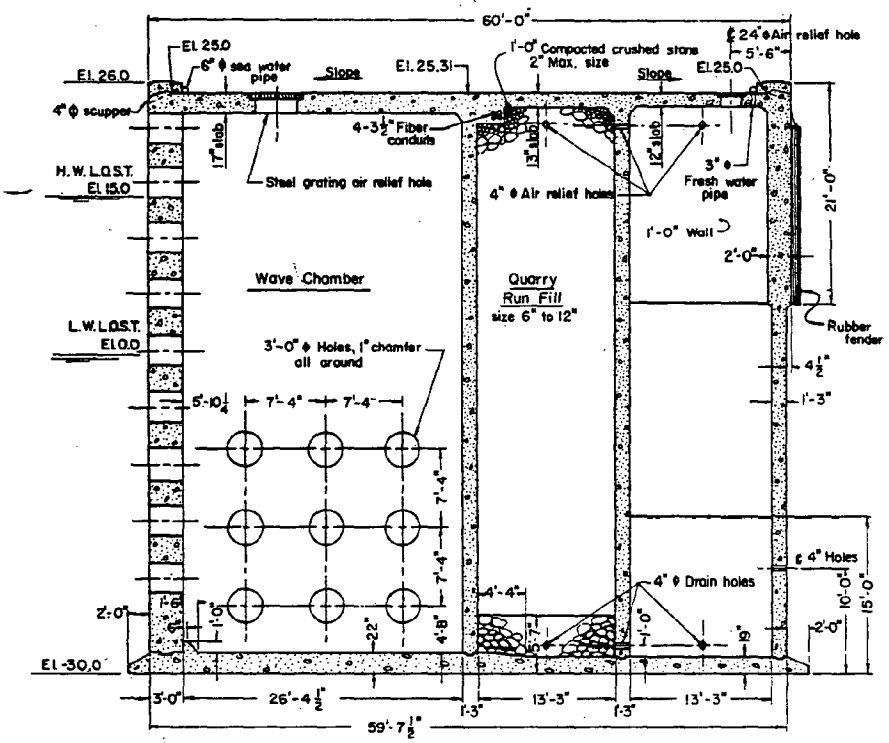


Figure III-2. Perforated Caisson Breakwater

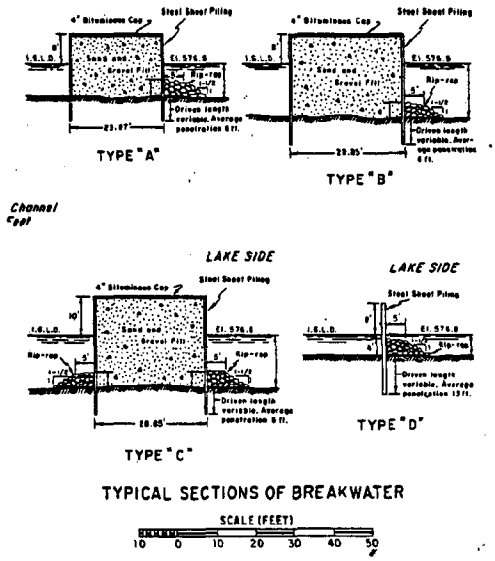


Figure III-3. Cellular Steel Sheet-Pile and Sheet-Pile Breakwater

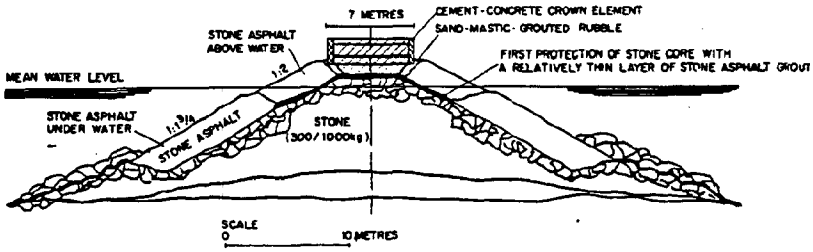


Figure III-4. Stone Asphalt Breakwater

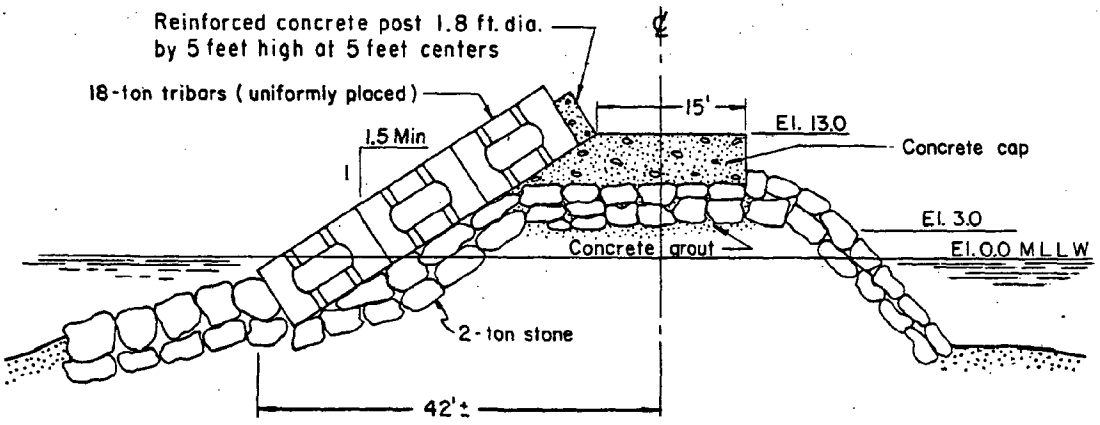
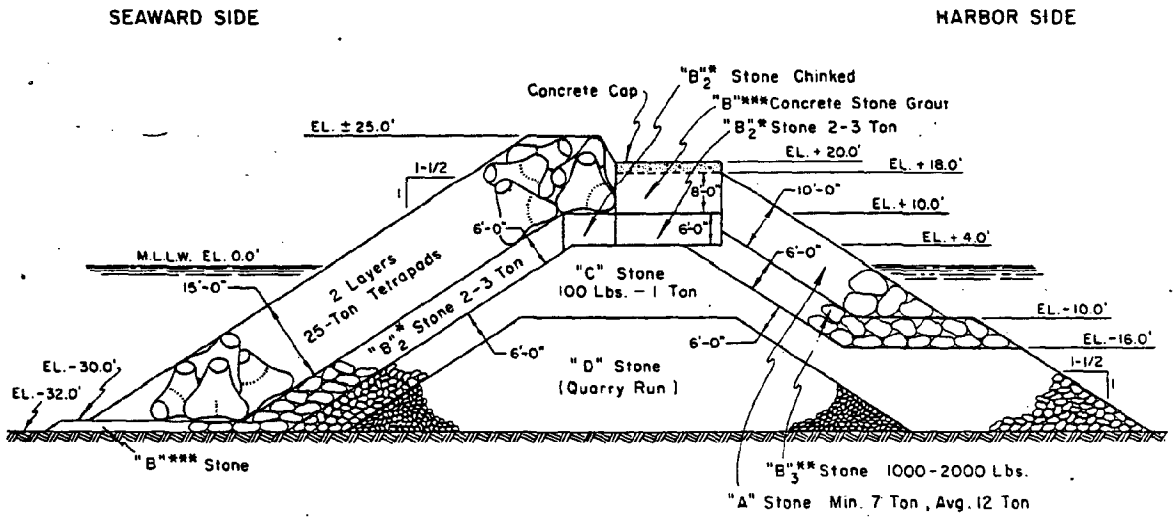


Figure III-5. Tribar-Rubble-Mound Breakwater



* "B"2 – One ton variation to 7 ton max

** "B"3 – 1/2 ton to 1 ton min. - 7 ton max. as available.

*** "B" – 1 ton to 7 tons or to suit depth conditions at seaward toe.

Figure III-6. Tetrapod-Rubble-Mound Breakwater

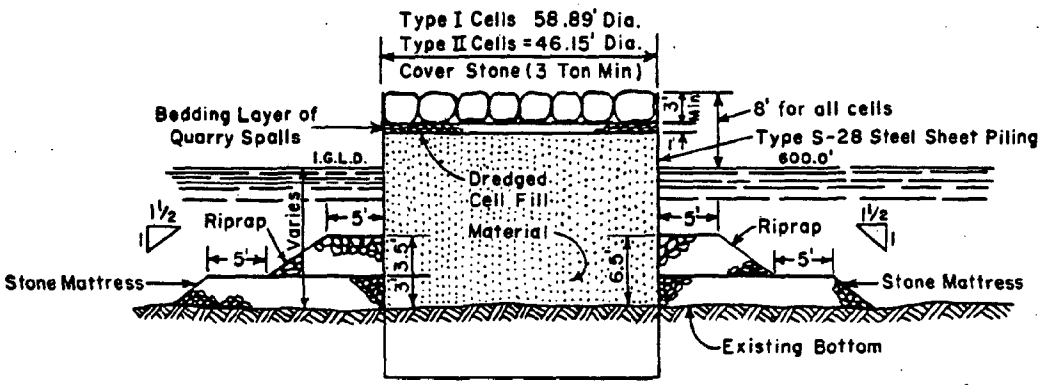


Figure III-7. Cellular Steel Sheet-Pile Jetty

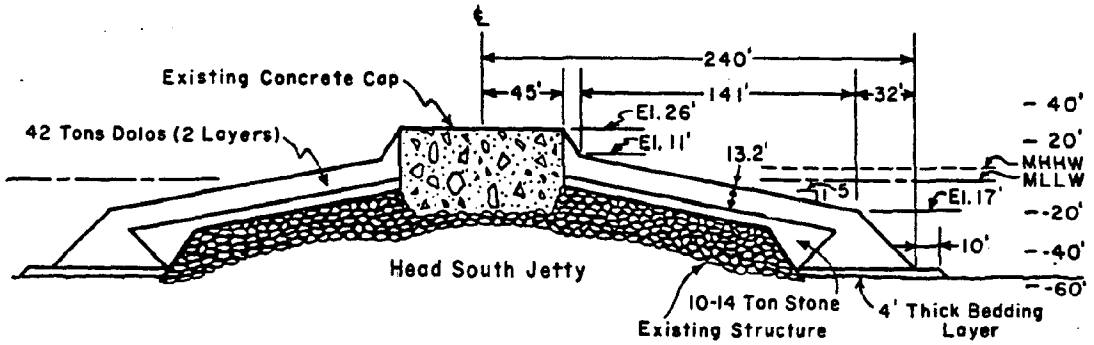


Figure III-8. Dolos-Rubble-Mound Jetty

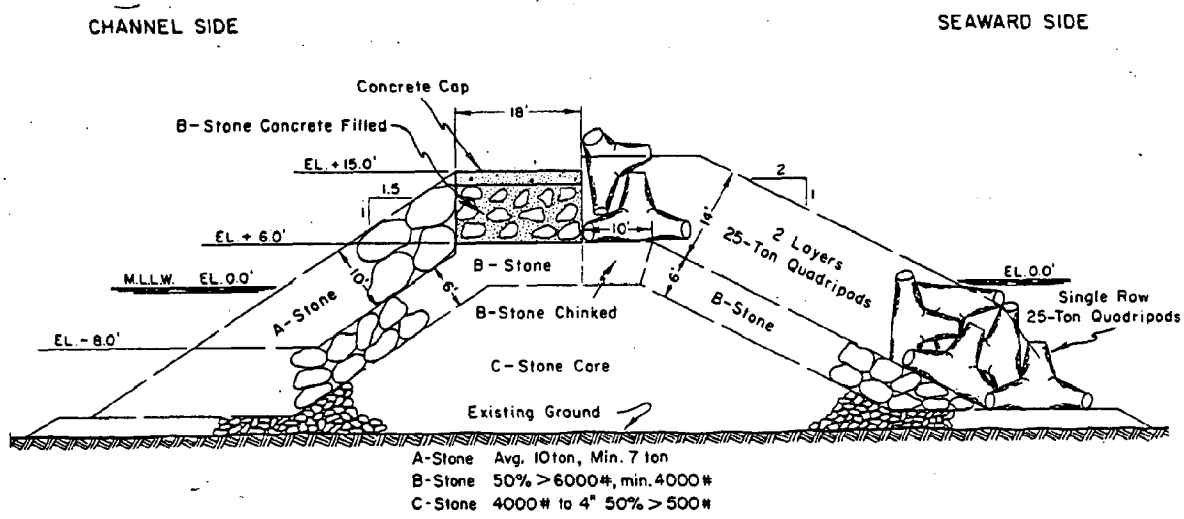


Figure III-9. Quadripod-Rubble-Mound Jetty

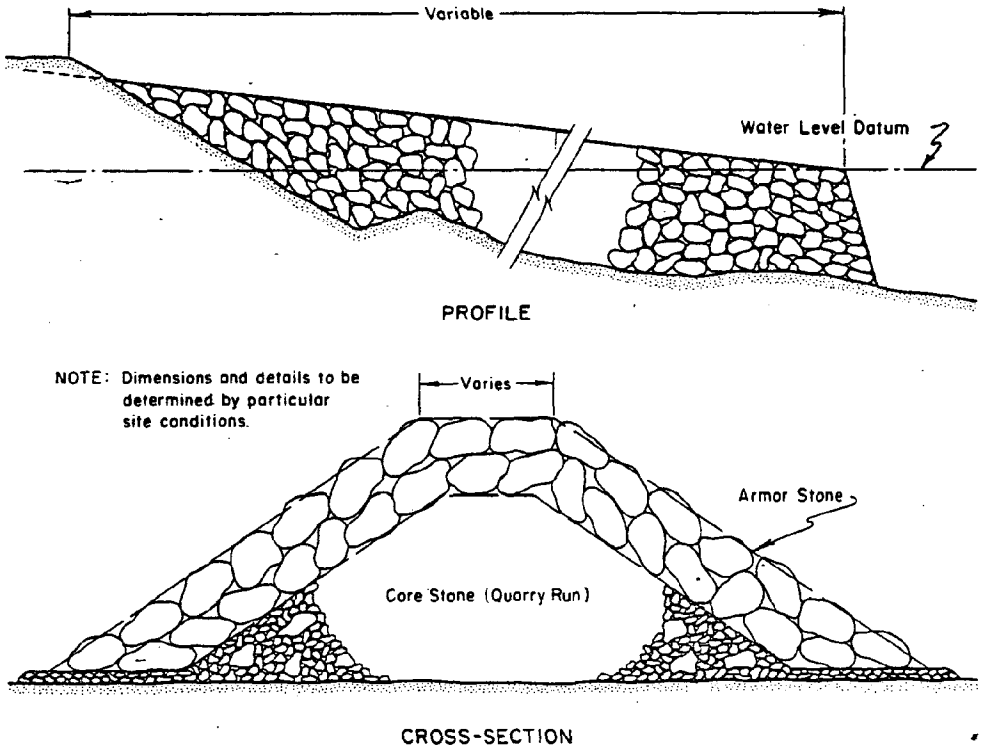


Figure III-10. Rubble-Mound Groin

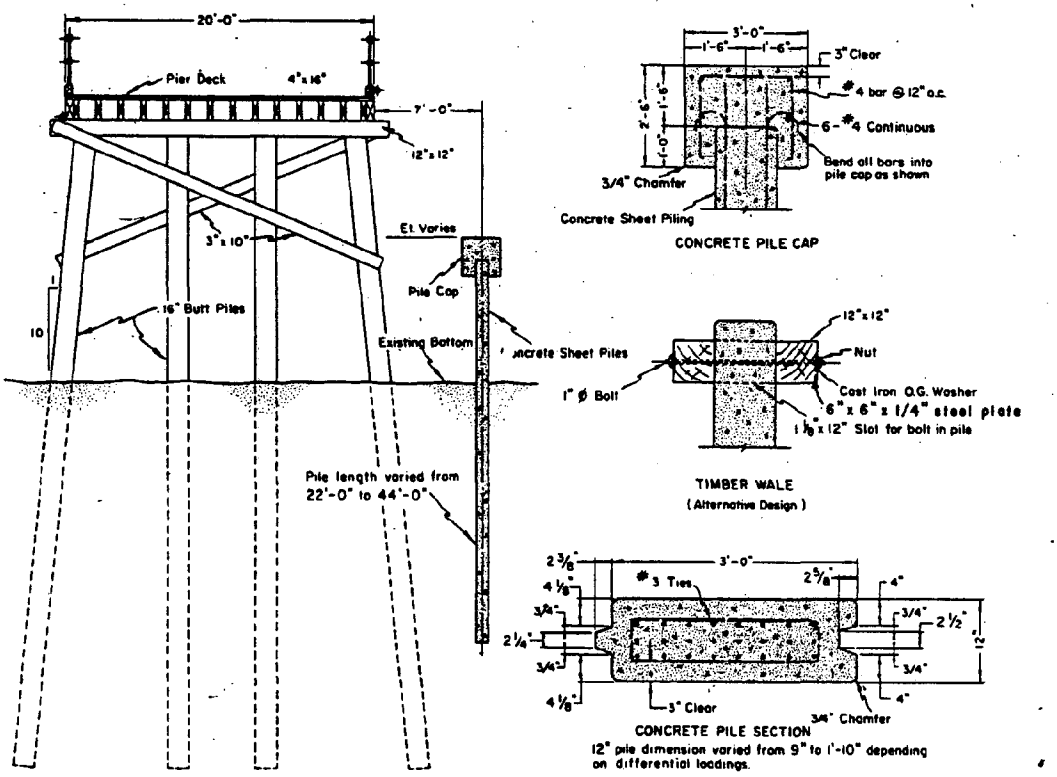


Figure III-11. Prestressed Concrete Sheet-Pile Groin

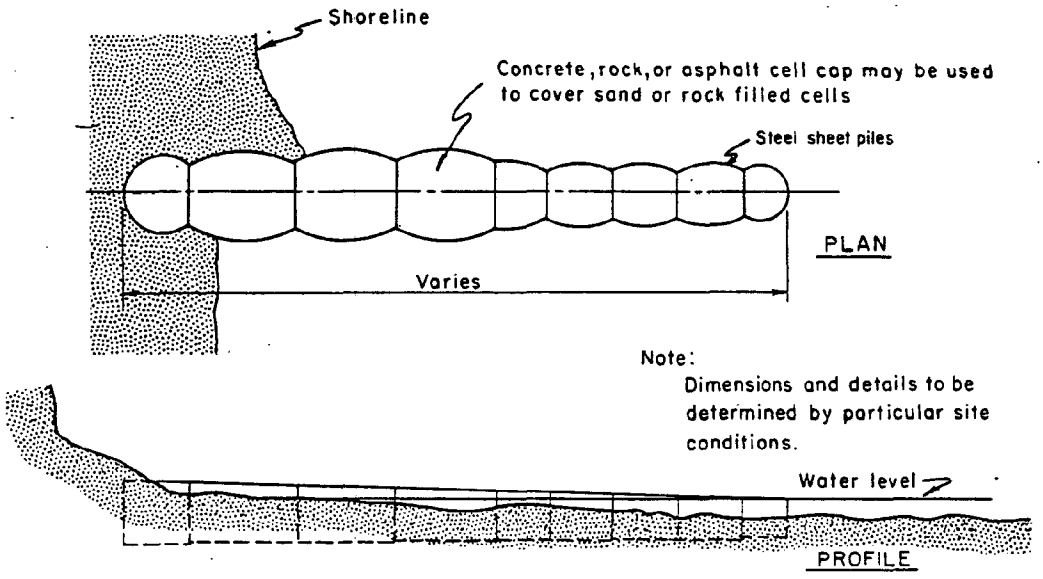


Figure III-12. Cellular Steel Sheet-Pile Groin

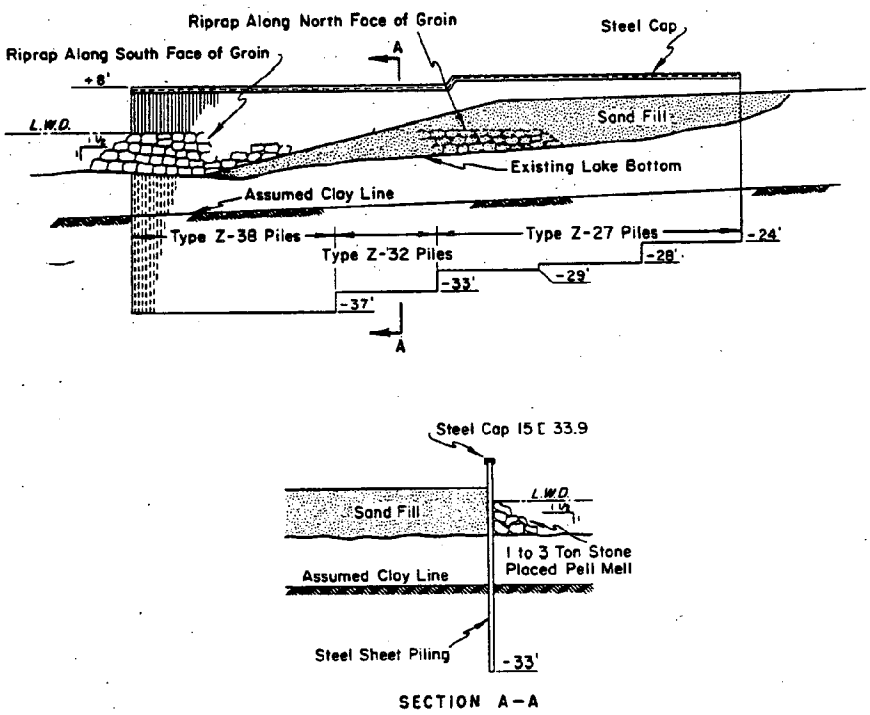


Figure III-13. Cantilever Steel Sheet-Pile Groin

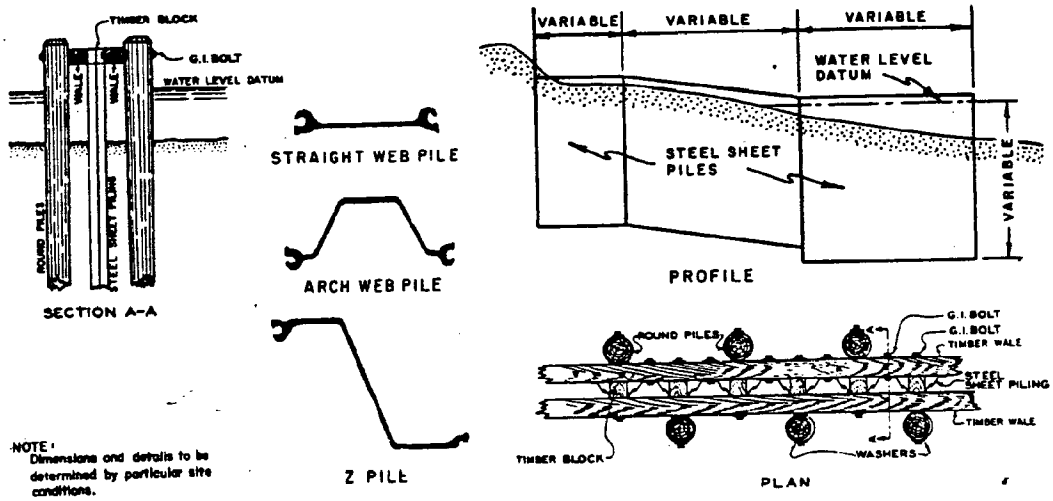


Figure III-14. Timber-Steel Sheet-Pile Groin

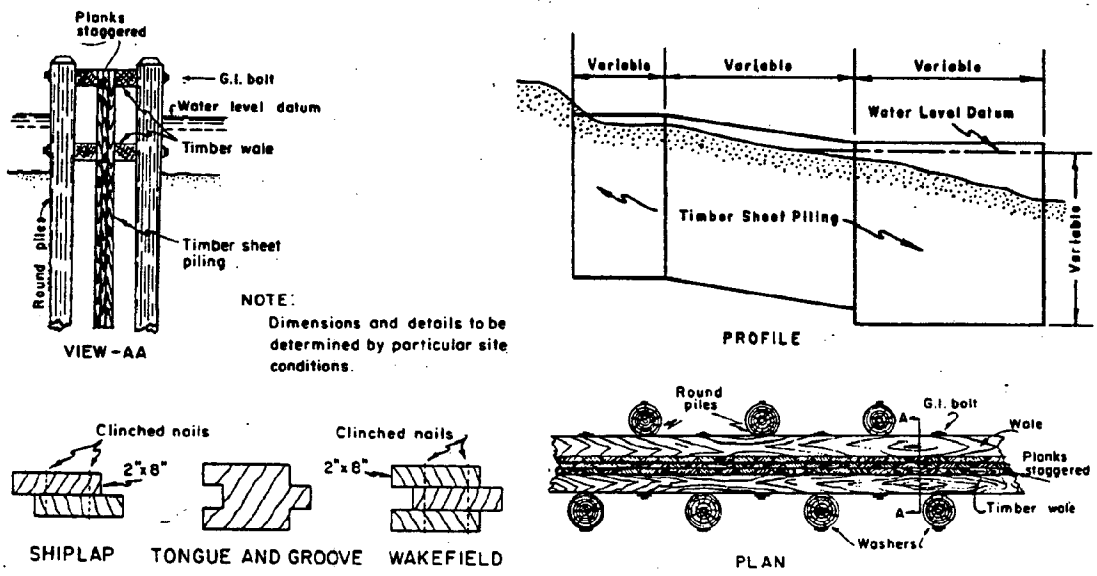


Figure III-15. Timber Sheet - Pile Groin

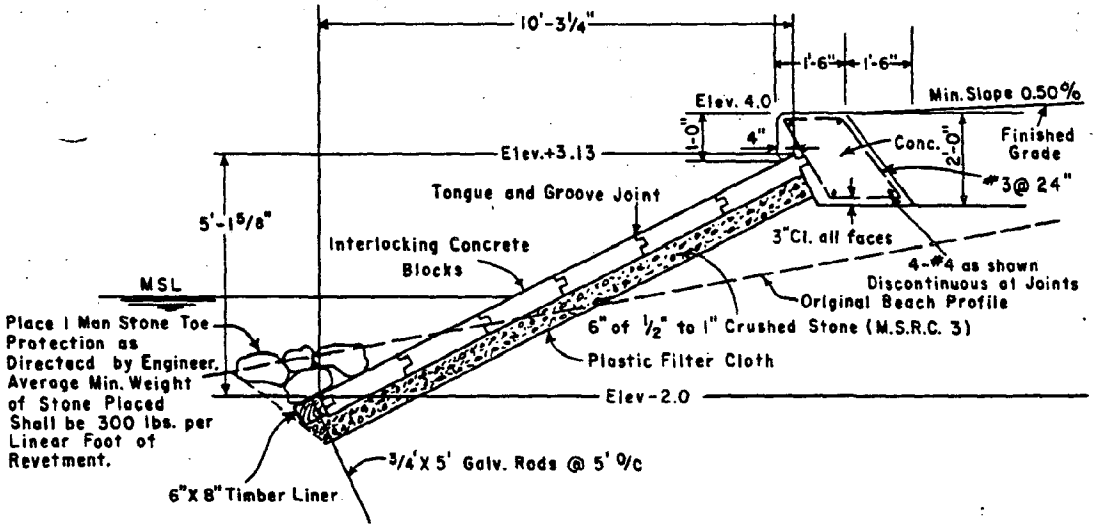


Figure III-16. Interlocking Concrete-Block Revetment

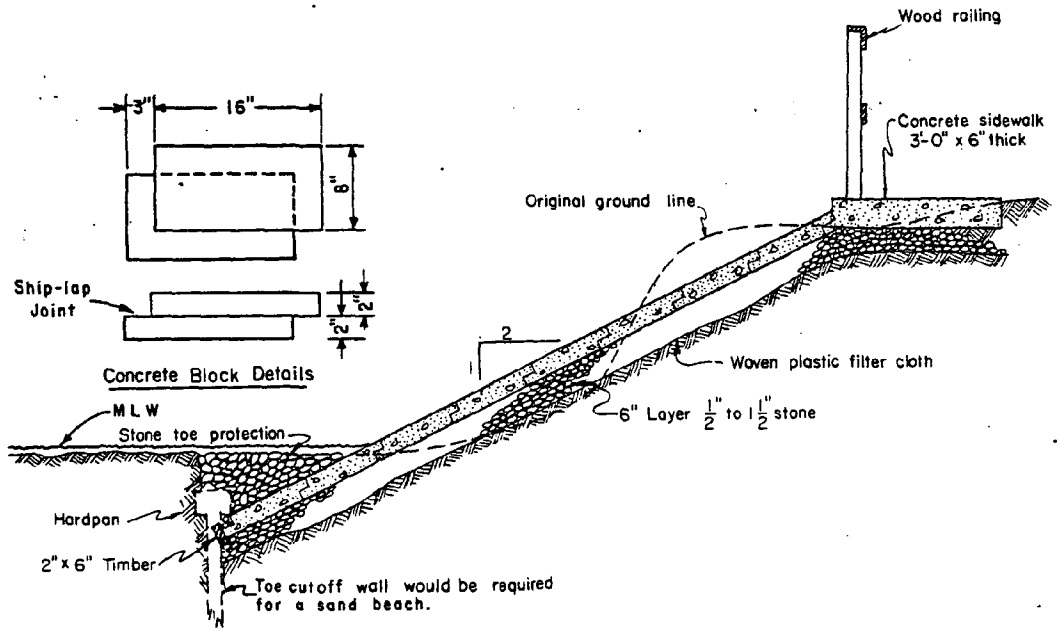


Figure III-17. Interlocking Concrete-Block Revetment

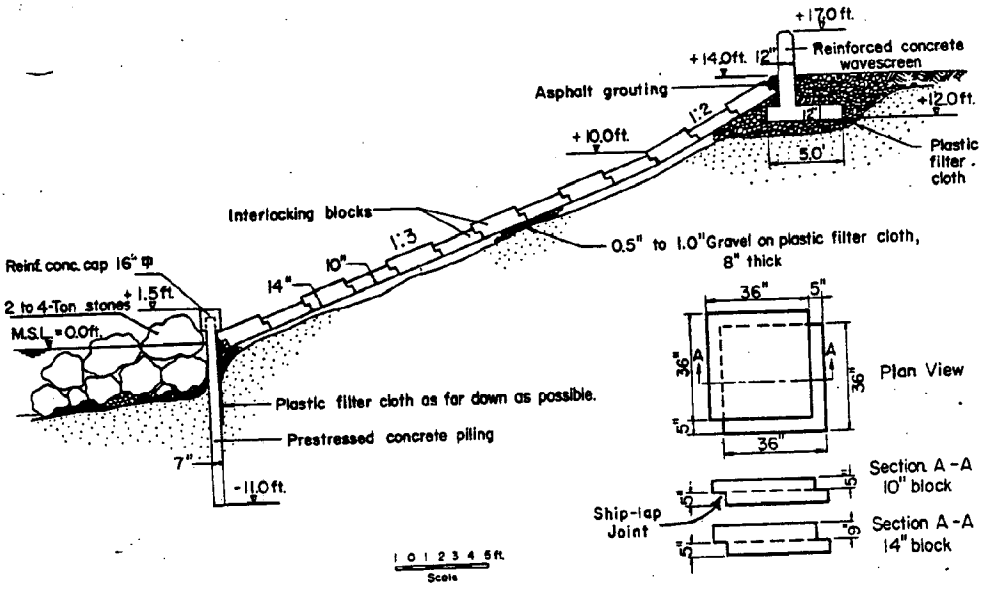


Figure III-18. Interlocking Concrete-Block Revetment

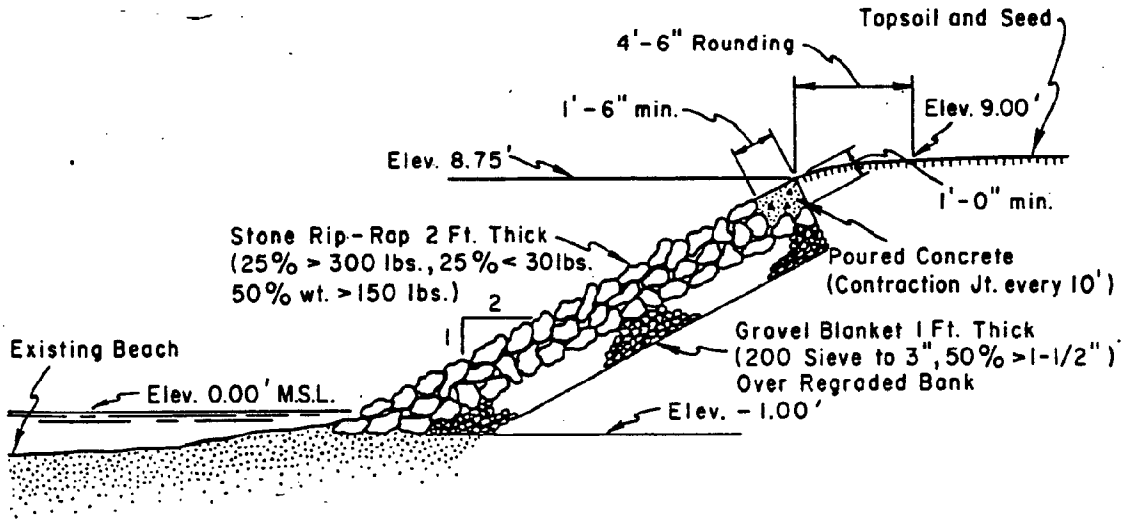


Figure III-19. Riprap Revetment

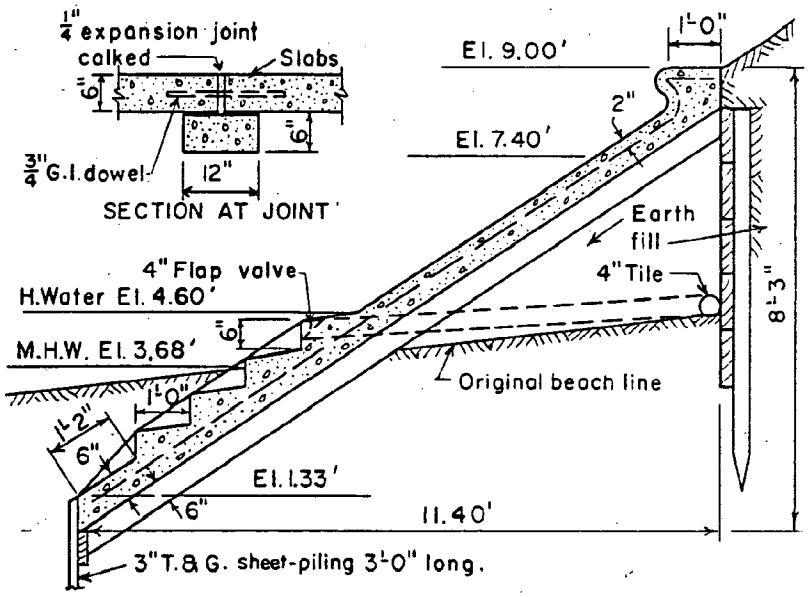


Figure III-20. Concrete Revetment

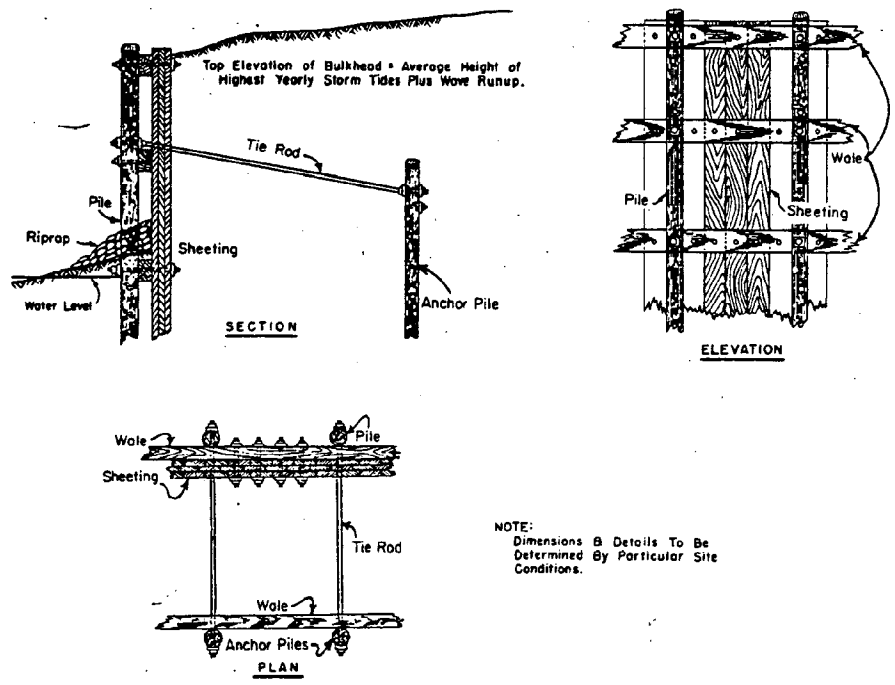


Figure III-21. Timber Sheet-Pile Bulkhead

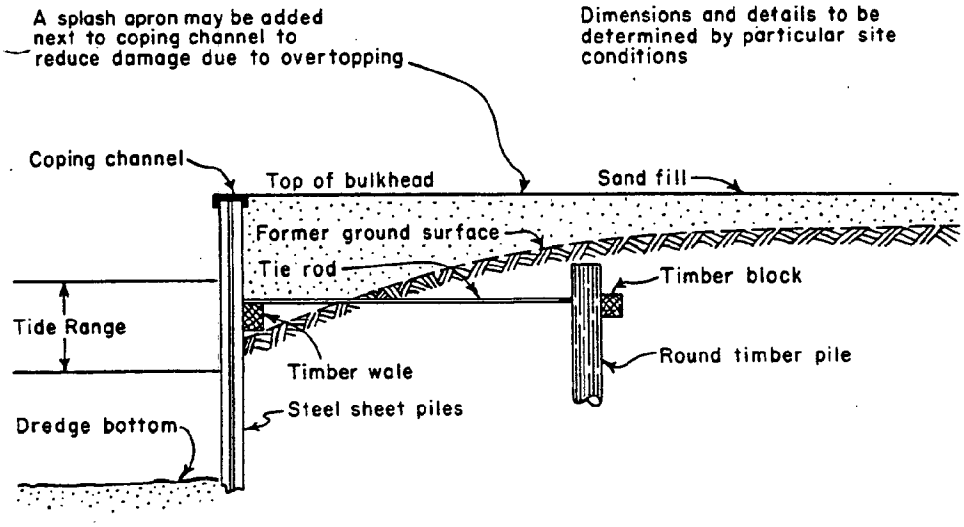


Figure III-22. Steel Sheet-Pile Bulkhead

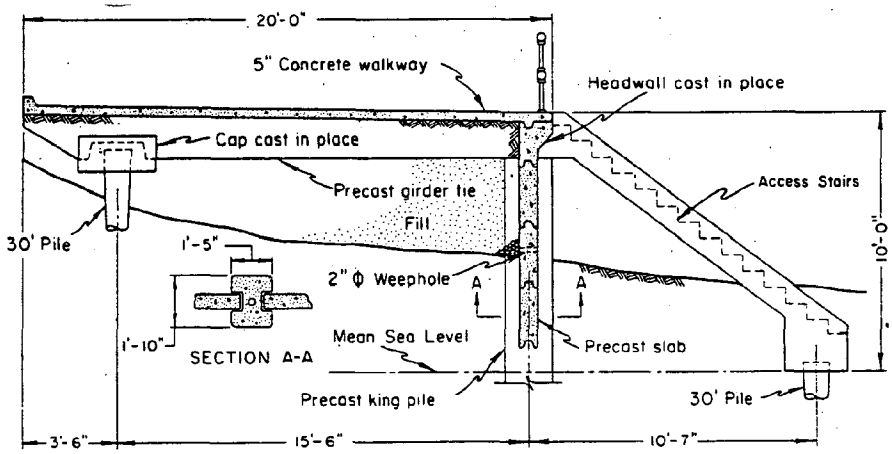


Figure III-23. Concrete Slab and King-Pile Bulkhead

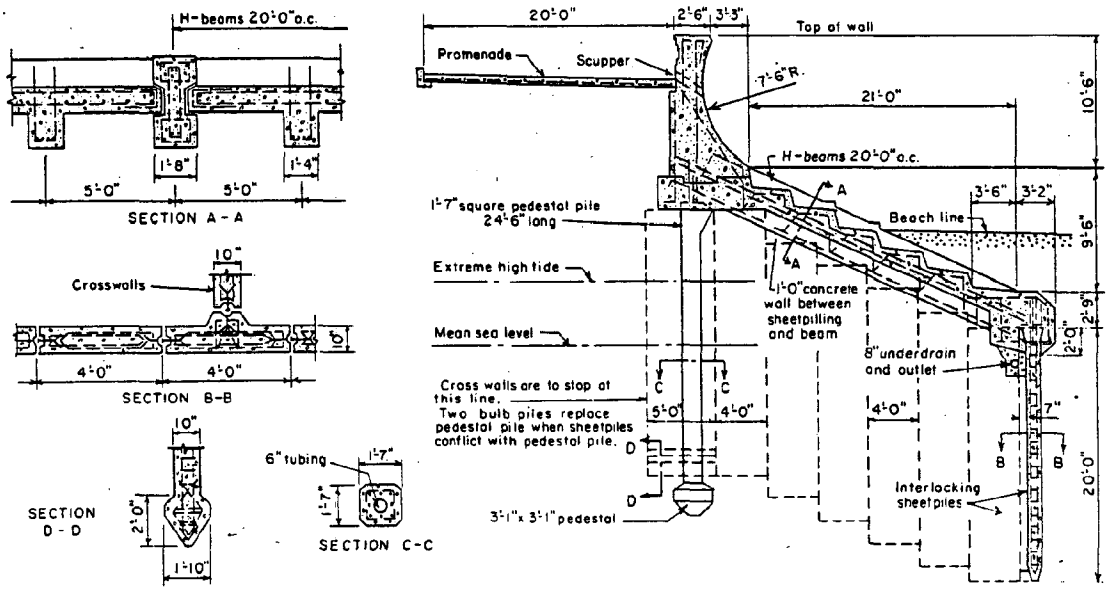


Figure III-24. Concrete Combination Stepped and Curved-Face Seawall

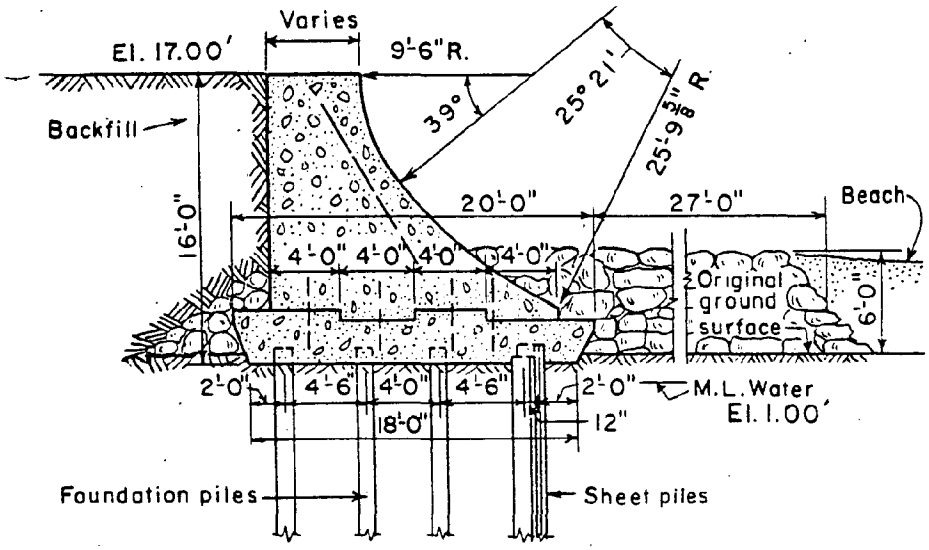


Figure III-25. Concrete Curved-Face Seawall

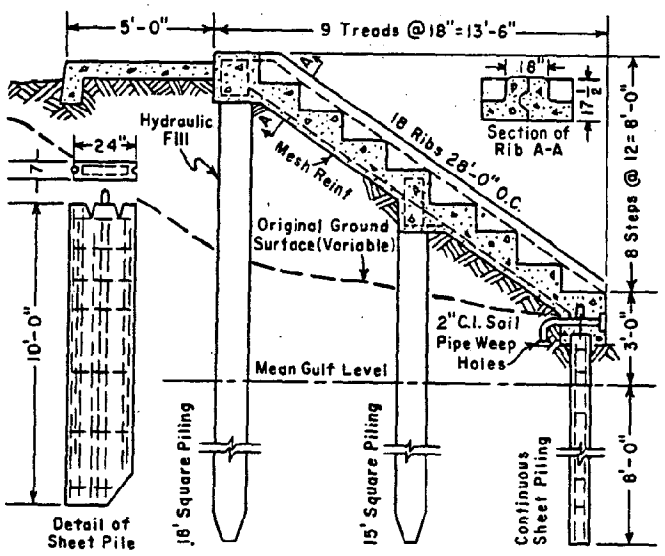


Figure III-26. Concrete Stepped-Face Seawall

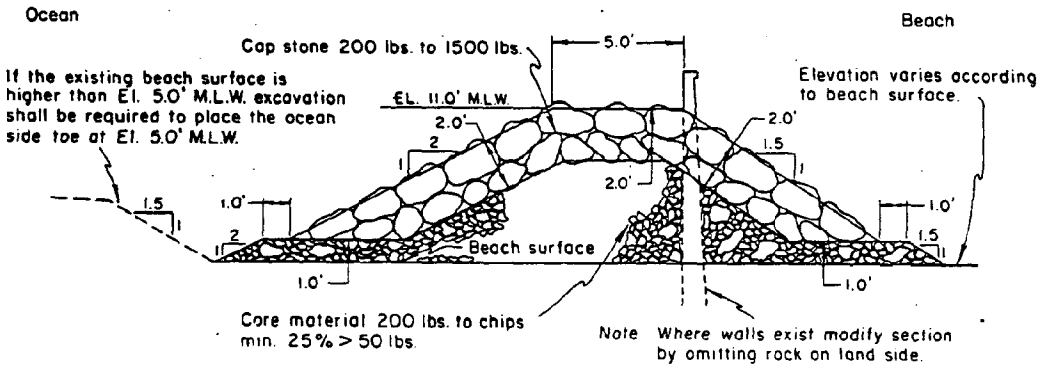


Figure III-27. Rubble-Mound Seawall

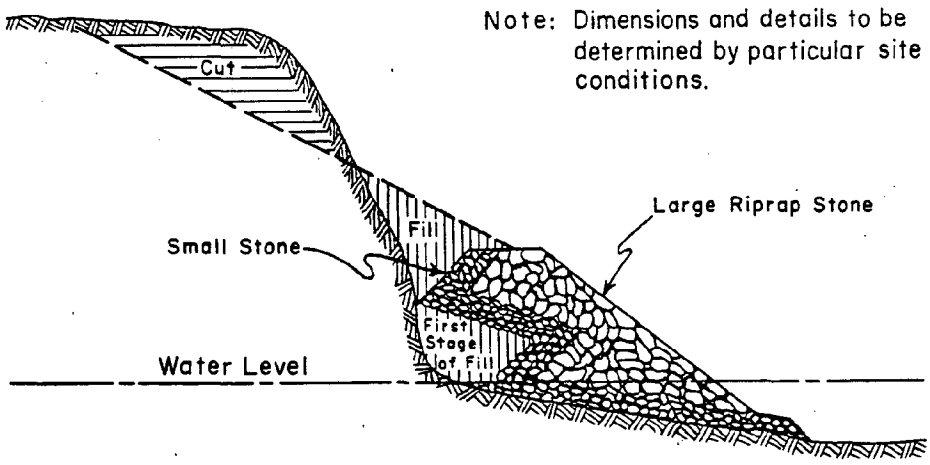
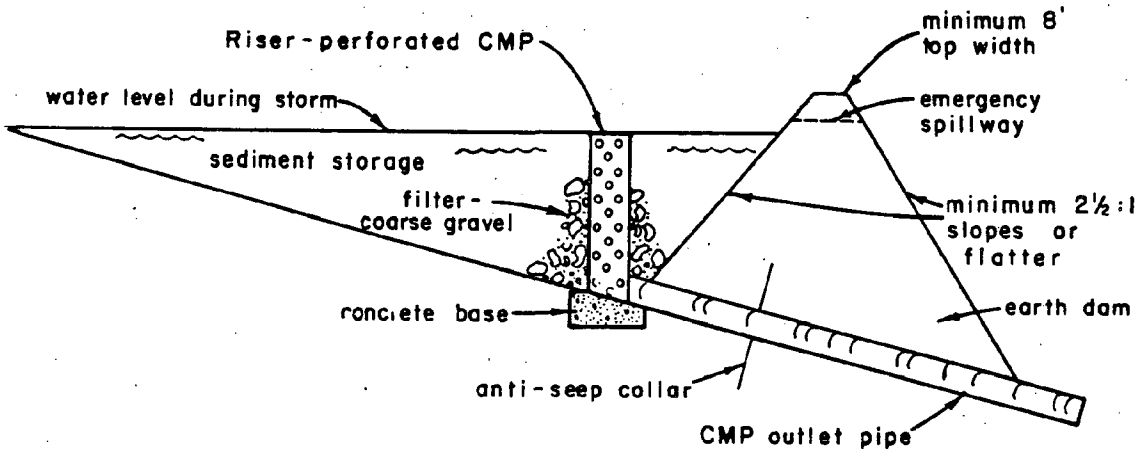


Figure III-28. Rubble-Mound Seawall (Typical-Stage Placed)



CROSS SECTION

Figure III-29. Resilting Basin

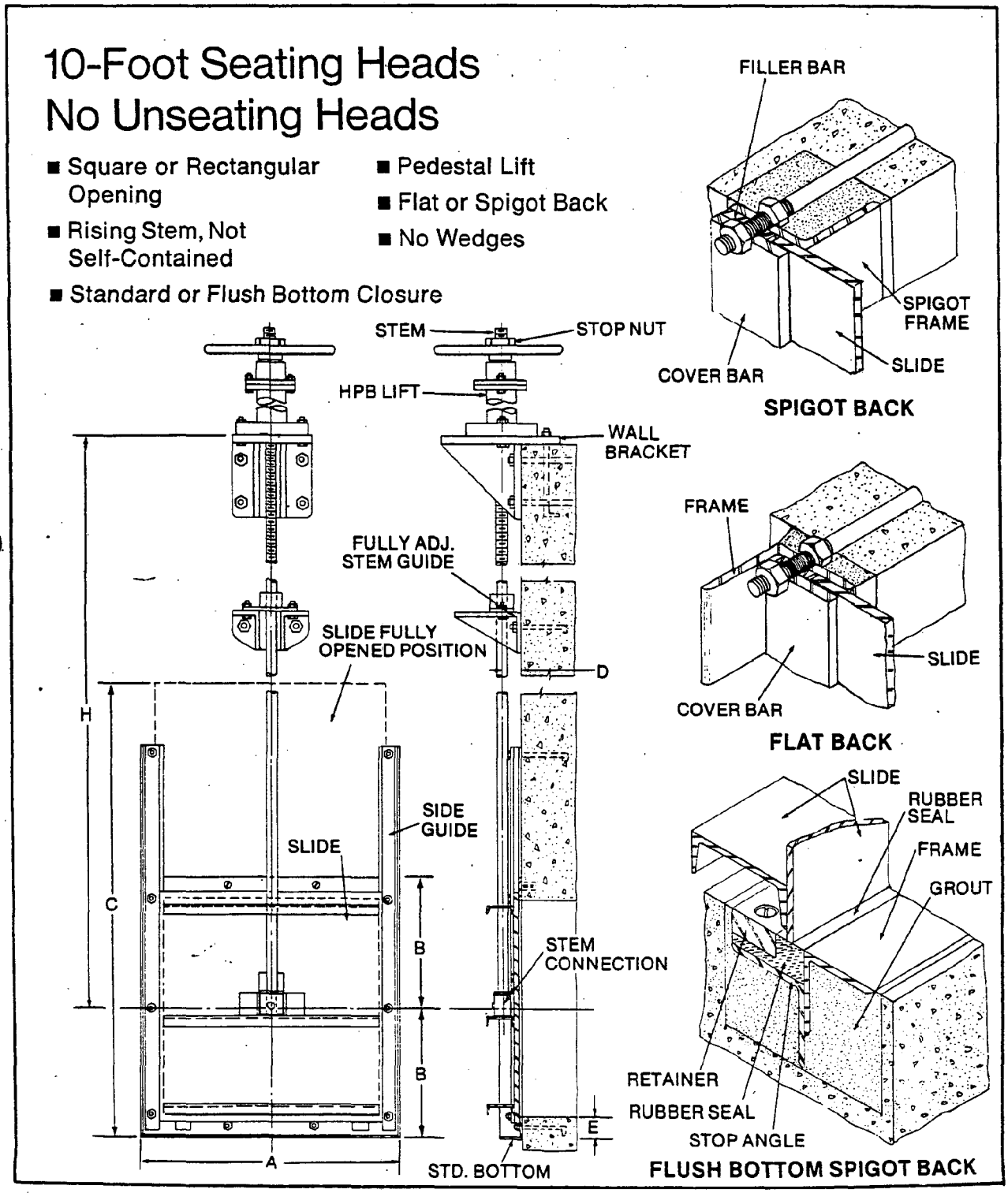


Figure III-30. Slide Gates, Medium Duty

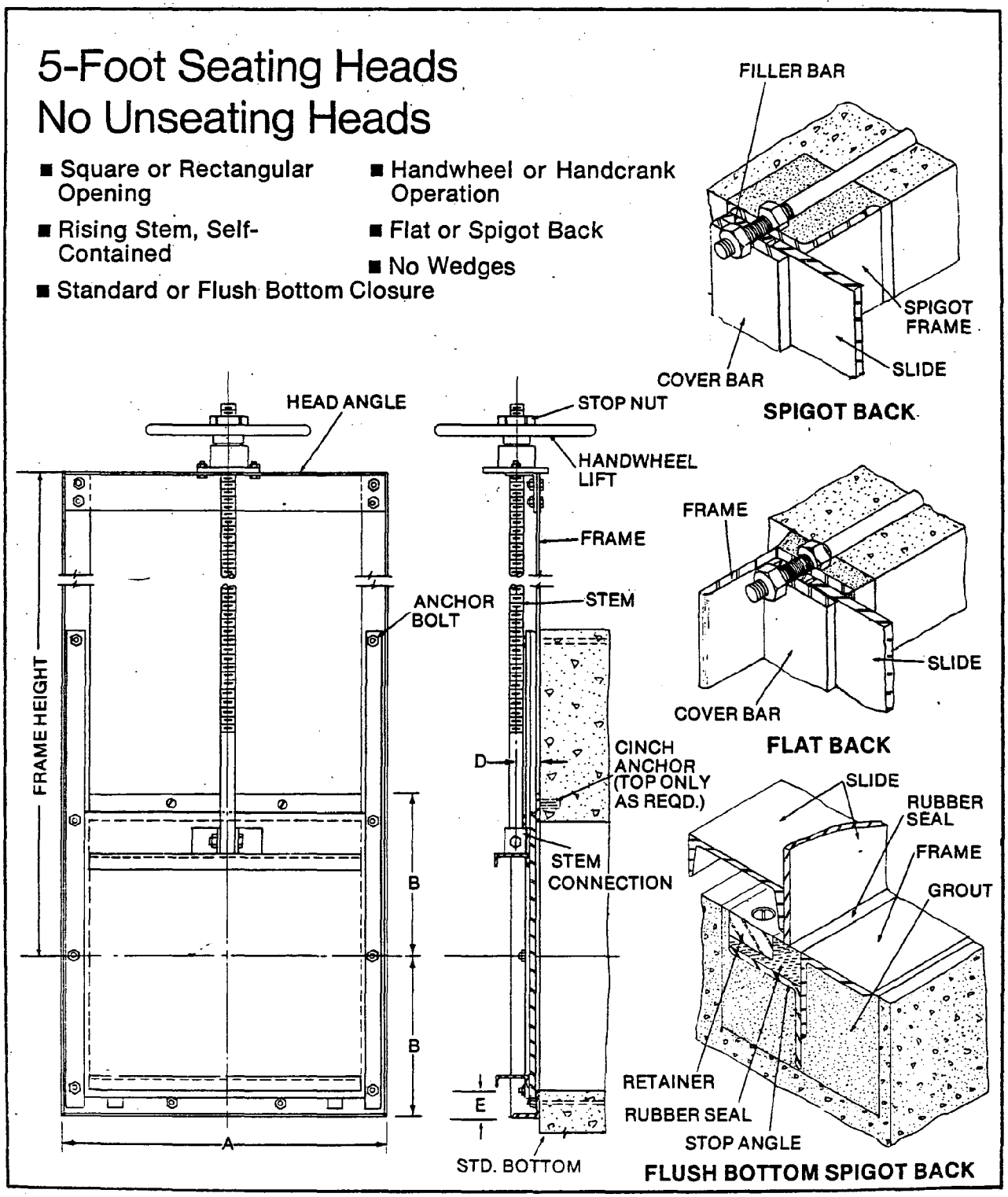


Figure III-31. Slide Gates, Light Duty

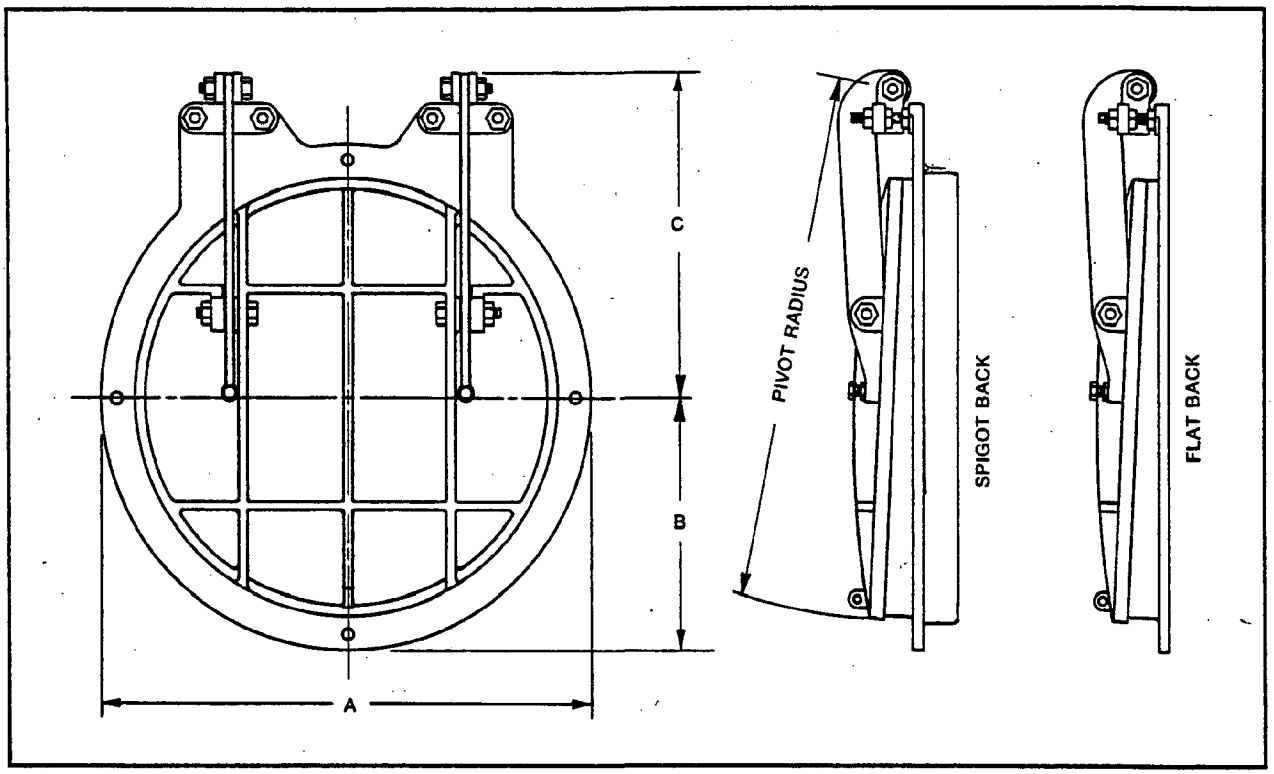
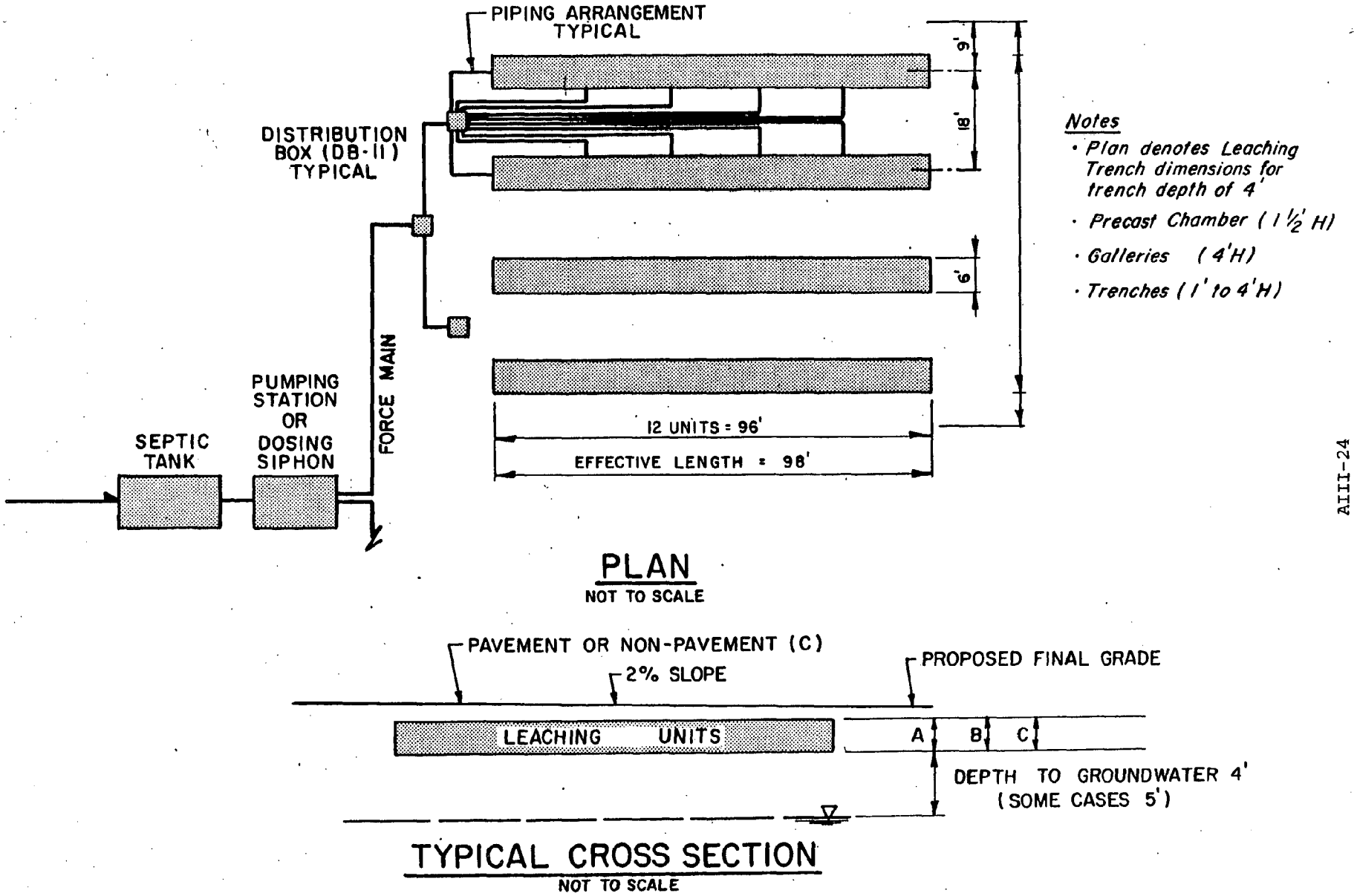


Figure III-32. Flap Tidal Gate



AIII-24

TYPICAL LEACHING SYSTEM - TRENCH TYPE

Figure III-33. Trench Type Leaching System

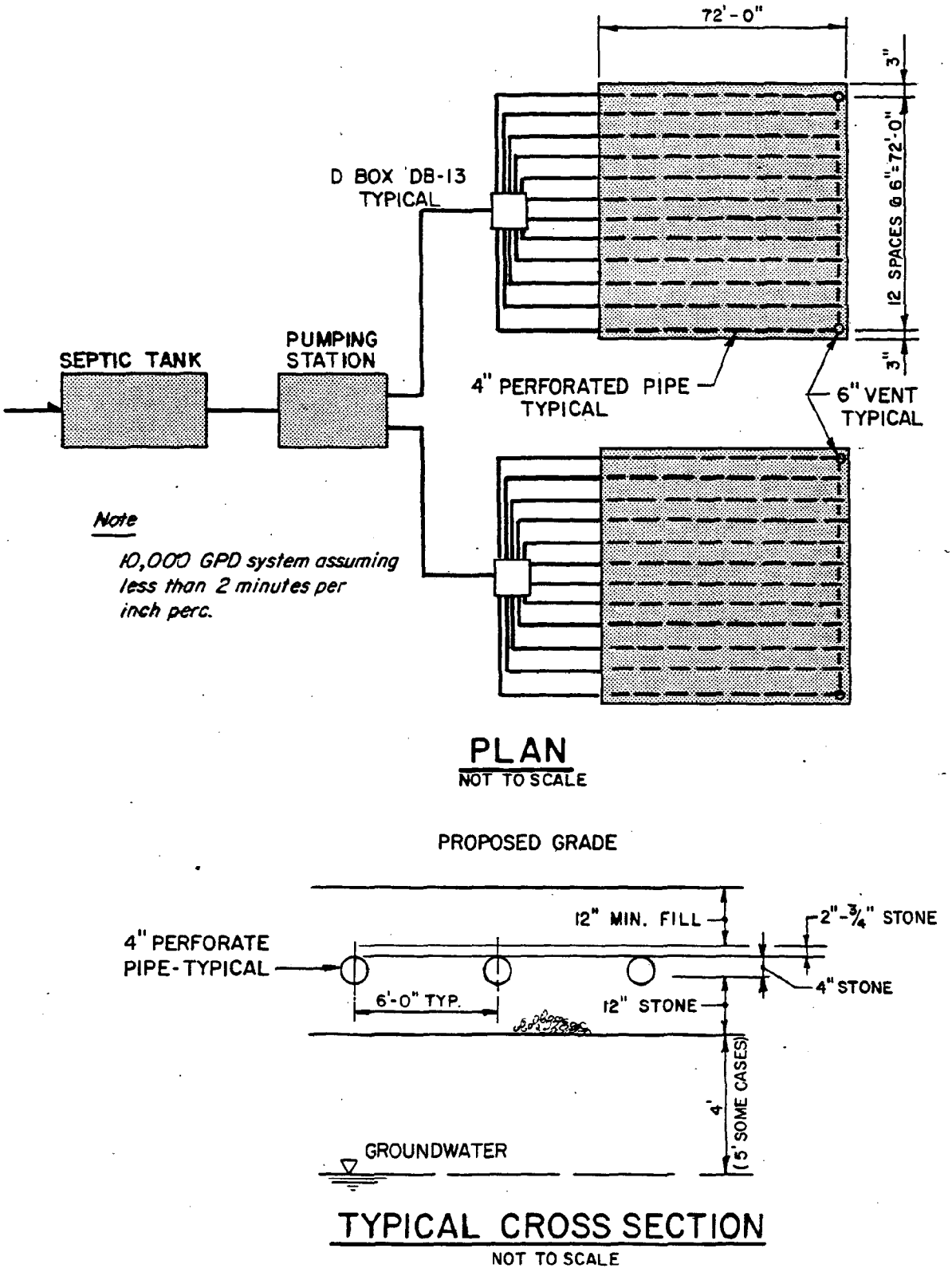


Figure III-34. Leaching Bed Septic System

APPROXIMATE COST DATA

	Breakwaters	Costs*
Figure III-1	Rubble-Mound	- -
Figure III-2	Perforated Cassion	$400-800/70 ft. cassion
Figure III-3	Cellular Steel Sheet Pile	$65-100/cell
Figure III-4	Stone Asphalt	$0.4-0.6/yd^2
Figure III-5	Tribar Rubble-Mound	$75-120/ft^2
Figure III-6	Tetrapod Rubble-Mound	$90-160/ft^2
	Jetties and Groins	
Figure III-7	Cellular Sheet Steel Pile	$150-250/cell
Figure III-8	Dolos Rubble-Mound	$100-180/1000 ft^2
Figure III-9	Quadripod Rubble-Mound	$85-140/1000 ft^2
Figure III-10	Rubble-Mound Groin	- -
Figure III-11	Prestressed Concrete Sheet-Pile Groin	$0.5-0.7/25 ft pile
Figure III-12	Cellular Steel Sheet-Pile Groin	$65-100/cell
Figure III-13	Cantilever Steel Sheet-Pile Groin	$0.9-1.2/linear foot
Figure III-14	Timber-Steel Sheet-Pile Groin	$0.35-0.5/linear foot
Figure III-15	Timber Sheet-Pile Groin	$0.25-0.35/linear foot
	Revetments	
Figure III-16	Interlocking Concrete Block I	$0.03-0.06/ft^2
Figure III-17	Interlocking Concrete Block II	$0.03-0.06/ft^2
Figure III-18	Interlocking Concrete Block III	$0.03-0.06/ft^2
Figure III-19	Rip-Rap	$0.15-0.3/yd^2
Figure III-20	Concrete	$0.01-0.3/yd^3
	Bulkheads	
Figure III-21	Timber Sheet-Pile	$0.6-0.9/linear foot
Figure III-22	Sheet Steel-Pile	$0.85-1.2/linear foot
Figure III-23	Concrete Slab and King-Pile	$0.25-0.5/linear foot
	Seawalls	
Figure III-24	Concrete Combination Stepped and Curved Face	$0.25-0.5/linear foot
Figure III-25	Concrete Curved Face	$0.4-0.7/linear foot
Figure III-26	Concrete Stepped Face	$0.25-0.5/linear foot
Figure III-27	Rubble Mound I	$0.2-0.4/yd^2
Figure III-28	Rubble Mound II	$0.3-0.7/yd^3
Figure III-29	Desilting Basin	$0.02-0.06/yd^3 for fill
	Tidal Gates	
Figure III-30	Slide Gates, Medium Duty	$5-10 each
Figure III-31	Slide Gates, Light Duty	$5-10 each
Figure III-32	Flap Gates	$5-10 each
	Septic Systems	
Figure III-33	Group Leaching System, Trench Type	variable
Figure III-34	Group Leaching Beds	variable
	Individual Septic Systems	$2-$20,000
	Municipal Sewer Systems	variable
	Dredging	$7/cu yd

* thousands of dollars

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