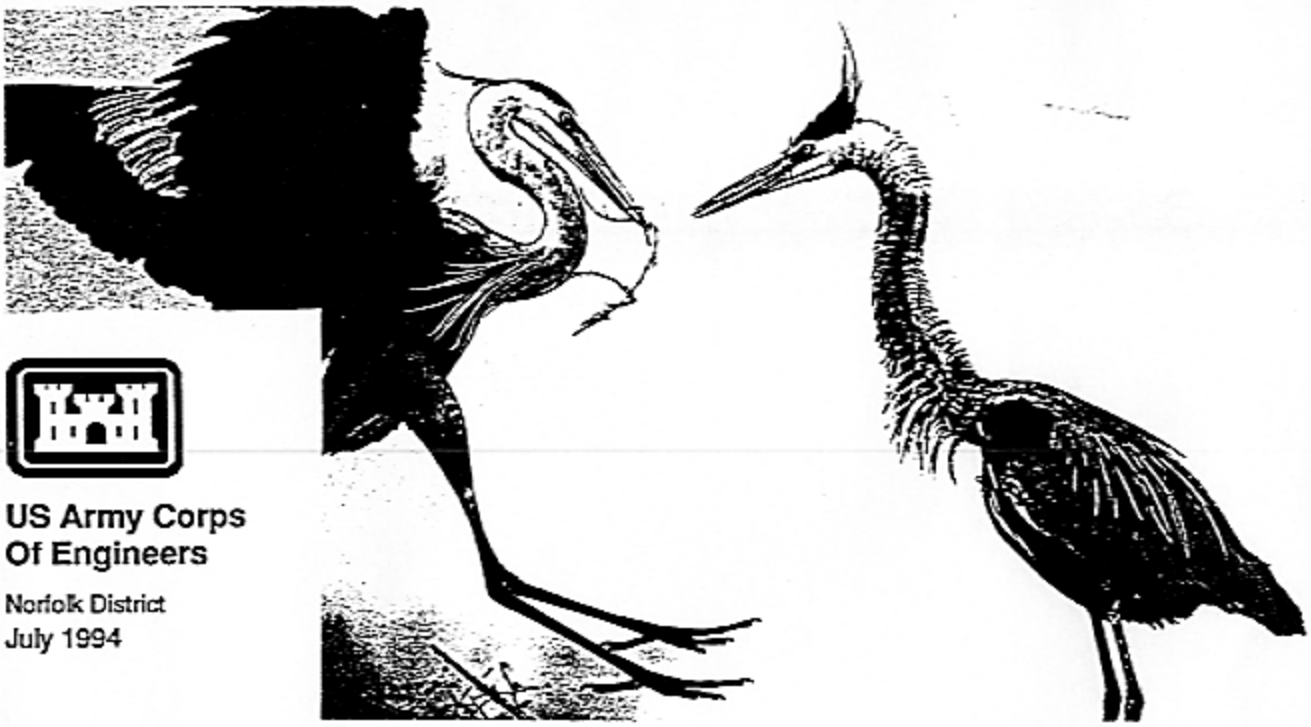
DRAFT INFORMATION REPORT TO THE COMMONWEALTH OF VIRGINIA AND THE VIRGINIA PORT AUTHORITY

NORFOLK HARBOR AND CHANNELS, VIRGINIA

LONG-TERM DREDGED MATERIAL MANAGEMENT

LOWER BAY BENEFICIAL USES OF DREDGED MATERIAL



US Army Corps
Of Engineers

Norfolk District
July 1994

NORFOLK HARBOR AND CHANNELS, VIRGINIA
LOWER BAY DREDGED MATERIAL
BENEFICIAL USES STUDY

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NORFOLK HARBOR AND CHANNELS, VIRGINIA
LOWER BAY DREDGED MATERIAL
BENEFICIAL USES STUDY

INTRODUCTION

Dredging navigation channels and maintaining appropriate navigable depths is vital to preserving the economic health of the Port of Hampton Roads. Recognizing this fact, the Norfolk District, in response to a 1986 request from the Commonwealth of Virginia, initiated a study of alternatives for replacing the Craney Island Dredged Material Management Area (CIMA) when its filling is complete in approximately 2010. A draft report of this study and an Executive Summary was submitted to the Virginia Port Authority (VPA) in June 1990.

In 1991, the General Assembly of Virginia passed a bill precluding any further expansion of CIMA. The Governor signed the bill into law in April 1991. As a result of the state's actions, new strategies were recommended and a Final Supplement was published in May 1992 by the Corps to address the need for long-term dredged material management in Hampton Roads.

Based on the results of the long-term dredged material management study for the inner harbor and the subsequent action by the Virginia General Assembly, the Corps recommended in the 1992 supplement that ocean placement of suitable material, restriction of CIMA for unsuitable material, and beneficial uses of dredged material should be pursued as long-term dredged material management strategies.

BACKGROUND

The following is a brief review of past events pertinent to authorization and preparation of the long-term dredged material management study and, specifically, how this report addresses the beneficial uses of dredged material.

In its review of the Corps district and division recommendations for deepening the harbor to 55 feet, the Board of Engineers for Rivers and Harbors concluded in January 1981 that while it appeared that ocean placement was more expensive, the Board believed that it was the preferred environmental approach (for deepening the harbor channels to 55 feet). Furthermore, the

existing CIMA was to be utilized for dredged material from the deepening project not suitable for ocean placement.

The Board further concluded that post authorization planning studies be conducted concurrently with the deepening project to identify an acceptable, economical, and environmentally feasible solution for long-term placement of dredged material. In accordance with the Board's recommendation, and pursuant to the authorization of the Norfolk Harbor and Channels Deepening Project by WRDA 86, a long-term placement study of dredged material from the inner harbor was conducted and a report and Executive Summary was prepared and submitted to VPA.

In 1990, the Norfolk District, Army Corps of Engineers (Corps), produced a study for VPA assessing various alternative means of replacing the Craney Island Dredged Material Management Area. The report was entitled "Norfolk Harbor and Channels, Virginia, Long-Term Dredged Material Management, Inner Harbor." Since dredged material placement is a non-Federal responsibility, the report was designed to assist the Commonwealth of Virginia, as local sponsor of the Norfolk Harbor Deepening Project, in making a decision concerning long-term dredged material management. The report disclosed two plans that appeared to be practical and feasible: an expansion of CIMA, and ocean placement.

However, the 1991 Virginia House Committee on Chesapeake and Its Tributaries found impacts associated with expanding Craney Island unacceptable, and passed House Bill No. 1478. Section (a) of the Bill states:

> "No agency of the Commonwealth, including the Virginia Port Authority, shall have the authority to expand the Craney Island Disposal Area northward or westward beyond it's present capacity or to cause activities which will result in such expansion of the Craney Island Disposal Area. In addition, no state funds shall be expended for any activities which will result in the expansion of Craney Island northward or westward or beyond it's present capacity as a disposal area for material dredged from any site, including Hampton Roads Harbor."

This decision ruled out any further expansion of CIMA and left VPA with an ocean placement primary option (and associated hauling expense), and a complementary secondary option to be evaluated further. The complementary option, also recommended by the Corps 1990 report, was to explore means to use suitable dredged material for beneficial purposes where possible in order to minimize use of CIMA and the ocean placement sites. Although it is unlikely that all material could be used beneficially, beneficial use could potentially cut down transport costs while enhancing the environment. VPA requested that the Corps follow up the inner harbor study with a comprehensive study of ways to beneficially use dredged material derived from Norfolk Harbor and Channels.

The 1992 supplement underscores the need to treat dredged material as a resource and, where possible, use it for beneficial purposes. This is a theme that is being emphasized nationwide throughout the Corps of Engineers. Also, there is opportunity to reduce overall dredging costs by implementing various cost effective alternatives which may also have beneficial effects. The Commonwealth of Virginia, through VPA, has expressed its strong desire to be an active cost-sharing partner with the Corps in a study of these needs and opportunities. In keeping with the Commonwealth's request, the Corps initiated a study in 1991 to investigate methods of using dredged material as a resource for beneficial purposes. In keeping with the resource initiatives of the 1987 Chesapeake Bay Agreement, the emphasis on beneficial uses was placed on the following:

a. Sediment substrate improvement for benthic organisms using dredged material (i.e., habitat enhancement for commercial shellfish and other benthos which serve as food for higher organisms);

b. Wetland creation, development, and enhancement, for shoreline erosion control, and habitat for living resources;

c. Creation of islands and underwater berms to provide habitat diversity/development for fish and wildlife resources;

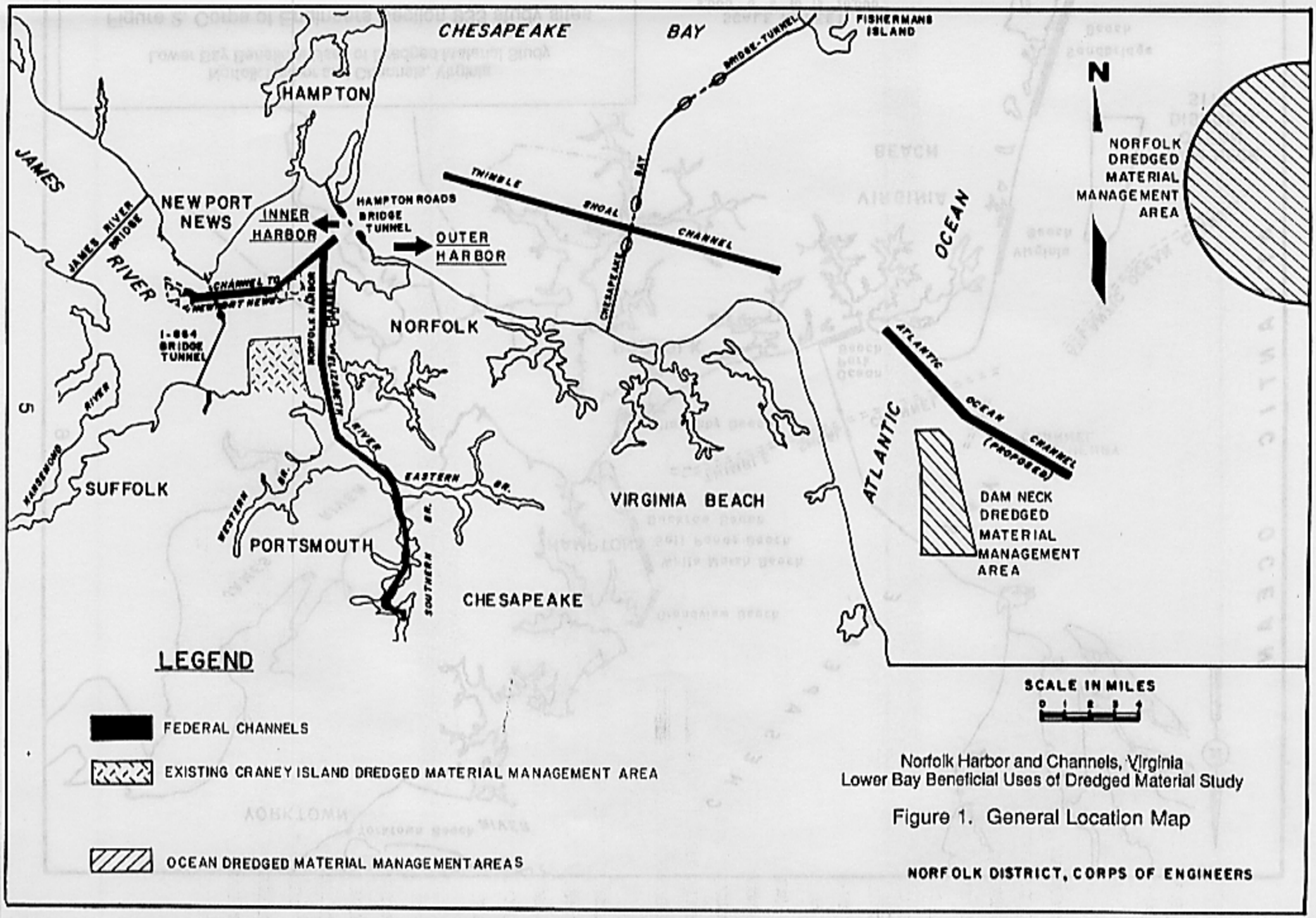
d. Development of possible mitigation banking alternatives for section 404 permit activities; and

e. Other nontraditional dredged material placement alternatives which offer environmental benefits and/or significant cost savings compared to ocean placement.

While the outer harbor does not have a dredged material capacity problem with the availability of two ocean placement sites-the Dam Neck Dredged Material Management Site and the recently designated Norfolk Dredged Material Management Site (July 1993), the inner harbor may eventually face serious dredged material capacity problems since the existing CIMA is gradually becoming filled. In 1981, the Craney Island Management Plan (CIMP) was developed by the US Army Waterways Experiment Station (WES) to extend the useful life of the site (Palermo, Shields, and Hayes 1981). The CIMP has been implemented and includes division of CIMA into three subcontainments, alternate disposal among the subcontainments, and removal of surface water by constructing surface trenching systems. WES (Myers, et. al., 1993) recommended the use of vertical strip drains placed through the deposited material and into the underlying strata to further dewater and consolidate the material and extend CIMA useful life.

Effective use of these management practices will extend the useful life of CIMA, but not indefinitely. Beneficial uses offer the potential of both cost savings and environmental enhancement and can be very effective in supplementing use of CIMA and implementation of a long-term dredged material management strategy for Norfolk Harbor and Channels.

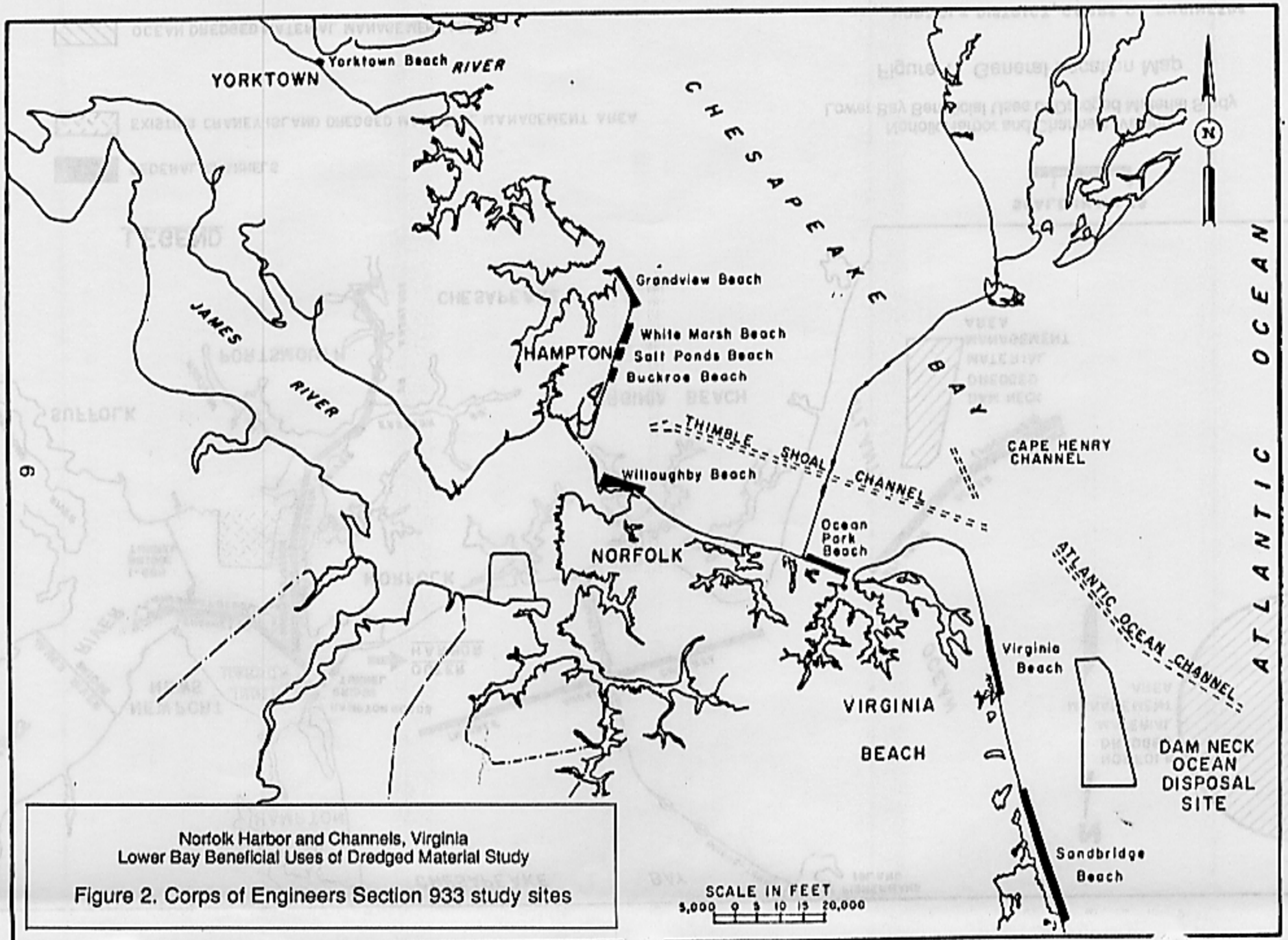
While the first part of the long-term dredged material management study concentrated on the needs of the inner harbor, the second portion of the study emphasizes the beneficial uses of dredged material and focuses not only on the inner harbor, but also on the outer harbor channels (figure 1). Ten Section 933 studies were conducted between 1989 and 1991 to determine the Federal interest in placing suitable sand dredged from Thimble Shoal and Atlantic Ocean channels in the outer harbor onto area beaches during construction of the 55-foot outbound project (figure 2).



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 1. General Location Map

NORFOLK DISTRICT, CORPS OF ENGINEERS



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 2. Corps of Engineers Section 933 study sites

Section 933 of the Water Resources Development Act of 1986 (WRDA 86) authorizes the Corps to place dredged material (sand) on beaches at the request of the state. Additional studies were initiated beginning in January 1991 to focus on beneficial uses of dredged material (other than beach nourishment) from both the inner and outer harbor channels. This would include the new work dredging required to construct the outbound channels.

The Norfolk District is conducting this continuing investigation in cooperation with VPA. The products of the beneficial uses study are two-fold. The initial product or first phase is a report to VPA evaluating an array of beneficial use opportunities and making specific recommendations for further action based upon engineering, economic, and environmental evaluations conducted with the U.S. Fish and Wildlife Service (F&WS) and an interagency workgroup of state and Federal agencies. The second phase, if pursued, would involve more detailed and in-depth environmental and engineering investigation into the recommended alternatives. During the second phase, environmental clearances such as National Environmental Policy Act (NEPA) documents and state and local permits would be secured to allow VPA to implement specific beneficial use plans.

This report documents the first phase of the investigation and identifies specific beneficial use options which can supplement dredged material placement strategies previously proposed or currently in use. It recommends beneficial use alternatives that the Commonwealth may wish to pursue as a complementary part of long-term dredged material management for Norfolk Harbor and Channels. Alternatives have been screened to identify those which are most feasible from environmental, economic, and engineering perspectives.

STUDY AREA AND LOCAL SPONSOR

Hampton Roads is located approximately midway on the Atlantic Seaboard, 180 miles southeast of Washington D.C., at the southern end of Chesapeake Bay as shown on figure 1. It is a natural roadstead of 25 square miles formed by the confluence of the James, Nansemond, and Elizabeth Rivers. Comprising a total land area of 1,500 square miles, the study area includes the cities of Norfolk, Portsmouth, Virginia Beach, Chesapeake, Suffolk, Newport News, Hampton, Poquoson, Williamsburg, and the counties of James

City and York. The harbor in Hampton Roads is recognized as one of the largest and finest natural harbors in the world.

The Federal deep-draft navigation projects in Hampton Roads, including those authorized in the Water Resources Development Act of 1986 (P.L. 99-662) consist of the Atlantic Ocean Channel, Thimble Shoal Channel, Norfolk Harbor Channel, Channel to Newport News and its anchorages, and the Elizabeth River. With regard to the authorized 55-foot improvement, it should be noted that the project is being constructed in stages or elements. The first element involves deepening the outbound lanes to a depth of 50 feet to accommodate loaded coal vessels leaving the port. This element has been completed. The second element involves deepening the outbound lanes to a depth of 55 feet for additional benefits to the loaded coal vessels. Deepening the inbound elements to 50 and 55 feet, respectively, is not necessary at this time and has been classified under the deferred category. It should be noted that the Channel to Newport News is being constructed to full width for both 50- and 55-foot elements.

The authorizing document (HD 99-85) provides for post-authorization planning studies to be conducted concurrently with the deepening project to identify an acceptable, economical and environmentally feasible solution for long-term placement of dredged materials.

Similar to the inner harbor interim study, the beneficial uses study, which represents the final portion of the long-term dredged material management study, will be cost shared with the Commonwealth of Virginia, acting through the Virginia Port Authority (VPA), during construction of the 55-foot outbound element of the Norfolk Harbor and Channels Deepening Project. This position was confirmed in a letter from VPA dated September 27, 1990, which stated (in part) "...we urge you to proceed immediately with the study of lower bay dredged material management alternatives and assure you that the Commonwealth will repay the non Federal share of the cost of the study (50%) during construction of the 55-foot outbound portion of the authorized project."

COORDINATION

From the very inception of this study, coordination with agencies outside the Corps of Engineers has been emphasized. In keeping with the Commonwealth's request to be a cost-sharing partner, the Corps initiatives to use dredged material as a resource, and the initiatives of the 1987 Chesapeake Bay Agreement to protect and restore the resources of the bay, a work group of Federal and state agencies and scientific institutions (appendix A) was convened to develop an array of beneficial use alternatives for consideration as projects in the lower Chesapeake Bay.

Alternatives were evaluated through group discussion, with a broad array of candidate proposals suggested for review. Included among these were:

(1) Construction of intertidal and subtidal oyster reefs using a dredged material substrate.

(2) Dredged material use for wetland restoration and enhancement, shoreline erosion control, and habitat for living resources.

(3) Re-creation of islands in the lower Bay which could provide habitat diversity for benthos, finfish, and colonial nesting birds.

(4) Value engineering recommendations such as thin layering of dredged material and deep trough deposition which may also have environmental benefits.

(5) Construction of underwater berms to provide habitat diversity for finfish at the state's man-made artificial reef sites.

(6) Beneficial use opportunities which can provide mitigation banking or credit to the Commonwealth for mitigation requirements on Section 404 permits.

Specific locations for the implementation of these proposals which were suggested included:

(1) Wetland/habitat creation along eroding James River shoreline

(2) Wetland/habitat creation at Windmill Point

(3) Island wetland/habitat creation and erosion control adjacent to, or offshore of, existing islands (e.g., Ragged Island Wildlife Management Area, Hog Island WMA, etc.)

(4) Fish structure at state's artificial reefs

(5) Stable berm, or feeder berm creation offshore of Virginia Beach or Chesapeake Bay beaches

(6) Island creation/enhancement in the James River and/or ocean side of Virginia's Eastern Shore

(7) Island/wetland/habitat creation along eroding sections of Fisherman Island National Wildlife Refuge (NWR)

(8) Contaminated sediments harbor/river bottom capping in the Elizabeth River using clean dredged material

(9) Borrow area reclamation at various sites in Hampton Roads

(10) Wetland/habitat creation at various sites in Hampton Roads

(11) Dredged material dewatering, storage, and rehandling area for future use in construction (CIMA could be assessed for this function)

(12) Wetland fringe creation around CIMA

A reconnaissance type of approach was used to conduct a preliminary investigation and screening of beneficial use alternatives suggested by the work group. This investigation/screening included the conduct of three interagency work group meetings, individual meetings with state and Federal resource agencies and other Corps districts, and funding of the U.S. Fish and Wildlife Service (F&WS) to help identify and evaluate potential projects in the lower Chesapeake Bay. The District also had meetings with personnel from the

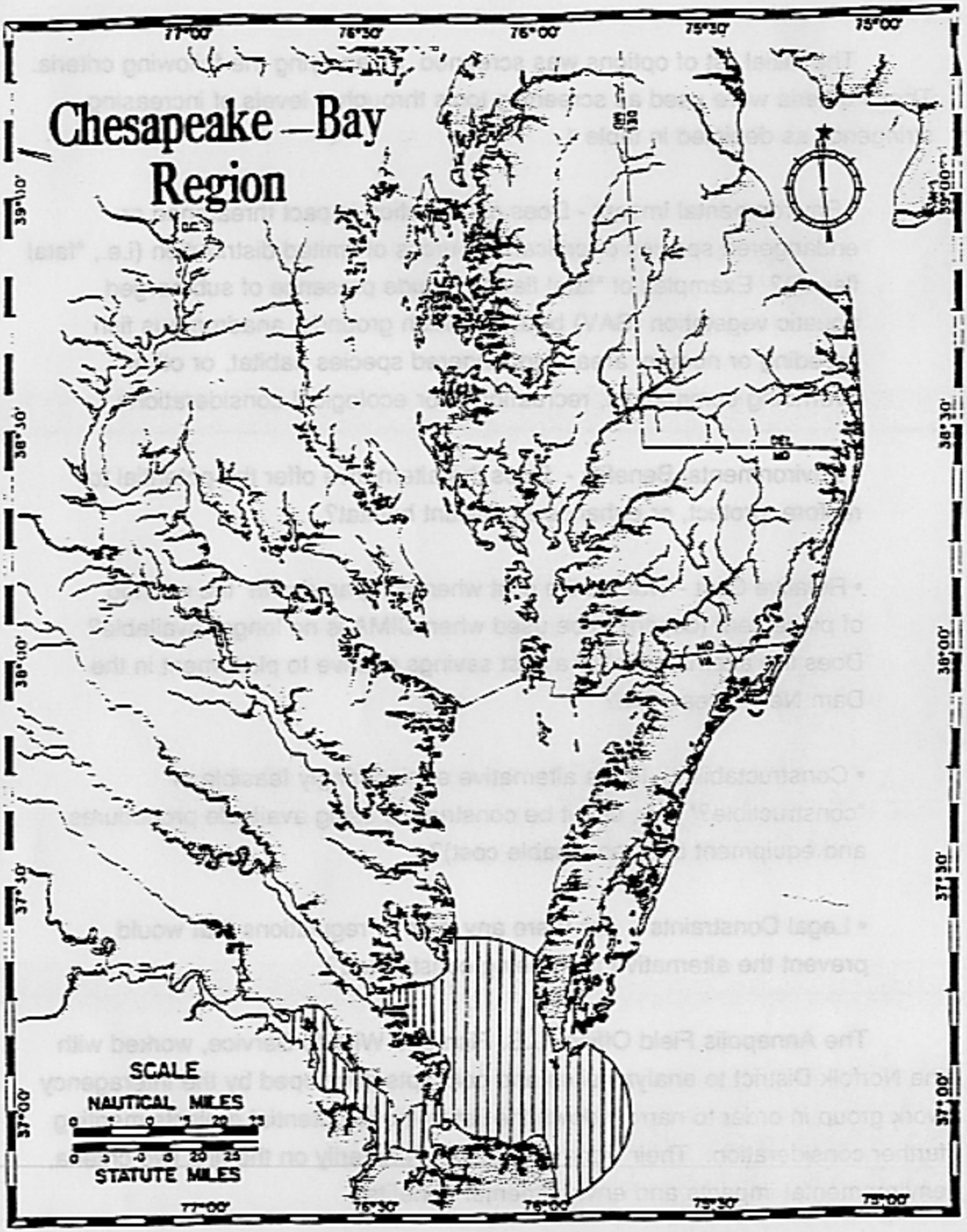
U.S. Army Waterways Experiment Station (WES) to discuss beneficial use projects being conducted nationwide, particularly as they applied to this study. The following is a list of meetings held during this study.

Agency Meetings

Date	Organization
24 October 1990	Virginia Institute of Marine Science
15 January 1991	U.S. Fish and Wildlife Service
28 January 1991	Corps of Engineers, Baltimore District
6 February 1991	Old Dominion University
12 February 1991	U.S. Fish and Wildlife Service
13 February 1991	Interagency Work Group Meeting
21 February 1991	Virginia Marine Resources Commission (VMRC)
6 March 1991	U.S. Fish and Wildlife Service
13 March 1991	VMRC (Fisheries Division)
20 March 1991	Dept. of Game & Inland Fisheries
22 March 1991	Virginia Institute of Marine Science
9 April 1991	Virginia Port Authority
10 April 1991	Interagency Work Group Meeting
19 April 1991	Old Dominion University
22 April 1991	Virginia Institute of Marine Science
6 May 1991	Hampton University
7 & 8 May 1991	Corps of Engineers - Waterways Experiment Station (WES)
30 & 31 May 1991	WES (Dr. Doug Clark, Dr. Gary Ray)
10 July 1991	U.S. Fish and Wildlife Service (Plum Tree Island NWR)
11 July 1991	Fort Eustis - Shoreline protection
14 January 1992	WES (Dave Richards) - Computer Modeling
22 January 1992	U.S. Fish and Wildlife Service
5 March 1992	U.S. Fish and Wildlife Service and Dept. of Game & Inland Fisheries (at Ragged Island WMA)
24 April 1992	Univ. of North Carolina, Wilmington (Dr. Jim Parnell)
14 May 1992	Virginia Institute of Marine Science (3-D Model)
8 July 1992	Interagency Work Group Meeting
27 September 1993	Virginia Institute of Marine Science (3-D Model)
9 November 1993	U.S. Fish and Wildlife Service

SCREENING PROCESS

The initial screening criterion used by the interagency task group related to distance of the proposed beneficial use alternative from the inner harbor. Because the Dam Neck ocean site is available for placement of most of the inner harbor material, the average distance to this site (approximately 37 miles) was used to delineate a study area for beneficial use options. Because placement of material for habitat creation requires more expense for construction of features, plantings, etc., than would ocean dumping, evaluating beneficial uses within that equivalent distance assured that all options having equal or lesser cost would be investigated, in addition to many which cost more than ocean placement. With only one exception, the options mentioned in this study were within that hauling distance, referred to as the economic haul distance (figure 3). If the project area and source of dredged material were outside the Hampton Roads inner harbor area, the list of relevant beneficial use options and their costs would change.



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 3. Economic hauling distance boundary

The initial list of options was screened by applying the following criteria. These criteria were used as screening tools through 4 levels of increasing stringency as depicted in table 1.

- Environmental Impact - Does construction impact threatened or endangered species or critical resources of limited distribution (i.e., "fatal flaws")? Examples of "fatal flaws" include presence of submerged aquatic vegetation (SAV) beds, shellfish grounds, anadromous fish breeding or nursery areas, endangered species habitat, or other overriding commercial, recreational, or ecological considerations.

- Environmental Benefits - Does the alternative offer the potential to restore, protect, or enhance significant habitat?

- Relative Cost - What is the cost when compared with the method of placement (ocean) to be used when CIMA is no longer available? Does the alternative offer a cost savings relative to placement in the Dam Neck ocean site?

- Constructability - Is the alternative engineeringly feasible or "constructible?" (i.e., can it be constructed using available procedures and equipment at a reasonable cost)?

- Legal Constraints - Are there any laws or regulations that would prevent the alternative from being constructed?

The Annapolis Field Office, U.S. Fish and Wildlife Service, worked with the Norfolk District to analyze sites and concepts developed by the interagency work group in order to narrow down the list to those potential projects meriting further consideration. Their work was focused primarily on the first two criteria, environmental impacts and environmental benefits.

Alternatives that addressed the screening criteria favorably were carried forward into the next level. Table 1 shows the various alternatives that were considered in the four levels of the screening process. Approximately half of the Level 1 alternatives were not carried into level 2 for various reasons, as noted in

the table. Alternatives at level 1 eliminated from further consideration were rejected because of obvious potential for adverse environmental impact, hauling distance, and questions regarding constructability. As noted in the table, several of these alternatives are discussed in detail in the F&WS reports (appendix C).

Table 1. NORFOLK HARBOR & CHANNELS, VA
BENEFICIAL USES OF DREDGED MATERIAL
SCREENING OF ALTERNATIVES

LEVEL 1

Wetland Creation & Erosion Control	Island Building	Underwater Fisheries Habitat	Habitat Restoration	Value Engineering Rec's
1. James R. shoreline (R/R* = F)	1. Ragged Is. WMA	1. Oyster ground creation/restoration	1. E. Shore of VA - NWR screen/berm** (R/R = D)	1. Deep trough deposition
2. Windmill Point** (R/R = F)	2. Hog Is. WMA	2. Fish Reef	2. Borrow area reclamation (R/R = A)	2. Thin-layering
3. Hog Is. WMA	3. Plum Tree Is. NWR** (R/R = A)	3. Underwater berms	3. Construction material (R/R = C)	
4. Ches. Bay/Bridge Tunnel Causeway** (R/R = D)	4. Hampton Flats Island		4. Contaminated sed's capping (Elizabeth R.) (R/R = D)	
5. Plum Tree Is. NWR** (R/R = A)				
6. Fisherman Is. NWR** (R/R = D)				
7. CIMA wetland**				
8. Mulberry Is. (Ft. Eustis)** (R/R = A)				

LEVEL 2

1. Hog Is. WMA (R/R = C)	1. Ragged Is. WMA	1. Oyster ground creation/restoration (R/R = C,D)
2. CIMA wetland (R/R = E)	2. Hog Is. WMA (R/R = C)	2. Fish Reef (R/R = A, D)
	3. Hampton Flats Island	3. Underwater berms (R/R = A)

1. Deep trough deposition
2. Thin-layering (R/R = A)

LEVEL 3

1. Ragged Is. WMA
2. Hampton Flats Island

1. Deep trough deposition (R/R = D)

LEVEL 4

1. Ragged Is. WMA
2. Hampton Flats Island

* R/R (REASON REJECTED) = A. Potential for adverse environmental impact; B. No significant environmental benefits; C. Relative cost; D. Constructability; E. Possible legal constraints; F. Outside of economic hauling distance (figure 3)

** see F&WS Reports (Appendix C) for discussion of this alternative

CIMA = Craney Island Dredged Material Management Area
WMA = Wildlife Management Area (State)
NWR = National Wildlife Refuge (Federal)

RELATIVE UNIT COSTS FOR COMPARING BENEFICIAL USE OPTIONS

Although the unit cost criterion was not used alone to reject any alternative within the economic hauling distance of the inner harbor, knowing what the potential additional cost of an option is compared with ocean placement gives a monetary framework for comparing the various environmental benefits which each beneficial use project provides. No monetary value can be assigned to the resource enhancing (or neutral) effects of a project, but converting preliminary unit costs (per cubic yard of material placed) to costs per acre allows incremental comparisons on the cost side.

Table 2 shows preliminary unit costs for various beneficial use alternatives carried to level 2 in the screening, and for ocean placement. Ocean placement is the option to which all others are compared because it assumed to be the primary option available once CIMA is filled. Cost estimates were developed in a form which allows comparisons of proposed beneficial use costs with the cost of material placement in the Norfolk ocean site. Their intended use is only in making comparisons among this group of options and as a screening tool to assist decision makers in selecting which options are worthy of further study. All of the estimates were made at an equivalent level of detail without the benefit of detailed engineering and design studies. They are based on specific assumptions about construction volumes, type of material, dredging plant, method of placement, haul distances and a number of other factors. No costs are included for monitoring, environmental studies, or grading and planting any of the constructed sites. The most economical equipment was selected based on the size of the job and the transportation distance from the dredging project to the beneficial use site. In some cases, local conditions such as water depth affected the type of equipment or plant selected. A more detailed description of the parameters used is contained in appendix F, the "cost estimate appendix."

Table 2. COST COMPARISONS BETWEEN BENEFICIAL USE OPTIONS AND PLACEMENT AT DAM NECK OCEAN SITE

OPTION	LOCATION	MATERIAL VOLUME (MCY)	OPTION COST ($000)*	OPTION COST PER CY	DNODS COST PER CY	PER CY COST RATIO**
1025 Acre Island	Ragged Island	16.3	242,704	$14.89	$7.51	2.00
200 Acre Island	Ragged Island	5.7	69,375	$12.28	$7.50	1.60
50 Acre Island	Ragged Island	1.9	24,811	$13.23	$7.50	1.80
250 Acre Island	Hampton Flats	5.0	33,130	$6.63	$7.50	0.90
46 Acre Wetland	Mulbery Island	0.34	5,356	$16.55	$7.60	2.00
8 Acre Oyster Reef	Point of Shoals	0.031	344	$23.05	$16.61	1.40
Thin Layer (3443 acres)	Thimble Shoals	5.5	45,375	$8.25	$7.29	1.10
Fish Habitat (0.8 acre)	Lower Bay	0.009	125	$14.50	$7.82	1.80
Deep Trough Placement	E of H.R. Br/Tunnel	5.1	34,784	$6.82	$7.75	0.90

* Island cost includes riprap, does not include shaping, planting, and monitoring

** COST RATIO = Alternate Disposal Option/Disposal Cost @ DNODS

DNODS = Dam Neck Ocean Disposal Site

As long as the major estimating parameters do not change, one would expect that the next level of detail in cost estimates (using hydrologic surveys, verified material characteristics and detailed plans) would still produce the relative cost differences seen in these preliminary estimates. Locations for options, sources of dredged material, or other conditions which vary from these scenarios will produce different results. Some options which may appear too costly based on current conditions and assumptions could become more economically favorable if the material source (location) were to change. All of the determinants of cost and the estimating calculations can be reviewed at Norfolk District.

In addition to advancing plans with environmental benefits and favorable unit costs, a corollary objective of the screening process was to identify plans with the potential to accommodate large quantities of material over multiple dredging cycles. Unfortunately, the repeated use of a site over a long period is generally inconsistent with establishing habitat. Only one very large island (near Ragged Island) had capacity large enough to hold material from several maintenance dredging cycles. Ultimately, material placement would cease, and planted or opportunistic vegetation would be allowed to develop for the intended habitat.

Before any full-scale beneficial use proposal was selected for implementation, detailed design and cost estimates would be required. Costs could be further developed through a feasibility level study. Some projects might require construction of a prototype, followed by evaluation in order to develop specific full scale design and costs.

BENEFICIAL USE COST ESTIMATES FOR OPTIONS CARRIED TO LEVEL THREE OF SCREENING

Preliminary costs of options still present for evaluation at level 3 of the screening process (table 1) show that most beneficial use projects would not be less expensive than ocean placement, which was used as the base case for purposes of comparing options. The two options with costs comparable to ocean placement were deposition in the deep trough near the Hampton Roads bridge tunnel and construction of an island off Newport News in the area known as Hampton Flats. The deep trough was eliminated as a potential option

because studies showed that material would not stay in place. While the proposed Hampton Flats island was slightly less expensive that using the Dam Neck site, there are some additional engineering, environmental and permit compliance costs which could negate any savings. The cost of constructing this 250 acre island was based on new work material from Newport News Channel (4.5 mcy) and the 55' anchorage (.5 mcy).

The beneficial use option which could use the largest volume of material and provide the greatest habitat value was an island offshore from the Virginia wildlife preserve at Ragged Island. Construction costs were estimated for three sizes of islands (50, 200 and 1025 acres), of which the 200 acre island had the lowest unit cost. The largest island would require 16.3 million cubic yards of material, and was the only one to use maintenance material (1.5 million cubic yards for each of 5 dredging cycles) to "fill in" the structure. Establishing vegetation at an island under construction for several dredging cycles would have to proceed in phases. The full value of the habitat would not be achieved until after the last material had been placed and the plantings matured.

The construction of an island as large as 200 acres could be accomplished in one phase with 4.3 million cubic yards from Norfolk Harbor channel and 1.35 million cubic yards from Newport News channels. This would be all new work material, predominantly coarse grained. It would cost approximately $5 per yard (about 65%) more than ocean placement, based on preliminary estimates. That translates to roughly $140,000 per acre in incremental costs (those greater than ocean placement) for a 200 acre site 19 miles from the channel. One way to judge the reasonableness of this value is to examine cost per acre of creating or preserving equivalent habitat by other means. The results of such comparisons will continue to change as dredging options and suitable land prices changes.

Assuming a small (50 acre) island could be built with the finer material (i.e., fine silts and clays) from maintenance work, there would be additional costs to handle and confine material because of its physical properties. The smaller island would use 1.875 million cubic yards.

RESULTS

During the first 2 years of the study, the Norfolk District completed an Initial Project Management Plan (IPMP) to identify level 2 projects and the costs, schedule and scope of work associated with study, design and implementation. Scoping meetings were held throughout this period with Federal and state agencies, and the F&WS participated with the Corps in extensive literature review to evaluate these alternatives. Limited field evaluations, engineering studies, and a cost analysis was performed to more critically examine and specifically analyze feasible alternatives. This screening process was designed to identify those beneficial use projects having the greatest potential to succeed from environmental, economic, and engineering perspectives.

Based upon detailed evaluations of the level 2 alternatives, two were selected at the conclusion of the 2-year process as level 3 options which could be constructed at a cost savings or reasonable additional cost to provide environmental (or economic) benefits compared to placement of dredged material in the ocean. The options identified included deep trough placement just east of the Hampton Roads Bridge-Tunnel and island development in the lower James River.

During the third year of the evaluations, the Corps Waterways Experiment Station (WES) was contracted to model the deep trough to further evaluate its potential for retention of deposited sediments and two potential island sites were modeled to assess potential sedimentation and circulation impacts in the lower James River. These modeling efforts resulted in the level four (final) recommendations of island building at two sites: Ragged Island WMA and Hampton Flats.

Detailed information used to evaluate each of the level 2 through level 4 alternatives, carry out the screening process, and arrive at the final recommendations is presented in the following section.

SCREENING OF ALTERNATIVES

OYSTER REEF CONSTRUCTION

Introduction

Oyster abundance in Chesapeake Bay is at its lowest level in history. Scientists estimate populations are no more than 1% of historic levels (Barber and Mann, 1991; Meyer, 1991). Only about 40,000 market bushels of oysters were harvested in Virginia waters between October 1, 1992, and May 15, 1993. That is 50% less than the previous season's harvest and only a fraction of the 4 million bushels taken by watermen in the 1950's (VMRC staff, pers. comm.). The continuing decline of the Bay's oyster population is a complex problem. Outbreaks of disease epidemics, commercial overharvesting and environmental degradation all have played roles.

Background Information

Much work is being done in an attempt to replenish oyster stocks. Up until 1991, approximately $1 million per year was spent by the Commonwealth on the oyster repletion program. Restoration and enhancement of natural oyster habitat has been endorsed by the Chesapeake Bay Program and continues to be one of its primary goals. Most of the oyster repletion in the James River involves "cultivation" of the beds, rather than actually placing shell on the beds. Cultivation is the physical turning of the shell bottom to clean the shell and expose clean surface for oyster larvae attachment. Scientists are now proposing the rebuilding of oyster beds or reefs, providing a more suitable habitat for the establishment and settling of oyster spat. The use of dredged material to recreate oyster reefs may have merits in this respect.

There are at least two methods available to attempt to restore oyster habitat using dredged material. One is to create new oyster bars in areas that are known to have viable oyster stocks (i.e., are parasite-free). In 1987, the Corps of Engineers, Baltimore District, in cooperation with the National Marine Fisheries Service evaluated the potential for oyster reef development using dredged material in the upper Chesapeake Bay (Slaughter Creek). Approximately 14,000 cubic yards of dredged material (60 percent fine sand and 40 percent silt) was placed in conjunction with 2,256 cubic yards of

contractor-placed oyster shell cultch to create 2.1 acres of oyster reef adjacent to a State-charted, productive oyster bar.

A survey conducted by Maryland Department of Natural Resources after 5 months indicated that the rehabilitated oyster bar yielded approximately 62 spat per bushel relative to a range of 39-341 spat per bushel at adjacent natural bars. Previous studies have established a wide degree of natural variation in spat counts ranging from 0.35 to 500 spat per bushel of shell, with a "typical" count estimated at 60 spat per bushel (Krantz and Meritt, 1977). Survival beyond the sublegal stage did not differ significantly between the experimental and natural bars. Mortality due to factors such as disease infections, water quality conditions, or substrate characteristics appeared to effect oyster populations equally at all three sites (experimental and two natural). Based on a three year study of this experimental oyster reef in Maryland, the use of dredged material as a substrate for oyster reef habitat is encouraging.

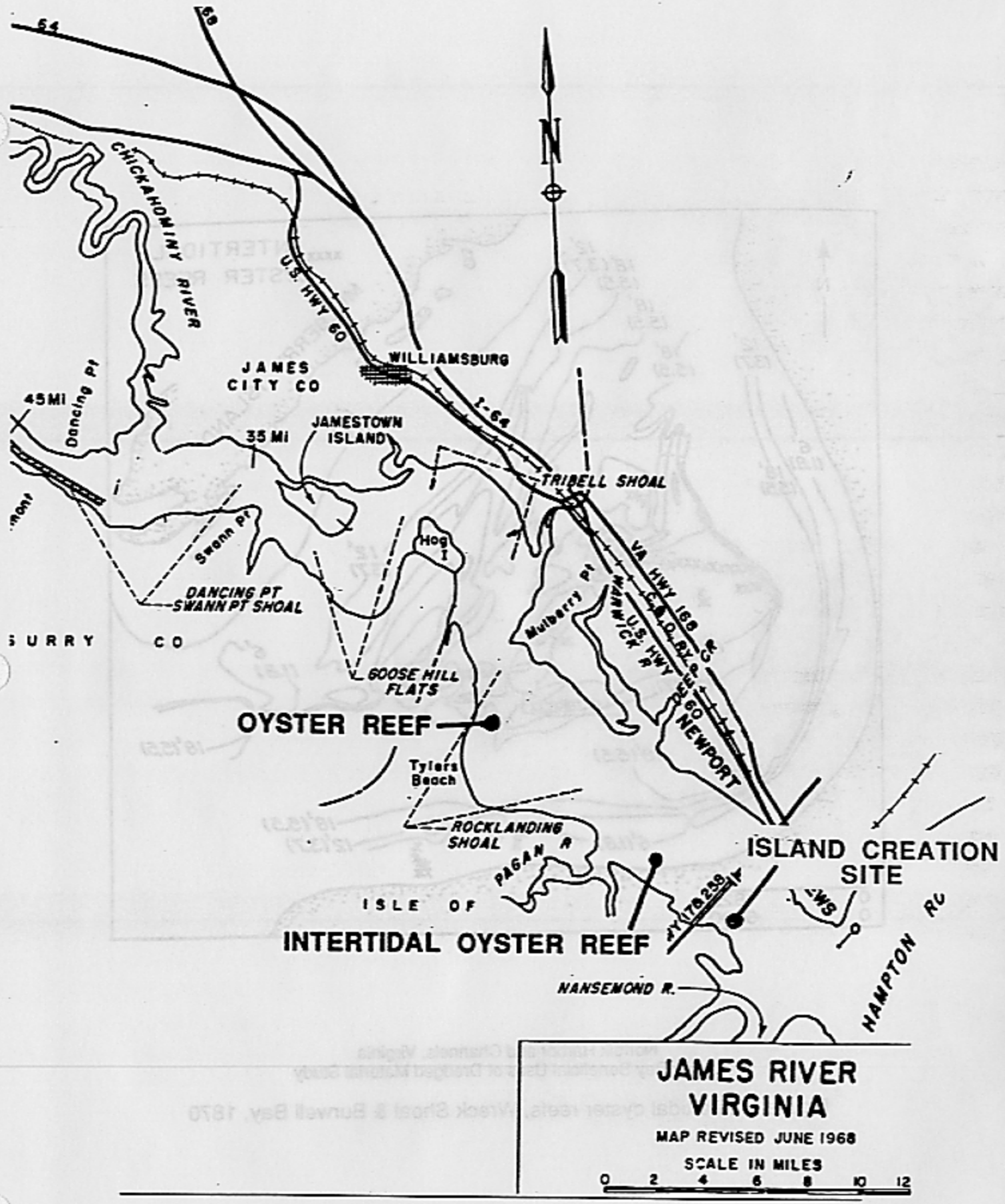
The other opportunity for oyster habitat restoration is to create oyster bars that are intertidal rather than subtidal. Placing newly-set oysters intertidally may not only serve to minimize the effects of predation and competition, but may also serve to increase the oyster's resistance to disease through exposure to air. The Virginia Marine Resources Commission (VMRC) has endorsed a plan to construct intertidal oyster shell reefs in the James, Piankatank and Wicomico rivers and along the Eastern Shore oceanfront using disease-free cultch material. These will be experimental reefs to test the survival of the oysters, the success or failure of which will be determined in approximately three to five years. The reefs will be monitored by researchers at VIMS.

The project specifics include the creation of 25,000 feet of reefs, 5 feet high in the James River below Fort Eustis; a 1,000 foot long, 100 foot reef created at the mouth of the Piankatank; the removal of disease-infected shells from oyster beds in the Piankatank and Wicomico River and replenishment of about 25 acres with cleaned oyster shells; and the restoration of old oyster beds along the Eastern Shore oceanfront using a machine to blow sand off old beds in preparation for new seeding.

Discussion

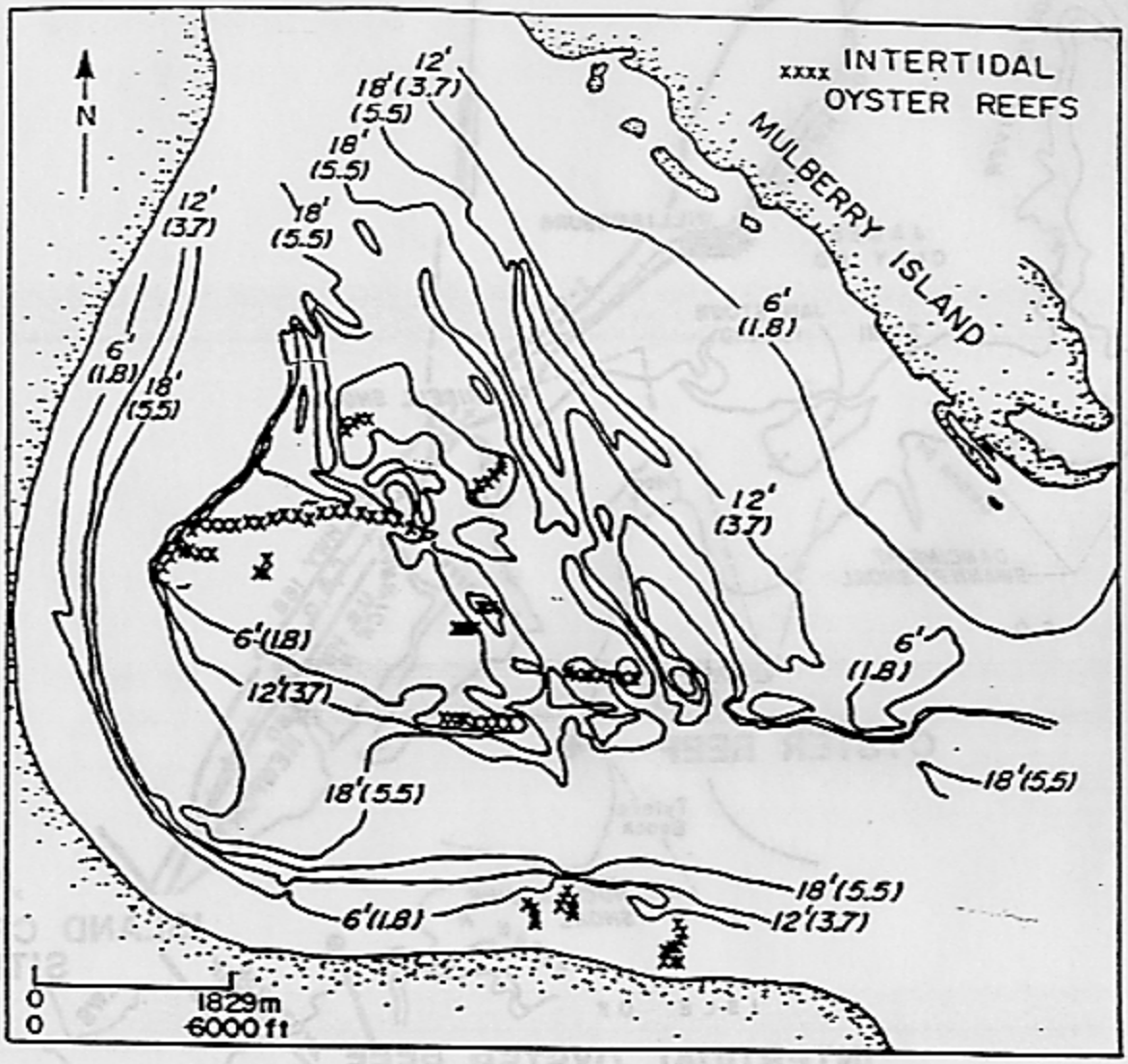
The survival of seeded oysters and of recruits will be a function of post-settlement processes, such as intensity of predation and competition, or resistance to detrimental physical stresses and diseases. In an environment which varies in the severity of biotic and abiotic stressors, the success of experimental beds may be largely dependent on the site or on subsequent management and monitoring of the beds. Crucial parameters to the success of oyster seed dispersal and habitat establishment include tidal flow and water circulation, therefore, these, along with the accessibility of proposed site, will be considered in determining placement of dredged material for oyster reef construction. An additional concern is the long-term stability of the dredged material for the success of the project. In high energy locations, coarser grains would be necessary. In addition, setting spat prefer stable, silt-free oyster shells (Barber, Mann, Walker, and Whitcomb 1990). Private oyster leasees in the James River may be concerned with water quality problems related to dredged material being placed near their beds.

Targeted sites for a beneficial use project would be relatively small (5 to 10 acres) located in the lower James River (figures 4 and 5). This area is both historically and currently successful with oyster populations, and may provide an additional source of oyster seed for potential beds downstream and in the Bay. The success of such a project could indicate promise for ensuing restoration efforts for the Bay. The benefits of restoration and creation of oyster reefs include water quality improvement as a result of increasing the Bay's filtering capacity, habitat diversity for benthic organisms and nektonic fishes, and the re-establishment of a historically critical commercial resource.



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 4. Potential site(s) for oyster reef & island habitat development



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 5. Intertidal oyster reefs, Wreck Shoal & Burwell Bay, 1870

The major concern of building oyster grounds with dredged material are related to costs associated with hauling dredged material from the dredging site to the proposed construction site(s). These costs are addressed in table 2 and appendix F. Placement sites which are typically shallower waters would require smaller loads in shallow draft barges, possible double-handling of material, and associated increased costs of implementation.

Material available for substrate building may be too fine to create a base upon which cultch (shell) can be placed successfully. Also, at this time, there is uncertainty of success of project due to relentless diseases. The VMRC test sites which are being monitored now have not been observed long enough to have produced any meaningful data. The project may require long term regular maintenance and care which would again, increase costs.

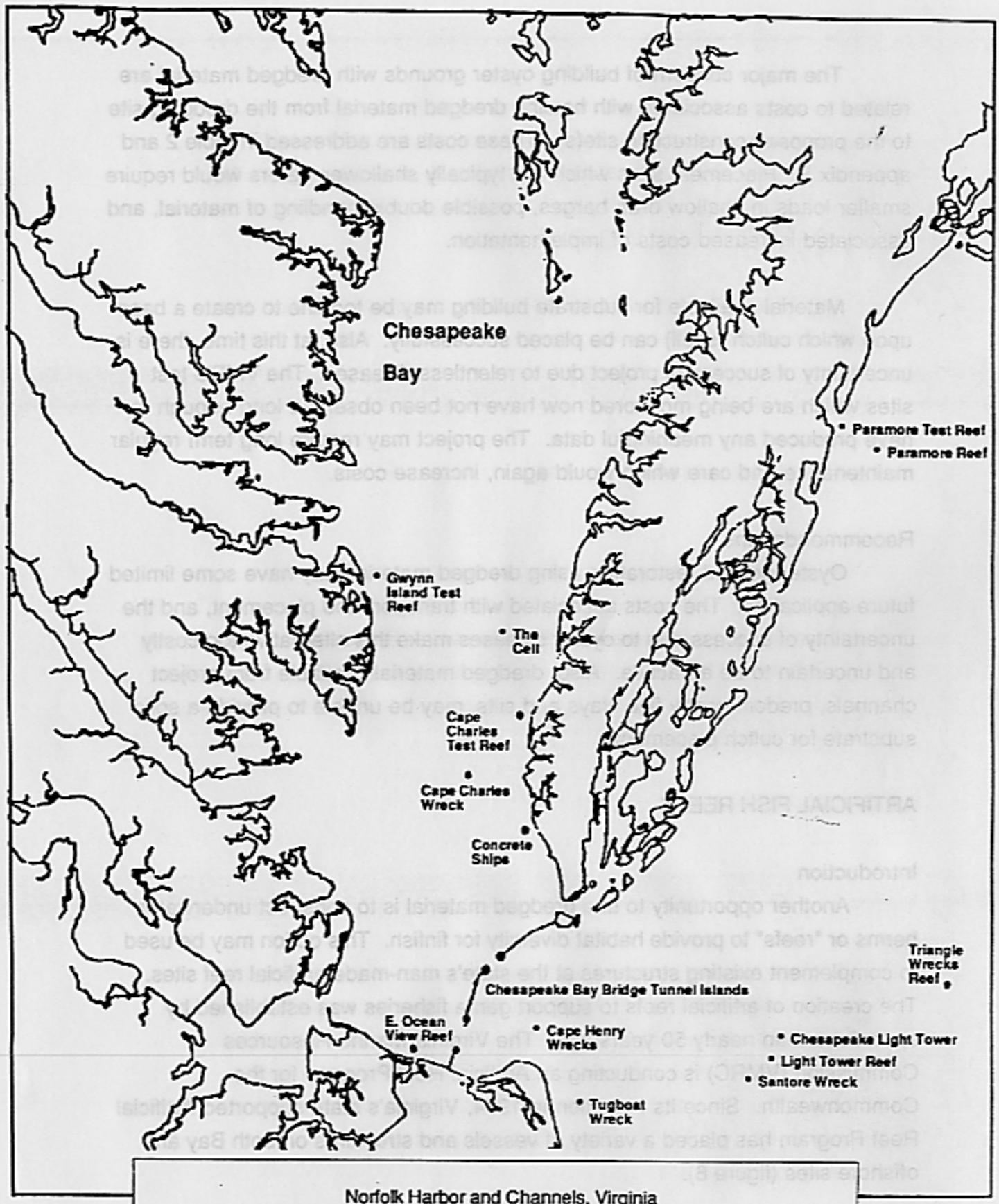
Recommendations

Oyster ground restoration using dredged material may have some limited future application. The costs associated with transport and placement, and the uncertainty of success due to oyster diseases make this alternative too costly and uncertain to be attractive. Also, dredged material available from project channels, predominantly fine clays and silts, may be unable to provide a solid substrate for cultch placement.

ARTIFICIAL FISH REEFS

Introduction

Another opportunity to use dredged material is to construct underwater berms or "reefs" to provide habitat diversity for finfish. This option may be used to complement existing structures at the state's man-made artificial reef sites. The creation of artificial reefs to support game fisheries was established by sport fisherman nearly 50 years ago. The Virginia Marine Resources Commission (VMRC) is conducting an Artificial Reef Program for the Commonwealth. Since its inception in 1974, Virginia's state-supported Artificial Reef Program has placed a variety of vessels and structures on both Bay and offshore sites (figure 6).



Norfolk Harbor and Channels, Virginia
Lower Bay Beneficial Uses of Dredged Material Study

Figure 6. Artificial reef and other popular wreck fishing sites in lower Chesapeake Bay and offshore waters of Virginia.
(from VIMS, 1989)

Liberty ships, barges, various structures utilizing automobile tires and concrete "igloos" have been placed at selected underwater sites to provide fish habitat. The purpose of the VMRC reef program is to enhance fishing, to provide fishing in easy reach of anglers, and to diffuse the fishing effort, so that no one particular area is fished too heavily.

An artificial reef may be of any material, man made or natural and is intentionally placed in an aquatic environment to attract fish. The surface of the reef becomes colonized by encrusting plants and animals, which, in turn, provide food and shelter for fish and other organisms; the reef structure provides a point of orientation and a feeding station for larger predator fish. The nooks and crannies of the structure afford protection from predators and currents and serve as a source of food and shelter like their natural coral counterparts.

VMRC indicated that there may be some potential to develop fisheries habitat diversity at the artificial reef sites (recommended by ODU) using dredged material. The man-made structures which have been and will be placed could be complemented by low relief berms (dredged material) surrounding, or in the vicinity of these structures.

When constructing and landing an artificial reef, planning must be conducted prior to the structure being placed on the bottom. Careful consideration is given to the species of fish present in the proposed placement site, and possible adverse impacts associated with placement to resident fishes and bottom organisms. Water quality, depths and currents are also important concerns when considering reef construction and placement. Consideration of stability and maximum species diversity is also important in deciding the type of structure utilized. Currently, VMRC is using two basic structures, along with discarded vessels to develop reef habitat. One is a combination of tires and concrete used in offshore reefs in combination with vessels, such as dry-docks and landing craft and barges to provide low profile forage habitat. The second structure is a dome-shaped "igloo", fabricated our of reinforced concrete. The "igloo" provides medium to high profile habitat in the bay.

Structures are presently in place at:

Cape Charles consists of 6 igloos and 7 concrete pipe stacks
Gwynn Island consists of 6 igloos, 8 stacked tire units, and 89 tire-in concrete units
E. Ocean View consists of 40 igloos

In evaluating the possibility of using dredged material for artificial reefs the following considerations were taken into account:

(1) A side slope must be achieved with the deposited dredged material, which requires a coarser sediment type. It is unclear if the material we have available would be able to achieve/accomplish and maintain such a slope.

(2) Reefs for fisheries habitat are built across current

(3) Dredged material would not be considered a "hard bottom", therefore, habitat diversity for finfish would be augmented by using the different sediment type.

(4) Use VMRC artificial reef projects (six as of April, 1992) in Chesapeake Bay (Poquoson, Cape Charles, Hungars Creek, Eastern Shore, near Norfolk and Gwynns Island, and off Northern Neck) which are intended to improve habitat for rockfish, cobia, seabass, and other species. They sink prefabricated concrete forms, or concrete-weighted tires. Sponges, tube worms, and assorted bottom organisms colonize on the structures and, in turn, attract game fish. The artificial reefs provide fish a source of habitat, a source of food and a source of refuge from predators. In some cases the reefs prove to be good, productive spawning habitat. Gwynns Island was deemed by ODU report (1986) to be unsuccessful, however, Cape Charles and Wachapreague were both successful.

Jim Eskridge of VMRC says the dredged material would need to be coarse-grained to be stable. "Quality of dredged material" is an important consideration since consideration must be given to scouring around the reefs once the material is placed.

As recommended by a study conducted by Feigenbaum and Blair, ODU, 1986 for VMRC, any reefs should not be build in proximity to shipping lanes, marked channels, and other heavy traffic areas as well as areas designated for anchorage or other restricted use. Active oyster ground should also be avoided as a reef site. Sites must be at least 14 feet deep to reduce the chance of a ship accident.

Lucy and Barr (VIMS, 1989) suggest that by diversifying materials on a reef site the mix of species at the reef site could be enhanced.

Recommendations

VIMS stated that, in their opinion, placing dredged material at the artificial reef sites could prove to be more of a detriment than an enhancement. The materials used in Virginia to construct artificial reefs are hard materials, i.e. concrete igloos, ships, etc. These provide a hard attachment surface for food organisms and a stable vertical profile, both of which are attractive to fish. Potential problems related to using dredged material are the uncertainty that dredged material (especially "fines") could provide and maintain the intended vertical profile, especially under storm-generated conditions. Current artificial reef sites are already experiencing problems of "sanding in" (i.e., shifting of bottom sediments covering the artificial reef structures). This condition could be made worse by placing dredged material in the vicinity. VIMS has stated that there may be some potential for making a hard bottom out of a soft bottom using dredged material. Sand or hard bottom is required to support the weight of reef structures. If sufficient quantities of sandy dredged material are available, and are not designated for beach nourishment, this may have some potential future application. For the majority of the dredged material, predominantly fines, concerns expressed by the reef managers have eliminated this option from further consideration.

UNDERWATER BERMS

Introduction

The underwater berm concept is to use dredged material to create an underwater mound for a specified purpose. There are presently two approaches to construction of underwater berms. They are referred to as feeder

and stable berms. The feeder approach involves relatively shallow water placement of dredged material which could move toward shore. Material utilized in this approach would be limited to beach quality sand. The stable approach involves placement in deeper water less susceptible to waves and currents. Placed in deeper water under low energy conditions, there is a higher potential of the material remaining in place, and a wider range of dredged material types may be used in the construction of a stable berm.

The primary benefit of feeder placement is to add sand to the nearshore zone so that it may potentially help to reduce erosion of nearby beaches. A stable berm would be a significant, relatively permanent bottom feature that could dissipate storm waves and thus contribute to a reduction in shoreline erosion rates. In addition, fishery benefits are expected as topographic irregularities are created on the ocean floor, enhancing fish habitats.

Background Information

The Mobile District, Corps of Engineers, has constructed two "mounds" or underwater berms near the mouth of Mobile Bay. One berm has already been constructed as a "feeder berm" (1986). The dredged material (sand) was placed in shallow water parallel to the shoreline. Feeder placement is expected to replace and supplement sandy material in the littoral process and over a period of time reduce to some extent the erosion to downdrift beaches. The feeder berm is expected to be a temporary feature and was completed in 1987 as part of a routine maintenance dredging contract. The feeder berm was build using 450,000 cubic yards of clean sand 6 feet high and one mile long is relatively shallow water, 18 feet deep.

To complement the feeder in the Gulf, the Corps built a larger offshore berm with about 19 million cubic yards of material. The "stable" berm is about 2 and one half miles long and one half a mile wide. Stable berms are expected to be relatively permanent bottom features which will trip the incoming storm waves and dissipate the majority of the wave energy, thus contributing to a reduction in erosion rates. The Alabama project was born of a Corps experiment in a placement site three to five miles east of Virginia Beach. In 1982, the Corps built a berm at the placement site with 800,000 cubic yards of sand and silt. The experiment proved to be successful in terms of its feasibility

to build a berm which would remain stable over time. The berm is 1,600 feet wide and 2,800 feet long by 11 feet high. It is situated 23 feet under the ocean.

These Mobile projects were monitored by U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center (CERC). The Environmental Protection Agency (EPA) participated in the monitoring of the stable berm. They conducted fisheries assessments to determine any changes in the fisheries potential caused by the stable berm, as well as tracking sediment movement. The principle objective of the monitoring was to measure the physical characteristics of both berms and how these characteristics might change over time. The program was also designed to measure some overall physical forces that cause these changes and any fisheries benefits that may accrue due to the stable berm.

Each of the Mobile District berm construction projects required agency coordination, field studies and the preparation of environmental documents (personal communication w Paul Bradley, Mobile District). Both the Chesapeake Bay and the Mobile Bay are extremely important estuaries to different water bodies, but there is no comparison when it comes to productivity. The Chesapeake Bay is the most productive estuary in the world. Living resources and estuarine circulation patterns in the lower Bay are extremely important and are not completely understood. Prior to construction of a mound in the lower Bay or vicinity, possible impacts on circulation patterns and resulting impacts on living resources must be thoroughly assessed. Site(s) should be selected to avoid commercial fisheries including fish and shellfish. The influence of the Chesapeake Bay plume (outflow from Bay) on the productivity, species composition, recruitment and physical processes of the area is thought to be pronounced. The Bay plume acts physically to transport planktonic organisms and may act as a chemical cue by which organisms find their way into the Bay. Any alterations in the lower Bay should be done only after a specific site is selected considering commercially and ecologically significant resources and physical processes to avoid changes which could have long-lasting impact on existing productive uses. The need for a new habitat, weighed against these potential impacts, should be carefully and scientifically evaluated.

Discussion

The construction of berms at Mobile Harbor may have been viewed by some as a simple task which required little, if any, environmental work. The more accurate picture given by Mobile District personnel who worked on this project is that much work was required and that, even now, there are some issues that are unresolved (e.g., it has recently been discovered that there are offshore oil leases at the site of the proposed stable berm). Construction of a permanent berm feature at the mouth of a major estuary may be relatively easy to conceive and design, however, the impacts associated with such a feature are not as obvious to assess.

Estuarine circulation patterns in the lower Chesapeake Bay are quite complex. Thimble Channel is a major ebb-dominated channel. Closer to the southern shore, there is a shallower flood-dominated channel which tends to migrate toward the shoreline. Little is known about the interaction of these two channels, the shoal areas west of and between the two, and the shoal areas north of Thimble. Current patterns around the Bay mouth are thought to play an important role in retaining blue crabs in Chesapeake Bay. Alterations in existing current patterns (local currents or Chesapeake Bay plume) could adversely affect blue crab recruitment and/or recruitment of larval planktonic finfish.

The ecology of the Chesapeake Bay and adjacent ocean waters is greatly influenced by the dynamics of the Chesapeake Bay plume. The outflow from the Bay enhances primary production by contributing nutrients and detrital material to the inner continental shelf region. Phytoplankton cell concentrations in the Bay plume water are significantly higher than in shelf waters outside the plume (Marshall, 1981). Marshall (1985) observed the seasonal changes in phytoplankton composition which he related, at least in part, to the Bay plume changes in composition, quantity of flow, temperature, and salinity. He indicated the trophic relevance of various size categories of the phytoplankton to faunal components of the region. It is not known conclusively how various species of migrating marine organisms find the Bay. It has been postulated that they are influenced by the physical and chemical properties of the Bay plume. These well defined chemical properties may be used as cues by fish, crabs, and juvenile sea turtles attempting to find their way into the Bay. If they do utilize

these chemical cues, then alterations in current patterns and chemical properties of water masses at the Bay mouth could delay or deter their entrance into the Bay.

Recommendations

Living resources and estuarine circulation patterns in the lower Bay are important, complex, and not well researched or documented. The influence of the Chesapeake Bay plume on the productivity, species composition, recruitment and physical processes of the area is thought to be pronounced. The Bay plume acts physically to transport planktonic organisms and may act as a chemical cue by which organisms find their way into the Bay. Research into this phenomena is ongoing but much work still needs to be accomplished in order to better understand the physical, chemical and biological dynamics of the Bay plume. A permanent feature such as a dredged material mound near the Bay mouth has the potential to affect plume dynamics. Until the tools are available to better predict potential changes, mound construction near the mouth of the Bay is not recommended.

THIN-LAYER PLACEMENT

Introduction

Thin layering is a form of dredged material placement first discussed during the late 1970's. Thin-layering placement was expected to have fewer short and long-term impacts on the aquatic ecosystem than conventional open-water placement. It involves the placing or spreading of dredged material on a subaqueous bottom in a thin layer, as opposed to the more traditional overboard placement method of mounding the material. Placing the material in a thin layer prevents the smothering of bottom organisms and allows the possibility of benthic habitat enhancement through changing bottom sediment type. Thin layer placement potentially reduces impacts to biota, making placement in certain areas environmentally acceptable.

Any type of removal and placement of dredged material causes immediate short term impacts to resident benthic communities. The objective of thin layer placement is to either greatly reduce these immediate impacts or to hasten the recruitment of native biota to the material without transforming the

habitat's ecological function. Repopulation varies with habitat type, including circulation patterns, sediment types, salinity variations, temperature, available nutrients, and the presence of pollutants. A thick covering of material in the actual placement site generally decimates the existing natural or established community. On the other hand, a thin layer, less than 32 centimeters (13 inches), minimizes the impact.

Thin layer placement is a relatively new technique, and has not been rigorously studied. The full impact of thin layering to physical, chemical, and biological components of the ecosystem remains to be addressed. The research to date has indicated that there is potential for thin layering as an alternative placement technique, and, therefore, was considered as a possible beneficial use of dredged material in Chesapeake Bay.

Background Information

Thin layer placement was studied in 1992 in shallow, subtidal, sand/mud habitats in the Fowl River, Alabama by the US Army Corps of Engineers (USACE), Mobile District. A year-long study was initiated to determine the physical and biological impacts thin layer placement. The Mobile District examined an estuarine area in the Fowl River following dredged material placement on the river bottom in a layer that generally ranged from 15-60 centimeters thick. They placed 145,000 cubic meters of dredged material (40% sand, 50% silt, and 10% sandy clay) in a 97-hectare placement area. Several types of monitoring data were obtained before and 2, 6, 20 and 52 weeks after placement of the material, including precision bathymetry measurements, sediment profile imagery, total suspended solids (TSS) and dissolved oxygen (DO), infauna abundance, diversity, biomass and recruitment, fish abundance and diversity.

Results indicate that, although the placed dredged material covered an area over 35 hectares greater than the planned placement area, the material remained within the designated 530 meter-wide buffer zone surrounding it. The thickness of the material was less than 15 cm over 36% of the area, 16-30 cm over 48% percent and deeper than 30 cm over only 16% of the area. There were temporary elevations in TSS which were generally confined to the placement site. TSS concentrations had very little effect on DO concentrations.

The placement site exhibited rapid recolonization of infaunal species with thinner areas becoming repopulated most quickly. Total fish abundances did not appear to be affected by the thin layer placement.

The Mobile District's thin layer project may have only limited application to thin layering in Chesapeake Bay because of geographic differences in habitat, species composition, sediment type and system resiliency. However, the success of the Fowl River thin layering placement does hold promise and serves as a reference for this and other proposed thin layer projects.

The potential for thin layering in Chesapeake Bay was investigated at the Wolf Trap (Alternate) Disposal Site located east of New Point Comfort and south of Wolf Trap light. In conjunction with the USACE, Waterways Experimental Station (WES), the Virginia Institute of Marine Science (VIMS) monitored a placement site in the Wolf Trap (Alternate) dredged material placement area which had received approximately 10 million cubic yards of fine sands (40-50%), silts (30-40%), and clays (10-15%) dredged material from the York Spit Channel between the fall of 1987 and the summer of 1989. They specifically examined the effects of various thicknesses of dredged material on benthic community structure and the recovery rate of benthic communities along gradients of dredged material overburden following placement. Changes in the resident benthic macroinfauna community are often used to assess the impacts associated with environmental perturbations. Because of their short life span and their relatively sessile nature, the organisms which make up this community are a good indicator of the integrated changes in the physical, chemical and biological environment over time.

The conclusions of the VIMS and WES investigations were that the impacts of dredged material on community structure depended on the depth of overburden and on individual species functional characteristics. The recovery process varied depending on the placement site in relation to the season of placement and sediment type. In general, dredged material of similar sediment type placed in a relatively thin layer allowed for better and more rapid recruitment of benthic organisms. Overall, assemblages within dredged material placement experimental sites were indistinguishable from

assemblages in control sites (no placement activity) within 2-3 years of the initiation of placement activities (USACE, 1992).

Discussion

There is some controversy as to whether thin layer placement of dredged material accrues environmental benefits. In a report highlighting environmentally enhancing uses of dredged materials, VIMS suggests two alternative management strategies for beneficial results of the thin layer placement alternative (VIMS, 1992, appendix E). The strategies involve the regulation of benthic species composition, abundance, and diversity by controlling the level of ecological succession or sediment grain size. Different benthic invertebrate assemblages vary in their importance as food for commercially and recreationally important finfish. The characteristics of benthic communities can be managed by a controlled disturbance of the seafloor through dredged material placement to maintain maximum fish food production. Dredged material might be used to enhance benthic resource value by simulating a natural disturbance to induce early successional stages or by changing the characteristics of the sediment.

Temporary increases in secondary production may be observed as opportunistic benthic organisms repopulate the site. Although application of the dredged material initially smothers the *in situ* fauna, during early recolonization many more individuals occupy the substrate which increases, for a relatively brief period, the habitat value to target fisheries populations. Rhoads, et al (1978) studied benthic assemblages on disturbed bottoms in Long Island Sound and found them to be dominated by species with short life spans, frequent reproduction, and high dispersability - characteristics well suited for the exploitation of continually changing habitats. Odum (1969) has suggested that necessary human disturbance of ecosystems can be managed in such a way as to enhance productivity while maintaining a degree of environmental resiliency. He recommends a compromise system between the highly productive, variable, youthful stage and the stable but less productive mature stage. Such a "compromise" system will be more productive than a mature stage, and the level of productivity will be kept predictable by managing the disturbance. Successive thin layer applications may restore the benefit, however, this approach is limited because significant depth changes are undesirable. The

"benefit" of this strategy to maintain an early successional state, therefore, is short-lived.

An additional strategy recommended by VIMS involves changing substrate characteristics. Recent scientific study indicates that some benthic habitats can be improved, long-term, for commercial shellfish and benthos through mixing of existing homogeneous silt and fine substrates with coarser materials. By careful selection of the contrasting materials, the resultant benthic community could be managed to provide an enhanced habitat value to support selected target finfish populations utilizing bottom organisms as a food source.

Thin layer placement is being referred to as a "beneficial" use of dredged material, implying that it "rejuvenates or enhances" the productivity or diversity of the immediate environment. The U.S. Fish and Wildlife Service expressed concern that the application of a thin layer of dredged material over a large area could cause damage to fish, shellfish, and benthic organisms. They warned that short term increases could not be considered environmentally enhancing or rejuvenating, and that continued disturbance to maintain an early successional state may have detrimental effects on resident fish, shellfish, and benthic organisms. Altering bottom types may result in changes in resident biota composition, not necessarily an environmental enhancement or rejuvenation.

Due to the lack of definitive information regarding the consequences of thin layer placement of dredged materials on resident biota, the thin layer method is emphasized as a "potential" beneficial use. Further studies would be necessary to verify the proposed beneficial impacts before thin layering is utilized in Chesapeake Bay. However, if not environmentally enhancing, per se, thin layering may result in fewer adverse impacts than traditional methods of overboard placement, and, therefore, provide a more appealing and viable alternative or augmentation to upland or ocean placement.

A literature search report discussing the feasibility of thin layer placement was presented by the Advanced Technology Department of Parsons, Brinckerhoff, Quade and Douglas, Inc. in November of 1988. Based on a number of studies using traditional methods of overboard dredged material placement, they determined that water quality parameters (suspended solids,

dissolved oxygen) return to ambient levels within hours after cessation of placement activities. They also found that no gross effects on phytoplankton, zooplankton, fish eggs, larvae or adults have been observed due to open water placement. In addition, benthic communities become reestablished on the new material, given that the placed material is uncontaminated and is of similar grain size and type to the native benthic material at the placement site. If the material is different from native sediments, then a different benthic community structure may result.

Few studies of the environmental effects of the thin layer placement technique have been conducted directly, therefore, caution must be used with information extrapolated from traditional placement methods.

Resource agencies have discouraged thin layer application within the geographical area of the Inner Harbor/lower James River due to the presence of valuable biological resources, including the state's only productive oyster grounds. However, sites within the southern-most sector of the Chesapeake Bay were evaluated. A thin layer site was considered in the vicinity of Horseshoe Shoal parallel to the Thimble Shoal Channel (figure 7). Thin-layering parallel and adjacent to the dredged channels, in the same locale and in the same environment, would eliminate the more costly transport of material to the offshore ocean site. Moreover, the placed material may be of similar type so as not to alter existing sediment types in the proposed thin layer placement location. Similarity of material was considered by the VIMS and WES study to be a major factor in determining the potential of an area to regain its predredged material placement biota composition.

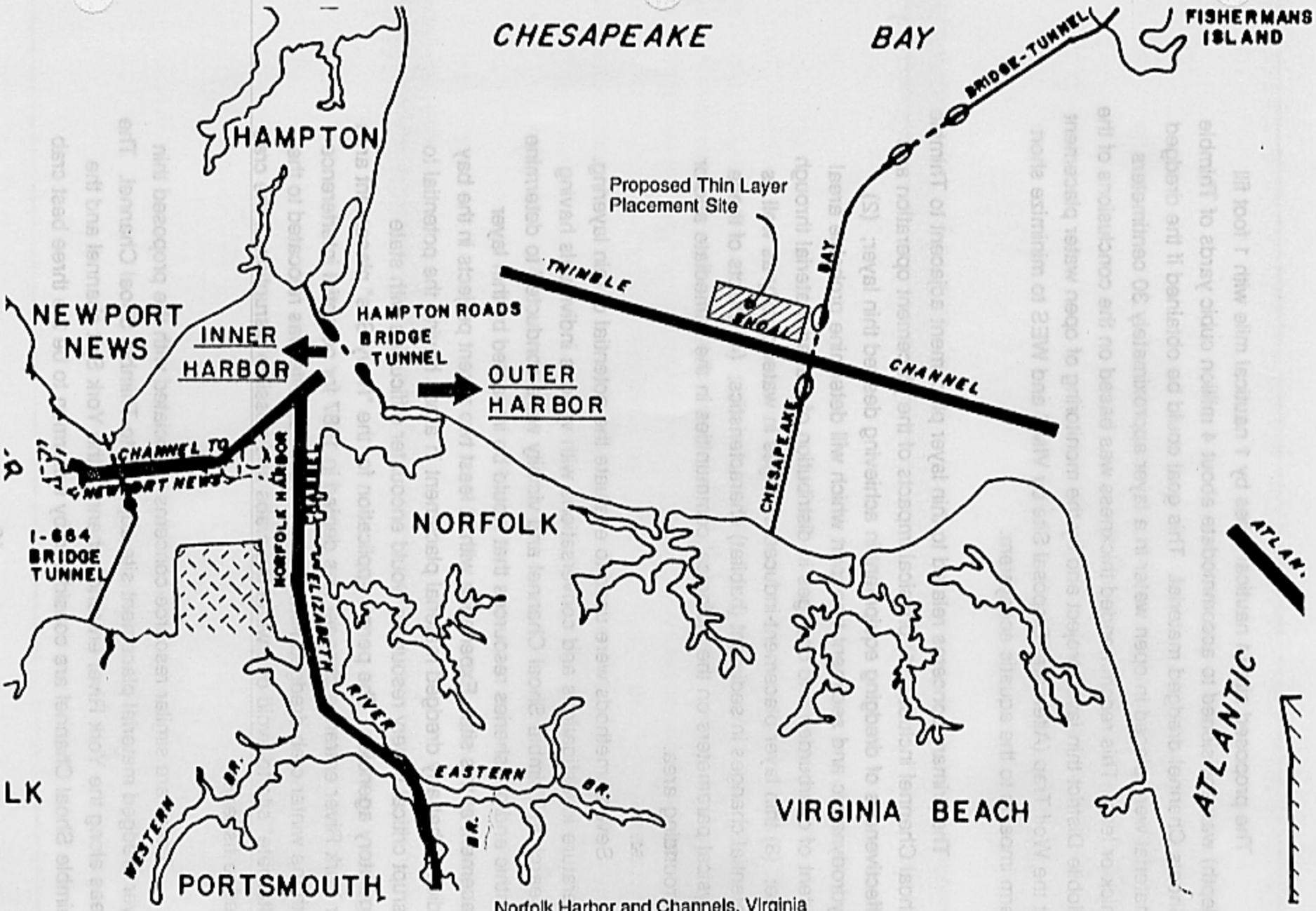


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Figure 7. Proposed thin layer placement site

The proposed site (4 nautical miles by 1 nautical mile with 1 foot fill depth) was envisioned to accommodate about 4 million cubic yards of Thimble Shoals Channel dredged material. This goal could be obtained if the dredged material were placed in open water in a layer approximately 30 centimeters thick or less. This recommended thickness was based on the conclusions of the Mobile District thin layer project and by the monitoring of open water placement at the Wolf Trap (Alternate) Disposal Site by VIMS and WES to minimize short term impacts to the aquatic ecosystem.

The primary concerns related to thin layer placement adjacent to Thimble Shoal Channel include: (1) physical impacts of the placement operation and effectiveness of dredging equipment in achieving desired thin layer; (2) hydrodynamic and sediment transport which will determine probable areal extent of overburden and changes in distribution of placed material through time; (3) thin layer placement-induced changes in water quality as well as potential changes in sediment (habitat) characteristics; (4) effects of these physical parameters on the biological communities in the immediate and/or surrounding area.

Several methods were used to evaluate the potential of thin layering. Literature investigations and conversations with various individuals having researched Thimble Shoal Channel and vicinity were conducted to determine benthic and/or fisheries resources that would be impacted by thin layer placement at this site. Experience with at least two recent projects in the bay indicate that any dredged material placement in areas having the potential to disrupt critical fishery resources would encounter difficulties with state regulatory agencies. The permit application for the "Navy Site" placement area for York River entrance channel was denied in 1987 for potential interference with the winter crab dredged fishery. The Wolf Trap Site was relocated to the "alternate" site to avoid overwintering crabs and possible disruption of the crab dredge fishery.

There are similar resource concerns associated with the proposed thin layer dredged material placement site adjacent to Thimble Shoal Channel. The areas along the York River entrance channel, the York Spit channel and the Thimble Shoal Channel are considered by watermen to be the three best crab

dredging areas in the lower bay during the winter months (Van Engel, pers. comm). Concentrations of crabs in the lower bay during winter occur as result of fall migration of adult females from rivers and upper bay following mating. Best catches are made on edges of broad banks adjacent to deep channels of the bay over muddy sand bottoms supporting beds of colonial hydroids in 25-75 feet depths (Van Engel, 1962). USF&WS's (1986) report prepared for the Corps of Engineers, Norfolk District, discusses the life history and ecology of the blue crab in the lower Chesapeake Bay. The winter dredge fishery for blue crabs extends as far north as Wolf Trap off Mathews County out to the mouth of the bay, but the areas of most intensive and consistent use are the deep waters in and along the channels of the lower Bay (Freeman, pers. comm).

Schaffner and Diaz (1988) looked at the distribution and abundance of overwintering blue crabs in the lower Chesapeake Bay during February 1986. In an investigation of habitat types, they found that crabs were most abundant in moderate energy, tide dominated basins and least abundant in wave and tide dominated spits and shoals. Crabs were significantly more abundant where sediments contained between 41 and 60% sand and at depths exceeding 9 meters. The observed patterns indicate that some differential habitat utilization occurs and that overwintering female crabs are found preferentially in areas characterized by moderate energy regimes and fine, but sandy sediments.

The U.S. Fish and Wildlife Service (Mayne, 1986) looked at impacts of dredged material deposition in areas with overwintering populations of blue crabs. They considered that the most likely adverse effects of dredged material deposition on blue crabs and the associated winter dredge fishery would be: (1) direct loss of crabs due to entrainment by the dredge and burial or gill clogging due to discharge of the dredged material; (2) potential for temporary habitat degradation if dredging or placement result in a significant change in bottom type; and (3) temporary disruption of the winter fishery until bottom contours become smooth enough for effective and safe operation of a dredge.

Hobbs and Schaffner (1990) performed a geological and benthic evaluation of sand resources in the lower Chesapeake Bay for the Virginia Council on the Environment. They studied a 353 square mile area bisected by the Thimble Shoal Channel to determine the feasibility of using the site for

mining sands. They concluded that the bay mouth region is an area of high resource value relative to the range of habitats comprising lower Chesapeake Bay. Overwintering blue crabs generally were as dense or denser in the study region as they have been in other areas of the bay where commercial harvesting occurs. Crustaceans, an extremely important food item in the diets of demersal fish in the study region, exhibited abundances 1 to 2 orders of magnitude higher in this region than have been observed in other lower bay habitats. Given the apparently high resource value of these areas relative to other habitats in the lower Chesapeake Bay, the area within the studied lower bay region was not recommended for sand mining.

The Thimble Shoals Channel and adjoining areas fall within the State's official "Crab Sanctuary", an area protected from crab-potting activities between June 1 and September 15 each year. During these summer months, this region apparently supports most ovigerous and spawning females of the Chesapeake Bay population (Van Engel, 1958).

Chittenden (1989) conducted a fishery resources investigation in Virginia mainstem Chesapeake Bay. He sampled 48 stations randomly each month in water greater than 12 feet depth. Two species made up almost 93% of total fish catch by numbers, the bay anchovy, Anchoa mitchilli (65%) and spot, Leiostomus xanthurus (28%). In February and October, blueback herring, Alosa aestivalis was dominant. These findings indicate that the area around the proposed site dies not appear to represent a major larval transport route for any but the most common and commercially insignificant species of finfish (anchovy).

Rhoads et al (1978) in the report about dredging disturbances in Long Island Sound indicated that dredged material placement should be performed between January and April, a period of low species recruitment and low bottom temperatures. From May to December, a period of intensive recruitment and population growth, placement should cease so that full colonization potential can be realized. Seasonal restrictions on placement activities in Chesapeake Bay, however, would not be sufficient due to the overwintering population of blue crabs and the status of "crab sanctuary" during the summer months.

Recommendations

Because of resource concerns along the Thimble Shoal Channel corridor, including the area's designation as a "crab sanctuary" during the summer months and its extensive use by commercial fishermen for crab dredging during winter months, the area adjacent to Thimble Shoal Channel was not recommended for the thin layer dredged material placement project. The Corps' experience (both Norfolk and Baltimore Districts) with using crab overwintering areas for dredged material placement is that it has not been well-received by the Federal and state environmental agencies, especially the permitting agencies of Virginia. Although the demonstration projects by the Mobile District indicate that it is logistically possible to place material in a thin layer (i.e., less than 32 centimeters), this technique has never been demonstrated in Chesapeake Bay where dredged materials are relatively coarser and are less likely to spread in a consistently thin layer. Additionally, preliminary cost estimates indicate that thin layering would be slightly more expensive than placement in Dam Neck Ocean site. This is primarily due to the need for special or modified equipment and logistical considerations associated with evenly distributing the material on the bottom.

DEEP TROUGH PLACEMENT

Introduction

The presence of a deep trough just east of the Hampton Roads Bridge Tunnel has stimulated interest in using this area as a potential dredged material placement site. The use of dredged material to fill deep pockets or depressions in aquatic floors has been suggested for a number of years. Potential areas may have occurred naturally or as a result of man made activities. In the Lower Bay of New York, the mining of sands for construction is creating an increasing number of deep pits. They are proposing to fill these pits due to the accumulation of muds and contaminants in the pits (Cerrato and Bokuniewicz, 1987).

Background Information

Since 1981, a deep depression, approximately 30 feet deep, has been used successfully as a placement site for dredged material from the Tylers Beach Channel in the James River. Approximately 35,000 cubic yards of fine to

medium sand from the channel throat were removed and placed into the depression via hydraulic dredging and pumping. Monitoring of the placement site was conducted by the US Army Corps of Engineers (USACE), Norfolk District before, during and following dredged material placement. The monitoring included biological sampling to establish benthic community structure, bathymetry studies to determine depth changes, and suspended solids monitoring to investigate plume movement. These monitoring studies indicated little plume movement beyond the depression boundaries, and re-establishment of benthic species diversity at the site. Other than an initial demise of resident biota following placement of dredged materials, placement has not resulted in adverse impacts to the area. Hydrographic surveys following initial placement verified the trough's capacity for the projected 50-year project life.

The deep trough under investigation in this beneficial uses study is located between Willoughby Bank and Thimble Shoal near the Hampton Roads Bridge Tunnel (figure 8). Preliminary research hinted that the trough was not created by natural scouring, but at least in part by dredging of a St. Petersburg, Florida contractor, Misner Marine. Several sources stated that the contractor apparently used the dredged material to cover the tunnels and create islands for the Chesapeake Bay Bridge Tunnel. However, no evidence was found to verify these accounts. Coastal charts from nearly 100 years ago indicate a deep trough at that location almost identical to the water depths in the trough under investigation. The existing trench is 90 feet deep, 15,000 feet long and 1,000 feet wide.

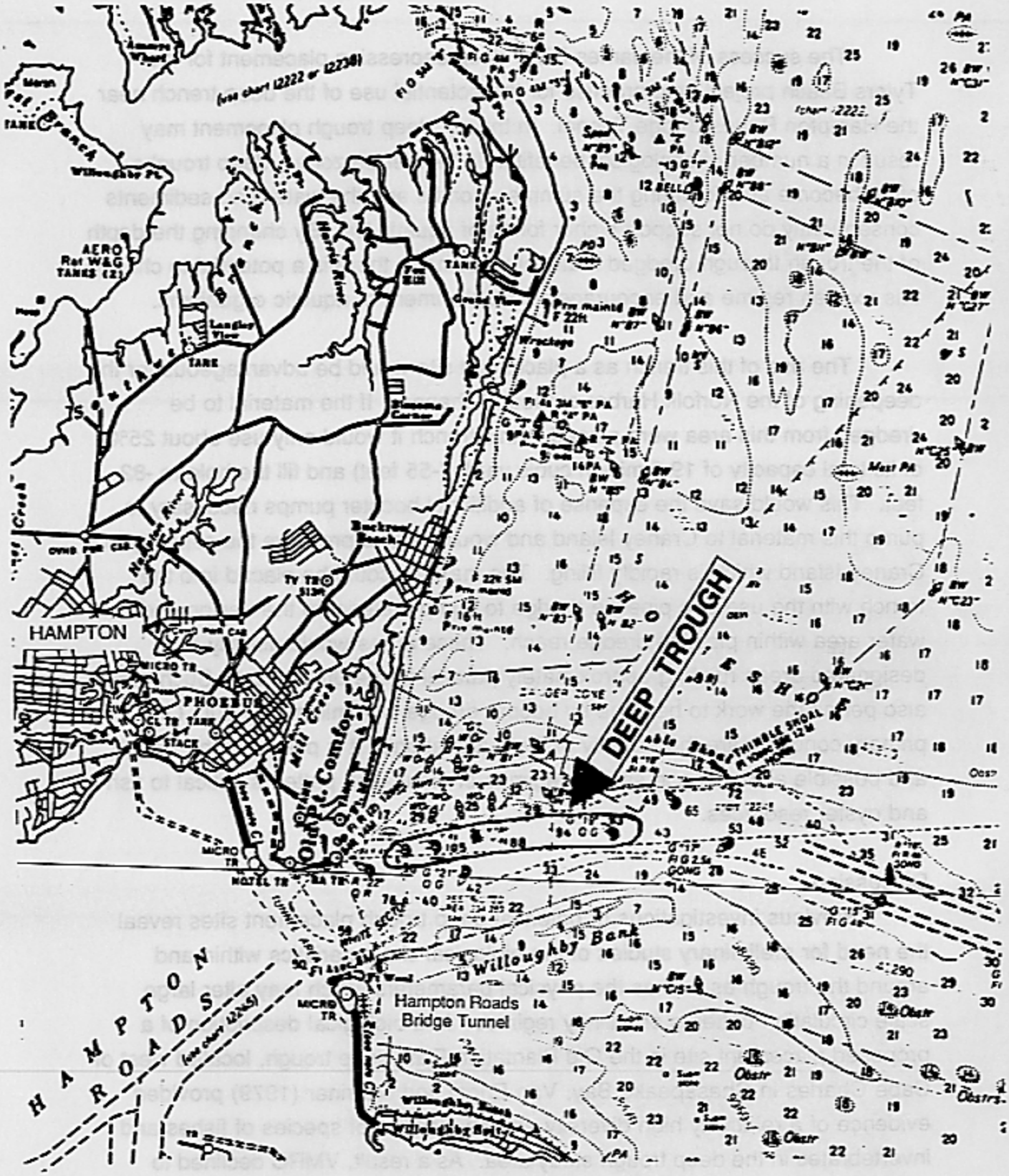

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Figure 8. Potential site for deep trough deposition of dredged material

The success of the James River deep depression placement for the Tylers Beach project held promise for the potential use of the deep trench near the Hampton Roads Bridge Tunnel. In theory, deep trough placement may result in a number of ecological benefits. In temperate zones, deep troughs often become anoxic during the summer months and the water and sediments consequently do not support higher forms of aquatic life. By changing the depth of the trough through dredged material placement, there is a potential to change this oxygen regime and encourage reestablishment of aquatic organisms.

The use of this trench as a placement site would be advantageous for the deepening of the Norfolk Harbor outbound channel. If the material to be dredged from this area were placed in this trench it would only use about 25% of its total capacity of 19.5 million cubic yards (-55 feet) and fill the hole to -82 feet. This would save the expense of additional booster pumps necessary to pump this material to Craney Island and would help to preserve the capacity of Craney Island which is rapidly filling. The material could be placed into the trench with the use of a pipeline dredge to pump material to the designated water area within pipeline dredge reach. These areas would usually be designated areas running approximately parallel to the dredge cut. Such areas also permit the work to be done by hopper dredge with minimum haul. Of primary concerns are the stability of the material once it is placed in the trough, and possible alterations in salinity regimes or circulation patterns critical to fish and oyster resources.

Discussion

Previous investigations of potential deep trough placement sites reveal the need for preliminary studies of the biological characteristics within and around the trough as well as the physical parameters which may alter large scale circulation patterns or salinity regimes. In a biological description of a proposed placement site in the Old Plantation Flats deep trough, located west of Cape Charles in Chesapeake Bay, Van Engel and Merriner (1979) provided evidence of a relatively high diversity and abundance of species of fishes and invertebrates in the deep trough study area. As a result, VMRC declined to permit filling of the Old Plantation Flats deep trough because they determined that it would adversely affect local biota. The site was not considered further as a dredged material placement site.

The Baltimore District, U.S. Army Corps of Engineers, prepared a Draft Environmental Assessment on a test placement of dredged material in a deep trough in the upper Chesapeake Bay (near Kent Island) in May, 1990. Maryland spent approximately $1 million to study placement of clean dredged material in the deep trough which is anoxic during the summer months. As a result of this seasonal anoxic condition, adverse biological impacts of placement were determined to be minimal. However, potential nutrient loading resulting from the placement of dredged materials from Craighill Channel, part of the south approach to Baltimore Harbor into Chesapeake Bay, was of significant concern. The Environmental Protection Agency ultimately rejected this proposal, on the grounds that placement of dredged material into the trough would cause an unacceptable release of nutrients. The Governor of Maryland also vetoed the plan because the additional release of nitrogen and phosphorous into the Bay would oppose the nutrient reduction goals of the Chesapeake Bay Agreement.

Literature investigations and conversations with various individuals having researched areas in the vicinity of the deep trough east of Hampton Roads bridge tunnel were conducted to determine any benthic or fisheries resources that would be impacted directly or indirectly by dredged material placement. Boesch and Rackley (1974) observed that benthic communities in the channel between Fort Wool and Old Point Comfort are depauperate and less diverse, less rich and abundant than communities in environments similar in salinity and temperature elsewhere in Hampton Roads and Chesapeake Bay. Their conclusion was that this was apparently due to instability of bottom sediments, although little is documented about currents or transport in the 90 foot trough.

In the same report on the environmental effects of the 2nd Hampton Roads bridge-tunnel construction, Boesch and Rackley indicated that the bottom area directly disturbed by the dredging activity was quickly repopulated by benthic organisms.

Birdsong et al (1983) sampled eight trawl stations in 1982 and 1983, including areas close to the proposed trough site. Greater than 87% of the total species caught were either the bay anchovy (64%) or spot (23%). The

remainder of the top five species caught at this station were weakfish, croaker, and flounder (8.5%).

Based upon these preliminary findings, there are no known "critical" resource concerns that would prevent use of the deep trough option. Resource agencies in the state have expressed concern about overwintering and migrating populations of fishes. Concerns have also been expressed by VMRC regarding the possible importance of the trough to circulation patterns as they affect conch, crab, and oyster fisheries. These concerns could be addressed more conclusively in subsequent field studies.

Equally important to evaluation of the deep trough is the question concerning the long-term fate of the deposited material. Will material placed in the trough stay there or will it be displaced by currents and eventually be redeposited in nearby navigation channels?

Limited 3-D Model - Direct observation or field measurement alone could not accurately determine if the material placed in the trough would be remain stable. Since this was one of the most important concerns related to dredged material placement in the trough, and would have to be answered before proceeding with further studies, more conclusive information was needed. The complex salinity regime of this deep trough placement alternative and the uncertainty of material stability once placed there prompted use of a limited 3-D numerical model to examine the fate of the deposited material and the feasibility of the project as an alternative for further consideration.

The model was run at the Corps Waterways Experiment Station (WES) and looked at 3-D current patterns in the trench and salinity distributions, and then a limited resolution flume-like model was built to mimic temporal and spatial scales of the prototype. All tidal and inflow boundary conditions and validation data was obtained form data produced by the USACE physical model of Chesapeake Bay in Matapeake, Maryland. Near-bottom velocities and shear stresses were developed based on the model allowing the extrapolation for erosion of the deposited material, which will infer if the placed material would remain in place or be transported out of the trough.

Results of the 3-D study indicate that the placement of dredged material would not remain stable in the trough. The area is subject to scouring and erosional forces which would prevent the material from settling in the trough even at great depths. Consequently, the site would apparently not exhibit seasonal anoxia, and the high-energy environment suggests an explanation for the depauperate benthic community. The full results of these model evaluations are found in appendix B.

Recommendations

Results of the 3-D model study conducted by WES indicate that dredged material deposited in a deep trough east of the Hampton Roads Bridge Tunnel would not remain stable. The area is subject to scouring and erosional forces which would prevent the material from settling in the trough even at great depths. Long-term placement would not be feasible without a protective armoring on the top. Based on these findings, there is reason to anticipate that material deposited in the trough could quickly be relocated in nearby navigation channels and could have more widespread impact to benthic resources in the vicinity of the trough. Although the preliminary cost estimates show that this option compares favorably with ocean placement (factor of 0.9), this may only be true in the short-term since material redeposited in nearby navigation channels would require more frequent dredging. There do not appear to be any environmentally enhancing attributes associated with placement in the trough. Because of these findings and concerns, the deep trough located east of the Hampton Roads Bridge Tunnel is not recommended as a beneficial use project for the placement of dredged materials.

ISLAND CREATION/RESTORATION

Introduction

As of 1986, over 2,000 man-made islands have been created throughout U.S. coastal waters, riverine waterways, and the Great Lakes using dredged materials. Many of these areas have become havens for fish and wildlife, and is some cases provide refuge for endangered species. The CE continues to maintain an interest in developing such islands because of its responsibility in using environmentally acceptable placement methods and sites, the increasing

shortage of upland placement sites, the need for wildlife habitats in waterway areas, and the island's recreational potential.

Recent island creations that have been extremely successful include Gaillard Island Contained Disposal Facility (CDF) in Mobile Bay, Alabama and Core Sound, North Carolina. Both of these sites have successfully created nesting areas and wetlands for waterbirds. Characteristic island isolation with fewer predators and lack of human disturbance makes them desirable as nesting grounds or stopover sites for waterfowl, shorebirds, colonial nesters, migratory birds, and various endangered and threatened bird species.

Background Information

Throughout the Chesapeake Bay, island habitats are being lost to erosion. Of the relatively few Chesapeake Bay islands remaining, most are erosional features which were formed when a peninsula was bisected, and the shoreline retreated inward, leaving the remaining landmass offshore. With much of the present Chesapeake shoreline developed, and erosional areas protected by bulkheads and revetments, fewer areas have island forming potential. Erosion is also severely impacting islands. These factors suggest that protection, and even re-creation of existing islands is becoming more critical.

In Chesapeake Bay, islands are preferred by many migratory bird species as nesting/production areas. Numerous species of wading birds, shore birds, waterfowl (including one of the North American Waterfowl Management Plan emphasis species, the American black duck), and endangered species such as the bald eagle (Haliaeetus leucocephalus), are either dependent on, or exhibit a preference toward, components which are heavily used by nesting northern diamondback terrapins (Malaclemys terrapin), as well as migratory birds. Although similar habitat conditions and vegetative communities may occur on the mainland, isolation, lack of human disturbance, and fewer predators make islands desirable. Species lists for select islands are provided by F&WS in appendix C.

Throughout the bay, island habitats are rapidly being lost to erosion. The significance of the problem can be seen by comparing historical island

acreages with present acreages on one section of Maryland's Eastern Shore - from Eastern Neck Island just north of the Chesapeake Bay Bridge, south to Barren Island located west of the Hooper Island complex. Historically (mid-1800's), this area included 35 islands with a total cumulative footprint acreage of approximately 55,500 acres. By the 1940's, 12 islands had been completely lost to erosion, and the footprint acreage of the remaining islands had been reduced to approximately 45,000 acres. More than 10,500 acres of valuable fish and wildlife habitat had been lost in less than 100 years. Much of the area lost was estuarine wetlands.

The habitat loss associated with island erosion is exacerbated by subsidence, exponential growth in human population, and urban expansion throughout Chesapeake Bay mainland areas. Living resources are more restricted in terms of potential habitat, and what habitat remains is being negatively affected. Both quality and quantity are becoming limiting habitat factors. This scenario is particularly worrisome because new islands, for the most part, are not being formed.

At present, Chesapeake Bay islands are erosional features formed when a peninsula is bisected, and the shoreline retreats inward, leaving the remaining landmass offshore. With much of the present Chesapeake shoreline developed, and erosional areas protected by bulkheads and revetments, fewer areas have island-forming potential. Of course erosion is also severely impacting islands. All of these factors suggest protection of existing islands is becoming more critical.

The 1986 North American Waterfowl Management Plan (NAWMP) sets broad goals for enhancing black duck and other waterfowl populations. One of the goals of NAWMP is to maintain the habitat value of designated areas of international significance to waterfowl. The Chesapeake Bay is a designated area. Island creation projects using dredged material offer habitat diversity (wetlands, uplands, and ponds) for migration, wintering, and production of waterfowl in compliance with the NAWMP goals.

An examination of early maps of the bay (17th, 18th, and 19th Centuries) show numerous islands at various locations throughout the bay. These islands

no longer exist. They have been destroyed by erosion probably due to sea level rise, and this has resulted in a loss of fish and wildlife habitat of substantial value. The U.S. Fish & Wildlife Service (Annapolis Field Office) has expressed interest in using dredged material for fish and wildlife habitat development, reclamation, and protection by reestablishing some of these bay islands.

F&WS is presently working with the Baltimore District to construct an island site using dredged material (Bodkin Island) in the upper bay which will provide a diversity of habitat types, including nesting for black duck.

In order to optimize positive effects to migratory birds (in terms of production habitat), the Service recommended creating islands in lieu of fringe wetland establishment (appendix C). Although similar habitat conditions and vegetative communities may occur on the mainland - isolation, lack of human disturbance, and fewer predators make islands more desirable. Islands must be sited far enough offshore to minimize predator and human intrusions from the mainland.

Screening considerations for proposed island creation sites include types of material available for island construction (e.g., finer grained silts and clays would have a greater tendency to suspend and erode), physical dynamics of the site including currents and circulation patterns, location relative to other living resources, potential disturbances as a result of island creation, potential consequences on local benthic communities and fish communities as shallow bottom would be converted to upland, the advantages of a created island for living resources and/or a combination of all other benefits (e.g., the extent to which the creation of the island would contribute to the goals set out by all parties involved and the 1987 Chesapeake Bay Agreement and other national and regional incentives).

Site selection for prospective islands were based on geographical boundaries defined as the economic hauling distance, review of existing resource information, identified resource needs for the lower Chesapeake Bay, and applicable candidate sites generated by the interagency work group. For each site, a preliminary conceptual project design was developed (or had been

previously provided) for fatal flaw analysis. The cost to implement any of the sites was not considered as an initial selection criteria.

Potential island sites considered included the James River just east of the Ragged Island Wildlife Management Area (WMA), the James River just east of the Hog Island Wildlife Management Area, the Hampton Flats area offshore of Newport News, and an area in the lower bay just east of Plum Tree Island National Wildlife Refuge (ruled out very early in the screening process due the presence of SAV's) (figure 9).

The Ragged Island and the Hog Island WMA sites island sites were evaluated in detail by F&WS (appendix C). They recommended building an island offshore of Ragged Island WMA (figure 10). It was concluded that Ragged Island had the greater potential to benefit fish and wildlife resources, due in large part to the areas surrounding it, relatively undeveloped landscape, existing fish and wildlife habitat value exhibited, and the ongoing habitat loss to erosion. Also, from a practical standpoint, the economics of transporting material upriver to Hog Island would be more expensive and not as attractive to the local sponsor.

One additional island site was evaluated by the Corps. It is located in the lower James River in Hampton Flats, just off Newport News (figure 11). This was the only island site evaluated which offered a cost savings versus ocean placement, and, while not offering the same environmental benefits as the Ragged Island site, could provide important habitat needs in the lower bay area.

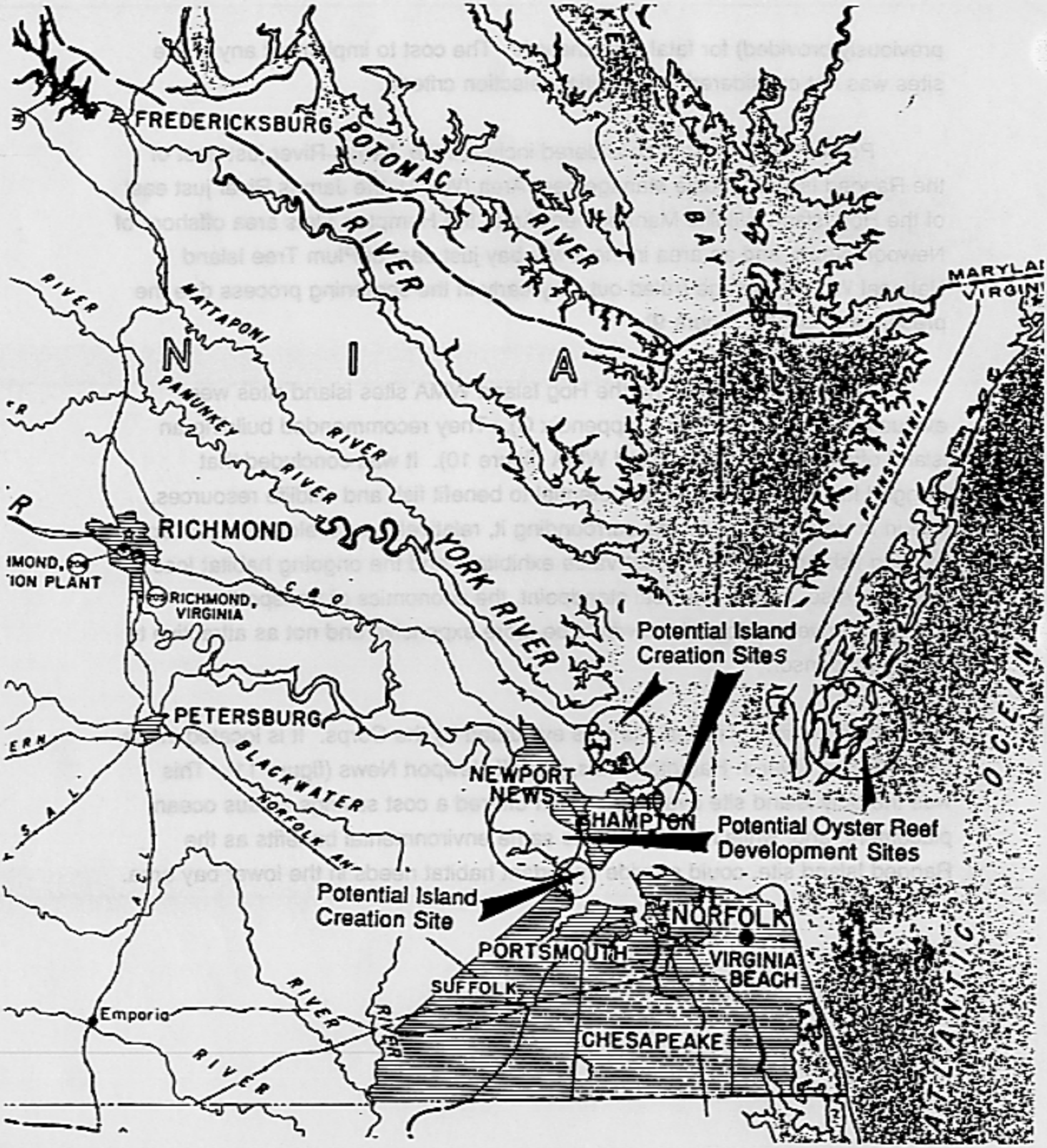

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Figure 9. Potential island creation & oyster reef restoration sites

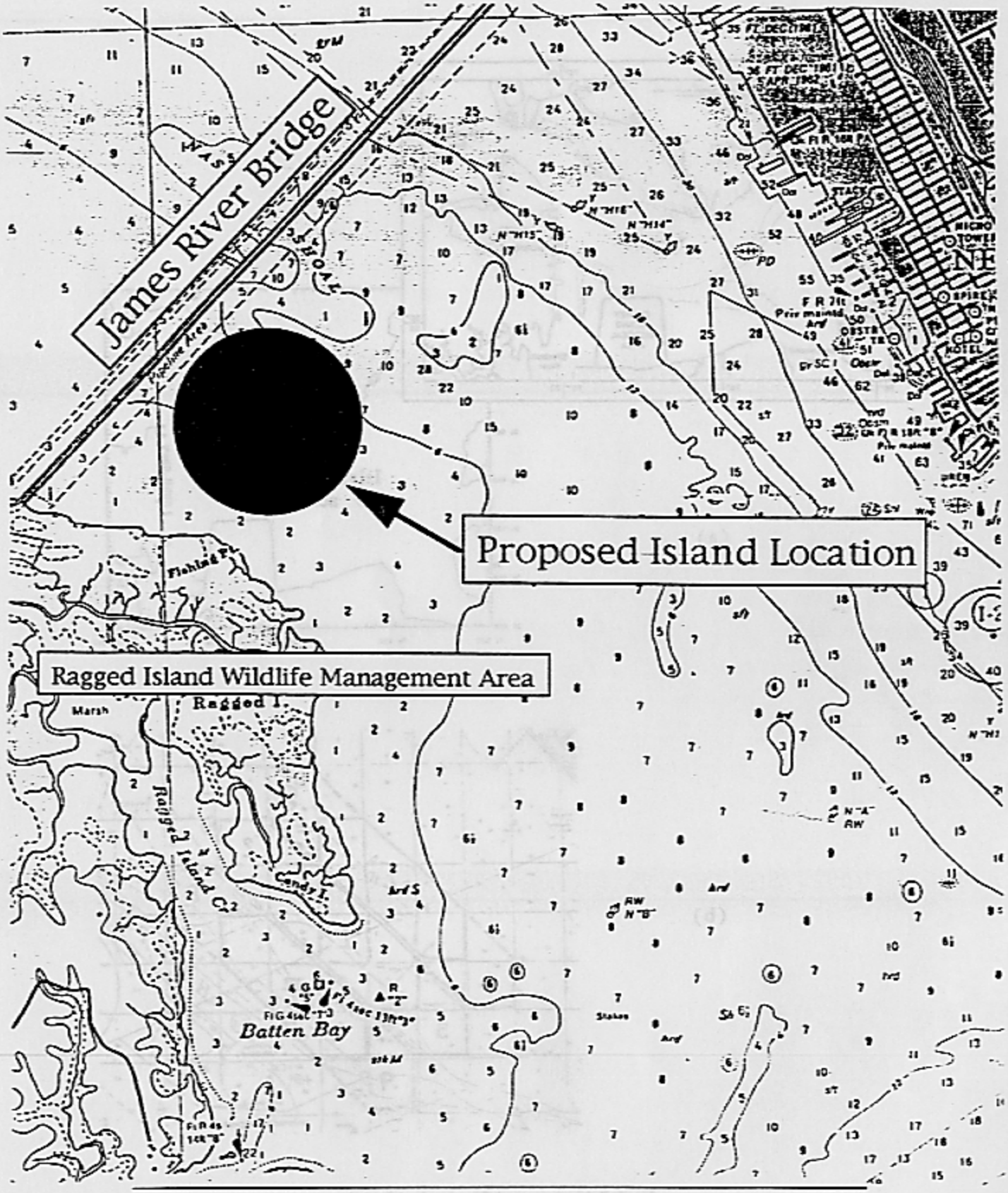

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Figure 10. Proposed island creation site - Ragged Island WMA

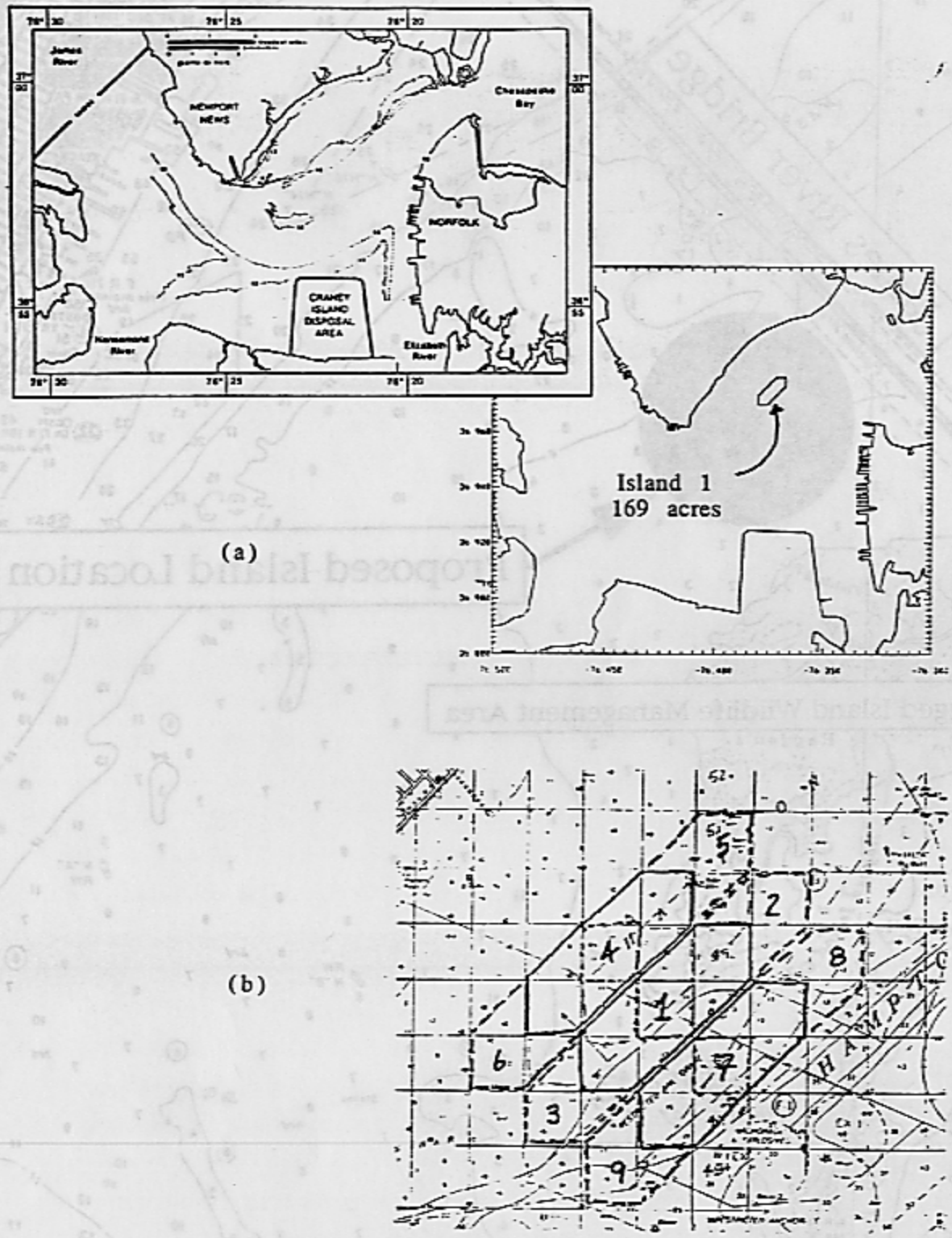

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Figure 11. Hampton Flats island proposal. (a) Island 1 shown on Hampton Flats, and (b) Model grid and location of other islands relative to Island 1.

The two prospective island sites are evaluated in the following paragraphs.

Ragged Island

Several sites were evaluated for island building by F&WS. Of all alternative beneficial use projects considered, F&WS's primary choice is island building just east of the Ragged Island WMA. The main resource concern is the displacement of some crabbers and 2 haul-seiners. However, most haul seining is done from Fishing Point, which is downriver of potential conflicts with this island proposal. Staked gill nets in the vicinity are set in deeper waters, channelward of areas being considered for island construction. Most recreational fishing is also associated with drop-offs and deeper waters, outside of shallow waters under consideration.

Waterfowl and/or shorebird use of the island would compensate for loss of aquatic habitat and benthic populations of relatively low resource value. F&WS expressed that the size of the island is not critical in creating multiple habitats. A "phased" development of the island (or islands), contingent upon successful performance of a "prototype" island, was discussed and recommended by F&WS. Initial construction of a 10-acre site could provide habitat/wetland, and waterfowl benefits. If the smaller island was successful, phased development would continue and, eventually, a larger scale island providing erosion protection and/or an embayment could be constructed. The ultimate size would be determined, in part, by the future dredged material deposition needs of VPA.

In most cases of island building, some type of containment berm would be built with the outside protected by riprap, and dredged material placed within. Initially, the containment area would be closed to tidal influences. After dewatering and dredged material consolidation, a mixture of upland, wetland (both low marsh and high marsh) and shallow water elevations would be provided by grading and sculpting. The containment berm would constitute the majority of upland habitat. Created wetland communities would be characterized by smooth cordgrass (Spartina alterniflora), saltmeadow hay (S. patens), and widgeon grass (Ruppia maritima). After site preparation and planting, the berm would be breached in several locations to open the system to

tidal inundation. Created habitats would be placed in protective public ownership, and managed for fish and wildlife resources.

A numerical model was used to evaluate the hydrodynamic effects of island creation near Ragged Island in the Lower James River. The Corps of Engineers numerical modeling system, Open-Channel Flow and Sedimentation, TABS-2 was used in this investigation. An island of approximately 300 acres was evaluated offshore of the Ragged Island WMA. The primary objectives were to assess general changes in circulation and currents in the vicinity of the island and within the James River estuary.

Based on the model results, the presence of a proposed island had no effect on the water surface elevations and only a slight effect on the local current velocities. The dominant erosional process in the vicinity of Ragged Island is by wave action. A slight increase in current velocities between the island and mainland is not expected to increase the existing shoreline erosion since wave protection provided by the created island would offset the effects of slightly increased current velocities. The full results of these model evaluations are found in appendix B.

The pros and cons associated with constructing an island at Ragged Island are found in table 3. The biggest concern with island building off Ragged Island may ultimately be economics. However, with increasing financial support of habitat restoration initiatives at national, regional and local levels, these costs may be offset by finding supplementary sources of funding. Federal agencies such as the F&WS, the National Marine Fisheries Service, and the Environmental Protection Agency are currently involved in numerous restoration projects throughout the Chesapeake Bay and tributaries. Also, as discussed in appendix D, under certain circumstances a wetland/island habitat created with dredged material may be used as a "mitigation bank" for wetland losses caused by other construction projects of the Commonwealth.

Table 3. RAGGED ISLAND WMA - ISLAND BUILDING PROS AND CONS

PROS

- Potential to create threatened/endangered species habitat (peregrine falcon, piping plover, etc.)
- Potential to offer shoreline erosion control where marsh is eroding @ 1 ft/year
- Potential to meet goals & objectives of North American Waterfowl Management Plan by providing duck overwintering, resting, breeding, and nesting habitat
- Because this (open water) habitat type, and the benthic assemblages it supports are widely distributed along the river, the proposed island site would not be deemed critical (VIMS, pers. comm.)
- Based on the conceptual Ragged Island proposal, Virginia Dept. of Game & Inland Fisheries supports the idea
- With no land connection, island would provide a habitat devoid of most predatorial species
- F&WS supports island building at Ragged Island WMA because "...it has the most potential to benefit fish and wildlife resources. This is due in large part to the areas surrounding, relatively undeveloped landscape, existing fish and wildlife habitat value exhibited, and the ongoing habitat loss to erosion."
- VIMS responded to Virginia Legislature (report dated Dec 1992, appendix E) that island development at Ragged Island may hold beneficial use potential and is worthy of further investigation.
- Results of a 2-D modeling effort to assess potential changes to sedimentation and circulation patterns from island building in lower James River indicate that there would be no significant changes.

CONS

- Given increasingly determined position of VMRC to preserve state bottom, it may be difficult to get VMRC permit to build proposed island.
- Perceptually, it may be difficult to "sell" a dredged material island to the public.
- The cost per cubic yard of building an island at Ragged Island is greater than 50% more than ocean placement. It would be necessary to identify sponsors at the Federal, state or local levels to cover some of these additional costs.
- The mitigation bank concept may not be endorsed by Federal/state agencies. Preliminary indications are that mitigation bank could only be used "as a last resort."
- The island site is located in a relatively high energy area (prevailing winds and shipping traffic). Structures for protection of the island would be necessary.

Hampton Flats Island

During 1993, VIMS conducted a model evaluation of artificial island creation alternatives in the Hampton flats area of the lower James River, Virginia for the Norfolk District. The three-dimensional character of the currents and salinity distribution in the Hampton flats and adjacent navigation channel have been shown to result in an intratidal frontal system occurring near Newport News Point at the western edge of the flats. The frontal system is postulated to be a significant mechanism for landward transport of seed oyster larvae which would otherwise leave the mouth of the James and be lost into the Chesapeake Bay. To evaluate potential impacts of artificial island creation in the Hampton flats, VIMS's general purpose three-dimensional environmental fluid dynamics modeling system, EFDC, was used to identify changes in the circulation and salinity distribution with respect to present conditions. Nine alternate locations for an approximately 250 acre, elliptical shaped, artificial island for dredge material placement were evaluated.

The analysis indicated that island locations 1-3 (figure 11) resulted in insignificant changes in the dynamics of the Newport News frontal system. Further analyses, focusing on potential large scale modifications to the circulation patterns and salinity distribution in the lower James River showed insignificant changes between the no island base case and the island 1 location. These results are consistent with those obtained for the Newport Island location C in a previous study (Byrne, et al., 1987). The primary conclusion of the VIMS study, therefore, is that construction of a 169 acre island at location 1 on the Hampton flats will not significantly effect circulation and mass transport in the lower James River. The present transport of materials, including living organisms, in the central portion of the river will remain unaltered. The primary conclusion of the frontal analysis is that construction of an island at the island 1 location will not adversely affect volumetric transport of material, including living organisms, through the frontal system upstream into the central region of the James River. The full results of the VIMS model evaluations are found in appendix B.

The Hampton Flats site is now being considered for island habitat development for waterfowl and/or shorebirds and colonial nesting birds.

Recommendations

Re-creation of islands in lower bay, replacing those lost to erosion or sea level rise, or creating new islands may provide additional spatial heterogeneity for benthic organisms, finfish, and birds - especially colonial nesters, waterfowl, and shorebirds - some of which are endangered or threatened due to anthropogenic and natural habitat depletion.

Potential island sites are available in the lower James River at both the Ragged Island WMA and Hampton Flats. Island sites offer the greatest potential for habitat development and dredged material use. Environmental impacts related to construction at the proposed sites appear to be minimal compared to the benefits to fish and wildlife that could be provided. Numerical model studies conducted for both sites indicate that island locations/configurations can be selected that would have no significant impact to circulation or sedimentation patterns in the lower James River. Cost is a factor in evaluating island creation potential. Building an island at Ragged Island would be more costly than ocean placement of the dredged material. The Hampton Flats island would be approximately equivalent to ocean placement but would not offer the same environmental benefits as the Ragged Island site. These issues would require a closer evaluation in subsequent studies.

WETLAND RESTORATION/SHORELINE STABILIZATION

Introduction

Together with its major tributaries, the Chesapeake Bay covers about 4,400 square miles of water and has 7,325 miles of shoreline. Earlier examinations have indicated that as many as 300 miles of this extensive shoreline are subject to severe erosion, with the possibility that many more miles may be of concern in the future. In some areas, the shoreline is eroding at a rate exceeding ten feet per year. While projections vary, it has been estimated that almost 45,000 acres of Chesapeake Bay shoreline (an area approximately equal to the size of Washington, D.C.) have been lost to erosion over the past century. Such erosion and storm related damages are having detrimental effects on the Bay's physical characteristics, biological productivity, water quality, commercial shipping, and recreational boating.

Wetlands may protect shorelines from erosion by the ability of wetland plants to reduce wave energy. Various researchers have compared storm damage to areas with and without salt marshes and concluded that the areas with salt marshes received relatively less storm damage. Different wetland plant species can reduce wave heights and energy.

The Corps of Engineers Dredged Material Research Program (DMRP) has demonstrated that wetlands can be created or improved using dredged material to stabilize eroding shorelines. Dredged material acts as a substrate which can be placed in shallow water, built up to proper elevation, and planted or seeded with wetland plants, including submerged aquatic vegetation (SAV). Wetland development using dredged material has been tried and proven in many Corps Districts (including Norfolk) and, with proper investigation, offers potential for habitat enhancement and shoreline protection in the bay environs.

Background Information

Between 1974 and 1985, more than 21,000 acres of fresh, brackish, and salt marsh wetlands (106 sites) have been created with dredged material by the Corps of Engineers. Many have achieved a high percentage of the values and functions provided by natural wetlands. Where wetlands are being lost to erosion and subsidence in the lower bay there is potential to reclaim these lost wetlands and provide shoreline stabilization using a combination of dredged material, wetland plants, and/or fixed structures. By far the most difficult aspect of the application of marsh development is location of suitable sites. Low energy, shallow-water sites are most attractive; however, cost factors become significant if long transport distances are necessary to reach low energy sites. Temporary protective structures may be required if low energy sites cannot be located. Such structures have been successful at several Gulf coast sites where moderate wave energy occurs. In high energy situations, perpetuation of the marsh may require planned periodic maintenance of protective structures and possibly periodic replanting.

Discussion

The creation of a marsh would come at the expense of shallow water habitat, which is considered ecologically valuable in its own right. Shallow waters provide nursery and adult feeding habitat for a variety of fishes. They

may also be used by waterfowl, shorebirds, wading birds and others. The may have significant benthic resources, including some of commercial importance such as oyster or clams. The presence of submerged aquatic vegetation with its high ecological value would be another reason that would discourage marsh creation.

Another limitation of marsh creation is that created sites generally cannot be used for dredged material placement more than once. This is an important factor considering that most dredged material in the harbor comes from projects which require regular maintenance.

Nevertheless, marsh creation with dredged material can be a good alternative - particularly in areas where there have been declines in native marshes which may have resulted from either natural or man-made causes, and where marsh creation could be viewed as offsetting some of these historical losses.

Marsh creation may also be desirable in areas where reducing the erosion rate of an existing productive marsh or upland habitat is an important objective. In higher energy areas a combination of a fixed breakwater and marsh may be used for erosion control purposes. Artificial marsh barriers may also be beneficial in fortifying natural embayments where breaches threaten to disrupt the sheltered areas behind them.

The Virginia Institute of Marine Science (VIMS) report entitled "Shoreline Erosion in Tidewater Virginia" (Special Report No. 111) was used to identify marsh (and some beach) areas where erosion has resulted in the loss of substantial acreage and where it may be feasible to provide shoreline restoration and stabilization using dredged material with wetland plants, riprap, breakwaters, or some combination of these features.

For the initial screening, eroding shorelines within the geographical hauling distance (figure 3) were identified as candidate wetland restoration sites. These included:

James River (figure 12)

- Ragged Island Wildlife Management Area
  (8.8 miles of shoreline, 227.3 acres lost over ~100 years)

- Hog Island Wildlife Management Area
  (6 miles of shoreline, 107 acres lost over ~100 years)

- Days Point

- Mulberry Island
  (4.4 miles of shoreline, 104.6 acres lost over ~100 years)

York River (figures 13 and 14)

- Goodwin Island
  (7.8 miles of shoreline, 103.2 acres lost over ~100 years)

- New Point Comfort

- Rigby Island
  (6.3 miles of shoreline, 119 acres lost over ~100 years)

York County (figure 15)

- Plumtree Island National Wildlife Refuge/Back River
  (8.7 miles of shoreline, 125.4 acres lost over ~100 years)

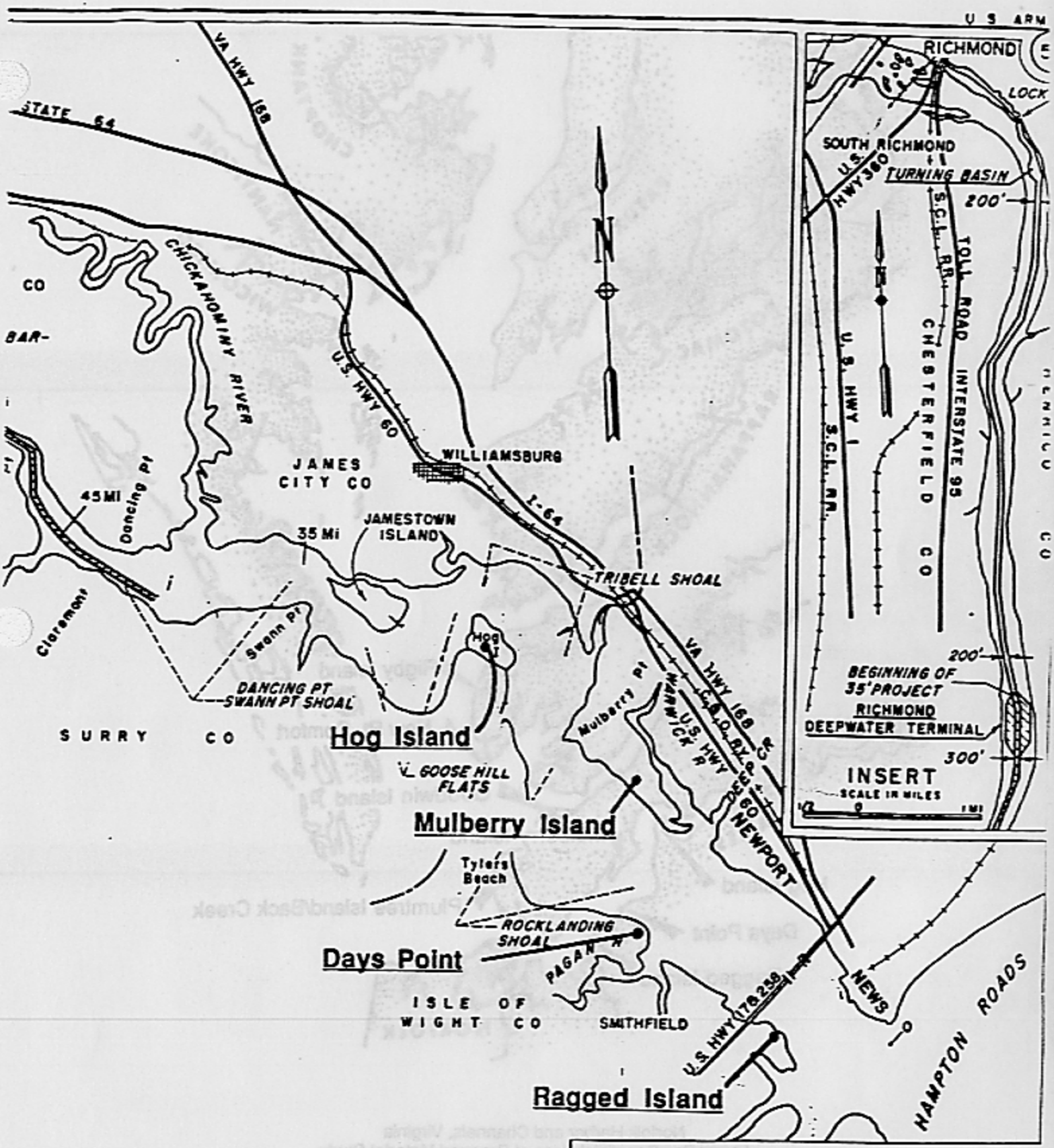

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Figure 12. Proposed wetland restoration sites James River

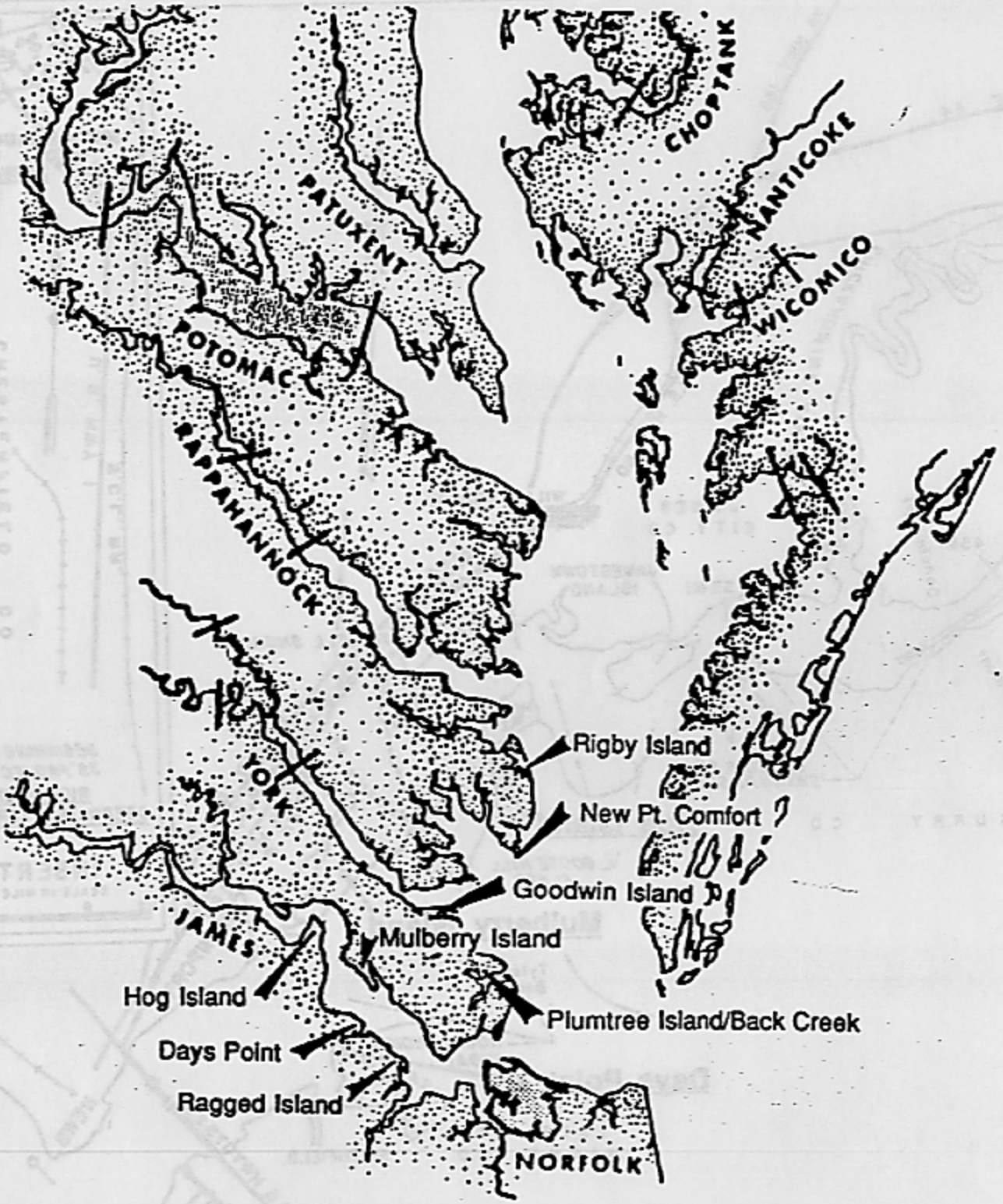

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Figure 13. Proposed wetland restoration sites James River & York River

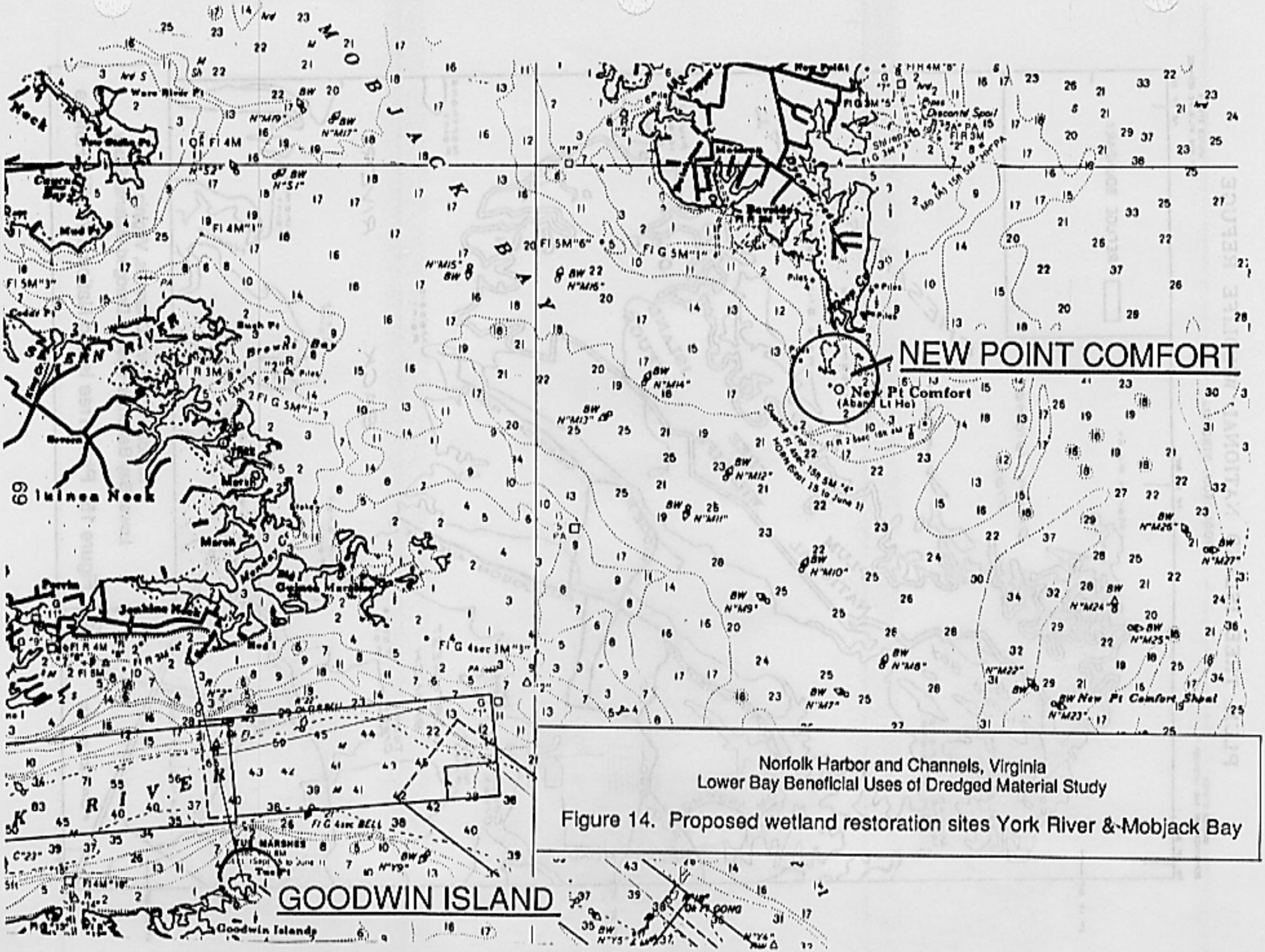

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Figure 14. Proposed wetland restoration sites York River & Mobjack Bay

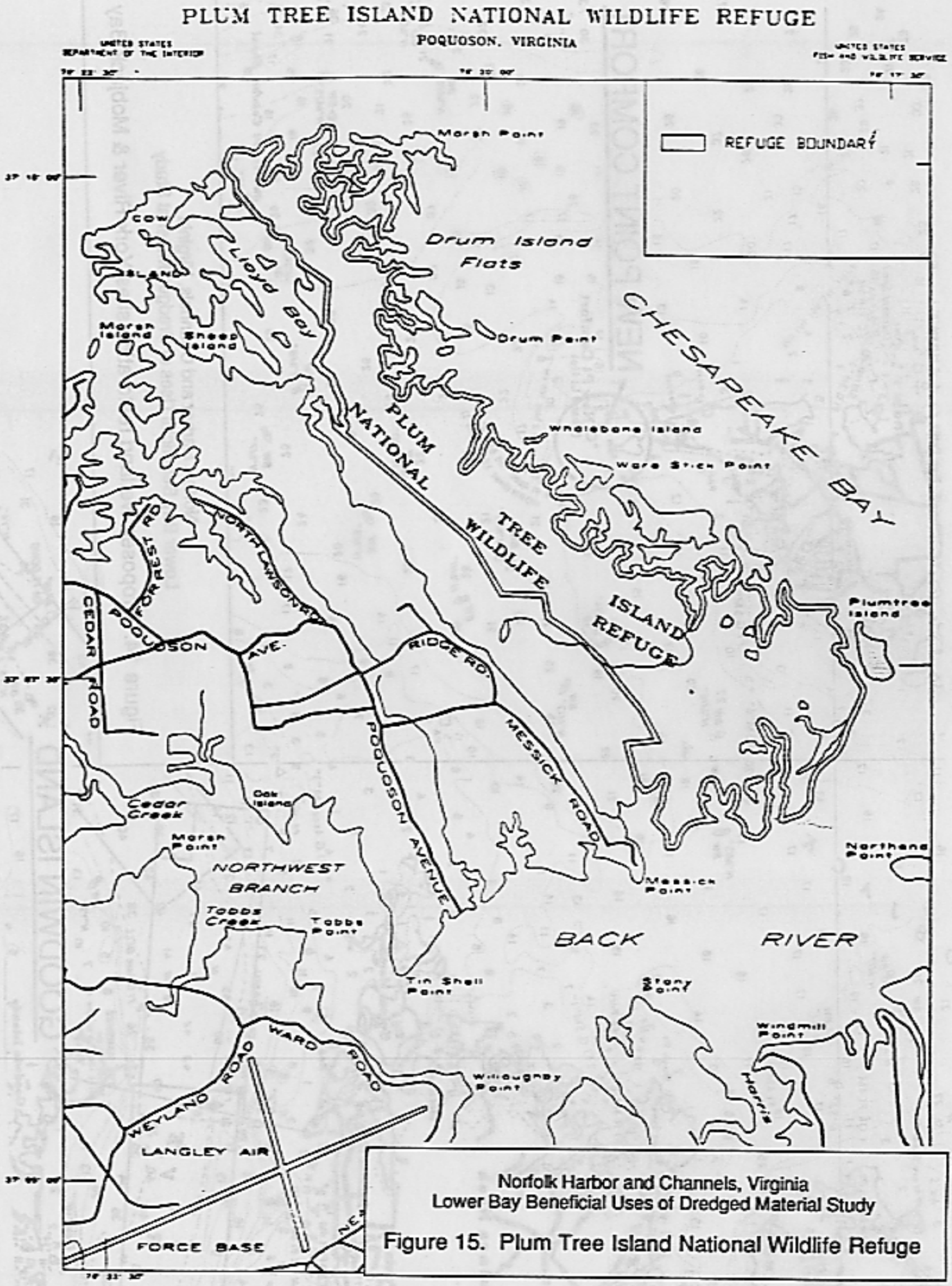

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Figure 15. Plum Tree Island National Wildlife Refuge

Specific projects for wetland restoration and enhancement, for shoreline erosion control and habitat for living resources suggested by the interagency workgroup and F&WS included:

1. Wetland creation and erosion control at the western side of the eastern shore approach causeway to the Chesapeake Bay Bridge Tunnel.

2. Fisherman Island NWR wetland/habitat creation and erosion control.

3. Plum Tree Island NWR wetland/habitat creation and erosion control.

4. Ragged Island Wildlife Management Area (WMA) wetland/habitat creation and erosion control.

5. Hog Island WMA wetland/habitat creation and erosion control.

6. Wetland creation adjacent to Craney Island Dredged Material Management Area.

7. Wetland creation and erosion control on the West side of Watts Island.

8. Wetland /habitat creation at the previously use beneficial uses site off Windmill Point.

Following initial evaluation/screening of the suggested sites, F&WS more closely examined 4 candidate wetland restoration sites (F&WS Report 1992, appendix C). These included: (1) fringe wetland creation around CIMA; (2) Ragged Island Wildlife Management Area Wetland/habitat construction and erosion control; (3) Mulberry Island wetland /habitat construction and erosion control; (4) Hog Island Wildlife Management Area wetland/habitat construction and erosion control. As mentioned under the island concept proposals, Hog Island is on the outer extremity of the economic hauling distance, would be more expensive, and therefore is not as attractive as other candidate sites.

Of the four considered, the Craney Island and Ragged Island conceptual proposals were favored by F&WS as they appeared to minimize resource trade-

offs. In addition, these sites were relatively close to the proposed sources of dredged material. The Ragged Island proposal was recommended as an island creation/wetland restoration project discussed previously to have the most potential to benefit fish and wildlife resources, and the habitats on which they depend. The rationale used to evaluate the candidate wetland creation sites is discussed in the following paragraphs.

Craney Island Management Area (figure 16)

Millions of tons of dredged material are removed from the Hampton Roads Channels every year and placed in Craney Island Management Area (CIMA). CIMA has been in continuous use since construction in the mid-1950's. The placement area is a 2,500 acre confined dredged material facility located in Portsmouth, Virginia.

The concept of a fringe wetland creation adjacent to the existing facility was evaluated by F&WS. The concept assumes limited dredged material placement capacity because of the relatively narrow fringe of wetland constructed. The design objective is to provide some fish and wildlife habitat, while creating an aesthetically-pleasing buffer around the site. An additional benefit could come from the nutrient/contaminant uptake capability of a created wetland. F&WS favors this proposal, however they have expressed concern about attracting wildlife to a site holding contaminated dredged material.

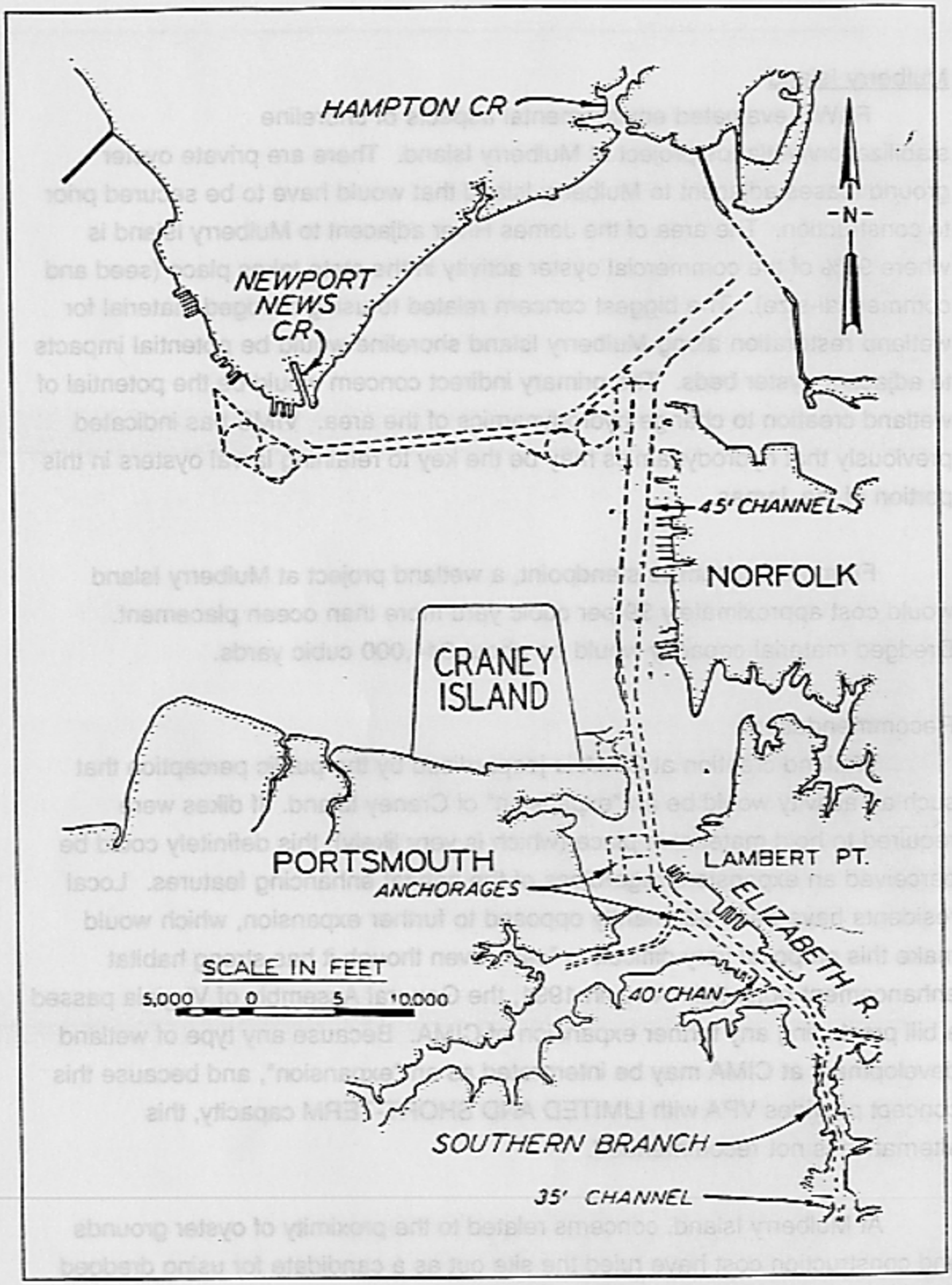

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Figure 16. Craney Island Dredged Material Management Area

Mulberry Island

F&WS evaluated environmental aspects of shoreline stabilization/wetlands project at Mulberry Island. There are private oyster ground leases adjacent to Mulberry Island that would have to be secured prior to construction. The area of the James River adjacent to Mulberry Island is where 95% of the commercial oyster activity in the state takes place (seed and commercial-size). The biggest concern related to using dredged material for wetland restoration along Mulberry Island shoreline would be potential impacts to adjacent oyster beds. The primary indirect concern would be the potential of wetland creation to change hydrodynamics of the area. VIMS has indicated previously that hydrodynamics may be the key to retaining larval oysters in this portion of the James.

From an economics standpoint, a wetland project at Mulberry Island would cost approximately $9 per cubic yard more than ocean placement. Dredged material capacity would be about 344,000 cubic yards.

Recommendations

Wetland creation at CIMA is jeopardized by the public perception that such an activity would be an "expansion" of Craney Island. If dikes were required to hold material in place (which is very likely), this definitely could be perceived an expansion, regardless of the habitat enhancing features. Local residents have been adamantly opposed to further expansion, which would make this proposal very difficult to "sell", even though it has strong habitat enhancement potential. Also, in 1991, the General Assembly of Virginia passed a bill precluding any further expansion of CIMA. Because any type of wetland development at CIMA may be interpreted as an "expansion", and because this concept provides VPA with LIMITED AND SHORT-TERM capacity, this alternative is not recommended.

At Mulberry Island, concerns related to the proximity of oyster grounds and construction cost have ruled the site out as a candidate for using dredged material for wetland creation/erosion control.

MITIGATION BANKING

Mitigation banking is a form of compensatory mitigation used to address activities having a negative impact on wetlands and would be one way that the Commonwealth could offset increased costs of using dredged material to build islands/wetlands. Section 404(b)(1) Guidelines of the Clean Water Act present a set of environmental standards and criteria to be addressed before permits for wetland impacts are granted. The guidelines allow compensatory mitigation only after an analysis of all practical alternatives in order to, primarily, avoid the impact or, at second best, to minimize the impact. Mitigation can occur through restoration of a historic, but non-functional, wetland, through creation of a wetland from upland or through the enhancement of certain functions of a degraded wetland. Whenever possible, up-front, on-site, in-kind mitigation is preferable. Up-front mitigation ensures that the wetland is functioning at targeted levels before the proposed impact begins. On-site and in-kind mitigation is designed to reduce the loss of specific wetland types and functions that are unique and ecologically valuable to the local landscape. Mitigation banking is intended to aggregate smaller wetland impacts by restoring, creating or enhancing larger wetland mitigation bank sites. By its nature, mitigation banking is an off-site but up-front form of mitigation that may or may not be in-kind. Mitigation banking and its application to this beneficial uses investigation is discussed in detail in appendix D.

FUTURE EVALUATIONS

In order to proceed to construction of either or both of the proposed islands sites, additional work would need to be accomplished. Figure 17 (adapted from VIMS, 1992) depicts the generalized environmental review process required for beneficial uses of dredged material in waters of the United States.

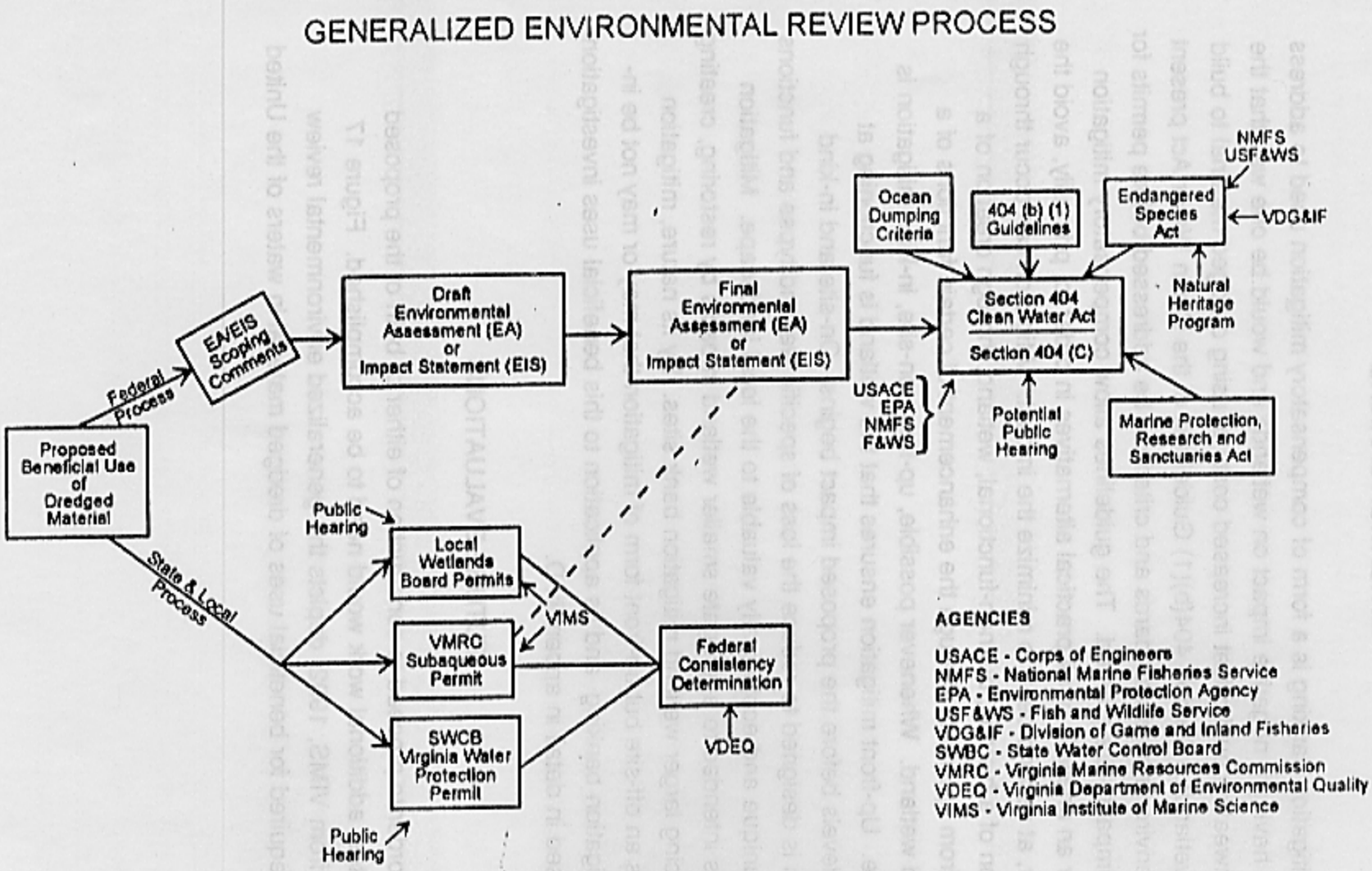

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Figure 17. Typical environmental review process
(from VIMS, 1992)

The outline which follows represents studies required to develop plans, construct, and monitor a project such as the Ragged Island or Hampton Flats island beneficial use proposals. This outline was presented in the F&WS 1992 report (appendix C) and was developed by a multiagency team working with the Corps of Engineers, Baltimore District on the Poplar Island (dredged material island) concept proposal in Maryland.

I. Engineering

- Bathymetric/topographic surveying and mapping
- Coastal Engineering
- Geotechnical engineering
- Design requirements
- Cost estimates
- Identify critical path of activities and sequencing to accomplish first/demonstration project

II. Environmental

- Coordinate with appropriate agencies/groups
- Review existing baseline information
- Collect field baseline information for data gaps in existing information
- Determine time-of-year restrictions for construction
- Conduct preliminary hazardous and toxic waste site assessment
- Assess existing habitat value
- Develop habitat design/enhancement plan
- Develop monitoring plan
- Describe future with and without project conditions
- Assess post-construction habitat value
- Develop environmental mitigation plan

III. Cultural

- Coordinate with appropriate agencies/groups
- Perform Phase I literature search, site file search, and field survey (if required)
- Assess impacts (Finding of Effects)
- Prepare Section 106 Report/MOA

IV. Benefit Analysis

- Establish baseline conditions for project area
- Determine commercial and recreational users
- Determine living resources benefits
- Determine water quality benefits
- Determine impact(s) on commercial and recreational users

V. Plan Formulation (for both demonstration and long-term)

- Formulate alternatives
- Establish evaluation criteria
- Analyze alternatives (comparison matrix)
- Select preferred alternative

VI. Demographics

- Determine current use

VII. Real Estate

- Determine ownership
- Secure land easement, ownership, and rights-of-way

VIII. Risk Assessment

- Assess and quantify containment failure consequences
- Determine non-targeted consequences (cumulative loss of small amounts of contained material)
- Determine other

IX. Public Involvement

- Designate lead for coordination
- Hold public hearings
- Develop program for public education

X. Study Management

- Develop funding and task schedule for feasibility study
- Schedule development of demonstration project and long term project
- Identify critical path sequence
- Assign tasks and monitor progress of tasks
- Convene meetings as required

XI. Report Preparation

- Prepare main report/integrated NEAP document
- Prepare Notice of Intent
- Prepare Record of Decision
- Prepare Notice of Availability
- Prepare DEIS/FEIS
- Prepare Finding of No Significant Impact (for EA, if applicable)

Any future studies will conform to and be fully compatible with the regulations on Project Management (ER 5-7-1), Planning Guidance (ER 1105-2-100), Engineering for Civil Works Projects (ER 1110-2-265 9 (draft)), Plans and Specifications (ER 1110-2-1200), the National Environmental Policy Act of 1969, as amended (NEPA), the Clean Water Act, 33 U.S.C. 1344, the Fish and Wildlife Coordination Act, 16 U.S.C. 661 et seq., and other applicable environmental laws and regulations. A Beneficial Uses Engineer Manual (EM 1110-2-5026) was published in June 1987 and provides "how to" guidance for planning, designing, developing, and managing dredged material beneficial use projects. This EM has wide-ranging application to this study and will be used to the greatest extent possible.

SUMMARY AND CONCLUSIONS

A multi-agency workgroup and the F&WS participated with the Corps in extensive evaluations to arrive at recommended dredged material beneficial use alternatives for Norfolk Harbor and Channels. Numerous and wide-ranging alternatives were given consideration. A preliminary screening process was accomplished to identify those projects having the greatest potential to succeed from environmental, economic, and engineering perspectives. While

environmental considerations or "fatal flaws" rule out some alternatives, cost is identified as a major consideration with beneficial use projects. Some of the alternatives considered were more than twice the cost of ocean placement. One method of offsetting these costs would be to use wetlands, islands, or other created habitats as compensatory "mitigation banks" for habitats lost or altered by construction activities of the Commonwealth. There would be specific limitations to the scope and applicability of such banks but they may offer some cost-effective beneficial alternatives compared to some other forms of compensatory mitigation, especially those which involve land acquistion.

Detailed discussions of seven potential beneficial use alternatives are presented in this report in order to allow the Commonwealth and VPA to see how the beneficial use recommendations were arrived at. The screening rationale presented is particularly important since changing economic, environmental, or other extenuating conditions may (in the future) shed more favorable light on beneficial use alternatives which were rejected at this time. In this sense, periodic review of this document would be important to "re-evaluate" the beneficial use options for future applicability as part of a long-term dredged material management strategy.

Based upon detailed environmental and economic evaluations of all alternatives, two were selected as options which could be constructed at a cost savings or reasonable additional cost to provide environmental benefits compared to placement of dredged material in the ocean. These are island building in Hampton Roads Harbor at Hampton Flats off Newport News and island development in the lower James River offshore of the Ragged Island WMA.

Of the all the beneficial uses options reviewed, creation of islands offers the greatest potential for habitat restoration/enhancement, in some cases at costs equivalent to ocean placement, and the potential for using the largest volume of dredged material per unit area. While substantial volumes of dredged material can be used to construct islands, island building has finite applicability and is only a complementary part of a long-term solution for dredged material placement for the Port of Hampton Roads. Other management strategies, such as continued intensive management of Craney

Island and ocean placement of suitable dredged material with restriction of Craney Island for unsuitable material, should also be pursued as part of a comprehensive long-term dredged material management strategy.

As recommended in the companion document to this report, the Final Supplement for Long-Term Dredged Material Management for the Inner Harbor, additional work will be necessary in order to implement a long-term dredged material management strategy for the Port of Hampton Roads. Solving the remaining issues will require the close attention and commitment of both the Commonwealth of Virginia and the Federal Government until a clear and acceptable plan is agreed upon and implemented.

REFERENCES

Byrne, Robert J. et. al., 1987, Newport Island: An Evaluation of Potential Impacts on Marine Resources of the Lower James River and Hampton Roads, Special Report in Applied Marine Science and Ocean Engineering No. 283, Virginia Institute of Marine Science

Baltimore District, U.S. Army Corps of Engineers. May, 1990. Draft Environmental Assessment, test placement of dredged material in the deep trough of the Chesapeake Bay.

Birdsong, R.L., et. al. 1983. Fin fish seasonality and utilization of Hampton Roads and the entrance channel. Old Dominion University for U.S. Army Corps of Engineers, Norfolk District.

Boesch, D.F. 1973. Classification and community structure of macrobenthos in the Hampton Roads area, Virginia: Marine Biology 21, 226-244.

Boesch, D.F. 1971. Distribution and structure of benthic communities in a gradient estuary: Ph.D. dissertation at VIMS, Marvin L. Wass, Chairman.

Boon, John D. III. 1975. Report on environmental effects of the 2nd Hampton Roads bridge-tunnel construction. Sediment distributions and bottom characteristics. VIMS Pub. (GC 380, B7)

Brush, E.R. 1978. The relationship of bottom sediments to the current-generated topography on Crumps Bank and Willoughby Bank, southern Chesapeake Bay, Virginia: Dept. of Ocean., ODU, Norfolk, Va. MS Thesis, 94 p.

Chittenden, M.E., Jr. 1989. Final report on "Initiation of trawl surveys for a cooperative research/assessment program in Chesapeake Bay. VIMS report.

Ewing, R.M., D.M. Dauer 1982. Macrobenthic communities of lower Chesapeake Bay. Kings Creek, Cherrystone Inlet and adjacent offshore areas. Int. Rev. Gestamen Hydrobiol 67(6).

Feigenbaum, D. and C. Blair. 1986. Artificial Reef Study, Final Report, ODU Dept. of Oceanography for VMRC.

Hobbs, C.H. III and Linda C. Schaffner. 1990. Geological and benthic evaluation of sand resources in the lower Chesapeake Bay. Report 2: Tail of the Horseshoe. Final Report to the Council on the Environment, Va. Coastal Res. Mgmt. Program. VIMS Report.

Jacobs, F. 1978. Zooplankton distribution, biomass, biochemical composition and seasonal community structure in lower Ches. Bay: Dissertation UVA, Geo. C. Grant, Chairman.

Lucy, Jon and Charles Barr. Sept. 1989. Development and implementation of a catch and effort data collection system for monitoring trends in fishing success on Virginia's artificial fishing reefs, 1987-1988. Project Completion Report, Year 2, Wallop-Breaux Project No. F-63-R

Ludwick, J.C. 1979. An analysis of bathymetric change in lower Ches. Bay. Corps Technical Rpt. #39, Contract DACW65-79-M-1172.

Ludwick, J.C. 1981. Bottom sediments and depositional rates near Thimble Shoal Channel, lower Ches. Bay, Va. Geol. Soc. Am. Bull., Part 1, Vol. 92, 496 - 506.

Mayne, K. L., 1986. U.S. Fish and Wildlife Service planning aid report, York and Pamunkey Rivers, Virginia. Prepared for U.S. Army Corps of Engineers, Norfolk District.

Meyers, T.E., Gibson, A.C., Dardeau, E.A., Schroeder, P.R., and T.D. Stark. 1993. Management plan for the disposal of contaminated material in the Craney Island Dredged Material Management Area. Technical Report EL-93-20, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M.R., Shields, F.D. and D.F. Hayes. 1981. Development of a management plan for Craney Island Disposal Area. Technical Report EL-81-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Pers. Conversation with Jon Lucy, VIMS. Nov. 27, 1991.

Pers. Conversation with Frank Steimle, Northeast Fisheries Center, Sandy Hook, N.J. Apr. 26, 1991.

Rhoads, Donald C., Peter McCall and J. Yingst. 1978. Disturbance and production on the estuarine seafloor. American Scientist, Vol. 66, 577-586.

Schaffner, Linda C. and Robert J. Diaz. 1988. Distribution and Abundance of Overwintering Blue Crabs, Callinectes sapidus, in the Lower Chesapeake Bay. Estuaries, Vol. 11, No. 1, p. 68-72.

Van Engel, W.A. 1958. The Blue crab and its fishery in the Chesapeake Bay. Part 1 - reproduction, early development, growth and migration. Commercial Fisheries Review 20: 6-17.

Van Engel, W.A. 1962. The blue crab and its fishery in Chesapeake Bay. Commercial Fisheries. Part II: Types of gear for hard crab fishing. Commercial Fisheries Review 24: 1-10.

Van Engel, W.A. 1962. The Blue crab and its fishery in Chesapeake Bay. Part 2. Types of gear for hard crab fishing. Comm Fish Rev 24(9) 1-10.

Van Engel, W.A., and J.V. Merriner. 1979. Biological description of old plantation flats deep trough: a proposed dredged material placement site. VIMS report to U.S. Army Corps of Engineers.

Virginia Institute of Marine Science. 1992. Beneficial uses of dredged material in Hampton Roads, Virginia. A report to the Governor and General Assembly of Virginia.

OYSTER REEFS

Barber, Bruce J. and Roger Mann. 1991. Estimation of standing stock of oysters in James River, Virginia using commercial fishing records. VIMS Special Report #310.
-Craig summary

Meyer,--1991. A battle in the Bay. Audobon 93:25-27.

Joyce,--1988. The scourge of the bivalve. New Scientist 117:56-59.

Hargis, William J. 1991. Virginia Institute of Marine Science, personal communication. 1991.

Roegner, G.C. and R. Mann. 1990. Settlement patterns of Crassostrea virginica (Gmelin, 1971) larvae in relation to tidal zonation. J. Shellfish Res. 9:341-346.

Krantz, G.E. and D.W. Merritt. 1977. An analysis of trends in oyster spat set in the Maryland portion of Chesapeake Bay. Proceedings of the National Shellfish Association. 67:53-59.

Barber, --, Mann,--, Walker, --, and Whitcomb. 1990. Settlement of oysters in oyster shell --- J. Shellfish Research. 9:173-175.

DEEP TROUGH

Cerrato, R.M. and H.J. Bokuniewicz. 1987. Innovative uses of dredged material: The benefits of subaqueous borrowpits as disposal sites. USACE Proceedings of the North Atlantic Regional Conference of Beneficial Uses of Dredged material pp 177-182.

Van Engel, W.A. and J.V. Merriner. 1979. Biological description of Old Plantation Flats deep trough: a proposed dredged material disposal site. Interim report, Virginia Institute of Marine Science.

Boesch,-- and Rackley. 1974. Environmental effects of the second Hampton Roads Bridge Tunnel construction to the Virginia Department of Highways.
-Craig summary.

Birdsong, R.S., R.L. Bedenbaugh, and R.D. Owen. 1983. Fin fish seasonality and utilization of Hampton Roads and the entrance channel. Report for USACE, Norfolk District.

Boon, J.D. III. 1975. Report on environmental effects of the 2nd Hampton Roads Bridge Tunnel construction. Sediment distributions and bottom characteristics. VIMS publication #GC 380.B7.

Ludwick, J.C. 1979. An analysis of bathymetric change in lower Chesapeake Bay. Corps Technical Report #39. Contract DACW 65-79-M-1172.

Ludwick, J.C. 1981. Bottom sediments and depostional rates near Thimble Shoal Channel, lower Chesapeake Bay, Virginia. Geol. Soc. Am. Bull. Part 1. 92:496-506.

THIN LAYERING

Atkin, David. 1988. Environmental aspects of cutter-suction dredging and "thin layer" disposal. Report for USACE, Norfolk District by the Advanced Technology Department, Parsons, Brinckerhoff, Quade and Doulas, Inc.

USACE. 1992. Navigation study of York River Entrance Channel. USACE, Norfolk District. Final detailed project report and environmental assessment. -get final report from Wolf Trap monitoring from Linda Schaffner, VIMS.

Rhoads, D.C., P. McCall, and J. Yingst. 1978. Disturbance and production in the estuarine seafloor. Am. Scientist. 66:577-586.

Odum, E.P. 1969. The strategy of ecosystem development. Science. 16:262-270.

Van Engel, W.A. 1962. The blue crab and its fishery in Chesapeake Bay, part 2. Types of gear for hand crab fishing. Comm. Fish. Rev. 24:1-10.

Mayne, K.L. 1986. USF&W service planning aid report, York and Pamunkey Rivers, Virginia. Prepared for USACE, Norfolk District.

Schaffner, L.C. and R.J. Diaz. 1988. Distribution and abundance of overwintering blue crabs, *Caleinectes sapidus*, in the lower Chesapeake Bay. Estuaries. 11:68-72.

Hobbs, C.H. III, and L.C. Schaffner. 1990. Geological and benthic evaluation of sand resources in the lower Chesapeake Bay. Report 2: Tail of Horseshoe, Final report to the Council on the Environment, Virgnia Coastal Research Management Program. VIMS Report.

Van Engel, W.A. 1958. The blue crab and its fishery in the Chesapeake Bay. Part 1: Reproduction, early development, growth, and migration. Comm. Fish. Rev. 20:6-17.

Chittenden, M.E., Jr. 1989. Final report on the initiation of trawl surveys for a cooperative research/assessment program in Chesapeake Bay. VIMS report.

APPENDIX A

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note: the Council on the Environment and the State Water Control Board are now part of the Department of Environmental Quality (DEQ)

APPENDIX B

MODEL EVALUATIONS:

DEEP TROUGH

HAMPTON FLATS ISLAND

RAGGED ISLAND

Miscellaneous Paper HL-94-
May 1994

James River Deep Trough Disposal Study

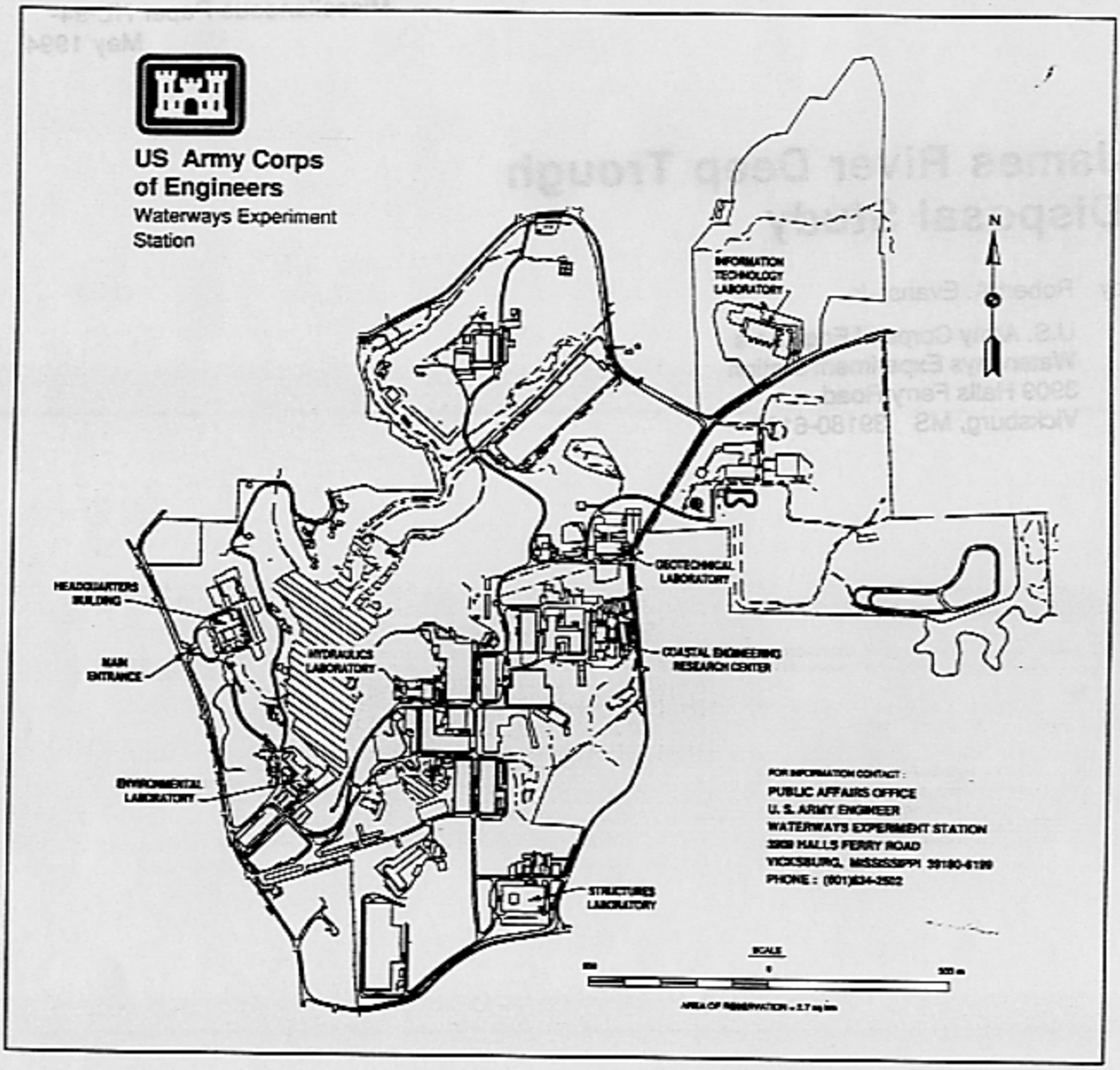
by Robert A. Evans, Jr.

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Engineer District, Norfolk
Norfolk, VA 23510-1096


US Army Corps
of Engineers
Waterways Experiment
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RESEARCH CENTER
ENVIRONMENTAL
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LABORATORY
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SCALE
AREA OF RESERVATION = 2.7 sq km

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Preface

The work herein was performed in the Hydraulics Laboratory of the U.S. Army Engineer Waterways Experiment Station (WES) as part of an investigation into sediment disposal in the James River for the U.S. Army Engineer District, Norfolk (NAO). This report presents the results of the three-dimensional numerical modeling work.

The work was conducted from November 1992 to April 1993 under the direction of the following personnel: Messrs. F. A. Herrmann, Jr., Chief of the Hydraulics Laboratory; R. A. Sager, Assistant Chief of the Hydraulics Laboratory; W. H. McAnally, Chief of the Estuaries Division, Hydraulics Laboratory; D. R. Richards, Chief of the Estuarine Simulation Branch, Estuaries Division; and Project Manager R. A. Evans, Jr., Estuarine Simulation Branch.

Mr. Evans prepared this report, and Messrs. Richards and McAnally, and Dr. R. C. Berger, Estuaries Division, assisted in the analysis of the results.

Mr. Mark Hudgins, NAO, served as the District's project coordinator.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

1 Introduction

Objective

Several dredged material disposal alternatives are being investigated by the Norfolk District (CENAO) for the Lower James River. They include, but are not limited to: (1) offshore disposal, (2) creation of wetland disposal islands, and (3) disposal into the deep trough at the entrance of the James River. CENAO has a thorough knowledge of offshore disposal issues and is currently conducting in-house investigations into the wetland island disposal alternatives. The third option, deep trough disposal, is much more difficult to evaluate due to the three-dimensional (3-D) nature of currents in the James River entrance. The objective of this study is to determine if disposal of dredged materials in the James River Deep Trough was feasible.

Approach

Due to the stratified nature of the lower James River estuary and the need to represent bed velocity and shear stress, a three-dimensional numerical model, RMA-10, was used to predict the hydrodynamics. Although the original scope of work required a limited resolution flume-like schematic model, a more detailed flume-like schematic model which incorporated more of the geographical features and a better representation of the tidal prism of the James River was used. While this model will give more accurate results than the limited resolution flume-like schematic model, it remains a flume-like schematic model and the results should be judged as such.

Several numerical model meshes were constructed to test different conditions. A Base geometry was made which consisted of prototype sizes and depths, with more detail in the area of the Deep Trough. Figure 1 shows the model boundary superimposed on the James River region. Note the location of the Deep Trough at the entrance. Natural bottom elevations in the Deep Trough exceed -85 feet MLLW. Three Plan geometries were constructed which consisted of changing the bottom elevations in the Deep Trough to simulate different levels of dredge material fill. The Plan geometry depths are shown in Table 1.

Table 1
Plan Geometry Depths

Plan	Deep Trough Depth (MLLW)
1	-60
2	-70
3	-80

2 Hydrodynamic Model Validation

Tidal stations, major tributaries and major freshwater inflows are shown in Figure 1. Note that the model has two tidal boundaries, one in the Chesapeake Bay, the other in the Atlantic Ocean. The elements of the model were divided into 15 material types based on depth, location, and whether the elements were two- or three-dimensional. Table 2 lists the material types and associated hydraulic parameters. Note that material types 6, 11, and 12 are listed as boundary elements. Hydraulic constants for these types were adjusted to control the instability near the boundaries. Elements with no 3-D layers are 2-D. Since the boundary conditions for these boundaries were not known and were difficult to define, large eddy viscosity values had to be used. These values are numerically rather than physically based but will not compromise results near the deep trough due to the large distance from the boundaries. It should be noted that the Manning's *n* values are generally higher than one would expect from previous 2-D modeling experience. This is a result of the 3-D hydrodynamic code using the near bed velocity to calculate shear stress, not a vertically averaged velocity.

Figure 2 shows the area of interest (the Deep Trough) with locations of velocity stations. The stations JG-xx-yy correspond approximately to velocity stations on the Chesapeake Bay Physical Model. The stations T1, T2, T3, TS, and TN are in locations in or near the Deep Trough.

The 3-D numerical model, RMA-10, was run for a total of 24.3 tidal cycles with a repetitive M_2 tide (period = 12.42 hours) for a total of 303 hours (12.74 days). Using the Base geometry, a single simulation of 253 hours was made as a spin-up to create hotstart conditions for the model. This hotstart was used with the Base and Plan geometries to generate 50 hours of simulation. Only the last 25 hours of these results were used in the validation and plan comparison in order to minimize the effects of the hotstart conditions. The tidal amplitude for the last 50 hours of the simulation was 4.2 feet. The salinity concentrations at the Chesapeake Bay and Atlantic Ocean boundaries were 22 and 25 ppt, respectively. Freshwater inflow at the upper end of the James River was set at 9,181 cfs.

Table 2
Hydraulic Constants

Material Type	Deep Range ft	Eddy Viscosity lb-sec/ft²	Manning's n	Number of 3-D Layers
1	0 - 6	750	0.030	1
2	6 - 18	650	0.030	1
3	18 - 30	500	0.025	1
4	30 - 45	450	0.025	1
5	> 45	250	0.025	2
6	Boundary	2200	0.050	1
7	0 - 6	500	0.025	0
8	6 - 18	450	0.025	0
9	18 - 30	300	0.020	0
10	30 - 45	300	0.018	0
11	Boundary	4000	0.060	1
12	Boundary	3000	0.055	1
13	6 - 18	2500	0.040	1
14	18 - 30	1800	0.035	1
15	> 30	1600	0.035	1

Since this is primarily a flume-like schematic model, the numerical results in the vicinity of the Deep Trough were the only results considered in the validation of the model. Figure 3 shows the numerical model predicted tide for Old Pt. Comfort and Newport News, with the physical model tide ranges. A comparison of tide ranges between the numerical and physical models shows a difference of approximately 0.12 feet for Old Pt. Comfort and 0.30 feet for Newport News.

Figures 4 through 6 show the numerical model surface and bottom velocities for the three physical model stations nearest to the Deep Trough. The dashed lines indicate the maximum flood and ebb velocities measured in the physical model for the same locations. The numerical model results are in fair agreement with the physical model results, with the best agreement being in the Deep Trough at station JG-01-03. Figure 7 shows the tide ranges predicted by the numerical model and compared to the physical model for three stations in the upper part of the model. Overall, velocities in the numerical model are too small compared to the physical model. There are two reasons for this. First, due to the schematization of the James, large amounts of intertidal areas were not included, resulting in a smaller tidal prism and, therefore, smaller velocities. Second, vertical mixing appeared to be greater in

the numerical model, reducing surface currents which would have been affected by a larger salinity gradient. These are somewhat related, but are not considered fatal flaws due to the limited expectations for a modeling effort of this level.

Figures 8 through 11 present the surface and bottom velocities for the Base and Plan geometries at three stations in the vicinity of Old Pt. Comfort. Figures 12 through 15 present the surface and bottom velocities for the Base and Plan geometries at three stations in the vicinity of Newport News.

Figures 16 through 23 show the surface and bottom velocities at locations in the trough (T1, T2, and T3) and both north and south of the trough (TN and TS, respectively). These also show very small changes in the velocities due to the various plans.

3 Shear Stress Analysis

Shear stress along the bottom was computed using the following formula:

$$\tau = 1/2\ \rho f_c u^2$$

with

τ = shear stress, lb/sq ft
ρ = water density, 1.935 slugs
f_c = current friction factor, 0.007
u = water velocity, ft/sec

Based on information provided by the Norfolk District, typical sediment size to be disposed in the trough will be approximately 0.2 mm (fine sand). The critical shear stress (τ_c) for quartz spheres of this size is approximately 0.005 lb/sq ft. This study examined scour patterns for two values of critical shear stress. Areas where the critical shear stress equalled or exceeded 0.008 lb/sq ft at any time during the last two tidal cycles were examined. This value is very conservative and erosion is most probable for such a high value. However, this value may only occur at maximum ebb and flood and may not be representative of a significant portion of the tidal cycle. In fact, this value was not exceeded for a significant portion of the tidal cycle. The second value of critical shear stress, 0.006 lb/sq ft, was used to develop scour patterns. But these patterns represent areas where the shear stress exceeded 0.006 lb/sq ft at least 33 percent of the time. While 0.006 lb/sq ft is a less conservative estimate of critical shear stress than 0.008 lb/sq ft, it still exceeds the value of 0.005 lb/sq ft given for quartz spheres.

Figures 24 through 27 show regions with shear stress greater than or equal to 0.008 lb/sq ft during some point in the last two tidal cycles of the simulations for the Base and Plan geometries. Note that all show regions of potential scour coincident with the Deep Trough. Figure 28 shows Plan 1 results superimposed on the Base results. Since Plan 1 is the most drastic change in geometry, it should show the most deviation from the Base. This figure shows very little change.

Figures 24 through 28 show only that, at some times in the tidal period, the shear stress will be large enough for scour to occur. However, they give no

indication of the amount of time that critical shear stress will be equalled or exceeded. Figures 29 through 33 show the regions in which shear stress exceeds 0.006 lb/sq ft at least 33 percent of the time. It is believed that these give a better estimate of scour potential. However, as shown in Figures 24 through 28, there appears to be no significant change in the scour patterns.

4 Conclusion

The 3-dimensional hydrodynamic model RMA-10 and a schematized model mesh, with average boundary conditions, was used to simulate water velocities and elevations of the lower James River. It is concluded that dredge material disposed in the Deep Trough is not likely to remain without protective armoring. This determination was made by calculating the bottom shear stress using the near-bottom water velocities and comparing with a conservative critical shear stress value. For each plan tested, water velocities were sufficient to cause scouring during parts of the tidal cycle. However, if a mildly dispersive site was desired, these results indicate that it could be feasible to use the Deep Trough as a disposal area without protective armoring. More accurate results will require a more detailed 3-D model mesh and, perhaps, a 3-D sedimentation model.

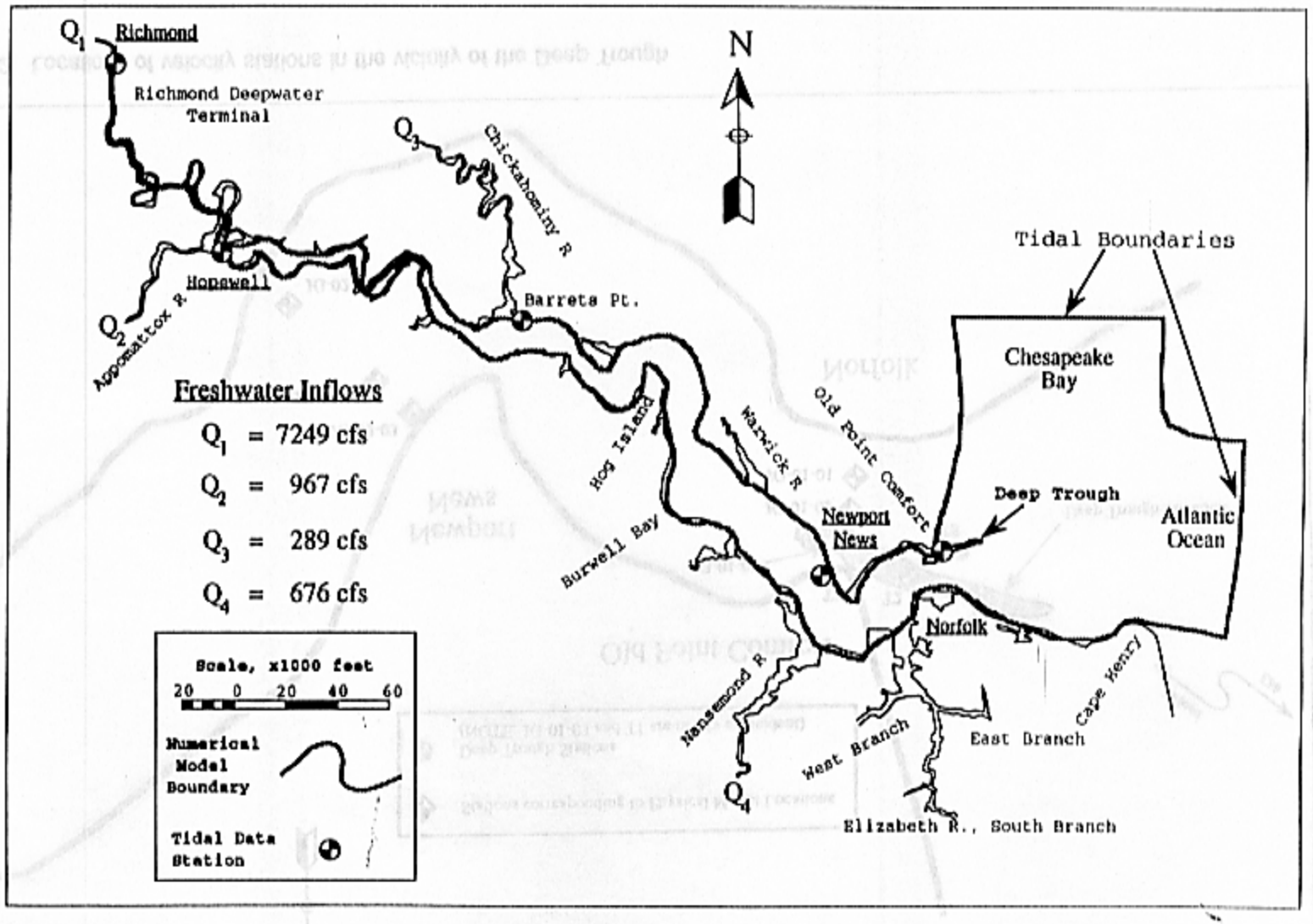

Figure 1. Location map showing numerical model limits, tide stations, and proposed Deep Trough disposal area

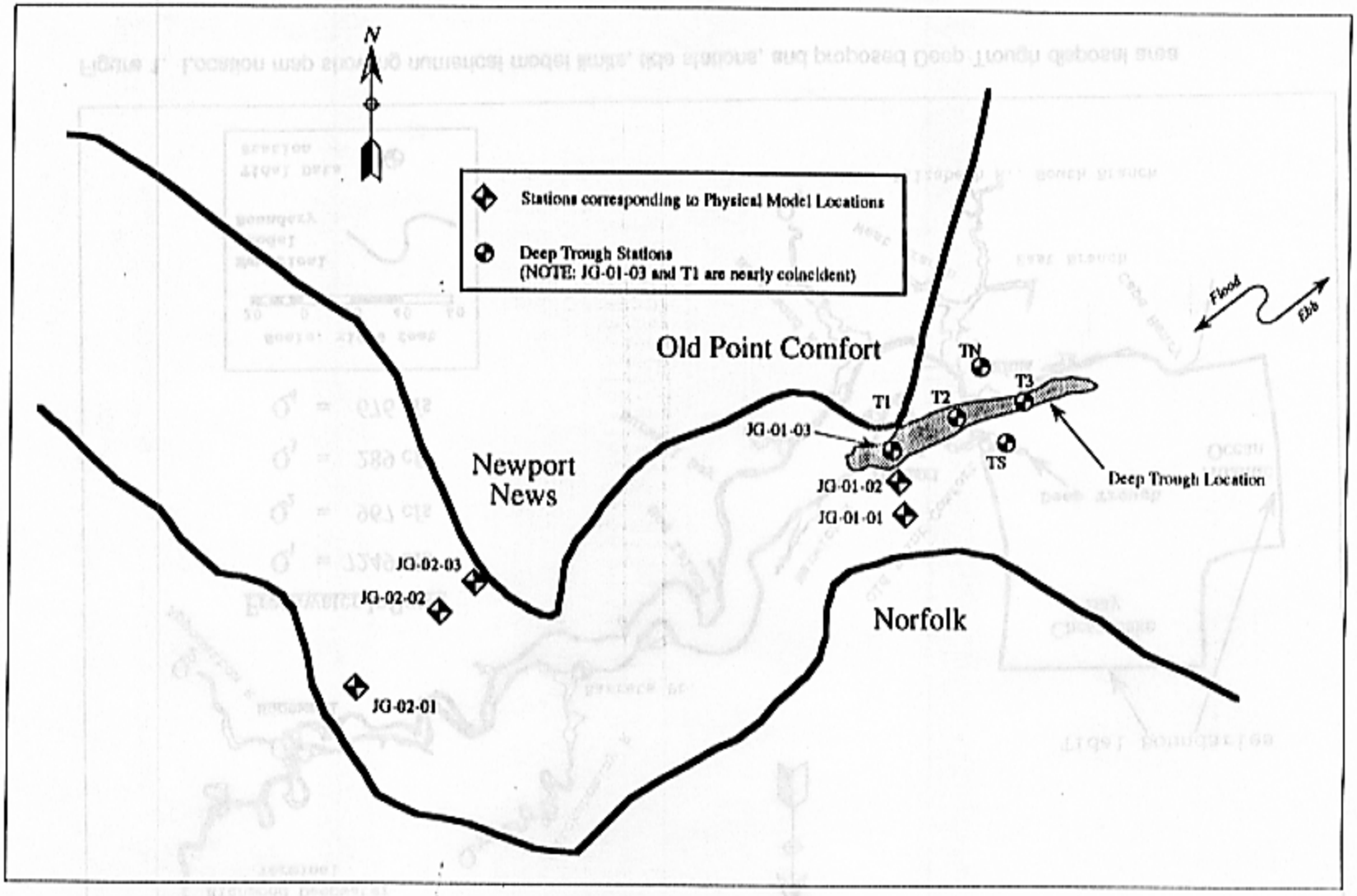

Figure 2. Locations of velocity stations in the vicinity of the Deep Trough

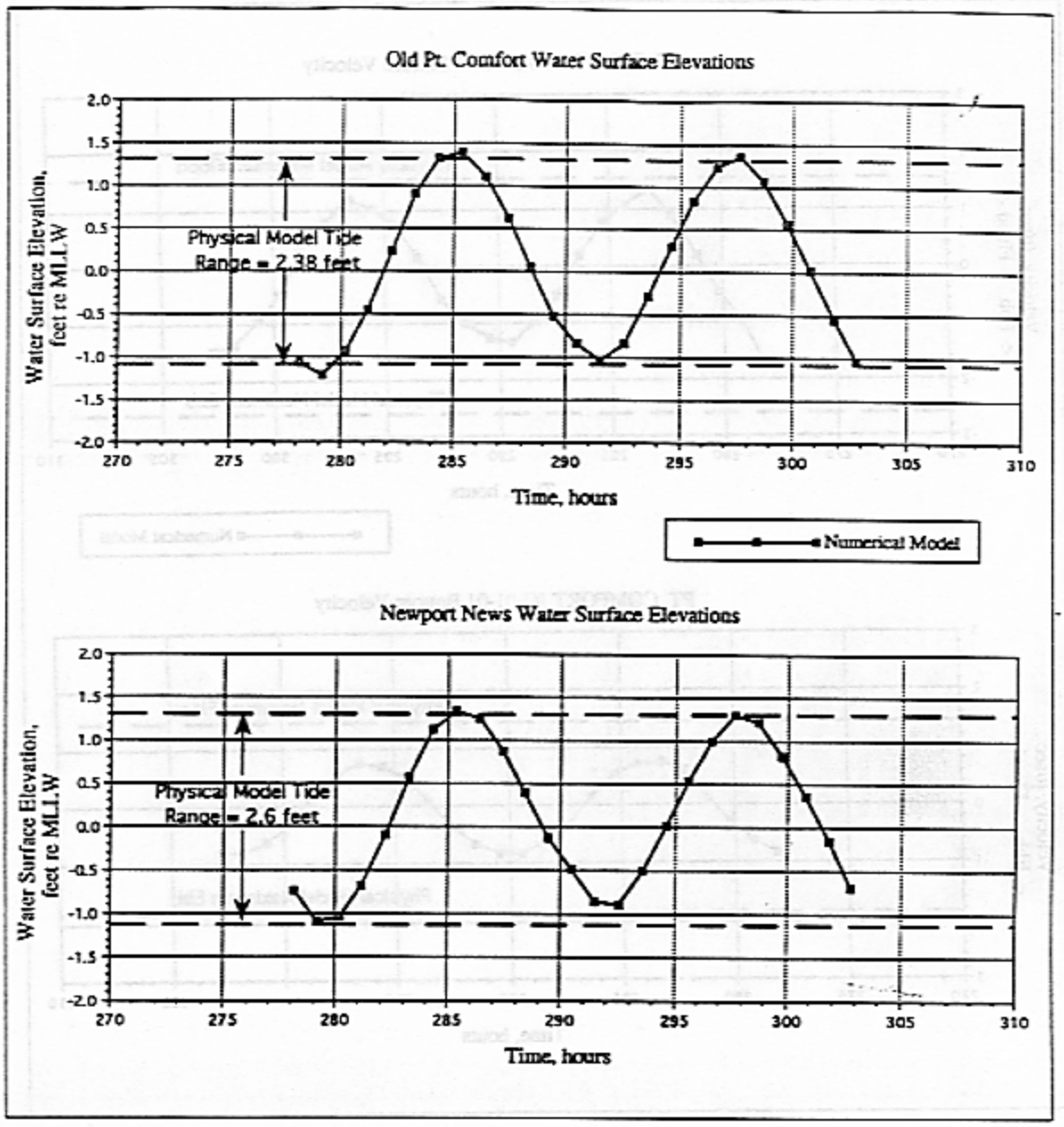

Figure 3. Numerical versus physical model tidal ranges, Lower James River

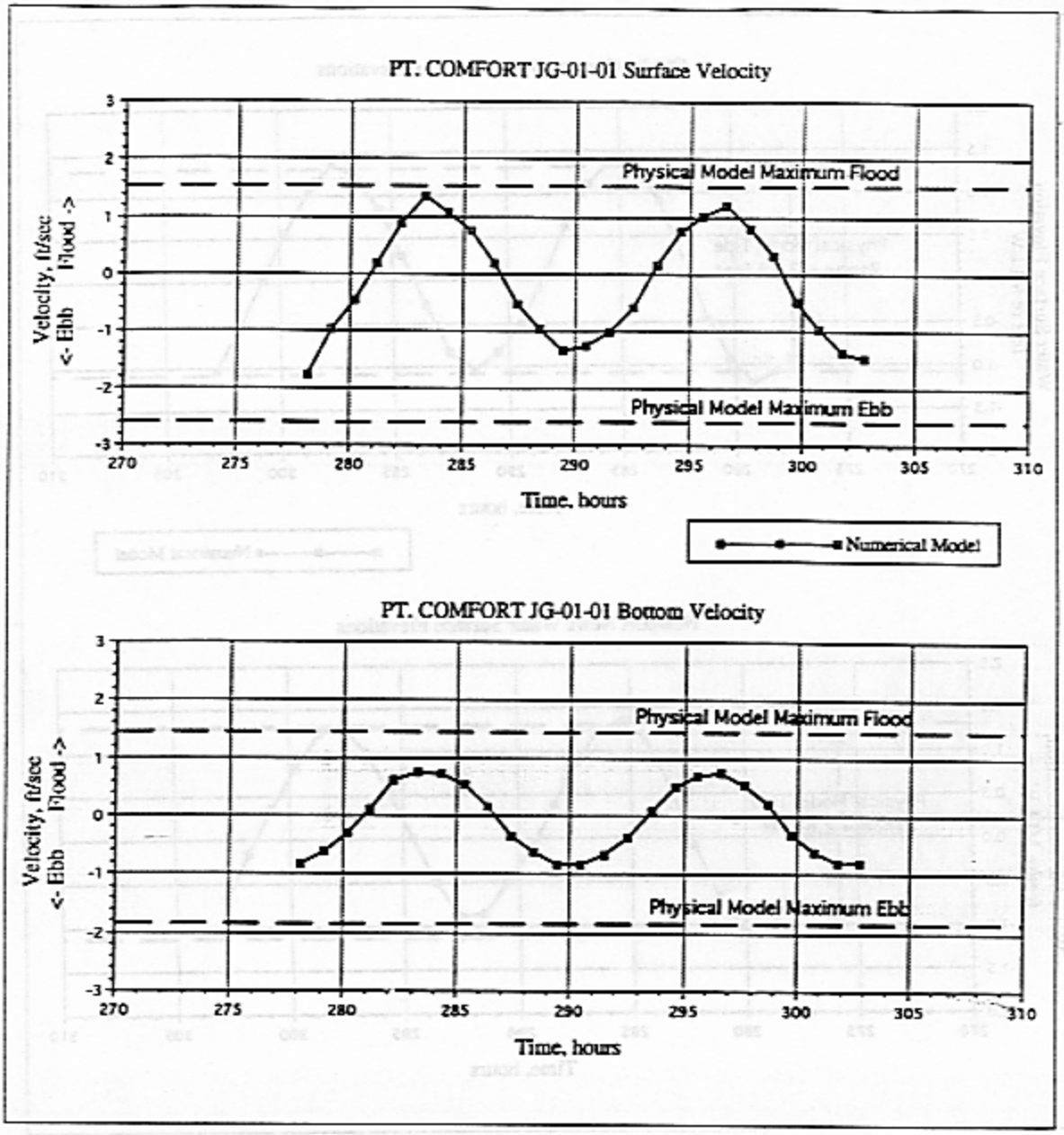

Figure 4. Numerical model surface and bottom velocities versus the physical model velocity ranges (M_2 tide), Station JG-01-01

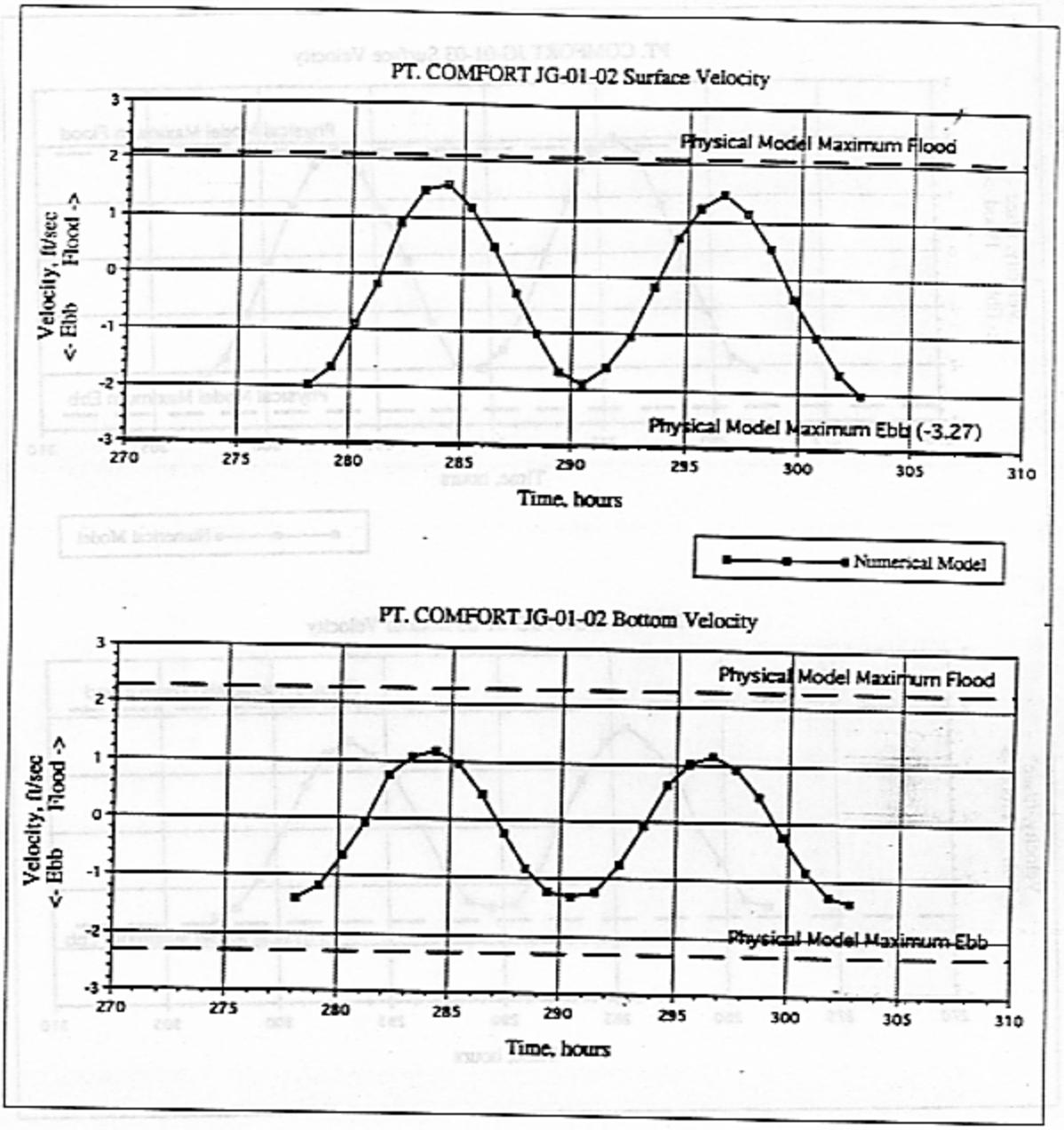

Figure 5. Numerical model surface and bottom velocities versus the physical model velocity ranges (M_2 tide), Station JG-01-02

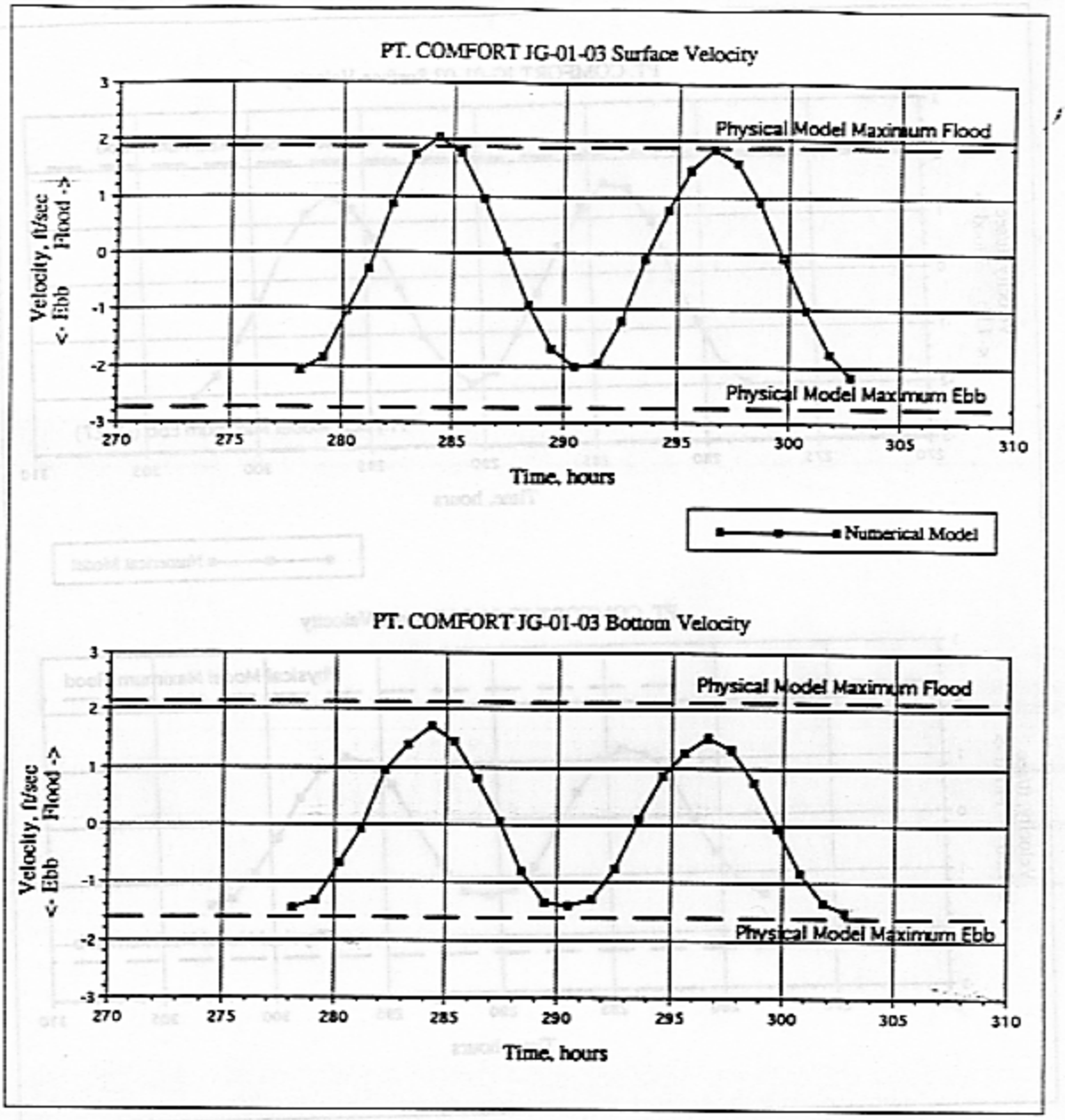

Figure 6. Numerical model surface and bottom velocities versus the physical model velocity ranges (M_2 tide), Station JG-01-03

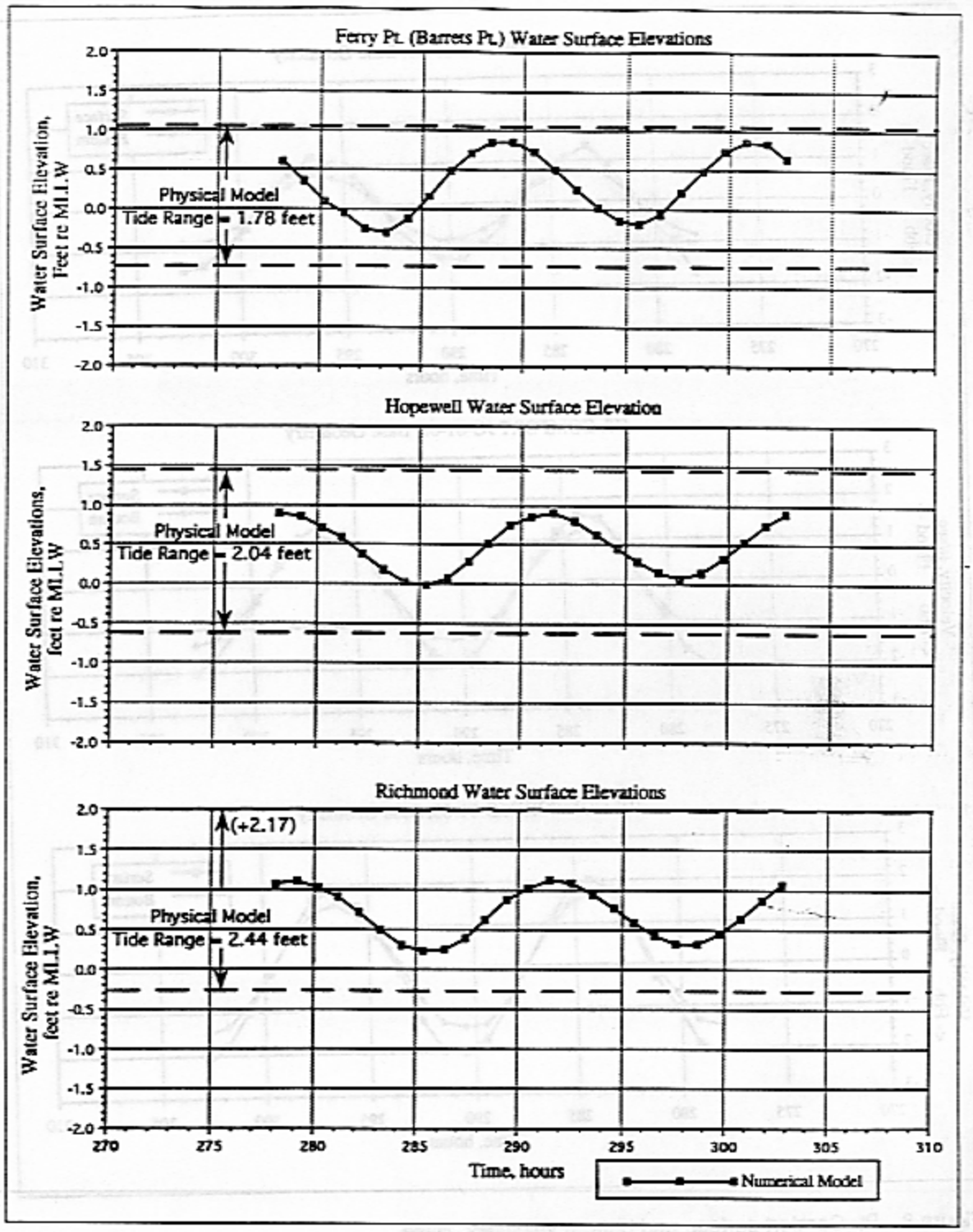

Figure 7. Numerical versus physical model tidal ranges, Upper James River

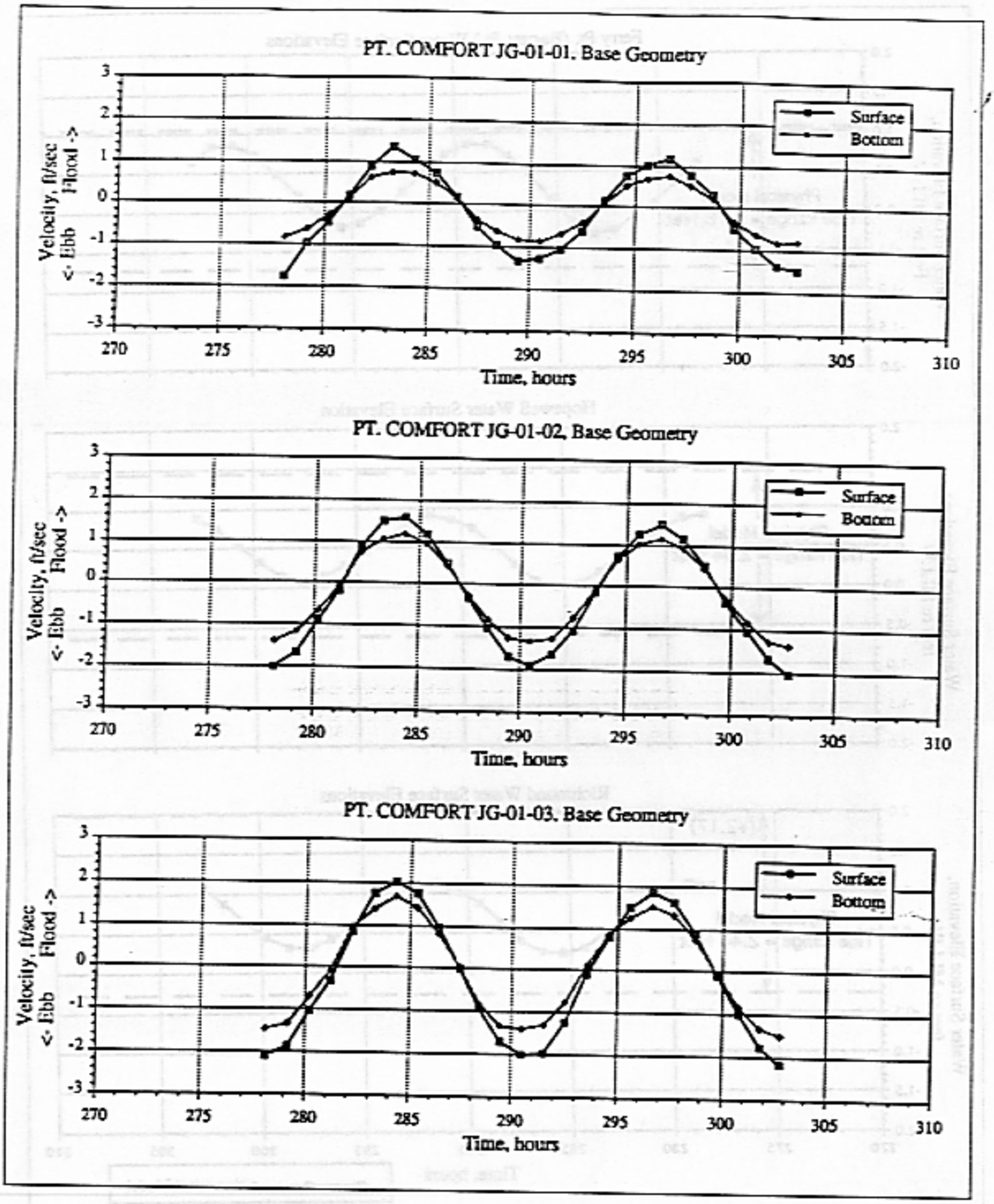

Figure 8. Pt. Comfort surface and bottom velocities, Base

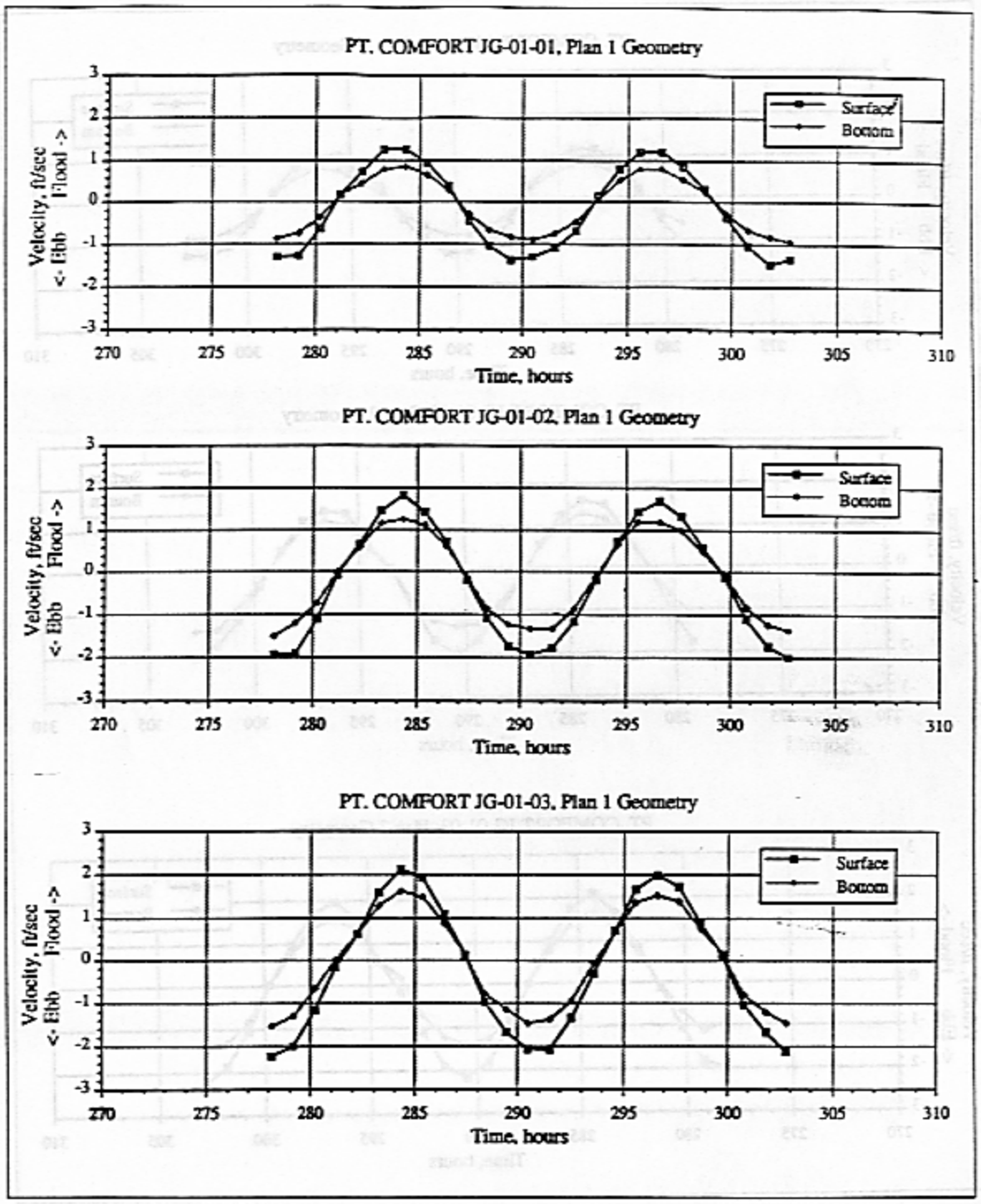

Figure 9. Pt. Comfort surface and bottom velocities, Plan 1

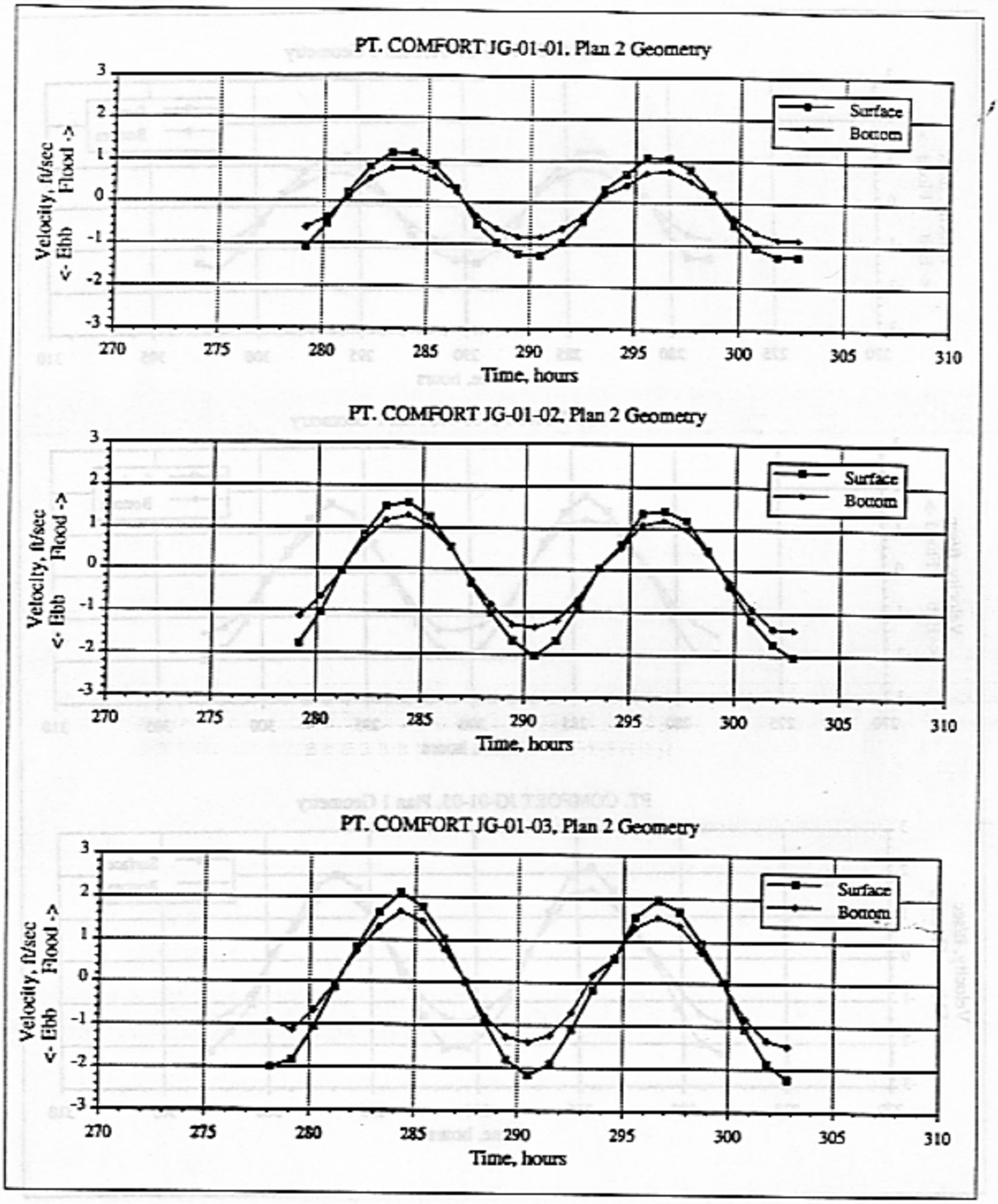

Figure 10. Pt. Comfort surface and bottom velocities, Plan 2

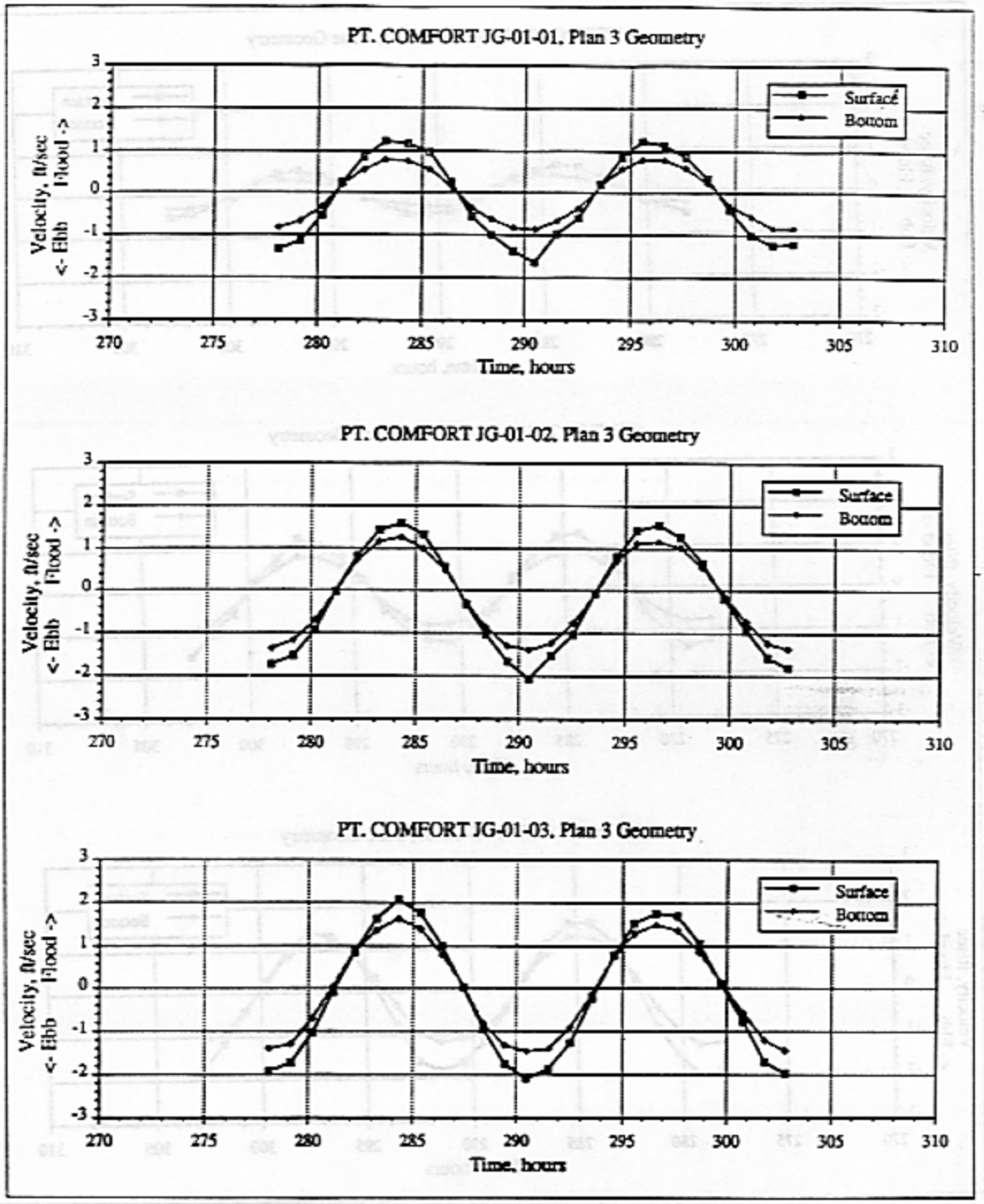

Figure 11. Pt. Comfort surface and bottom velocities, Plan 3

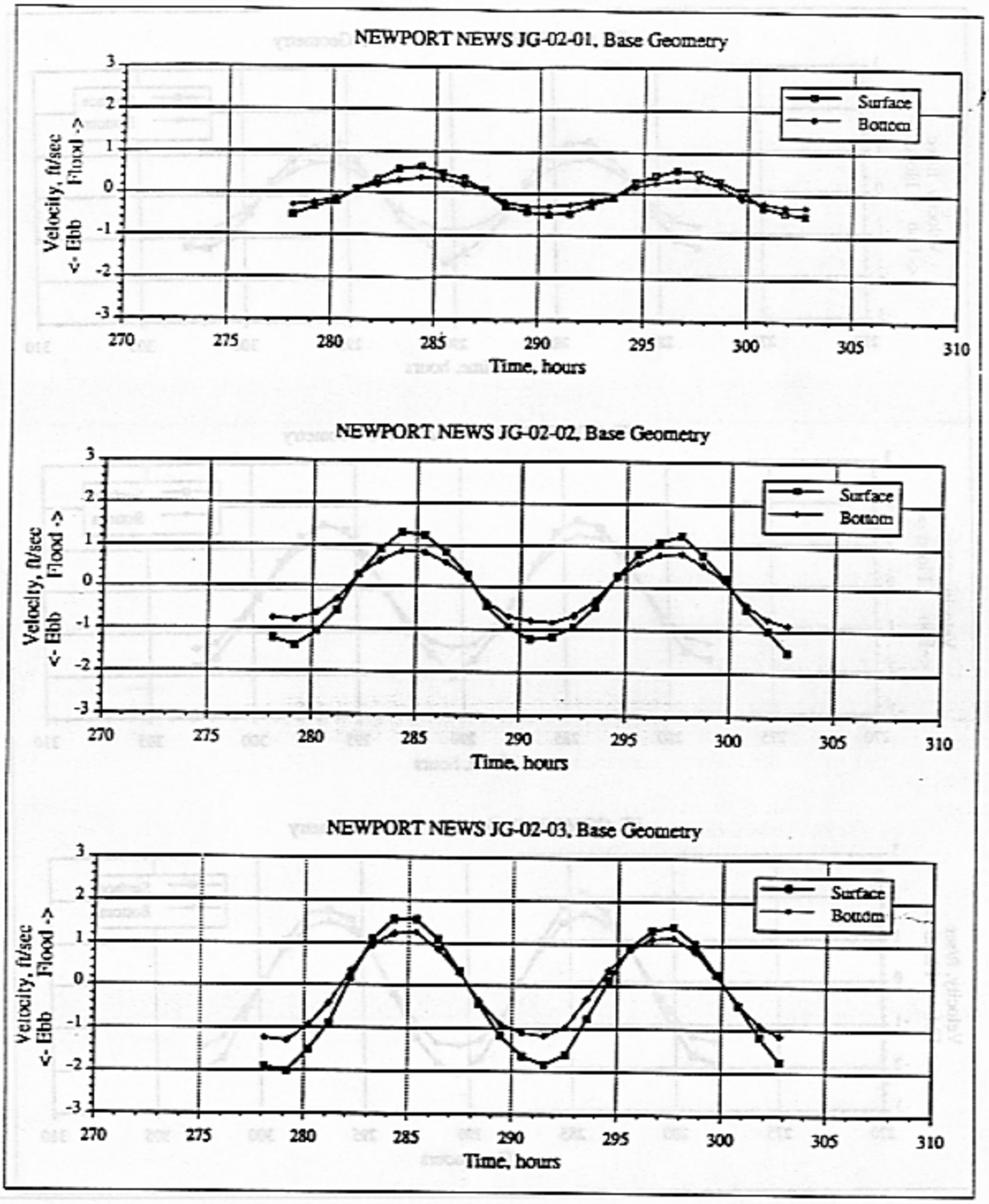

Figure 12. Newport News surface and bottom velocities, Base

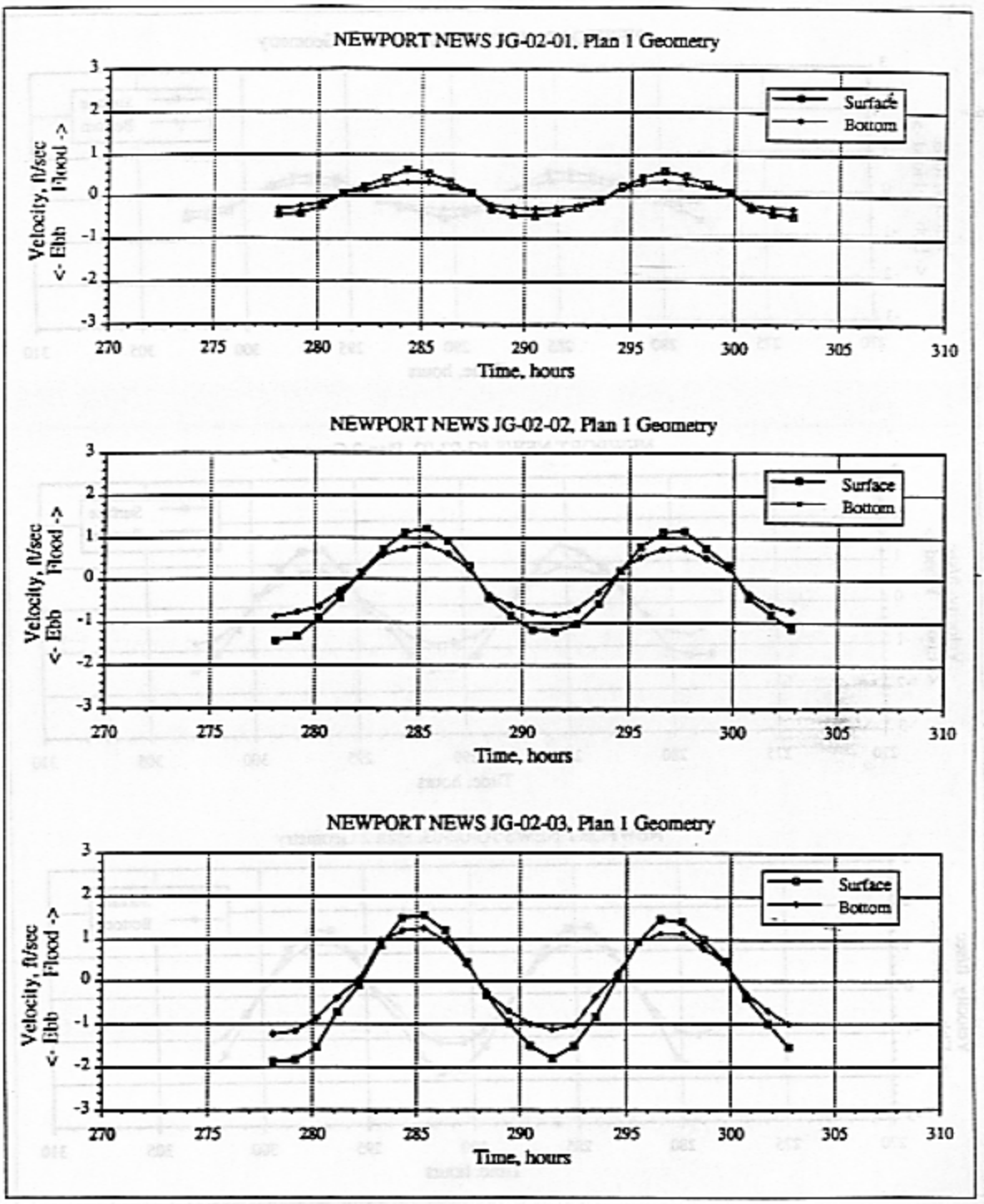

Figure 13. Newport News surface and bottom velocities, Plan 1

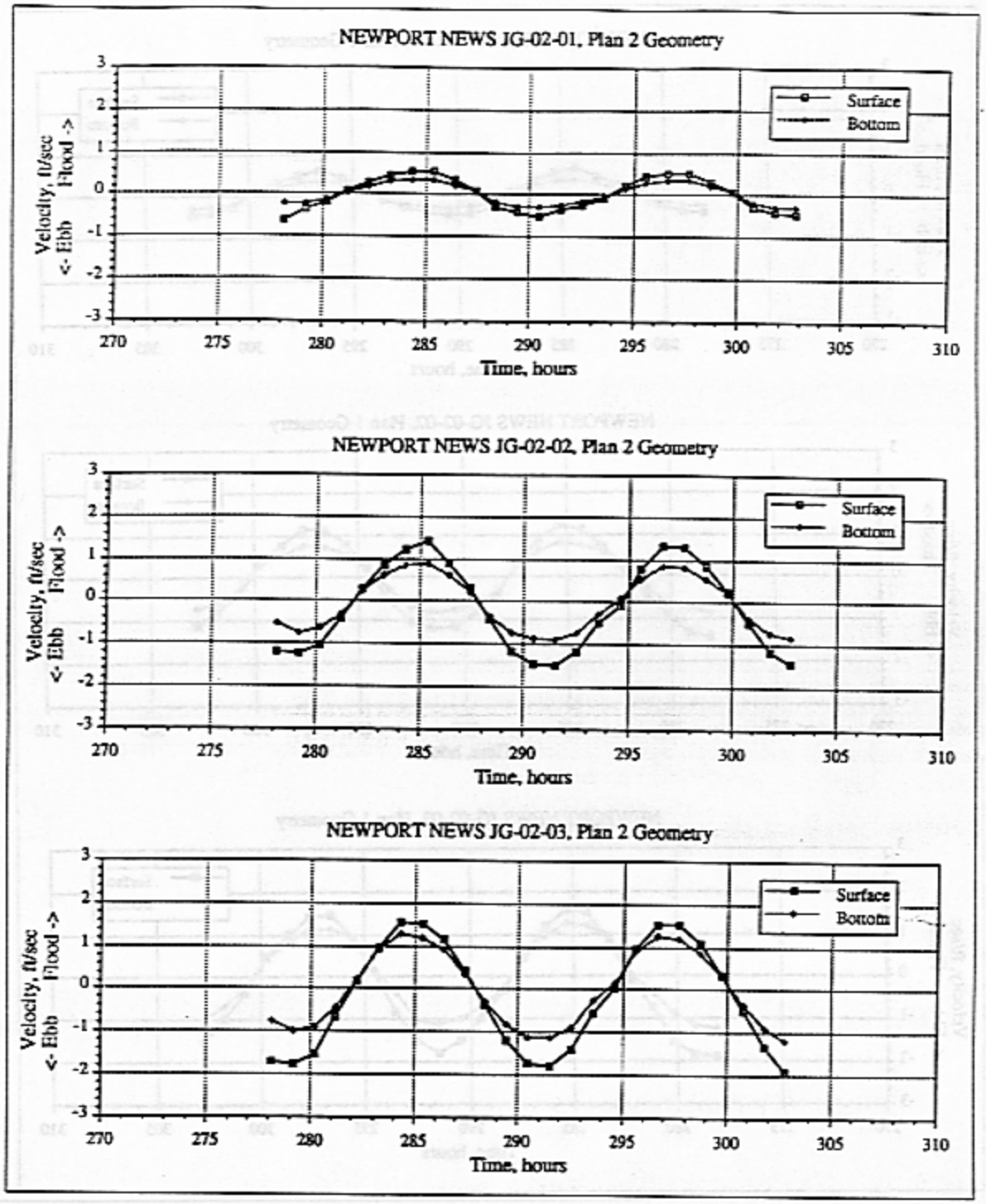

Figure 14. Newport News surface and bottom velocities, Plan 2

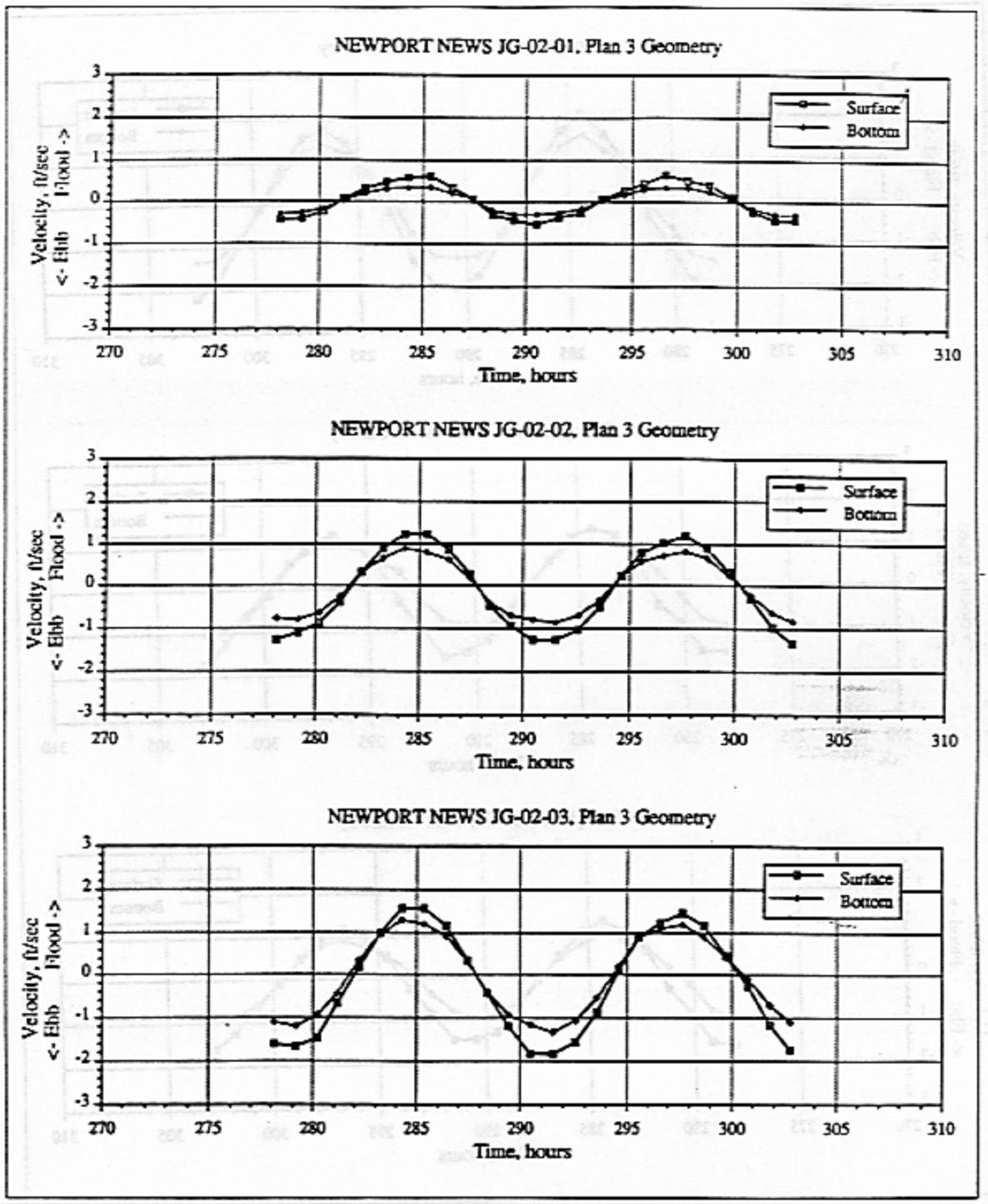

Figure 15. Newport News surface and bottom velocities, Plan 3

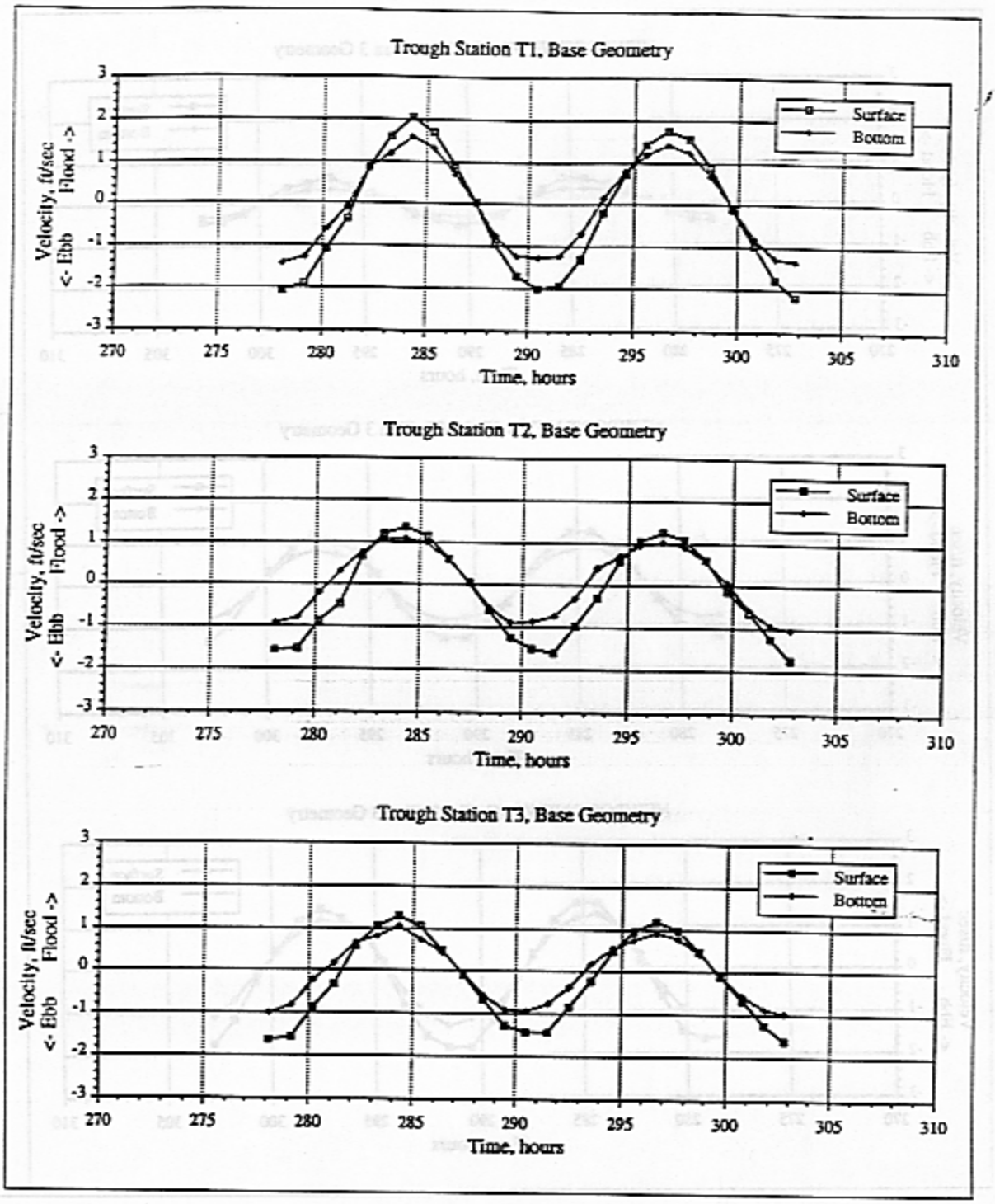

Figure 16. Base condition surface and bottom velocities, Stations T1-T3

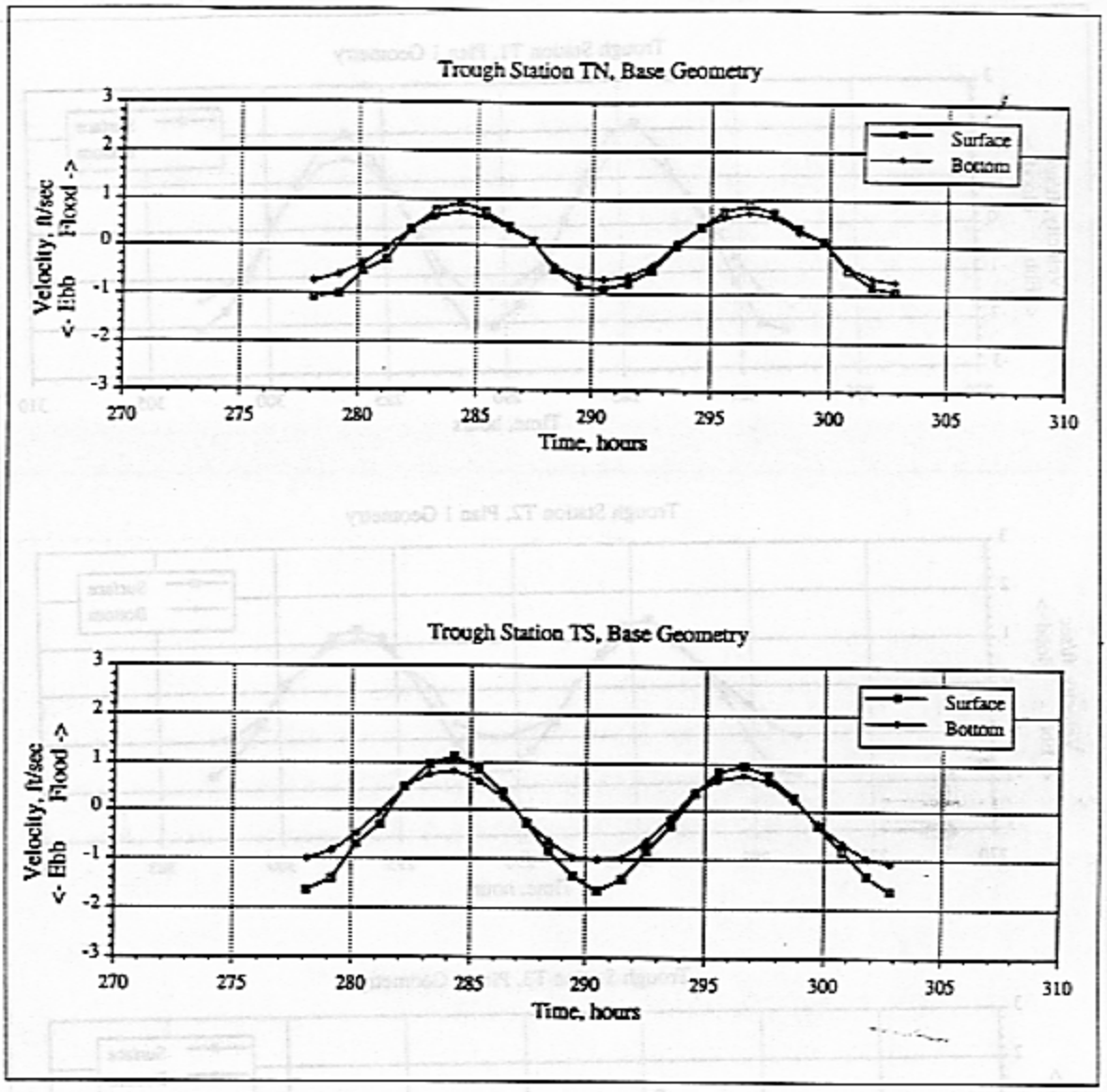

Figure 17. Base condition surface and bottom velocities, Stations TN and TS

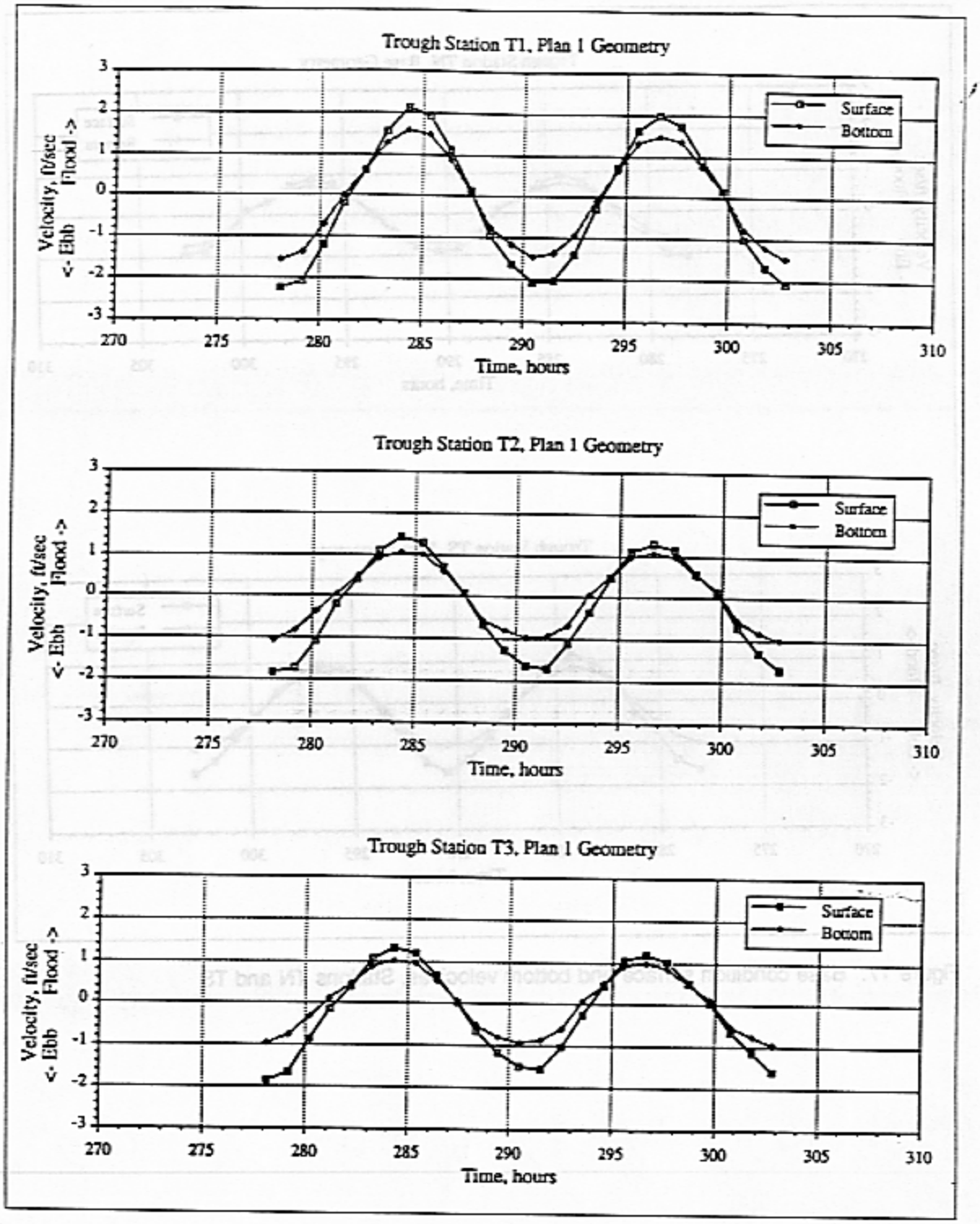

Figure 18. Plan 1 surface and bottom velocities, Stations T1-T3

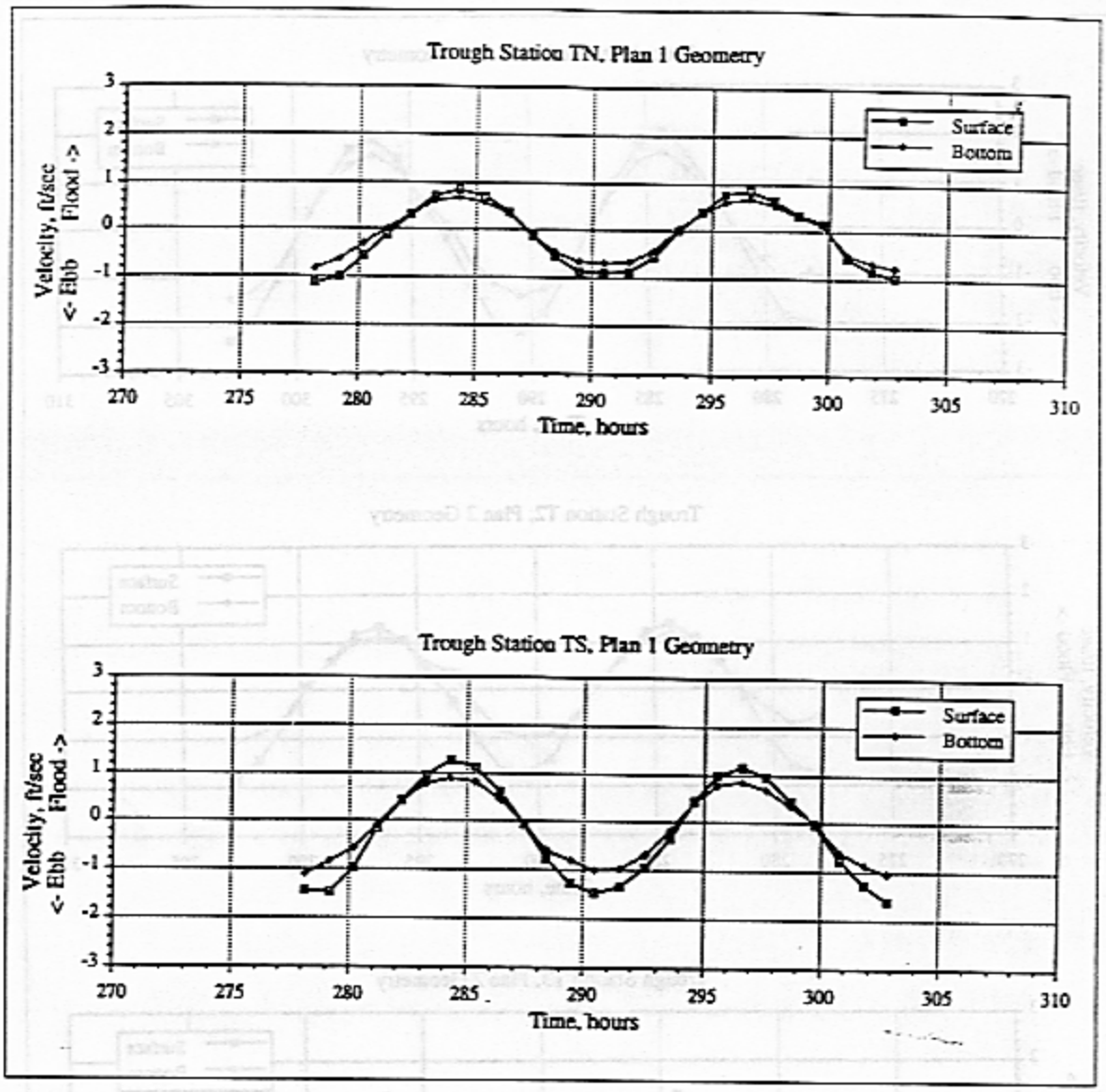

Figure 19. Plan 1 surface and bottom velocities, Stations TN and TS

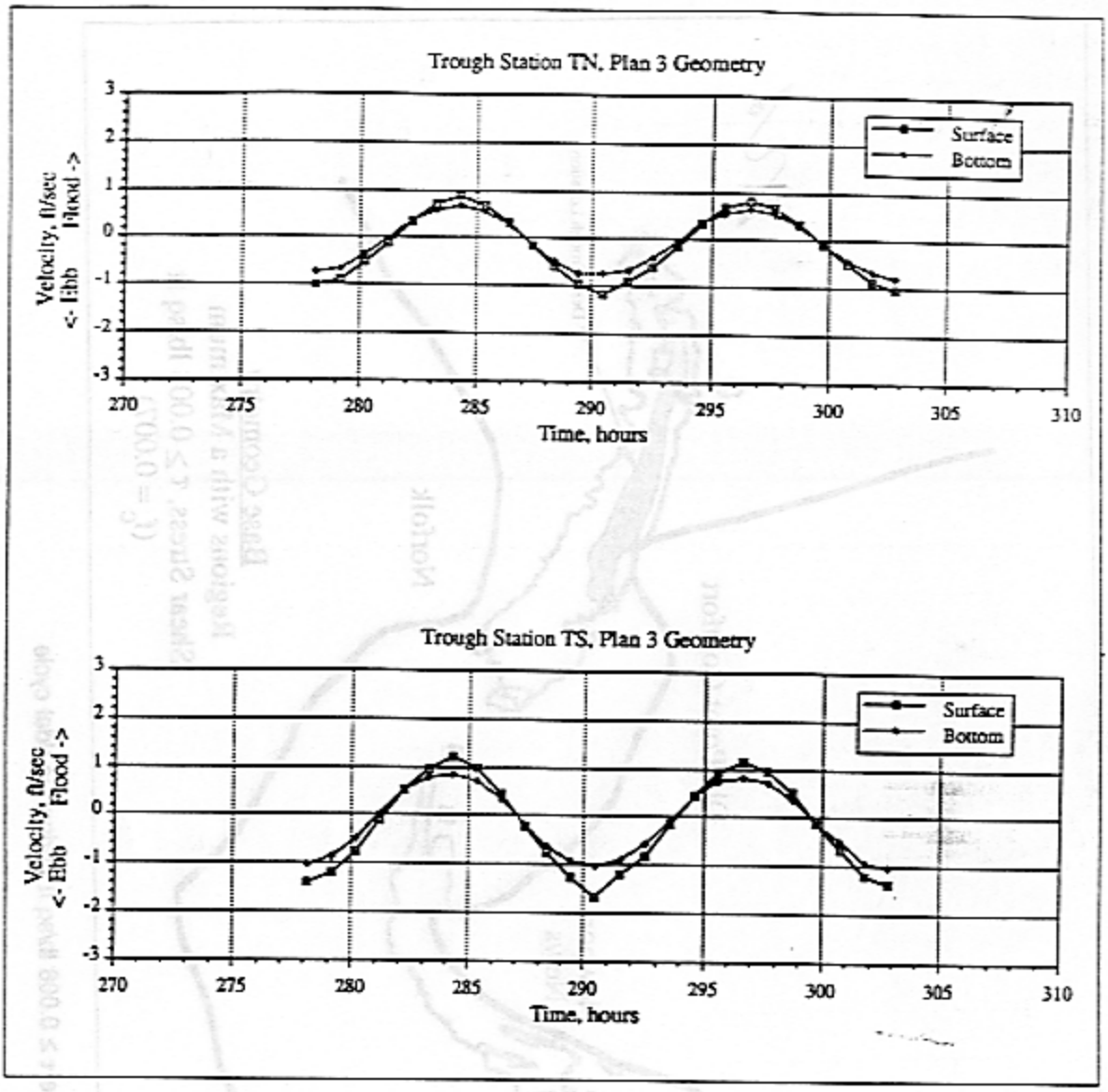

Figure 23. Plan 3 surface and bottom velocities, Stations TN and TS

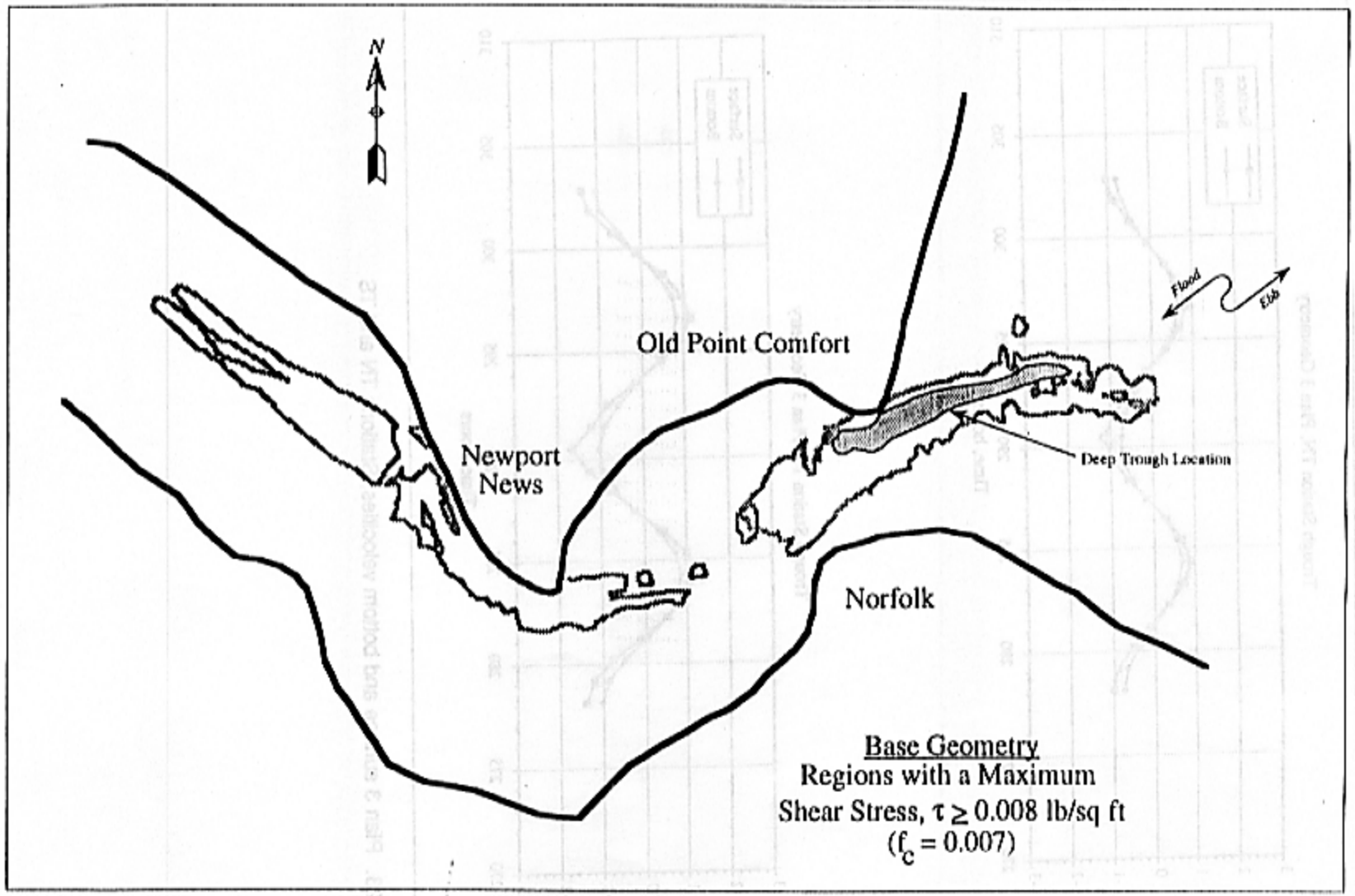

Figure 24. Base geometry - areas where τ ≥ 0.008 lb/sq ft during the tidal cycle

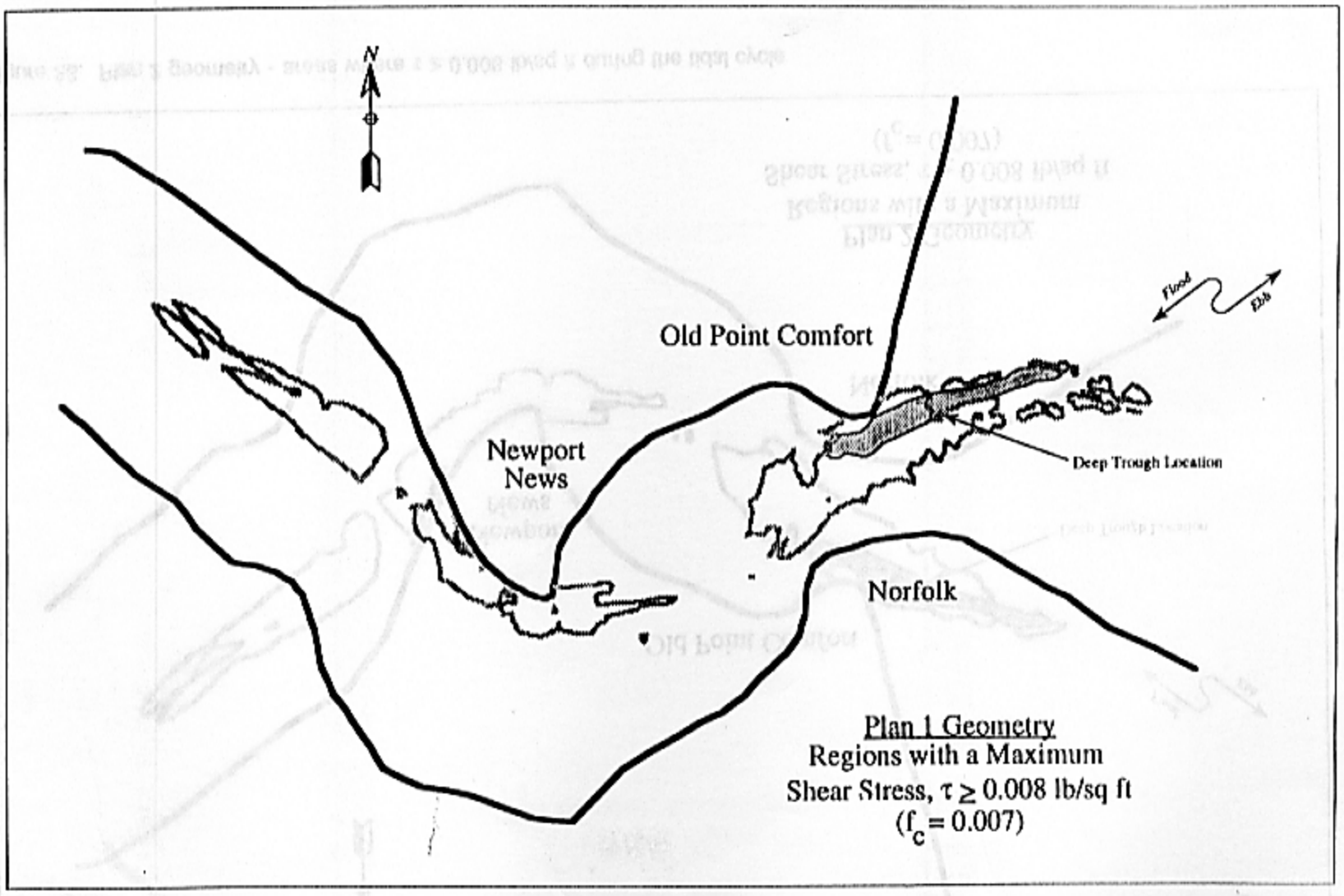

Figure 25. Plan 1 geometry - areas where τ ≥ 0.008 lb/sq ft during the tidal cycle

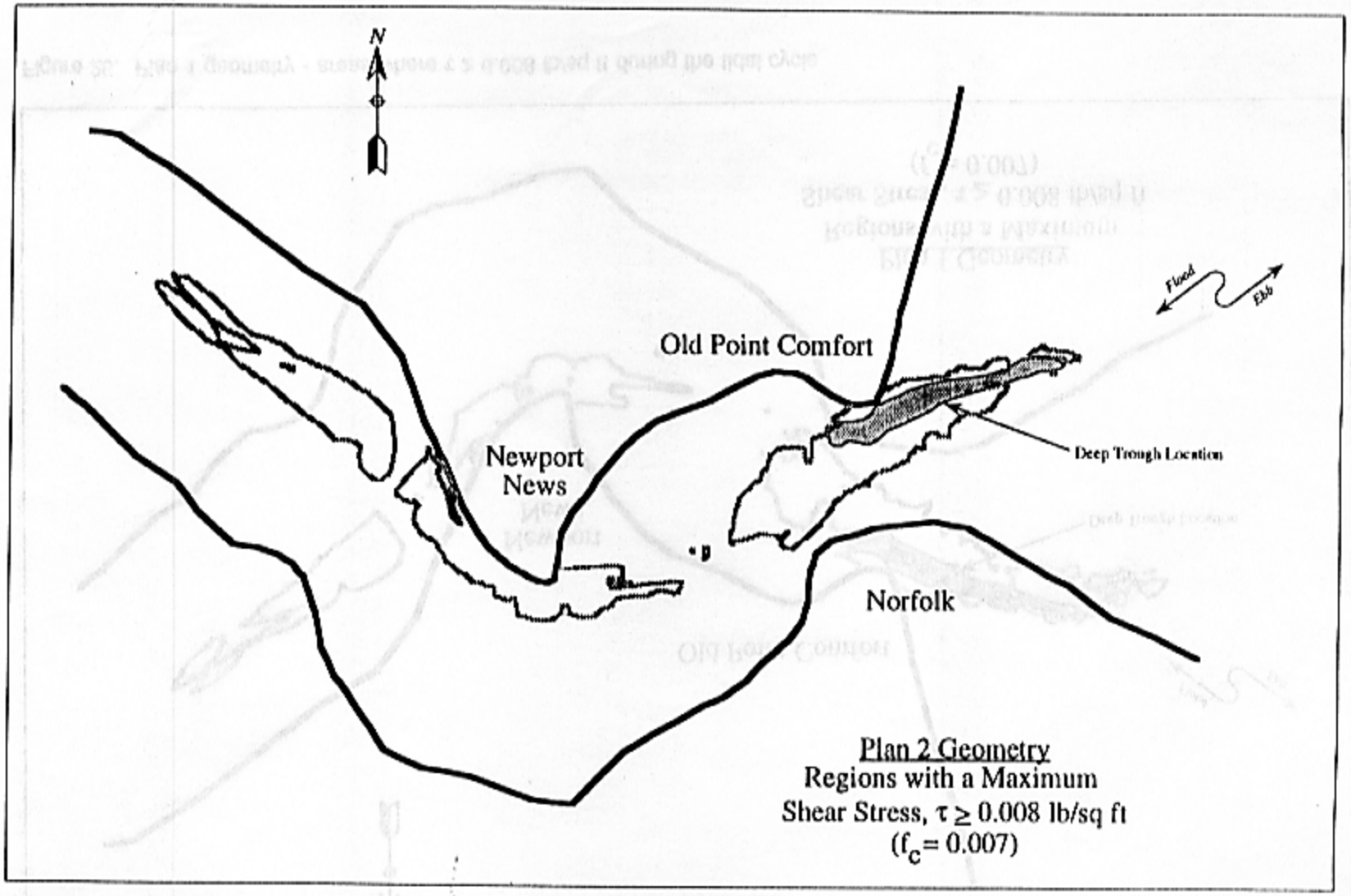

Figure 26. Plan 2 geometry - areas where $\tau \geq 0.008$ lb/sq ft during the tidal cycle

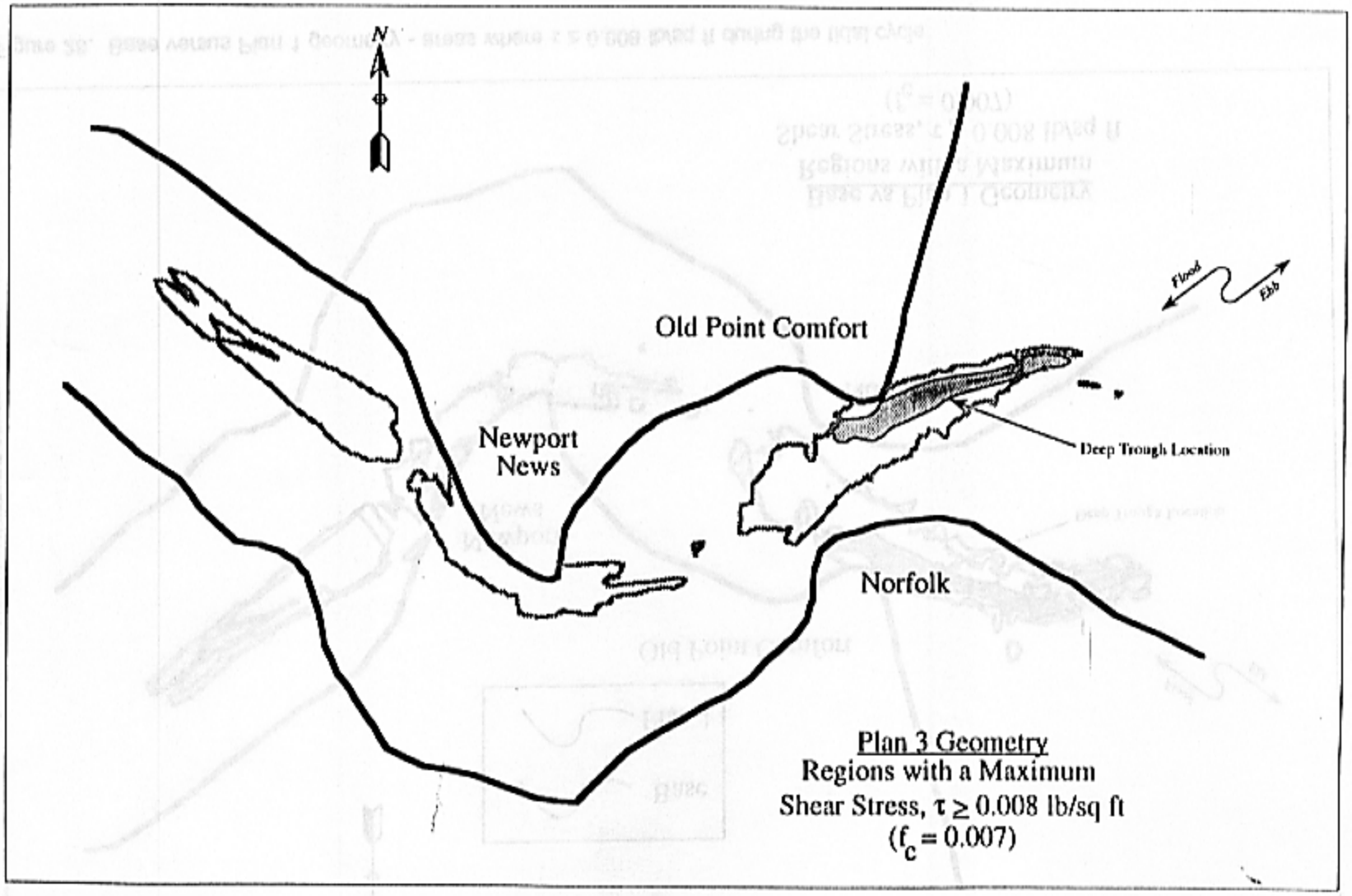

Figure 27. Plan 3 geometry - areas where $\tau \geq 0.008$ lb/sq ft during the tidal cycle

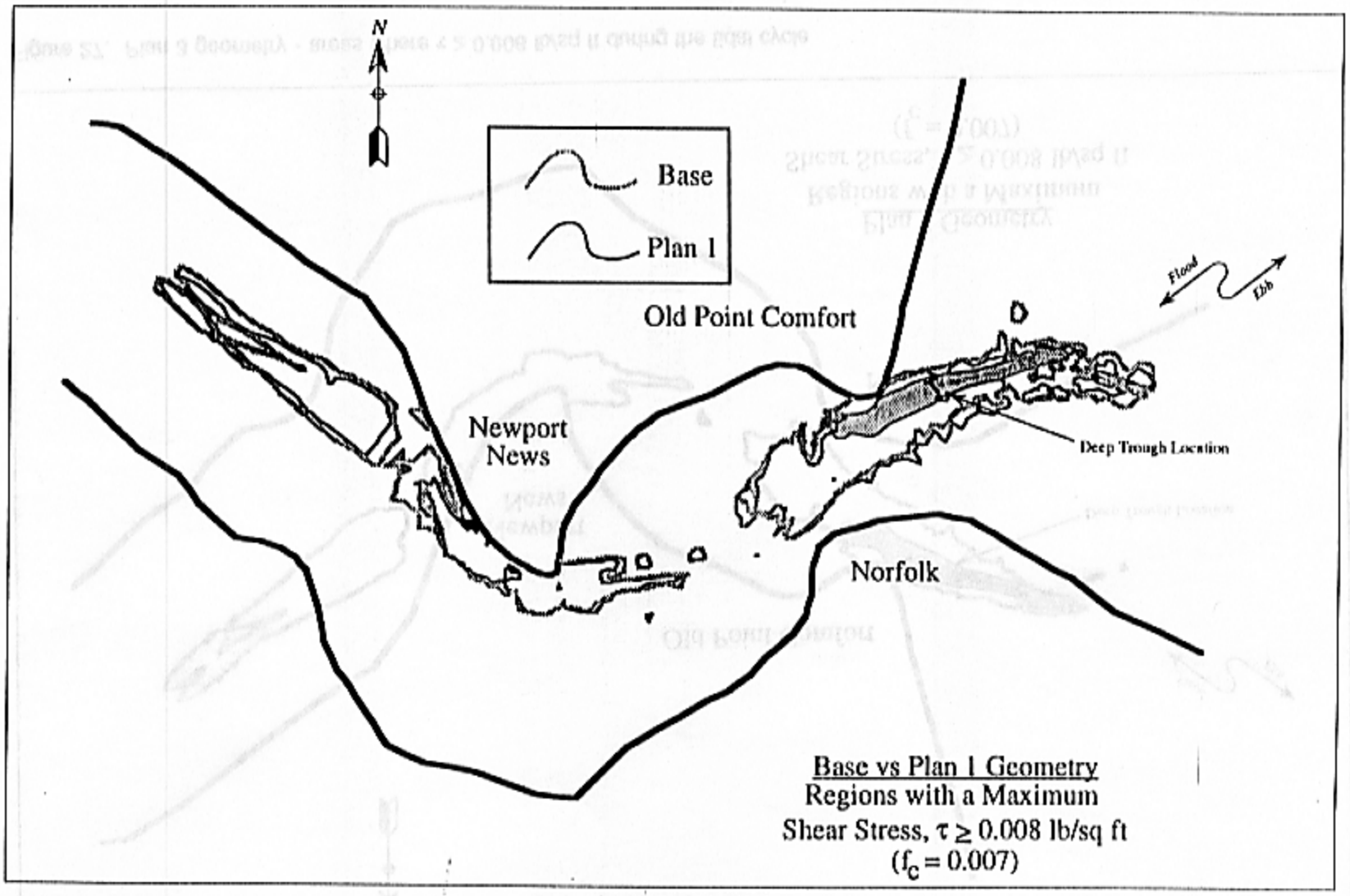

Figure 28. Base versus Plan 1 geometry - areas where $\tau \geq 0.008$ lb/sq ft during the tidal cycle

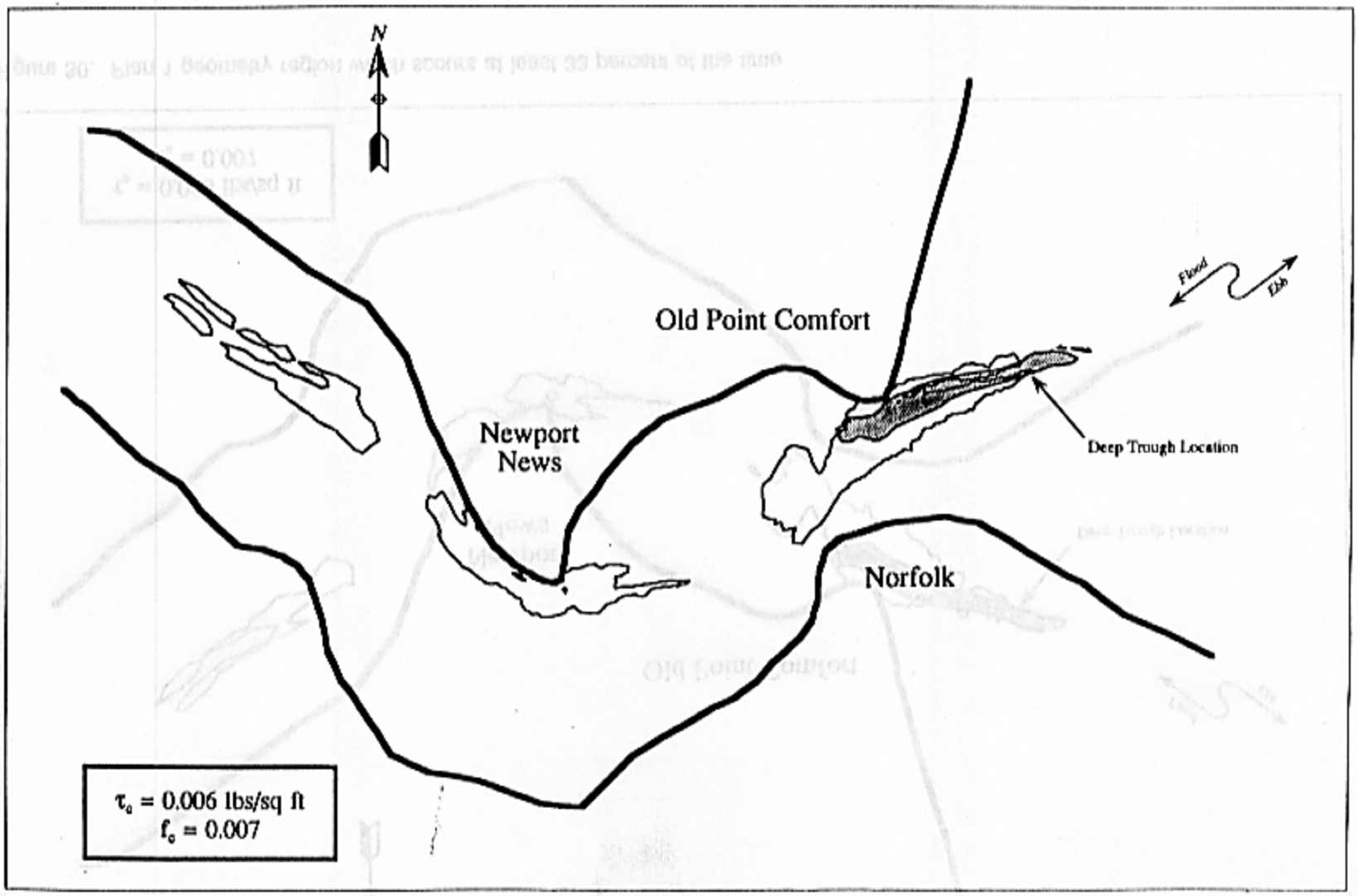

Figure 29. Base geometry region which scours at least 33 percent of the time

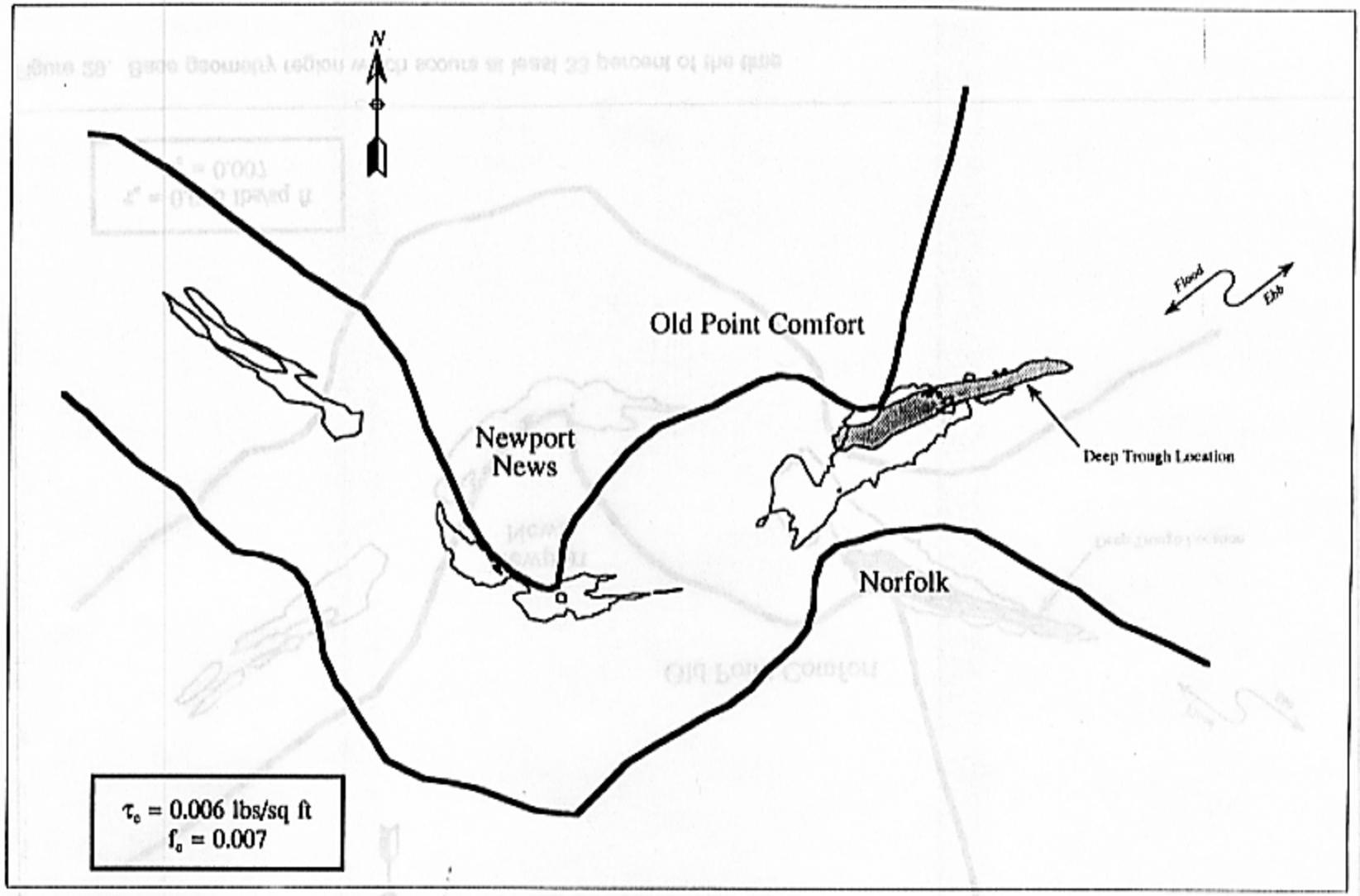

Figure 30. Plan 1 geometry region which scours at least 33 percent of the time

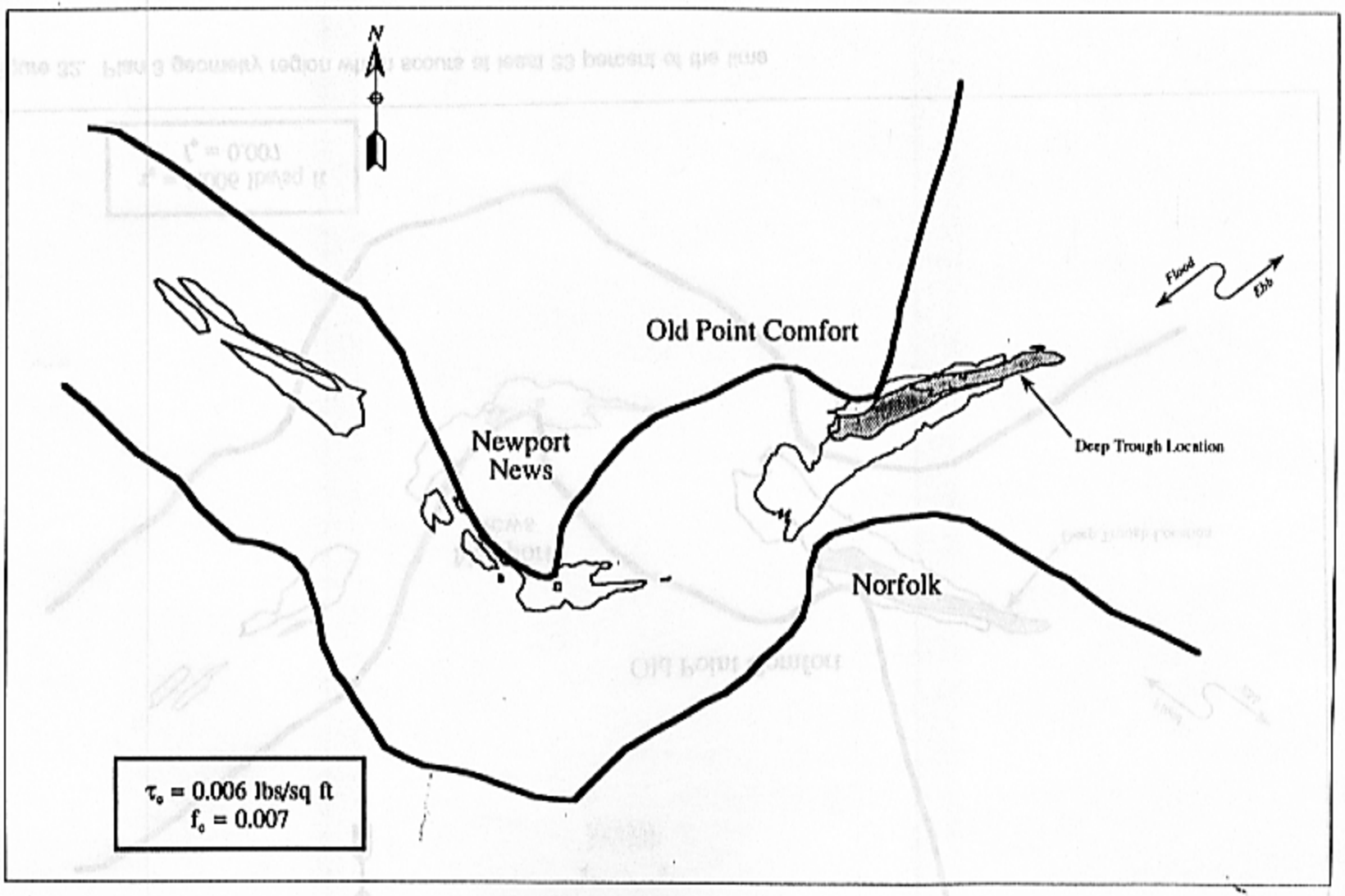

Figure 31. Plan 2 geometry region which scours at least 33 percent of the time

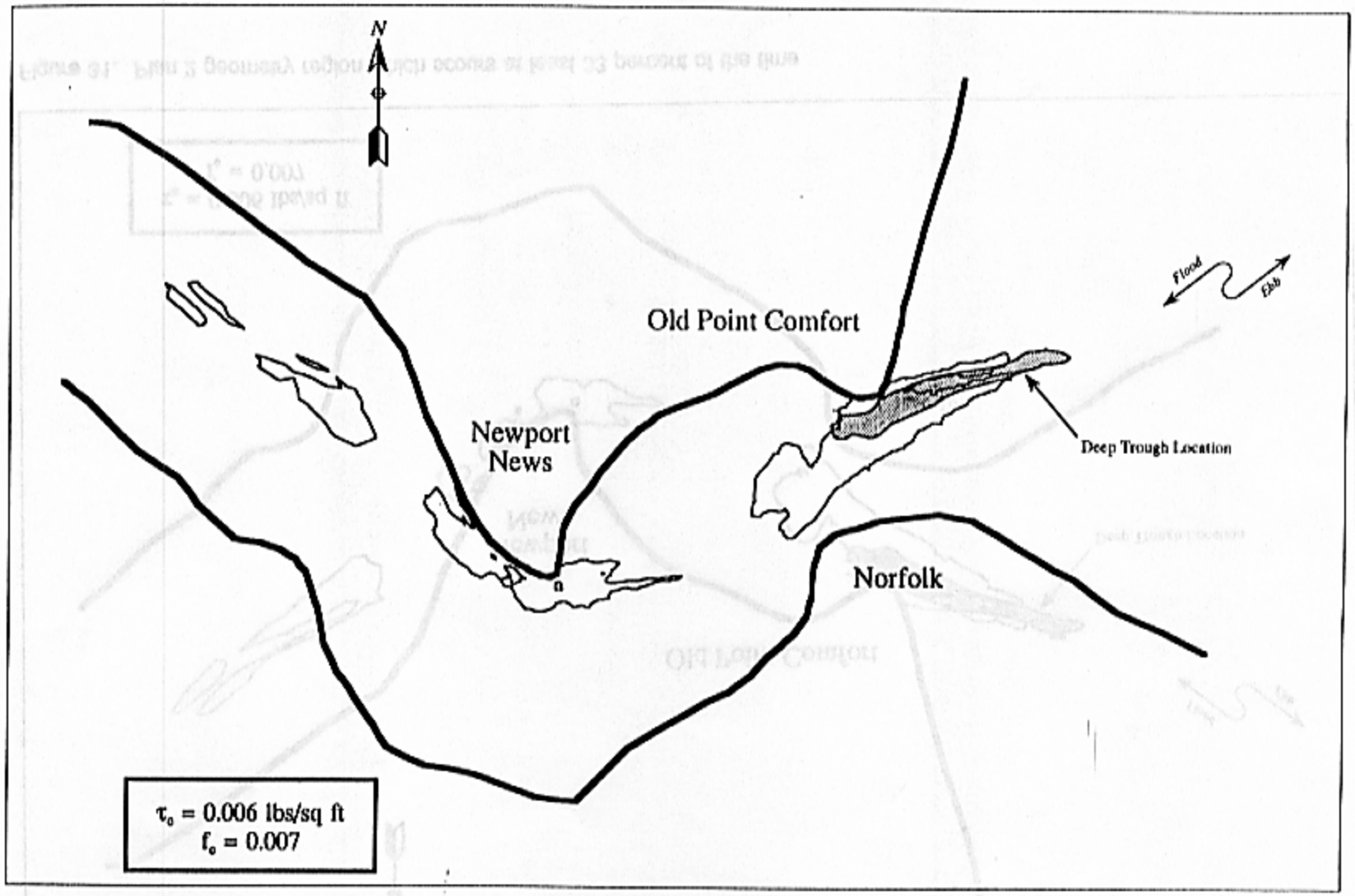

Figure 32. Plan 3 geometry region which scours at least 33 percent of the time

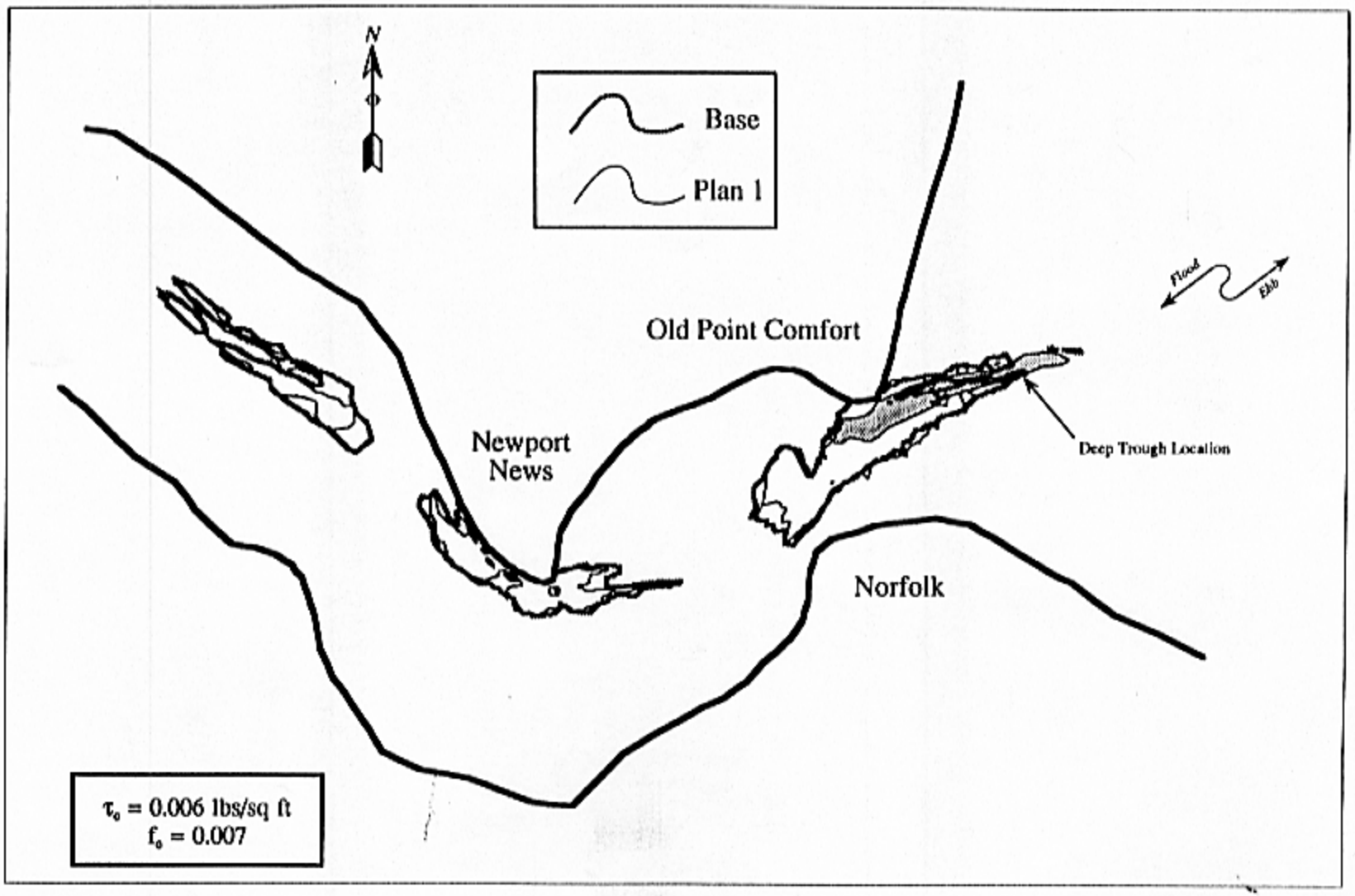

Figure 33. Base versus Plan 1 geometry region which scours at least 33 percent of the time

Evaluation of Island Creation Alternatives in the Hampton Flats of the James River

by

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A Report To

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Executive Summary

This report describes and documents an evaluation of artificial island creation alternatives in the Hampton Flats of the James River, Virginia. Nine alternate locations for an approximately 250 acre, elliptical shaped, artificial island for dredge material disposal are evaluated with respect to physical alterations of the presently existing circulation and mass transport patterns in the Hampton Roads area of the lower James River. The primary island location proposed by the U. S. Army Corps of Engineers, Norfolk District, is shown to result in minimal modification to present circulation and mass transport patterns.

ACKNOWLEDGMENT

The work described in this study was funded by the U. S. Army Corps of Engineers, Norfolk District, under contract 599301 to the Virginia Institute of Marine Science, College of William and Mary. The cooperation and assistance of Mr. Craig Seltzer and Mr. Mark Hudgins of the Norfolk District is acknowledged.

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Evaluation of Island Creation Alternatives in the Hampton Flats of the James River

I. Introduction

This report documents the evaluation of potential impacts on the circulation and transport in the lower James River, Virginia, which might result from the construction of an artificial island for dredge material disposal in the Hampton Flats. The U. S. Army Corps of Engineers District, Norfolk is investigating a number of alternatives for dredged material placement in the Lower James River. These alternatives include, but are not limited to: (1) offshore placement, (2) placement in a deep trough at the entrance of the James River, and (3) creation of islands similar to Bodkin Island in the Chesapeake Bay. The Hampton Flats has been identified as a possible location for island creation, Figure 1. The three-dimensional character of the currents and salinity distribution in the Hampton flats and adjacent navigation channel have been shown to result in an intratidal frontal system occurring near Newport News Point at the Western edge of the flats (Byrne, *et. al.*, 1987). The frontal system is postulated to be a significant mechanism for landward transport of seed oyster larvae which would otherwise leave the mouth of the James and be lost into the Chesapeake Bay. An artificial island constructed in the Hampton flats should result in minimal changes in the transport dynamics of the frontal system. To evaluate potential impacts of artificial island creation in the Hampton flats, the Virginia Institute of Marine Science's general purpose three-dimensional environmental fluid dynamics modeling system, EFDC, was used to identify changes in the circulation and salinity distribution with respect to present conditions. The EFDC model has been applied for a number of studies in the James and York Rivers of Virginia (Hamrick, 1991, 1992b). The calibrated and verified James River version of the model has previously been used to investigate the periodic formation of the frontal system near Newport News Point in the lower James.

2. Description of the EFDC Model

The Environmental Fluid Dynamic Computer Code, EFDC, (Hamrick, 1992a,b) is a general purpose, three-dimensional circulation and transport model for rivers, lakes, wetland systems, estuaries, and coastal regions. The model code solves the vertically hydrostatic, free surface, variable density, turbulent-averaged equations of motion and transport equations for turbulent kinetic energy and turbulent length scale, salinity and temperature in a stretched, (sigma), vertical coordinate system, and horizontal coordinate systems which may be Cartesian or curvilinear-orthogonal. The code uses a three time level, finite difference scheme with an internal-external mode splitting procedure to separate the internal shear or baroclinic mode from the external free surface gravity wave or barotropic mode. The external mode solution is implicit, with the model simultaneously computing the two-dimensional surface elevation field by a conjugate gradient procedure. The external solution is completed by the calculation of the depth averaged barotropic velocities using the new surface elevation field. The implicit external solution allows large time steps which are constrained only by the stability criteria of the explicit advection scheme used for the nonlinear accelerations.

The code's internal solution, at the same time step as the external, is implicit with respect to vertical diffusion. The internal solution of the momentum equations is in terms of the velocity shear, which results in the simplest and most accurate form of the baroclinic pressure gradients and eliminates the over-determined character of alternate internal mode formulations. The vertical diffusion coefficients for momentum, mass and temperature are determined by the second moment closure scheme of Mellor and Yamada (Mellor and Yamada, 1982; Blumberg and Mellor, 1987; Galperin, et al, 1988) which involves the use of analytically determined stability functions and the solution of transport equations for the turbulent kinetic energy and the turbulent length scale. Time splitting inherent in the three time level scheme is controlled by periodic insertion of a two

time level step. The two time level step may also be used for startup and restart, eliminating the need for initial conditions at two time levels. Other features of the code include additional transport equations for conservative and nonconservative tracers and suspended sediment. Various options for advective transport of scalar variables include conventional upwind and central difference schemes and Smolarkiewicz's multidimensional positive definite advection transport algorithm with an optional flux limiter (Smolarkiewicz and Grabowski, 1990). A complete description of the code's theoretical and computational aspects are presented in Hamrick (1992a).

3. Base Case Model Configuration and Description of General Circulation Features in the Lower James River

For this study, the James River version of the EFDC model is utilized with appropriate modifications to represent alternate island locations in the Hampton Flats. The base configuration for the James River uses a square 370 m Cartesian grid with six layers in the vertical, and a total of approximately 27,000 cells. The grid in the vicinity of the proposed Island locations is shown in Figure 1(b). The EFDC model was originally calibrated for the James River using a comprehensive set of field data collected in 1985 by the Virginia Institute of Marine Science (Kuo, *et al.*, 1988, 1990). The 1985 calibration involved the adjustment of only bottom roughness to achieve an acceptable agreement between measured and model simulated least squares determined tidal and residual components of surface elevation and horizontal velocity at selected locations. The validity of the calibration was determined by the model's ability to predict field measured three-dimensional salinity distributions during a two month transient simulation.

For the comparison of three-dimensional circulation features, the May through July 1985 period, corresponding to a field measurement program, was selected. Comparisons were made of hourly

instantaneous and 25.84 hour averaged surface and near bottom horizontal velocity and salinity fields, and normal and tangential velocity and salinity in three vertical transects. The vertical transects include the James River Bridge transect and north-south and northeast-southwest transects through the frontal region at Newport News Point. The predominant mean circulation feature of the central region of the James River is a modified two layer circulation with a preference for seaward flow on the south side of the channel and land flow on the north side. Figure 2 shows the M2 tidal cycle averaged normal velocity and salinity over a central transect at the James River Bridge for the current situation. This residual circulation forms a large scale horizontal loop with material flowing seaward potentially being lost from the estuary, Figure 3. The frontal system at Newport News Point provides a mechanism to close this loop. Figure 4 shows the instantaneous surface velocity near the end of ebb where water leaving the estuary is caught in a large eddy over the Hampton flats east of the point and advected toward the point where it plunges under the front and is transported back upstream at depth to the central region of the estuary. Such a mechanism had been suggested to exist based on observations of dye releases in a hydraulic model (Ruzecki and Hargis, 1989). Field observations by Kuo, *et al.*, (1988) further identified an estuarine front near Newport News Point as the closing link in the circulation loop.

The frontal system results from the convergence of higher salinity flood flow coming off the Hampton flats, northeast of Newport News point, with lower density ebb flow in the deep channel immediately south of the point, Figure 4. Figure 5 shows instantaneous sections of salinity and tangential velocity along a northeast-southwest section through the front for the current base case situation. Figure 6 shows the trajectory of a particle released in the surface layer passing through the front. The circle indicates the particle's horizontal position, while the vertical line indicates relative local depth. The position of the circle on the line indicates the particle's position vertically in the water column. The time increment between

successive positions is approximately 10 minutes. As the trajectory shows, the particle plunges to mid depth as it passes through the frontal system and continues upstream. Tracking of multiple particles, released over the course of an hour, through the frontal system indicated that approximately 50 per cent of the particles were entrained into the large scale, counter-clockwise, horizontal circulation system in the central portion of the river northwest of the James River Bridge and southeast of Wreck Shoals. Longer term particle tracking in the central portion of the river indicated typical residence times of days to weeks in this area. The remaining particles were entrained into the net seaward flow along the southern shore of the river, south of Newport News Point, and either discharged into the Chesapeake Bay or recirculated through the frontal system.

For the present study, the James River bottom bathymetry has been updated to 1993 conditions including a 50 ft channel to Newport News and the I664 tunnel islands. The base case corresponds to quasisteady tidal and freshwater inflow forcings. A single constituent tide at the M2 frequency and having an amplitude corresponding to the mean tide range is used for the open boundary forcing and applied along the open boundary, approximately 10 kilometers east of the Hampton Roads Bridge-Tunnel. A constant fresh water discharge of 300 cms, corresponding approximately to the annual mean, was introduced at the model's landward boundary, corresponding the limit of tidal propagation in Richmond.

4. Analysis of Alternate Island Locations

The general procedure for evaluating alternate island locations involves comparison of a number of physical circulation and transport features between the base case, with no island, and nine alternate island locations. The physical features selected for comparison include: tidal surface displacement amplitudes and phases; instantaneous surface velocity fields at the time of the

frontal system formation; vertical plane salinity sections through the frontal system; and vertical plane normal velocity component sections through the frontal system. For the single island location resulting in the least significant physical changes in the frontal system, comparisons with the base case are made for larger scale circulation and transport features, including tidally averaged or mean horizontal and vertical plane velocity and salinity distributions in the lower James.

The primary island location, island 1, is in the general vicinity of the Newport Island study, island C, (Byrne, *et al.*, 1987) Figure 1(a). The island is represented as an oblong dry region in the flow field, with dimensions of 5151 ft along a major southwest-northeast axis and 1717 ft along a minor southeast-northwest axis. The dry, or above the water line area of the island is approximately 169 acres, equivalent to five model cells. This island size corresponds very closely to the Norfolk District COE specified elliptic (racetrack) island which has major and minor axes of 4800 ft and 1600 ft, respectively, and an above water area of approximately 160 acres. The sensitivity of island induced circulation and salinity distribution modifications was systematically investigated by separate and combined longitudinal and lateral shifts of the island 1 location by increments of 1717 ft resulting in eight additional island locations, Figure 1(b). Three of these island locations, 7-9, corresponding to southeast shifts are not feasible sites since they fall within restricted anchorage areas. They were included in the preliminary analysis, however, to provide a more complete understanding of the sensitivity of circulation and transport modifications with respect to island location.

The impact of the alternate island locations on vertical tides in Hampton Roads was analyzed by comparing distributions of tidal surface displacement amplitude and phase with the base case. All alternate island locations resulted in tidal amplitude (1/2 tidal range) changes of less than 1 cm in very localized areas, and phase changes less than 6 minutes. The least significant changes were

associated with the island 1 location and are shown in Figures 7 and 8, with corresponding results for the no island base case. The dashed lines on the island 1 case, Figures 7b and 8b, indicate differences from the base case. Analysis of changes in the instantaneous tidal velocity field focused on the surface velocity distribution over the Hampton Flats and in the vicinity of Newport News point at the time of the formation of the frontal system. Island locations 4-6, corresponding to northwest shifts in island location resulted in the most significant blocking of the tidal flow over the flats approaching the frontal zone at Newport News Point, while locations 1-3 resulted in the least significant changes. Figure 9 shows the instantaneous surface velocity distributions for the base case and island 1 at the beginning of flood tide on the Hampton Flats.

To analyze further the influence of the alternate island locations on the dynamics of the frontal system, vertical plane salinity distributions along a southwest to northeast transect passing through the frontal convergence at the time of occurrence of the maximum salinity gradient across the convergence were compared. The island 1 location resulted in the least modification to the vertical plane salinity structure with respect to the no island base case, Figure 10. To quantify changes in the upstream plunging flow transport across the frontal system, sequences of 15 minute averaged normal Eulerian transports across a southeast to northwest section, perpendicular to the preceding salinity transects were compared. Only island locations 4-6, which were previously noted to block flood flow over the flats, resulted in quantifiable change in the upstream transport. However, transport reductions for locations 4-6 were relatively insignificant being less than 5 per cent. Figure 11 shows a comparison on the 15 minute averaged upstream plunging transport across the frontal system for the no island base case and the island 1 location. The primary conclusion of the frontal analysis is that construction of an island at the island 1 location will not adversely affect volumetric transport of material, including living organisms, through the frontal system upstream into the central region of the James River.

The results of the above described analyses tend to support the conclusion that island locations 1-3 result in insignificant modifications to the Newport News frontal system. Since island location 1 is the geographically favorable, analyses were conducted to ascertain if the island 1 location resulted in any significant large scale modifications to the circulation and mass transport patterns in the lower James River. Figures 12-17 show comparisons of instantaneous surface tidal velocities at 2 hour intervals over a tidal cycle, with hour 0 corresponding to maximum ebb flow, for the no island base case and the island 1 location. Figures 18-23 show similar comparisons for near bottom velocities. Figures 24-29 show the surface salinity distributions and Figures 30-35 show the bottom salinity distributions at corresponding 2 hour intervals. Visual inspection of theses instantaneous tidal velocity and salinity sequences indicated that changes in the velocity and salinities fields were confined to a region approximately 1 km seaward of the island 1 shoreline. Figures 36 and 37 show the surface and bottom Eulerian mean or residual transport velocity fields (tidally averaged velocity fields) for the base case and the island 1 location, and indicate insignificant modification of the large scale mean circulation in the lower James. Figure 38 shows a comparison of the vertical distribution of the Eulerian mean or residual velocity (tidally averaged velocity) across a southwest to northeast transect at the James River Bridge, while Figure 39 shows a corresponding distributions of the tidally averaged salinity. These figures indicate that the large scale circulation and transport field in the central portion of the James River is not influenced by the presence of an island at the island 1 location in the Hampton flats, and that the present transport of materials, including living organisms, in the central portion of the river will remain unaltered.

5. Summary and Conclusions

A preliminary screening analysis of 9 alternate island locations on the Hampton Flats of the lower James River indicated that island locations 1-3 resulted in insignificant changes in the dynamics of the Newport News frontal system. Further analyses, focusing on potential large scale modifications to the circulation patterns and salinity distribution in the lower James River showed insignificant changes between the no island base case and the island 1 location. These results are consistent with those obtained for the Newport Island location C in a previous study (Byrne, *et al.*, 1987). Thus the primary conclusion of this study is that construction of a 169 acre island at location 1 on the Hampton flats will not significantly effect circulation and mass transport in the lower James River.

6. References

Blumberg, A. F., and G. L. Mellor, 1987: A description of a three-dimensional coastal ocean circulation model. *Three-Dimensional Coastal Ocean Models,* N. S. Heaps, Ed., American Geophysical Union.

Byrne, Robert J. *et al.*, 1987, Newport Island: An Evaluation of Potential Impacts on Marine Resources of the Lower James River and Hampton Roads, Special Report in Applied Marine Science and Ocean Engineering No. 283, Virginia Institute of Marine Science

Galperin, B., L. H. Kantha, S. Hassid, and A. Rosati, 1988: A quasi-equilibrium turbulent energy model for geophysical flows. *J. Atmos. Sci.,* 45, 55-62.

Hamrick, J. M., 1991: Analysis of mixing and dilution of process water discharged into the Pamunkey River, a Report to the Chesapeake Corp. The College of William and Mary, Virginia Institute of Marine Science, 50 pp.

Hamrick, J. M., 1992a: A Three-Dimensional Environmental Fluid Dynamics Computer Code: Theoretical and Computational Aspects. The College of William and Mary, Virginia Institute of Marine Science, Special Report 317, 63 pp.

Hamrick, J. M., 1992b: Estuarine environmental impact assessment using a three-dimensional circulation and transport model. *Estuarine and Coastal Modeling, Proceedings of the 2nd International Conference*, M. L. Spaulding *et al*, Eds., American Society of Civil Engineers, 292-303.

Kuo, A. Y., R. J. Byrne, J. M. Brubaker, and J. H. Posenau, 1988: Vertical transport across an estuary front. in *Physical Processes in Estuaries*. J. Dronkers and W. van Leussen, Eds., Springer-Verlag. 93-109.

Kuo, A. Y., J. M. Hamrick, and G. M. Sisson, 1990: Persistence of residual currents in the James River estuary and its implication to mass transport. in *Residual Circulation and Long-term Transport in Estuaries and Shallow Bays*. R. T. Cheng, Ed., Springer-Verlag.

Mellor, G. L., and T. Yamada, 1982: Development of a turbulence closure model for geophysical fluid problems, *Rev. Geophys. Space Phys.*, 20, 851-875.

Ruzecki, E. P. and W. J. Hargis, Jr., 1989: Interaction between circulation of the estuary of the James River and transport of oyster larvae. in *Estuarine Circulation*. B. J. Neilson, A. Y. Kuo, and J. M. Brubaker, Eds., Humana Press. 255-278.

Smolarkiewicz, P. K., and T. L. Clark, 1986: The multidimensional positive definite advection transport algorithm: further development and applications, *J. Comp. Phys.*, 67, 396-438.

Smolarkiewicz, P. K., and W. W. Grabowski, 1990: The multidimensional positive definite advection transport algorithm: nonoscillatory option, *J. Comp. Phys.*, 86, 355-375.

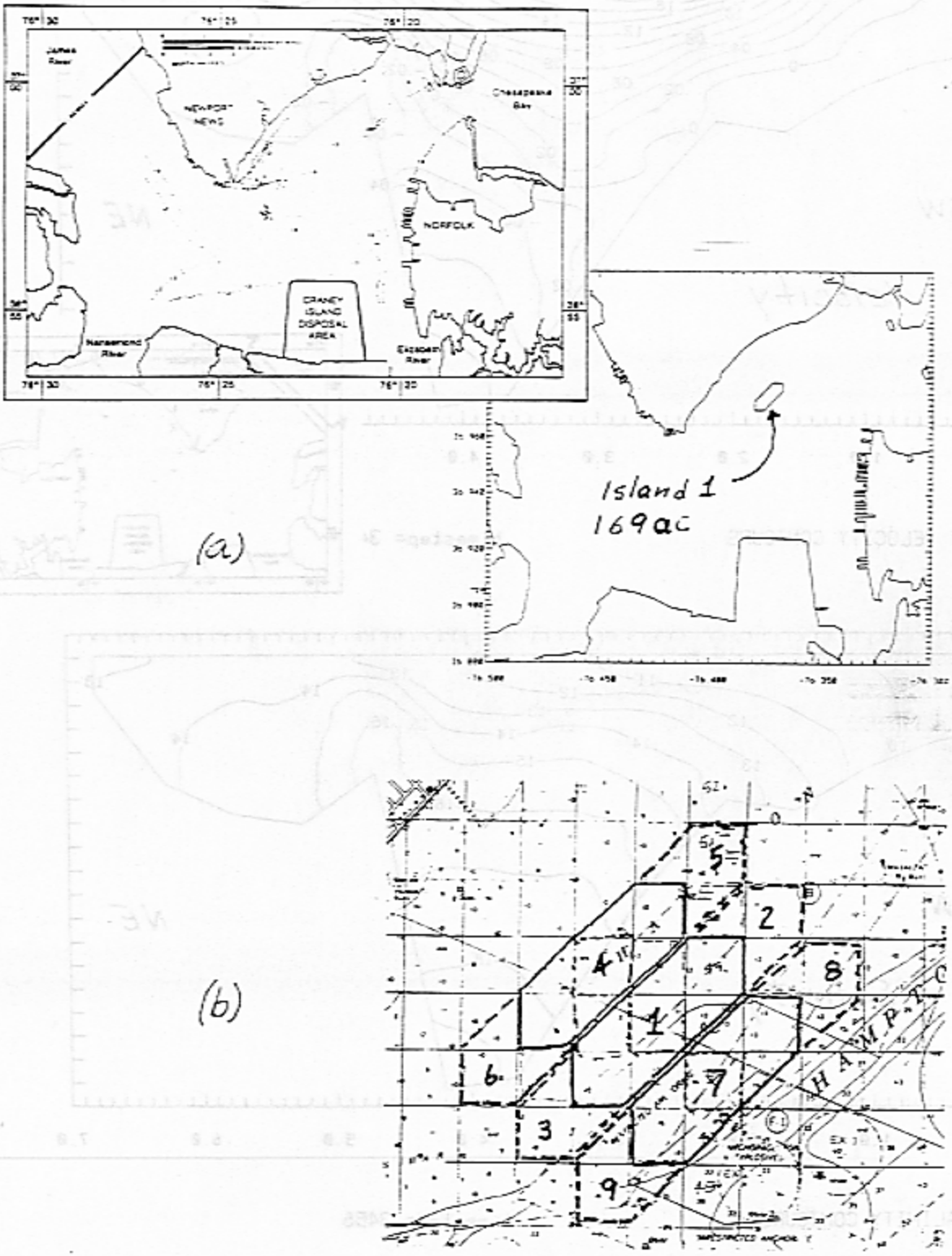
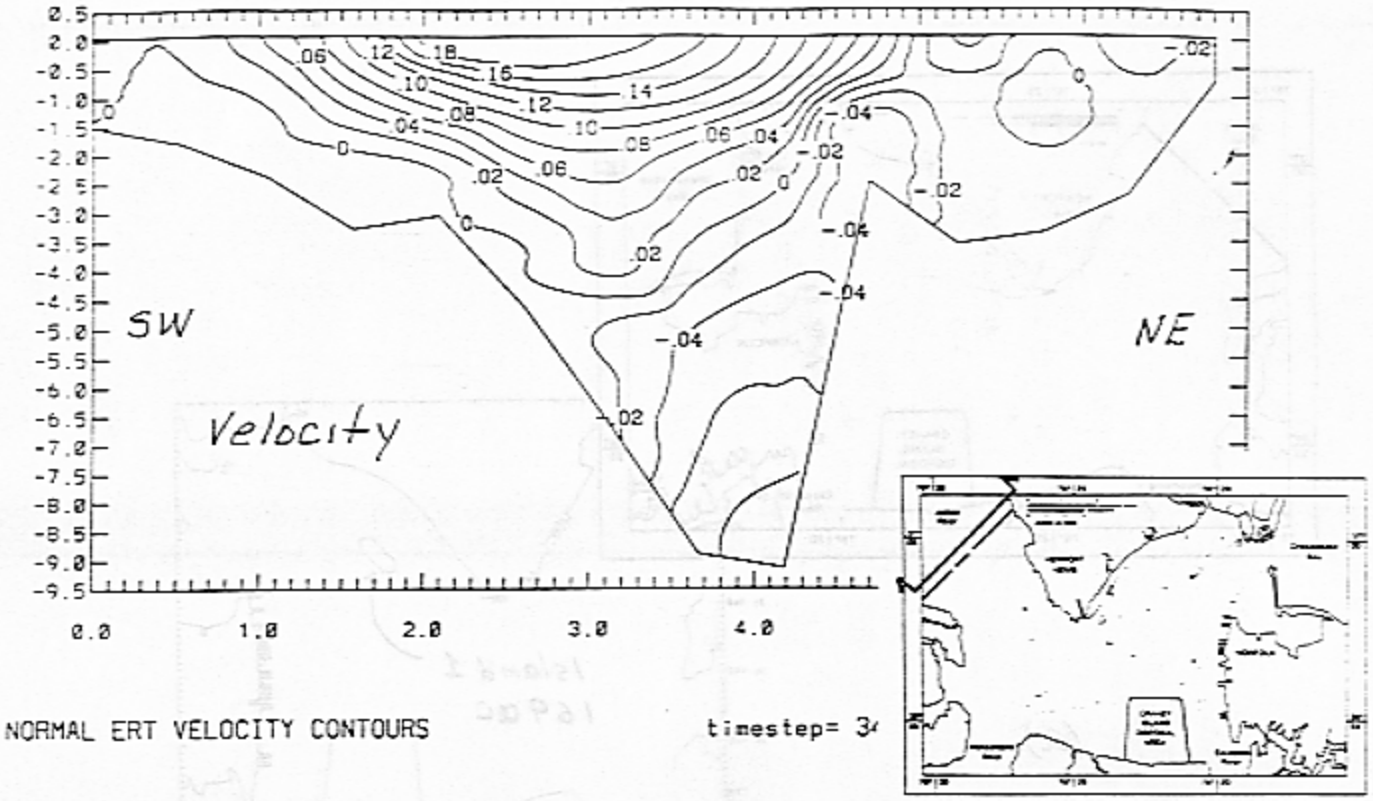


Figure 1. Lower James River. (a) Island 1 shown on Hampton Flats, and (b) Model grid and location of other islands relative to Island 1.



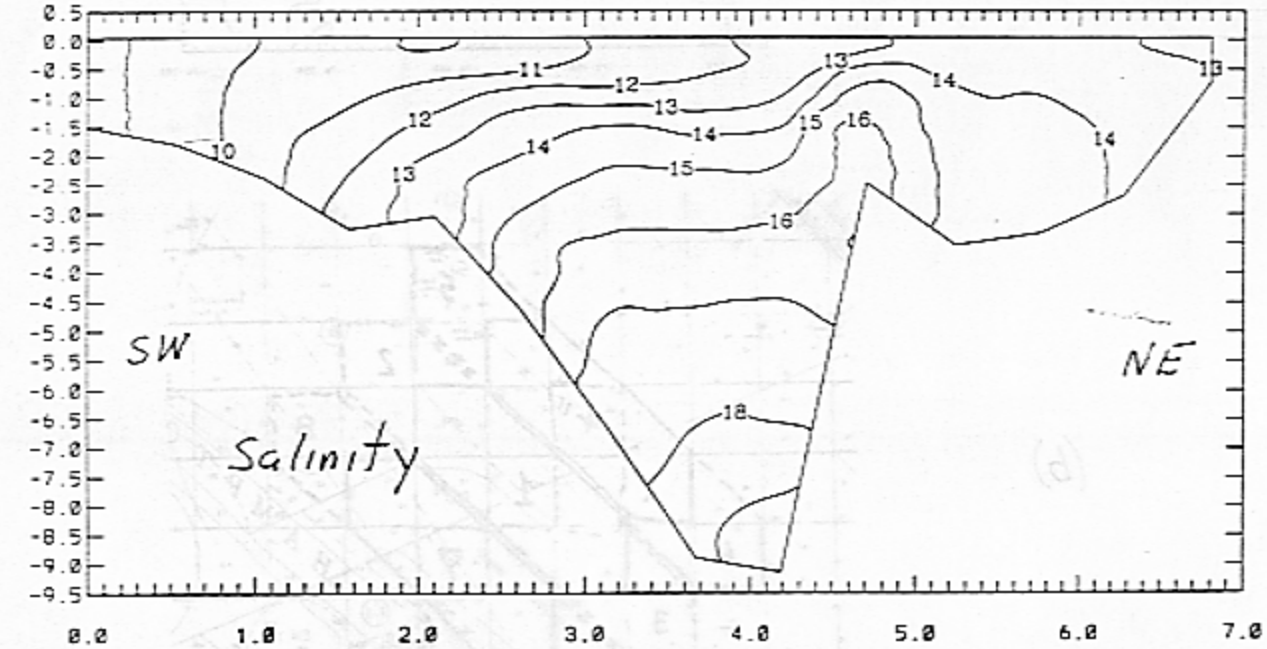


Figure 2. Tidally averaged normal velocity (m/s) and salinity at the James River Bridge.

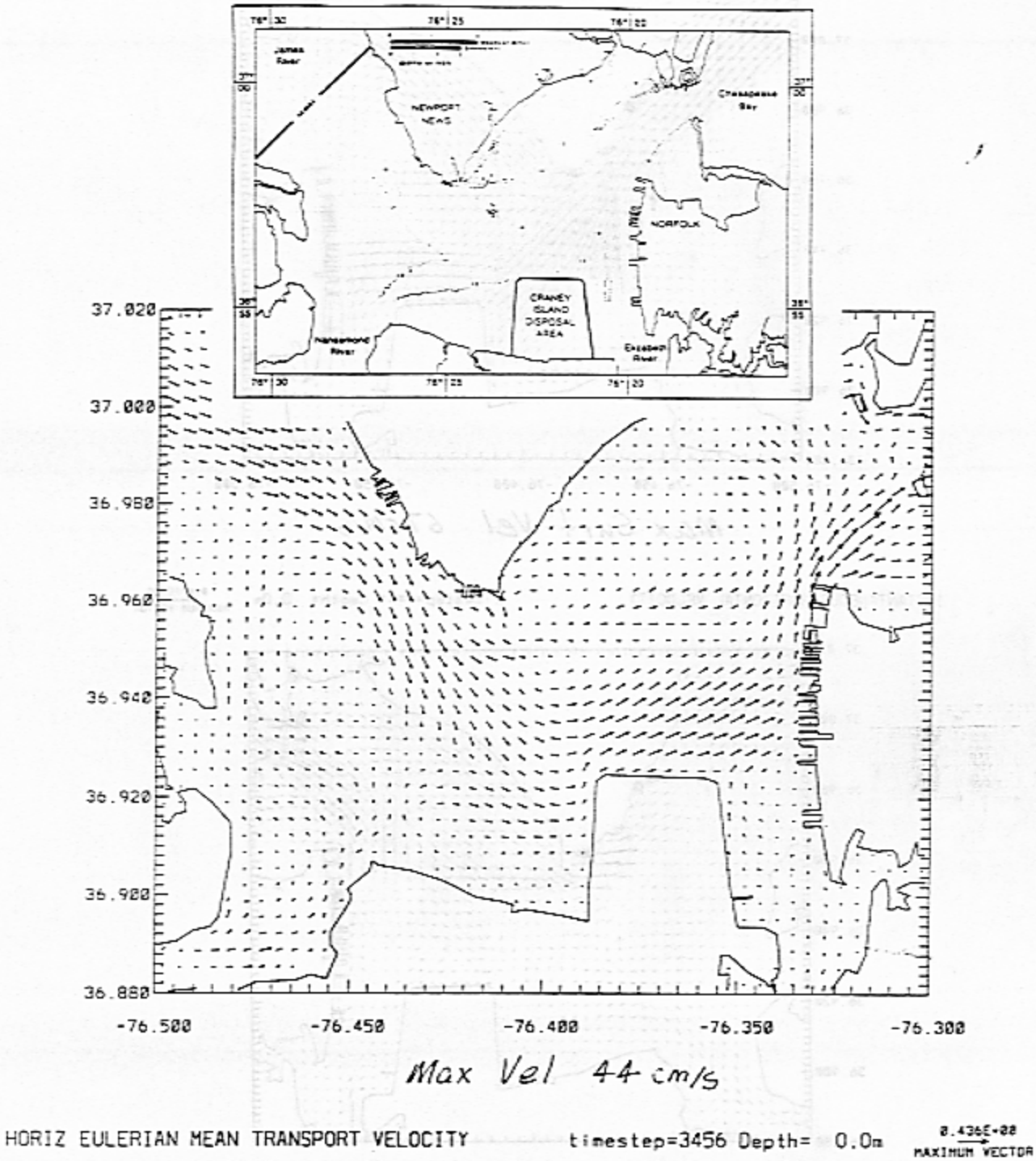
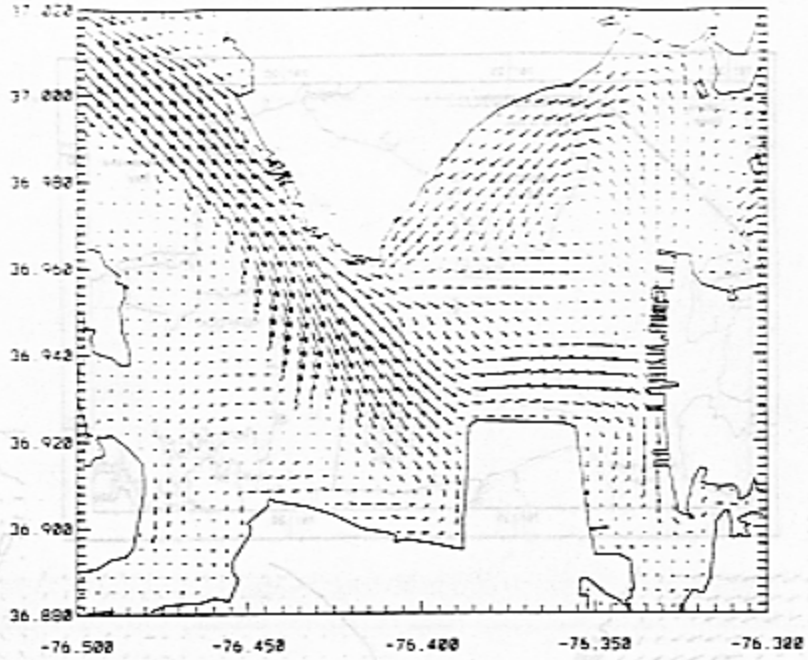
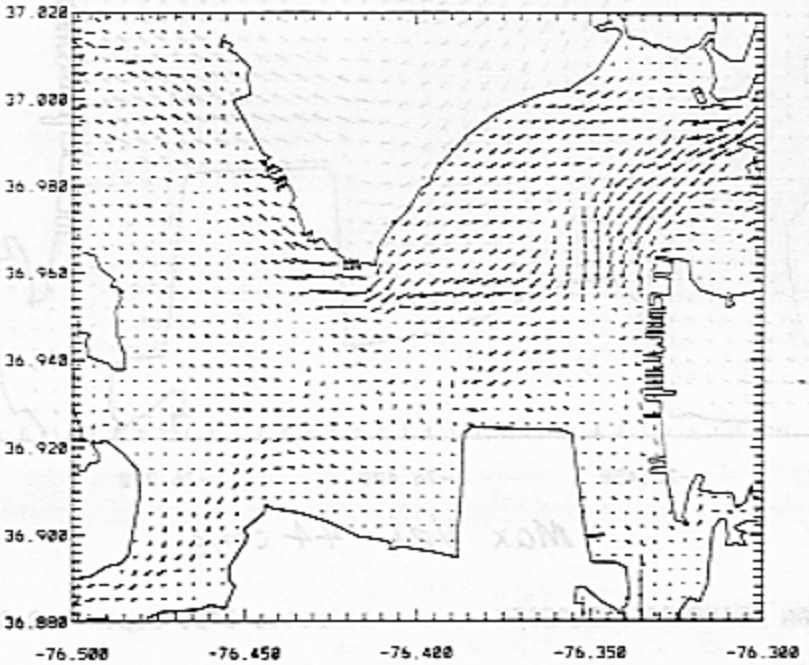


Figure 3. Tidally averaged surface velocity (m/s) field for base configuration.



Max Surf Vel 67cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=xxxx Depth= 0.0m 0.671E-00 MAXIMUM VECTOR



Max Bottom Vel 31cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=xxxx Depth= 99.0m 0.312E-00 MAXIMUM VECTOR

Figure 4. Instantaneous surface and bottom velocity fields (m/s) at the beginning of flood flow, for base configuration.

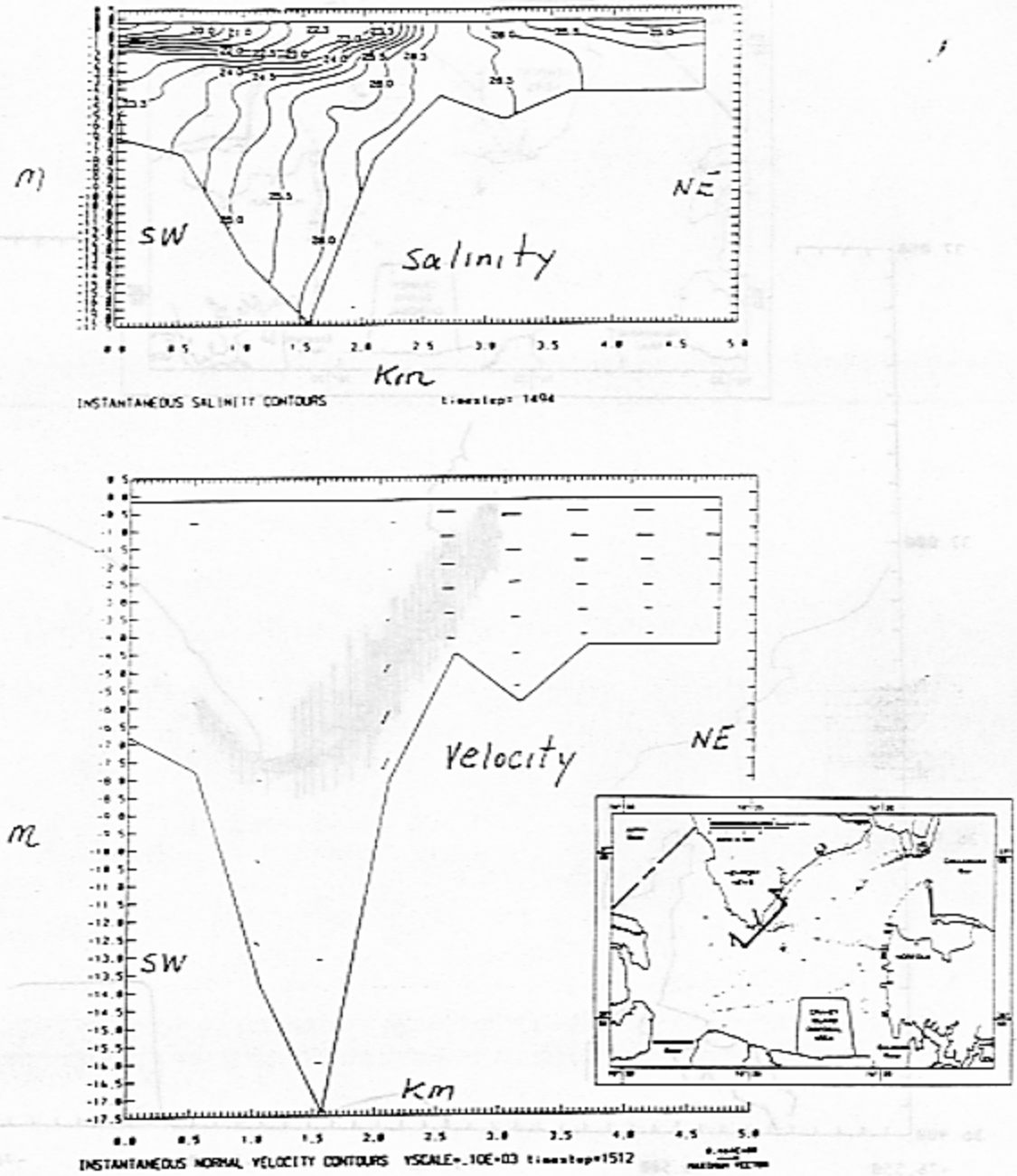


Figure 5. Instantaneous tangentical velocity (m/s) and salinity distribution over a southwest to northeast section across the frontal system, base configuration.

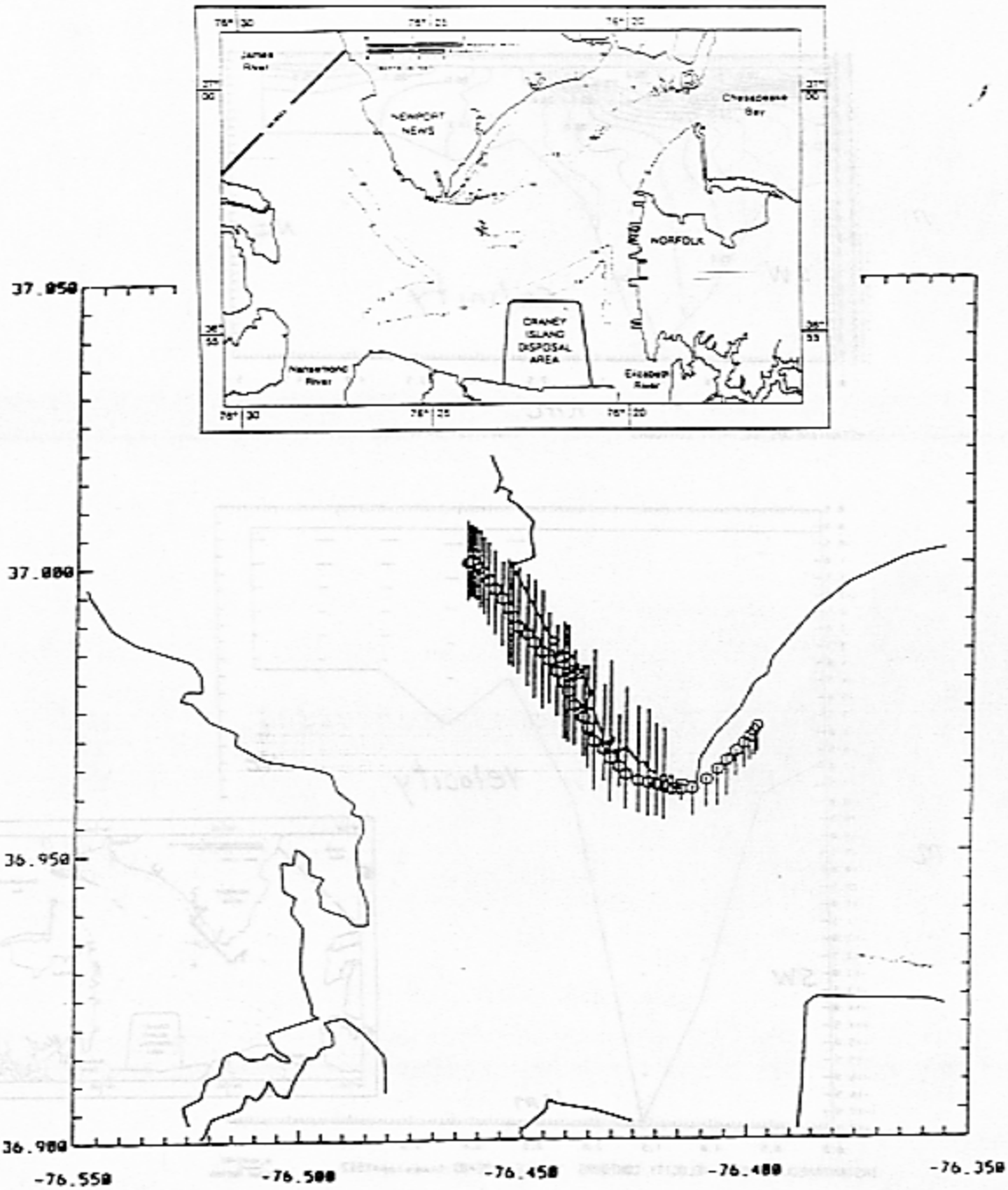


Figure 6. Trajectory of a neutrally buoyant particle through the frontal system for the base configuration.

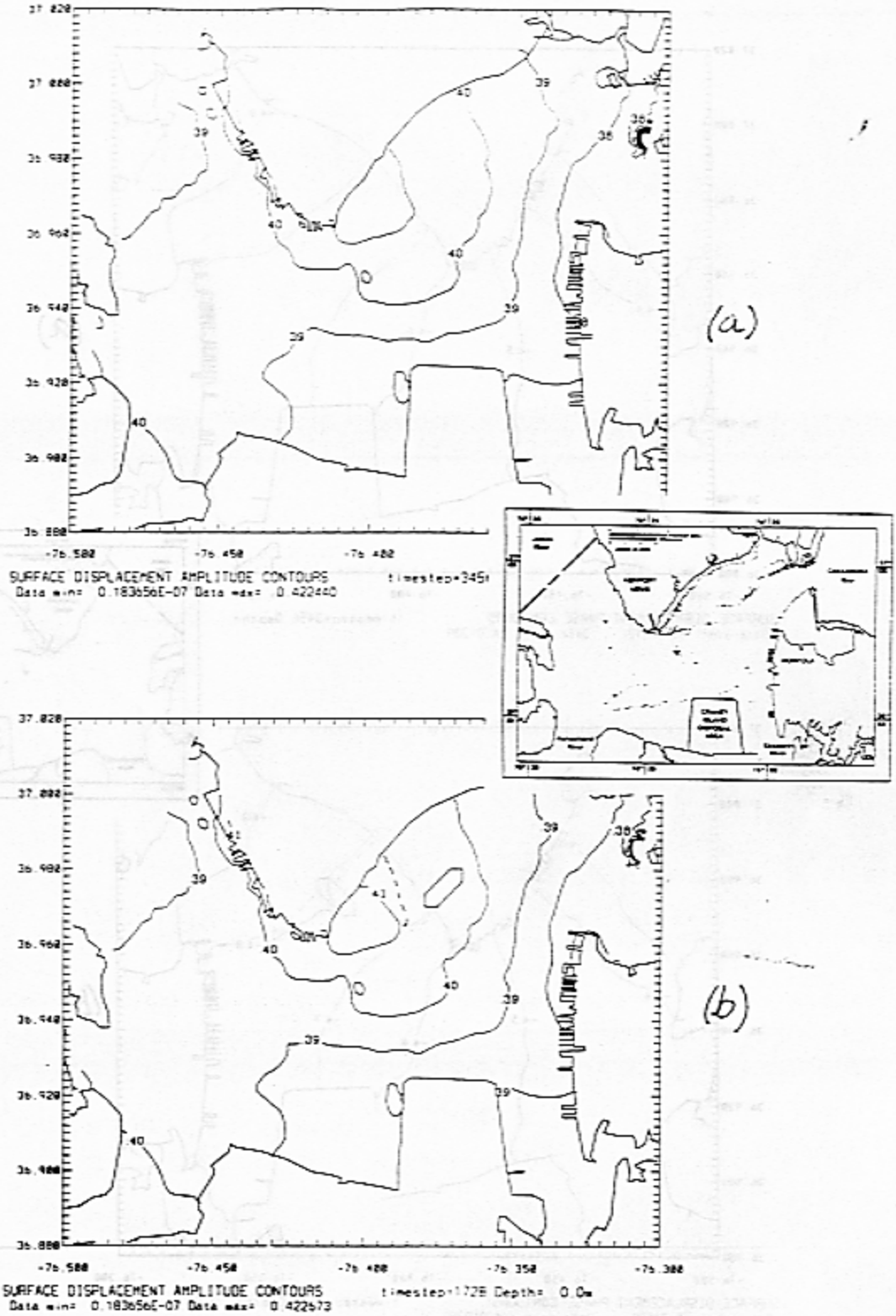


Figure 7. Tidal surface displacement amplitude (in meters) distribution for the base (a) and island 1 (b) configurations.

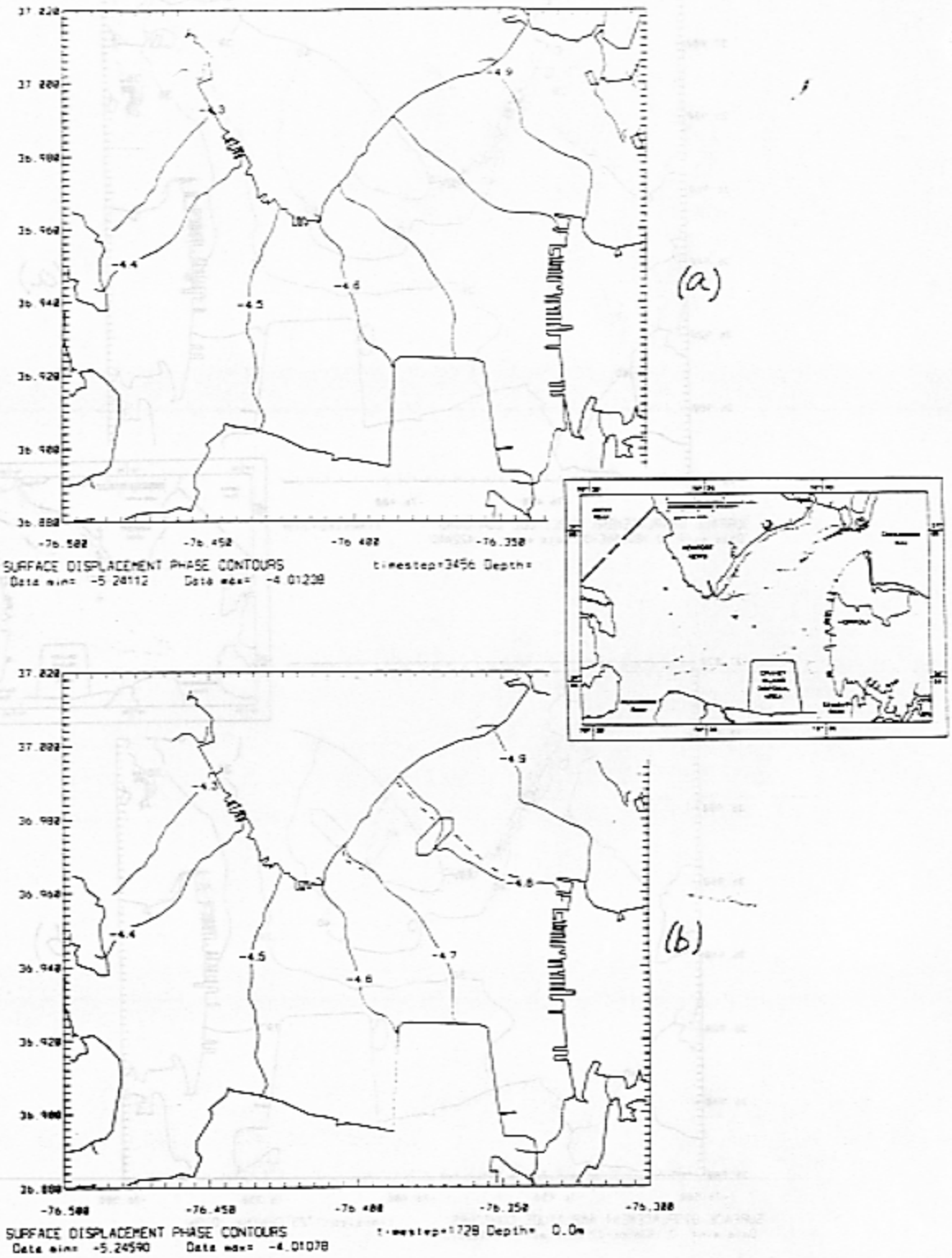
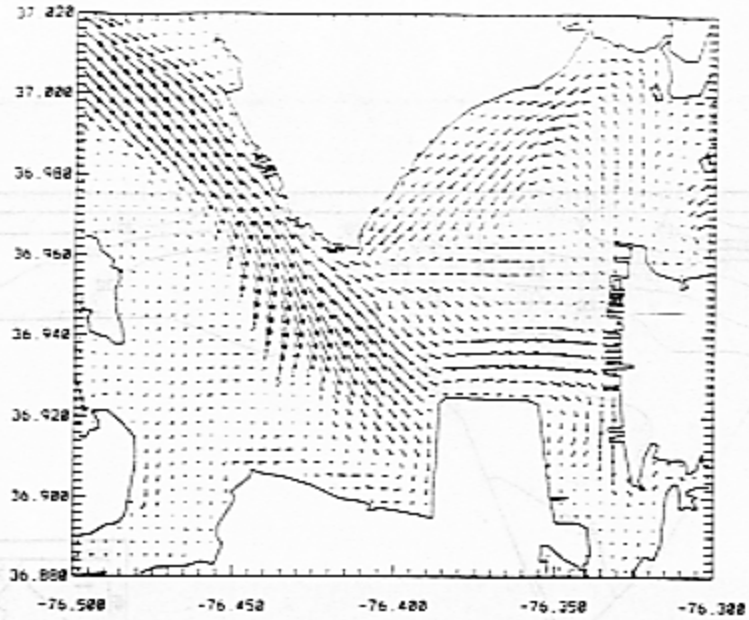


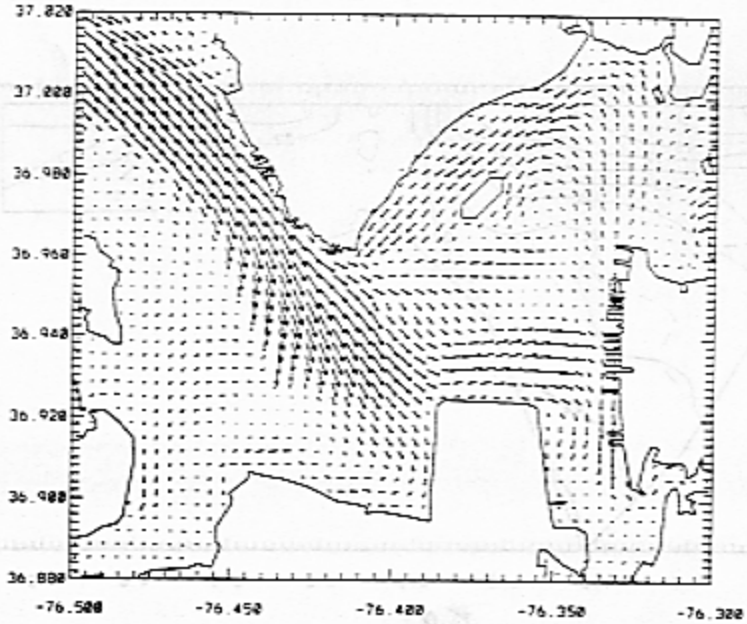
Figure 8. Tidal surface displacement phase (in hours) distribution for the base (a) and island 1 (b) configurations.



(a)

Max Vel 67 cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=**** Depth= 0.0m MAXIMUM VECTOR



(b)

Max Vel 67 cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=1404 Depth= 0.0m MAXIMUM VECTOR

Figure 9. Instantaneous surface velocity (m/s) distribution for the base (a) and island 1 (b) configurations, at the beginning of flood on the Hampton Flats.

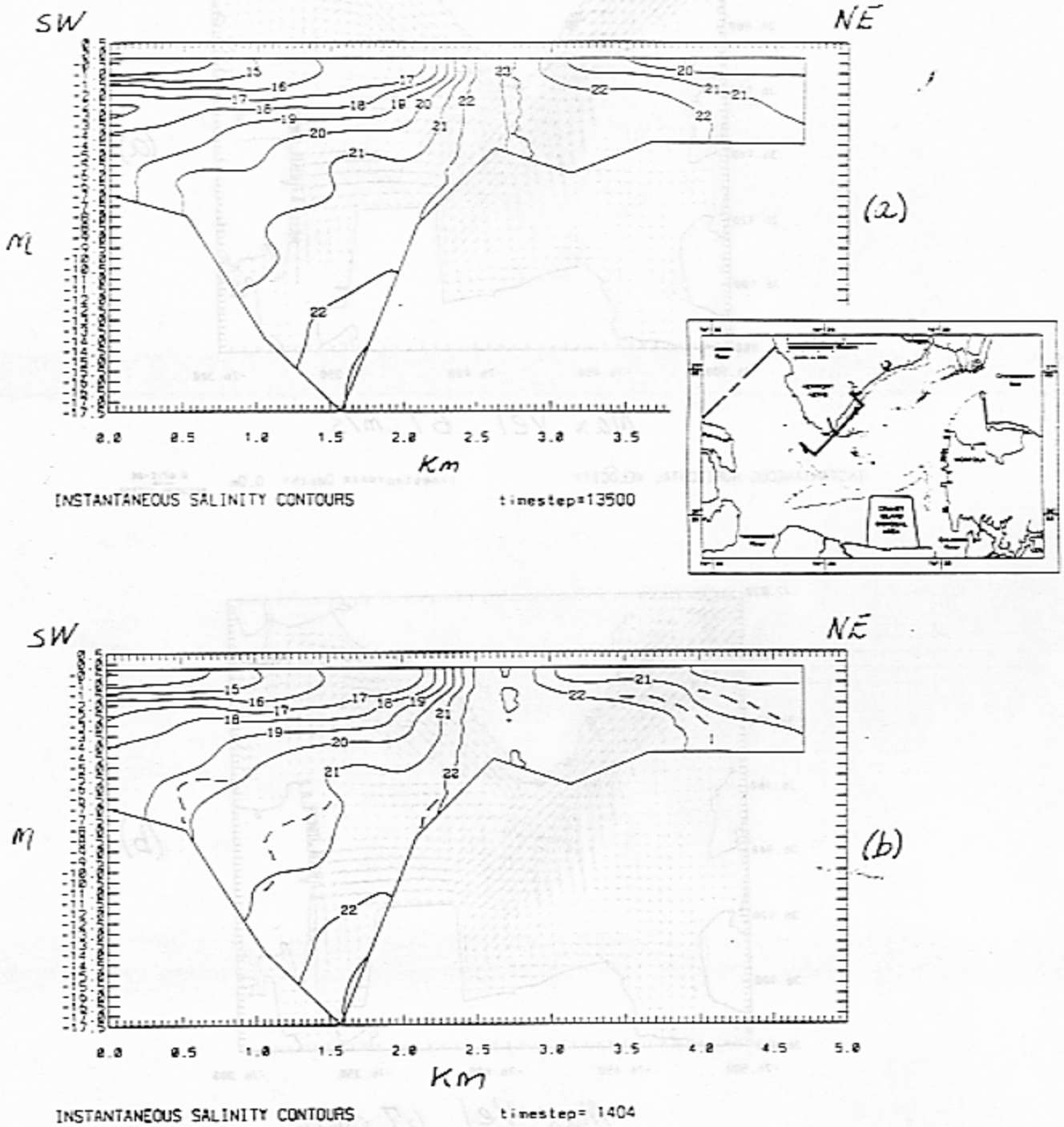


Figure 10. Vertical salinity section (from southwest to northeast) across the frontal system for the base (a) and island 1 (b) configurations.

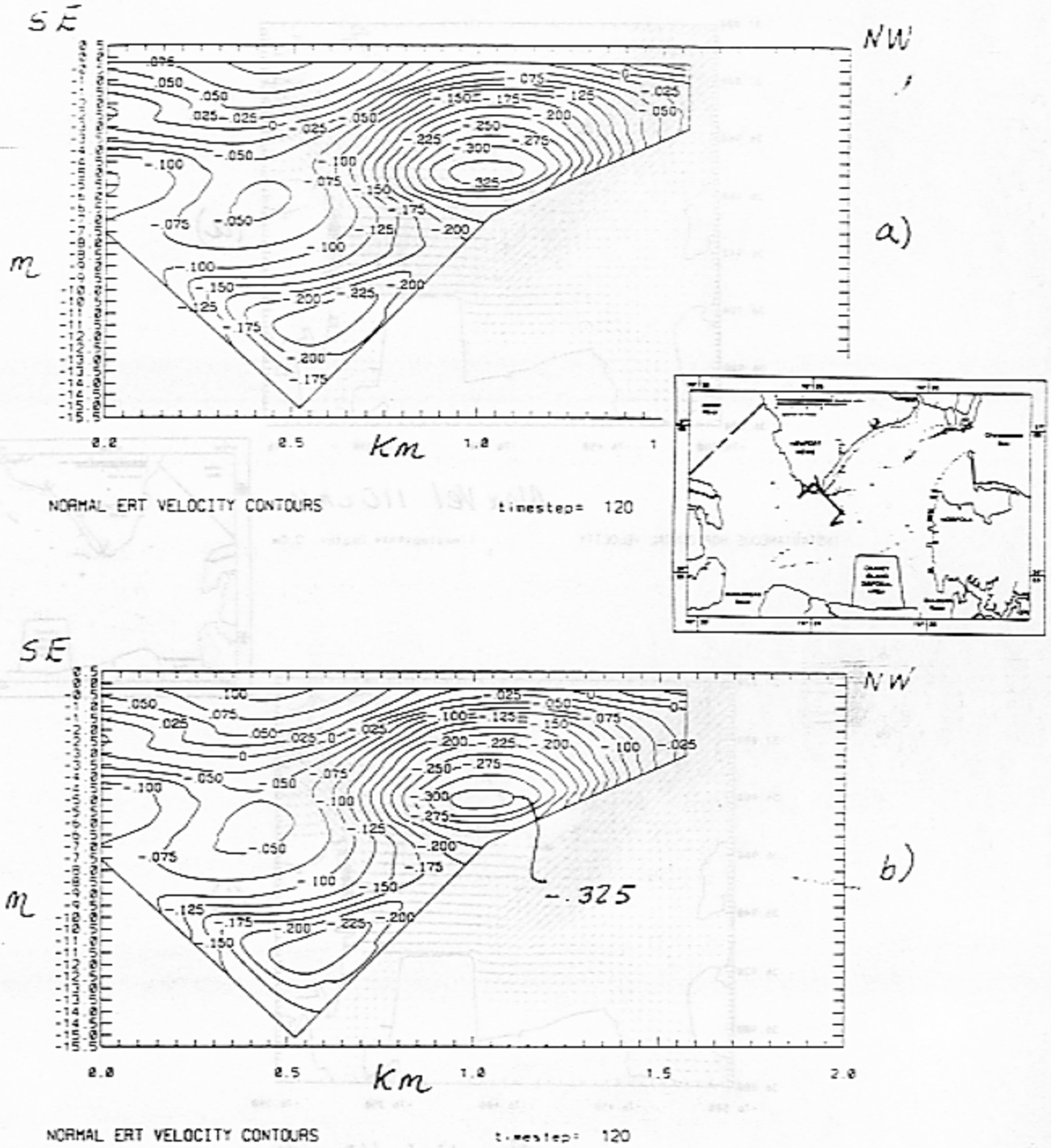


Figure 11. Vertical normal velocity (m/s) section (from southeast to northwest) across the frontal system for the base (a) and island 1 (b) configurations.

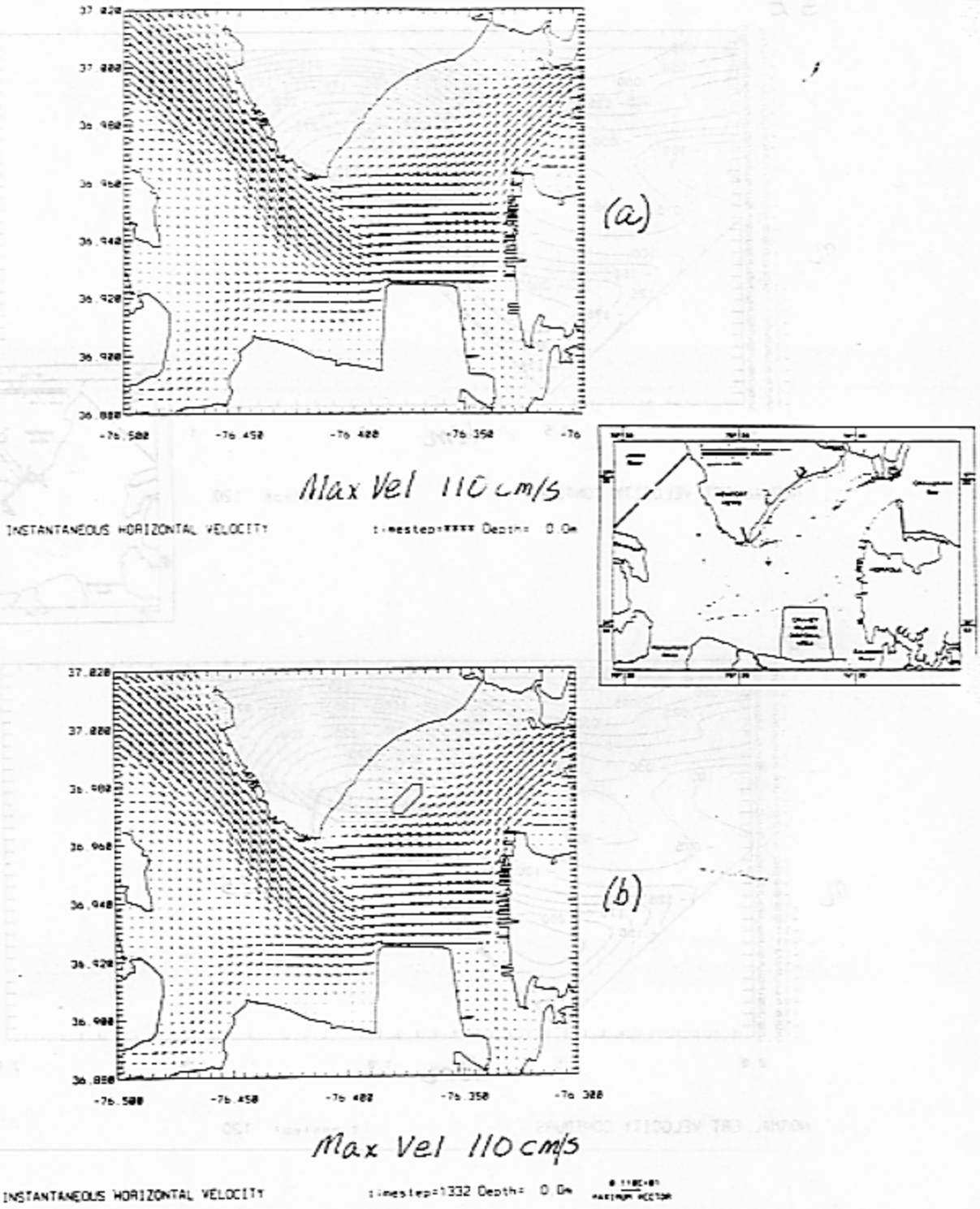
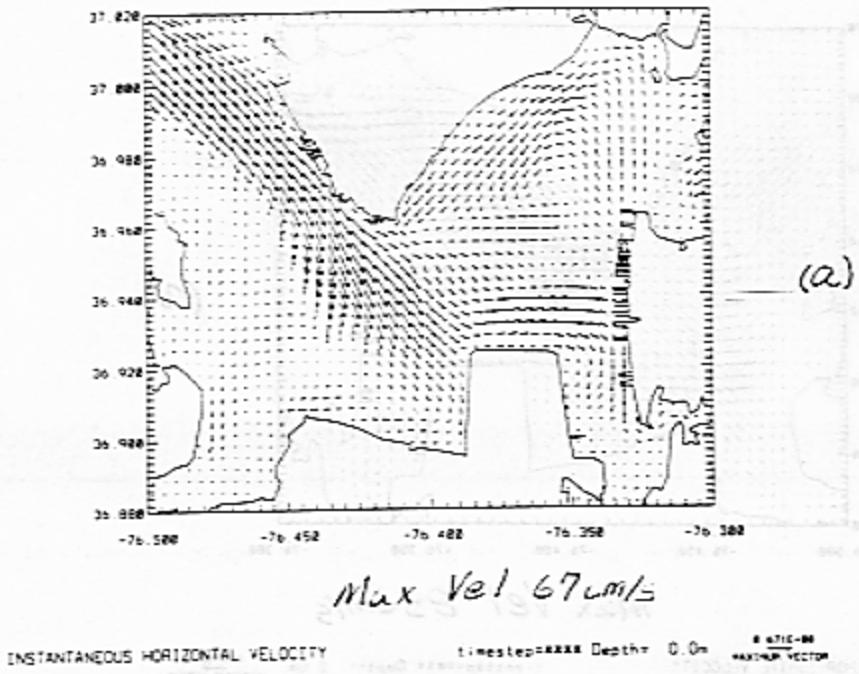


Figure 12. Instantaneous surface velocity (m/s) at hour 1, for the base (a) and island 1 (b) configurations.



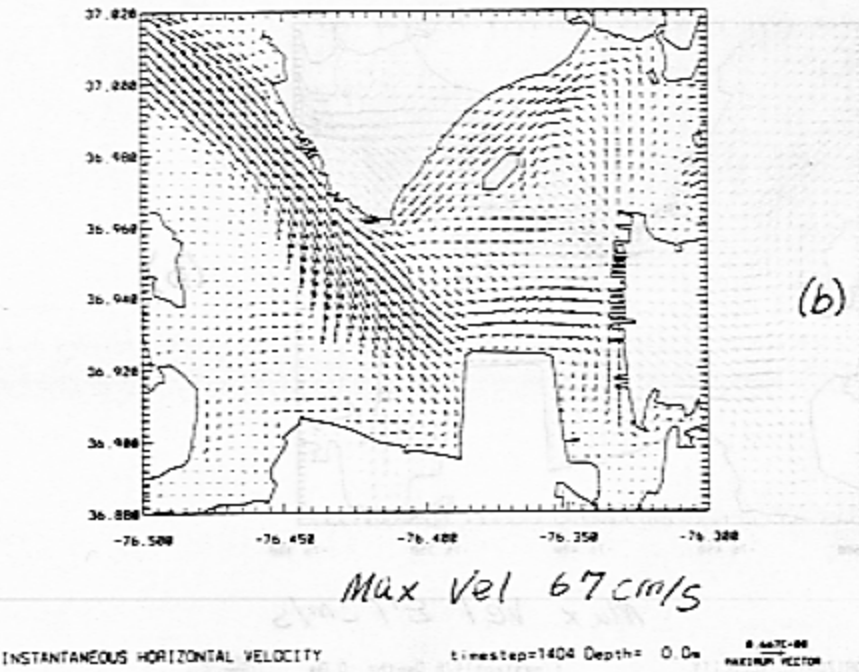
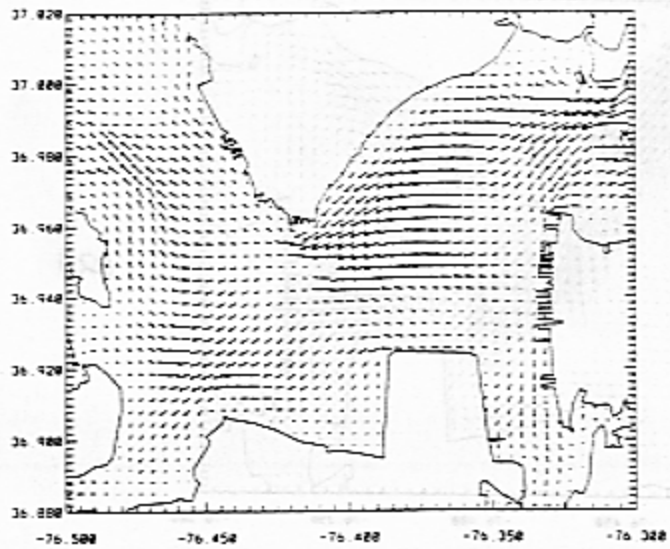


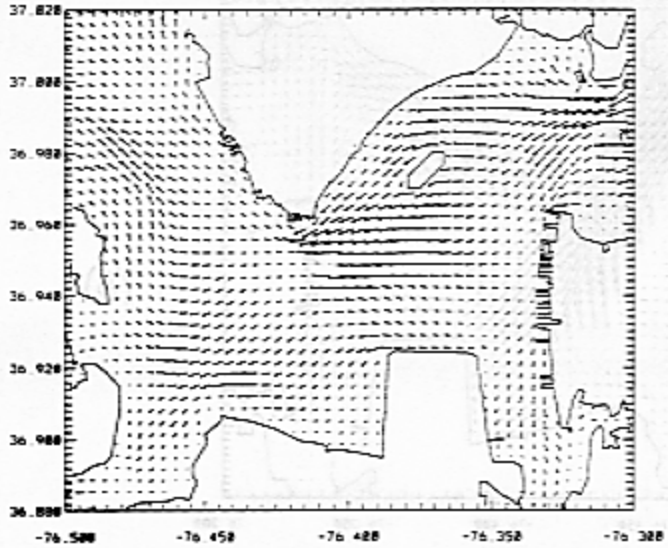
Figure 13. Instantaneous surface velocity (m/s) at hour 3, for the base (a) and island 1 (b) configurations.



(a)

Max Vel 89cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=#### Depth= 0.0m

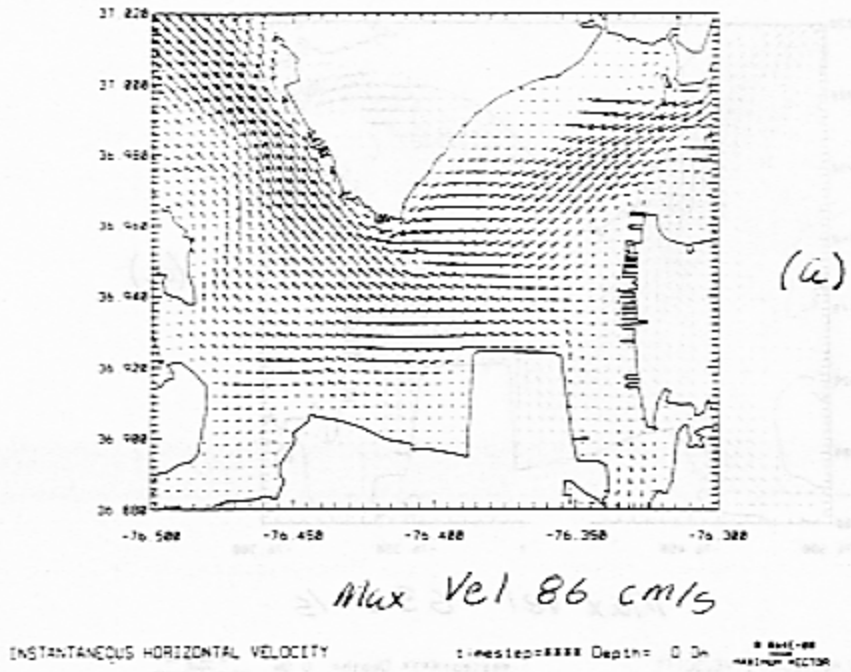


(b)

Max Vel 87 cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=1476 Depth= 0.0m

Figure 14. Instantaneous surface velocity (m/s) at hour 5, for the base (a) and island 1 (b) configurations.



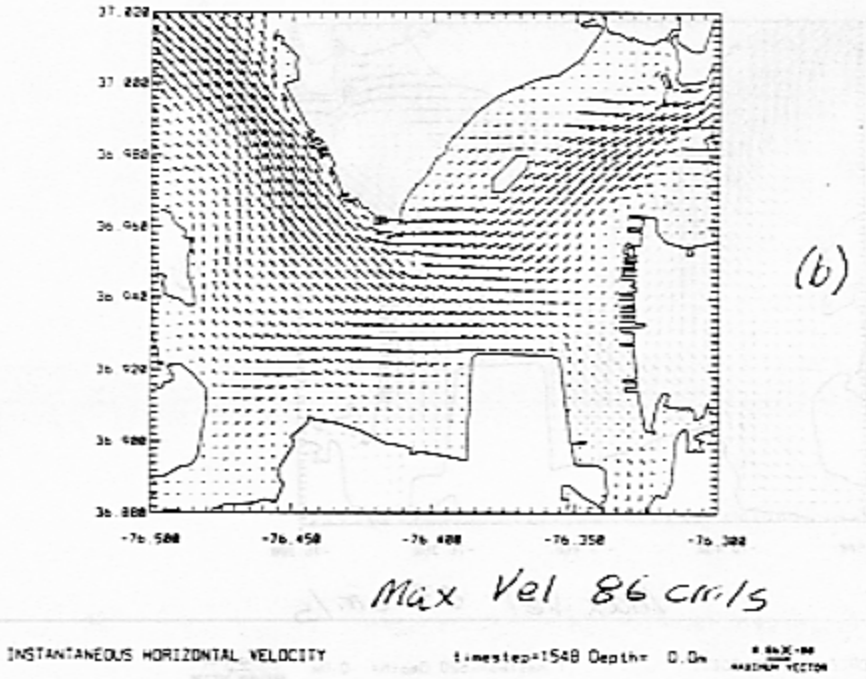
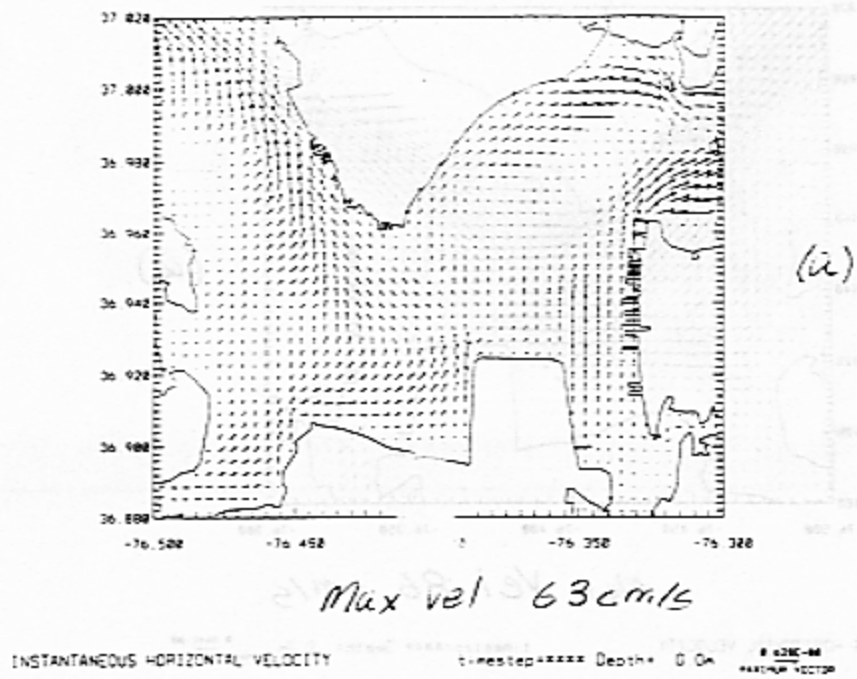


Figure 15. Instantaneous surface velocity (m/s) at hour 7, for the base (a) and island 1 (b) configurations.



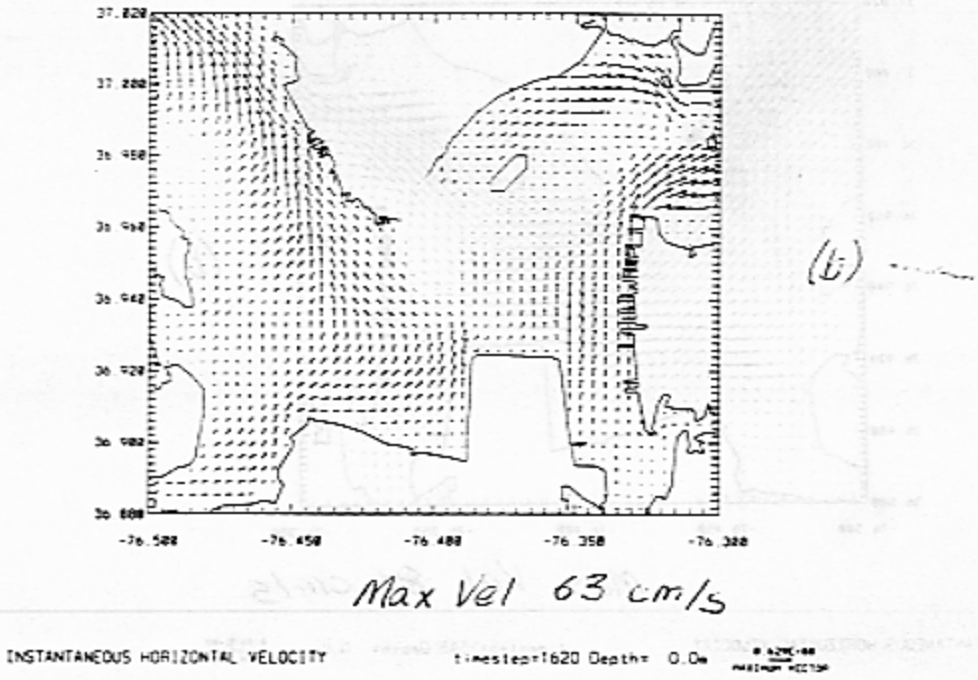
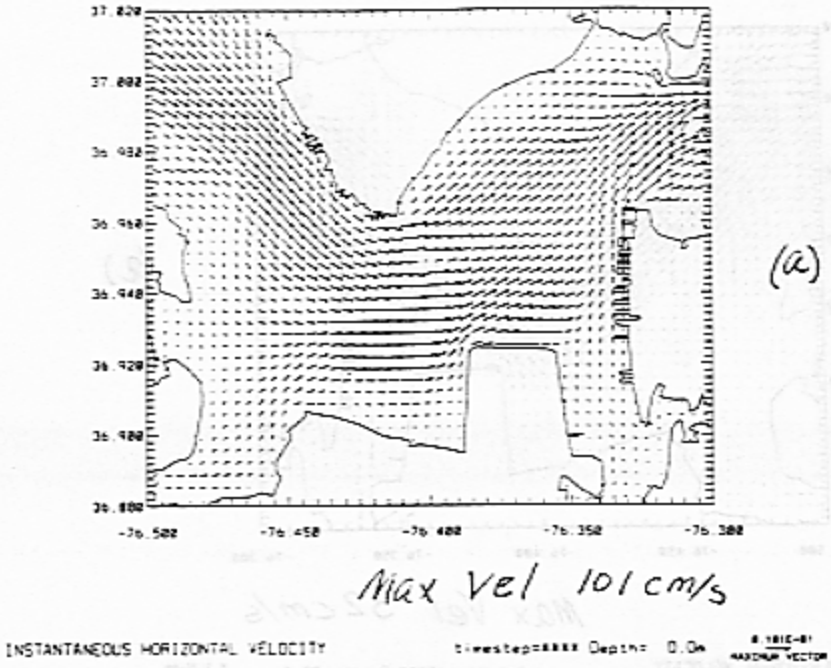


Figure 16. Instantaneous surface velocity (m/s) at hour 9, for the base (a) and island 1 (b) configurations.



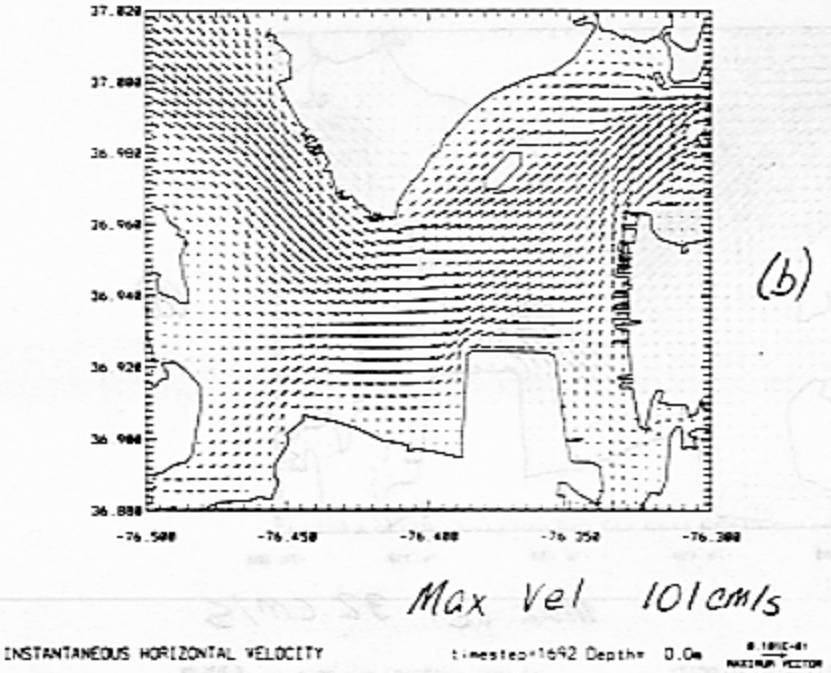
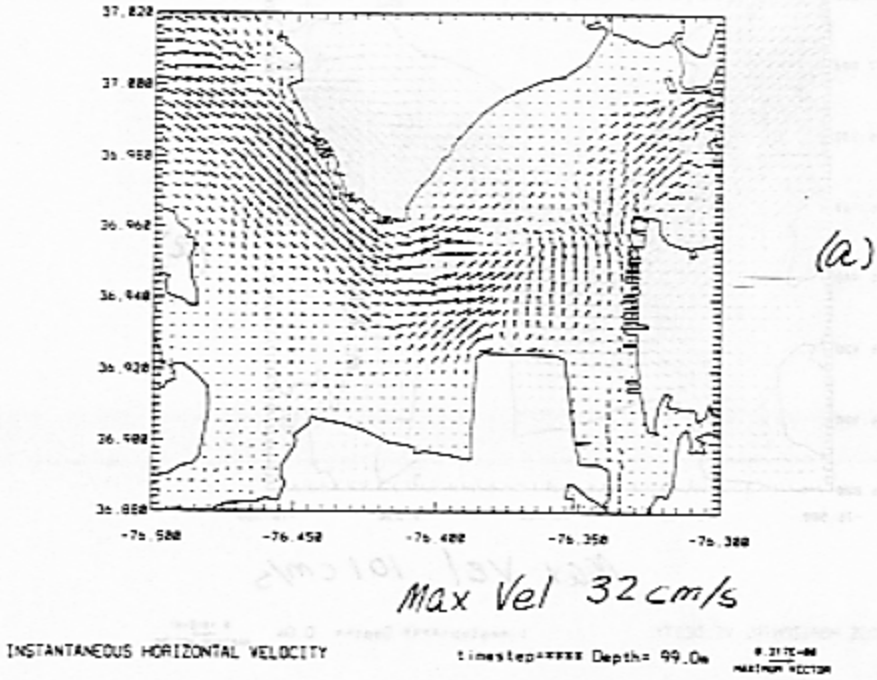


Figure 17. Instantaneous surface velocity (m/s) at hour 11, for the base (a) and island 1 (b) configurations.



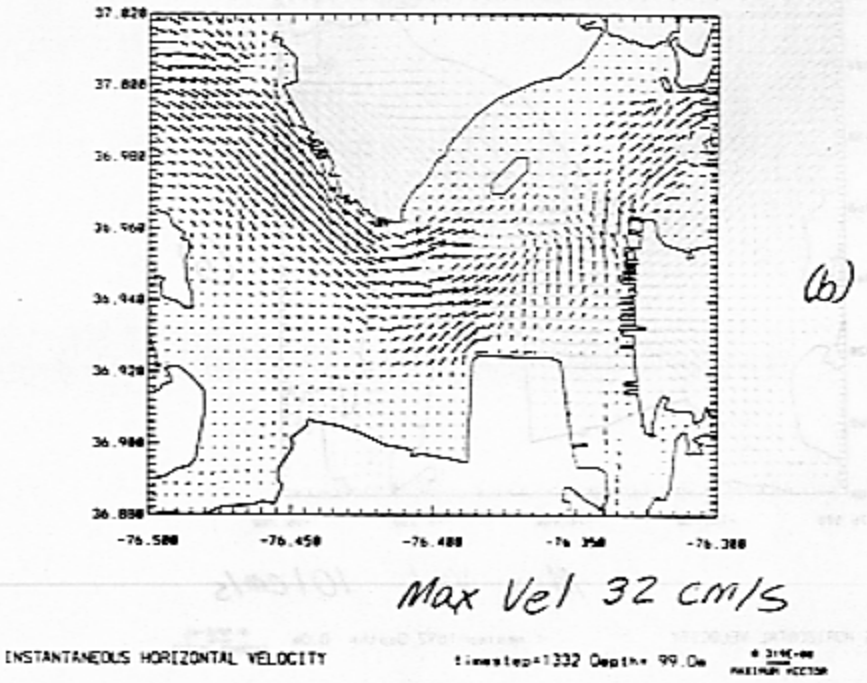
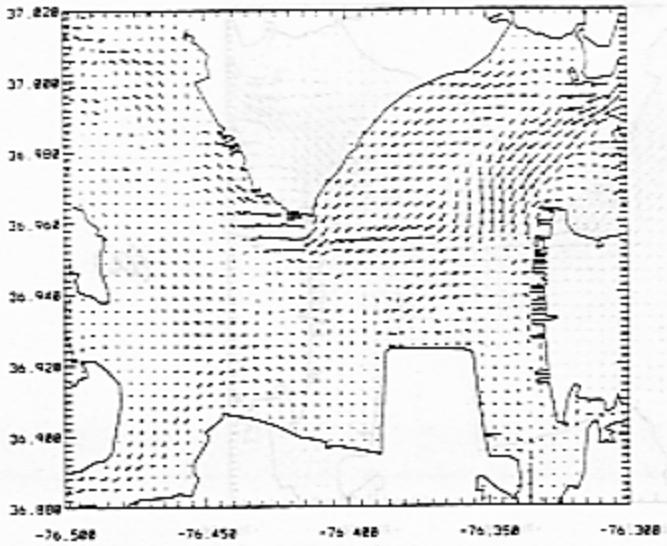
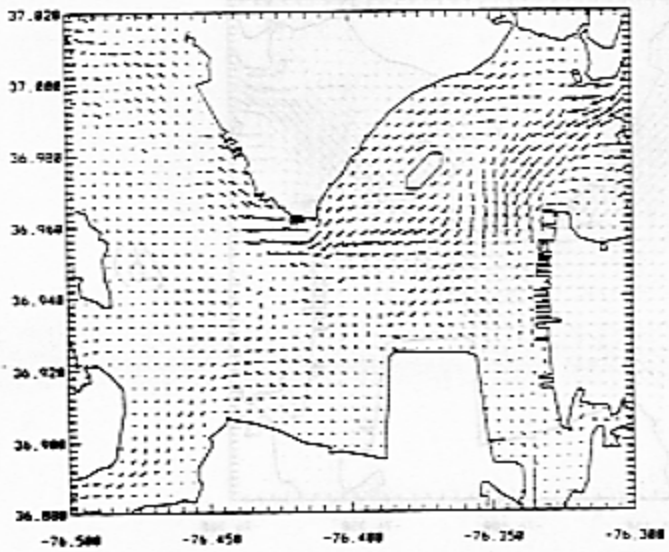


Figure 18. Instantaneous bottom velocity (m/s) at hour 1, for the base (a) and island 1 (b) configurations.



Max Vel 31 cm/s

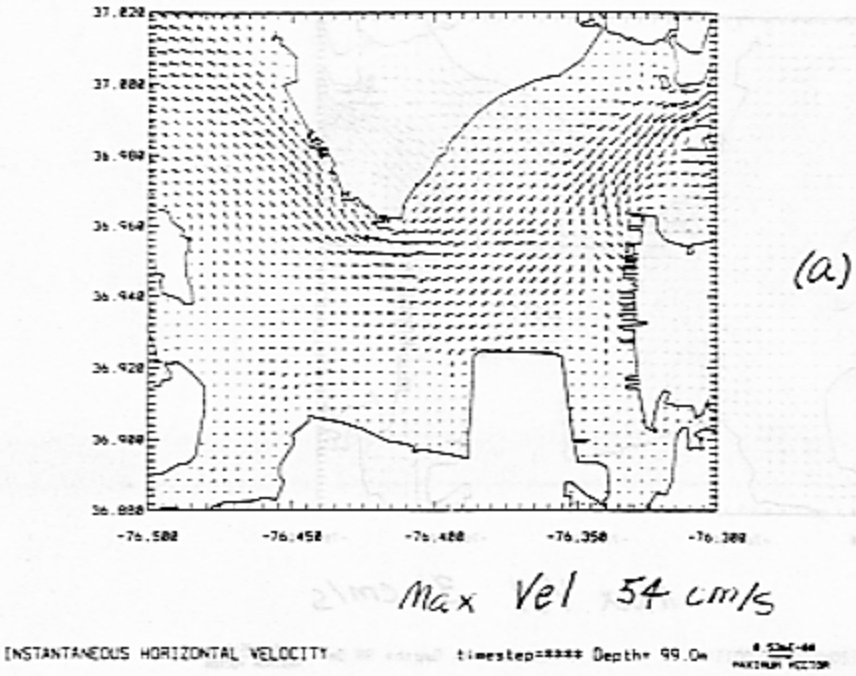
INSTANTANEOUS HORIZONTAL VELOCITY timestep=xxxx Depth= 99.0m 0.312E+00 MAXIMUM VECTOR



Max Vel 31 cm/s

INSTANTANEOUS HORIZONTAL VELOCITY timestep=1404 Depth= 99.0m 0.312E+00 MAXIMUM VECTOR

Figure 19. Instantaneous bottom velocity (m/s) at hour 3, for the base (a) and island 1 (b) configurations.



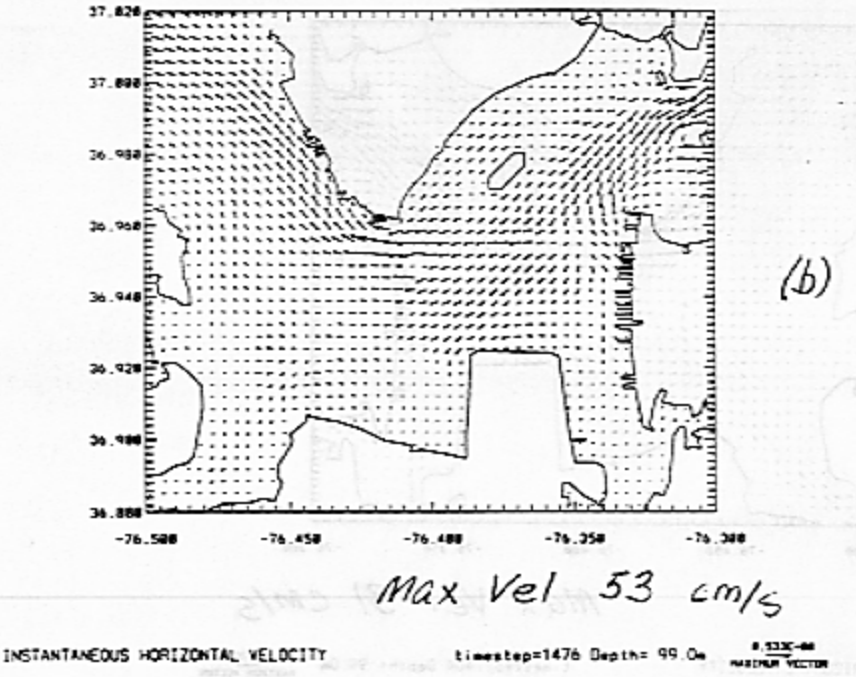
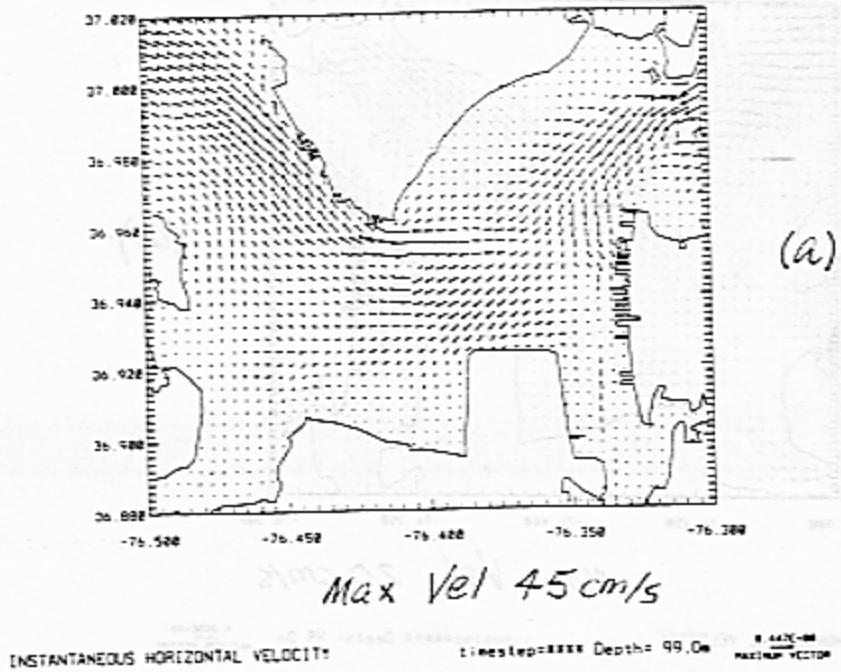


Figure 20. Instantaneous bottom velocity (m/s) at hour 5, for the base (a) and island 1 (b) configurations.



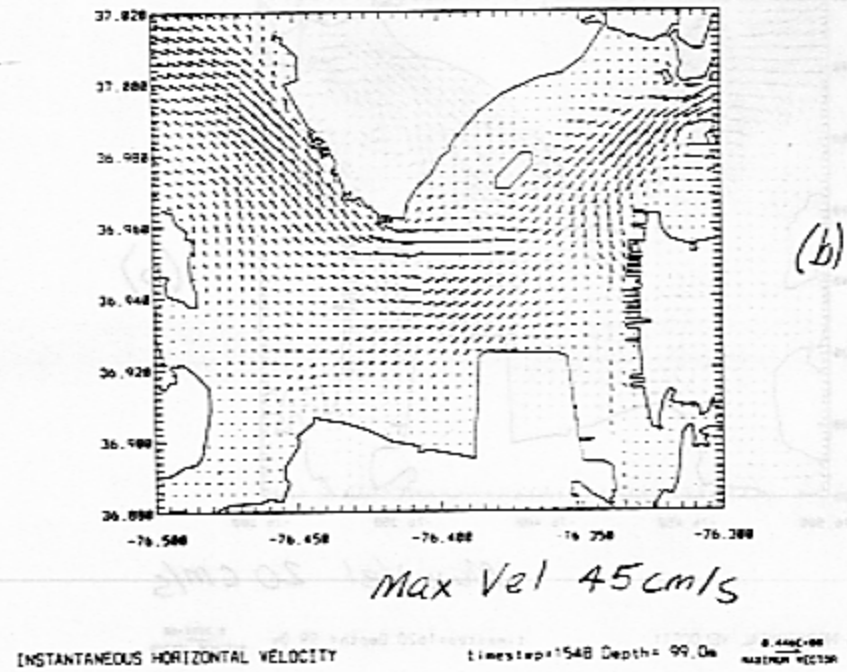
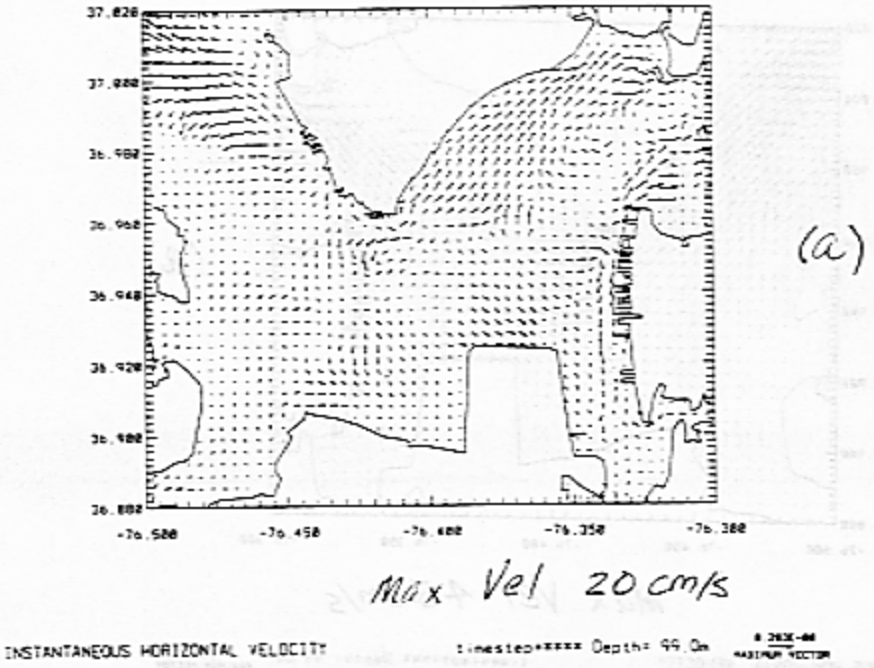


Figure 21. Instantaneous bottom velocity (m/s) at hour 7, for the base (a) and island 1 (b) configurations.



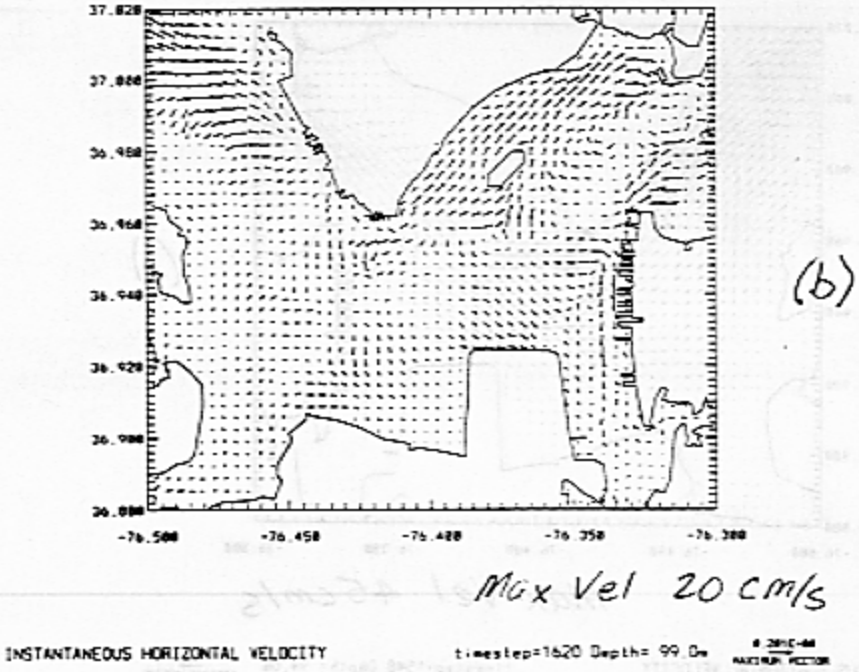


Figure 22. Instantaneous bottom velocity (m/s) at hour 9, for the base (a) and island 1 (b) configurations.

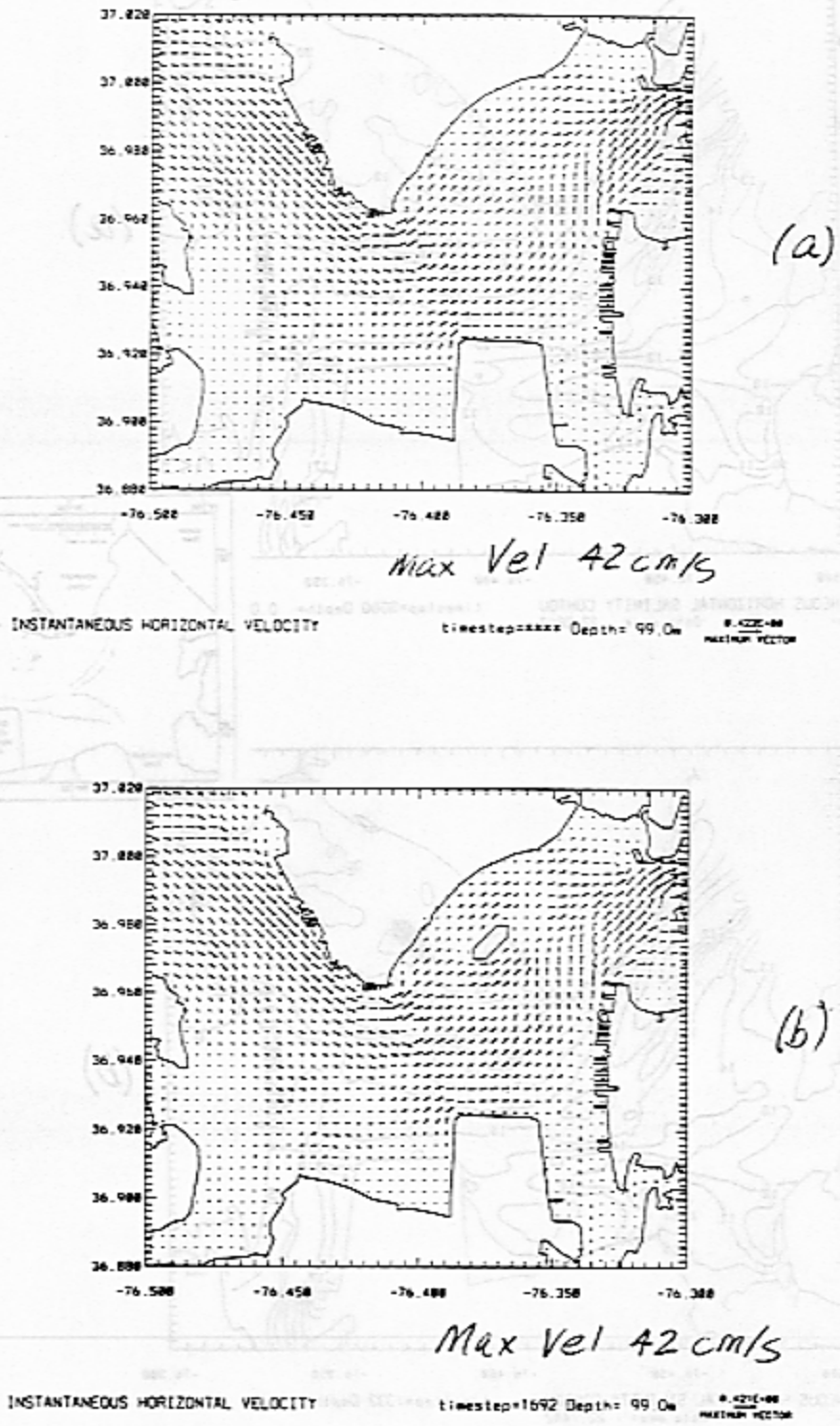


Figure 23. Instantaneous bottom velocity (m/s) at hour 11, for the base (a) and island 1 (b) configurations.

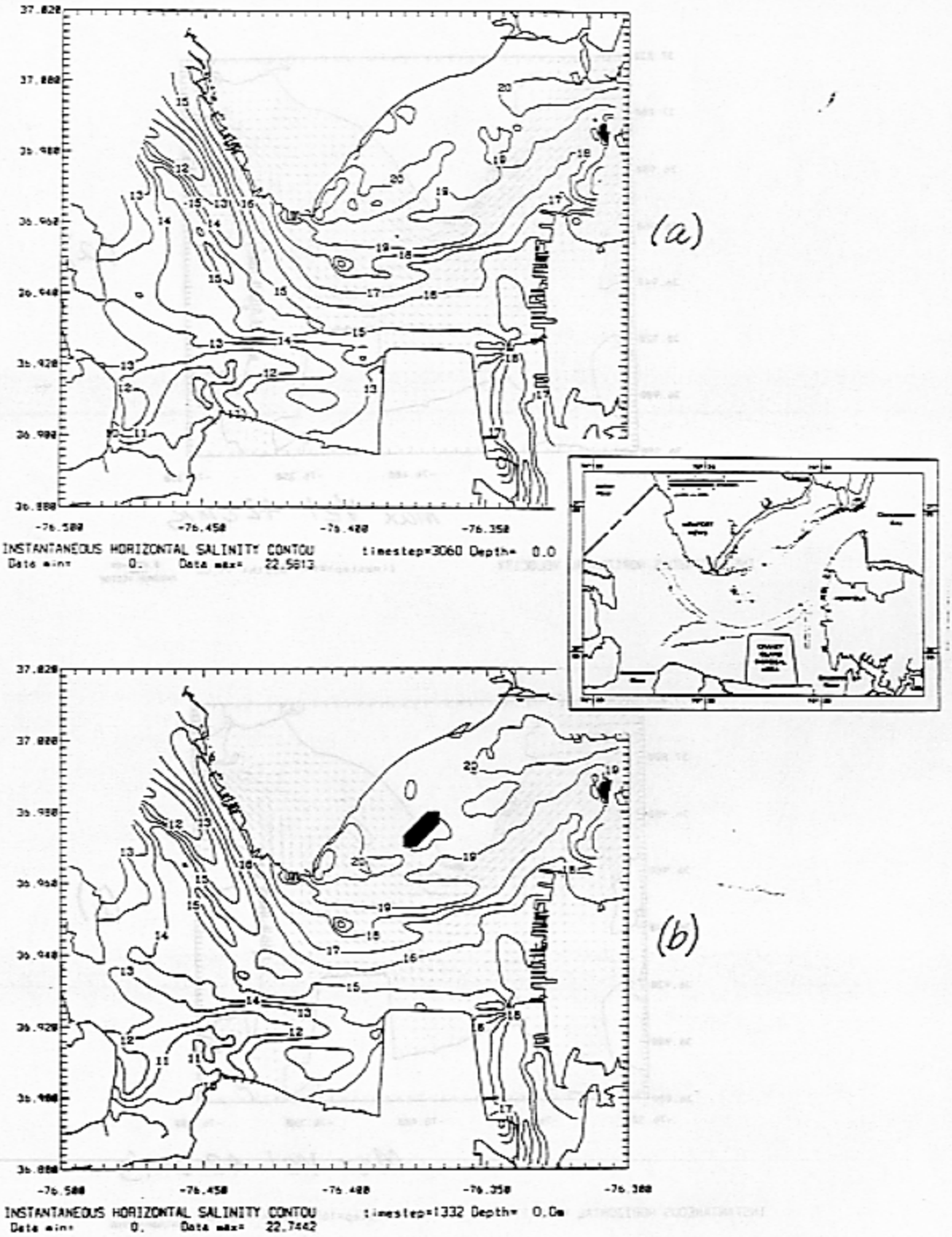


Figure 24. Instantaneous surface salinity at hour 1, for the base (a) and island 1 (b) configurations.

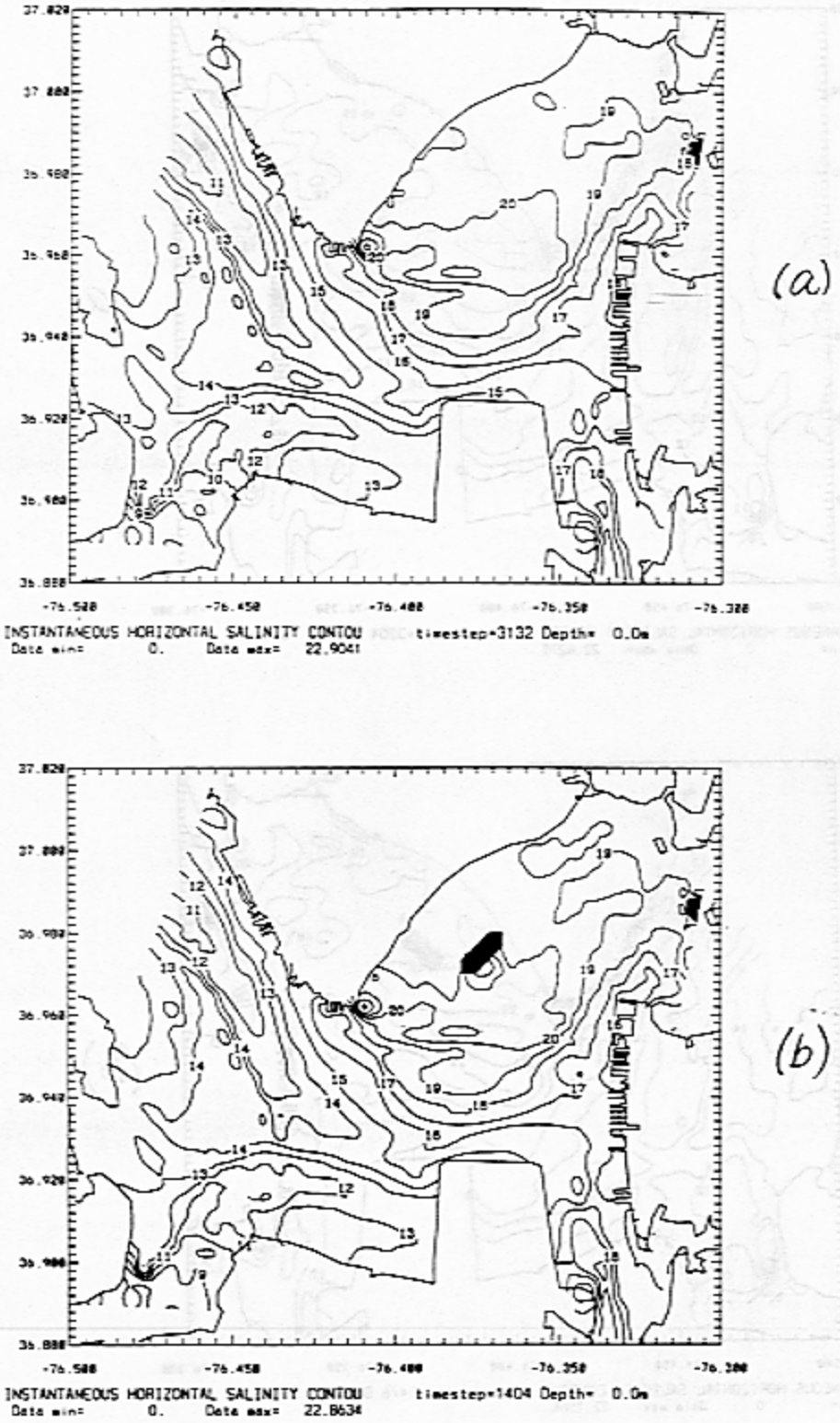
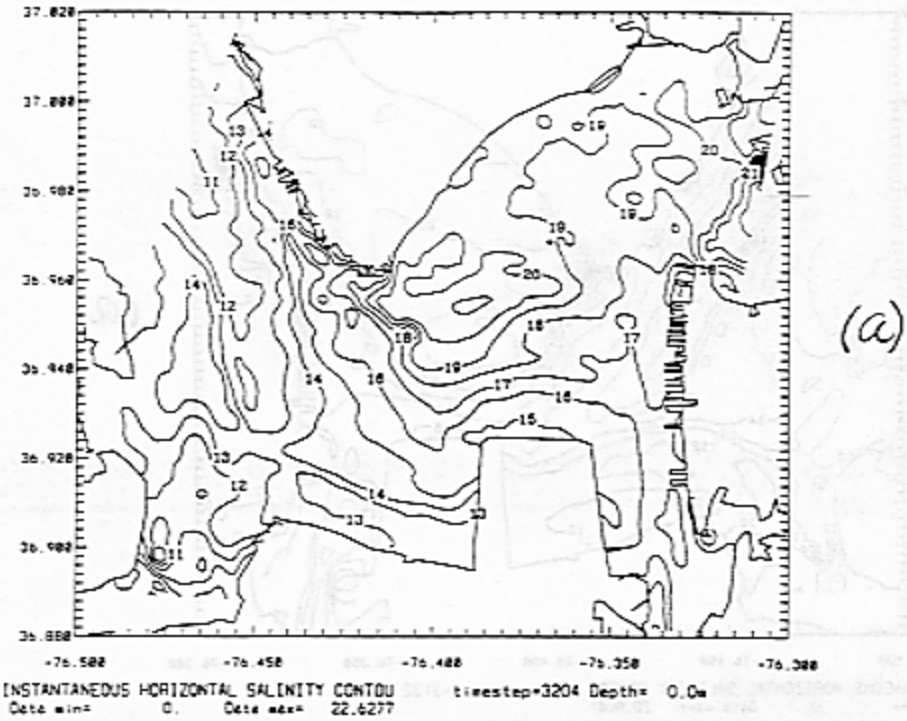


Figure 25. Instantaneous surface salinity at hour 3, for the base (a) and island 1 (b) configurations.



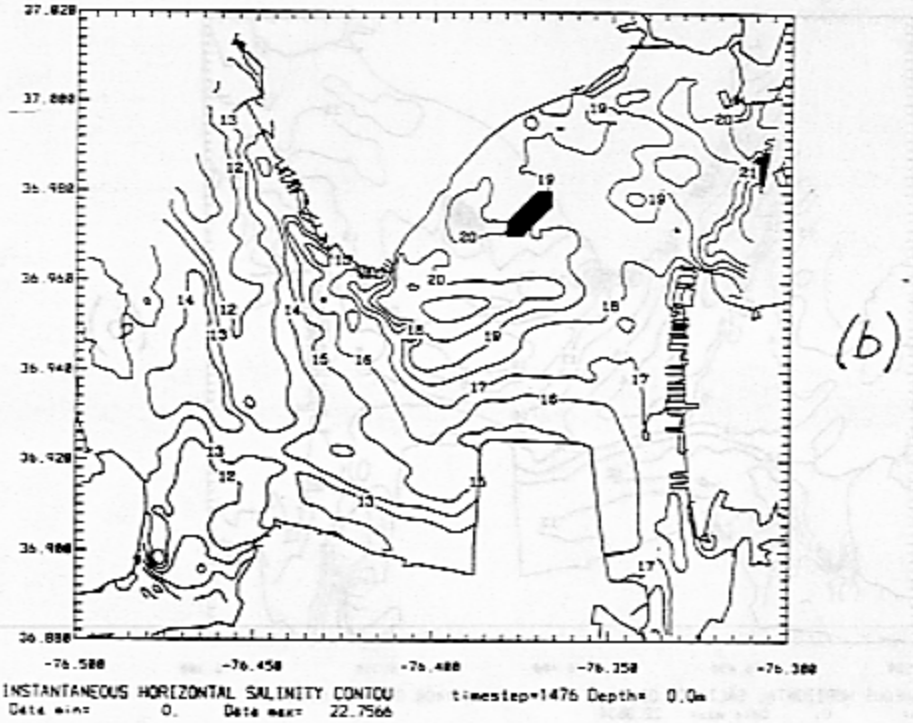


Figure 26. Instantaneous surface salinity at hour 5, for the base (a) and island 1 (b) configurations.

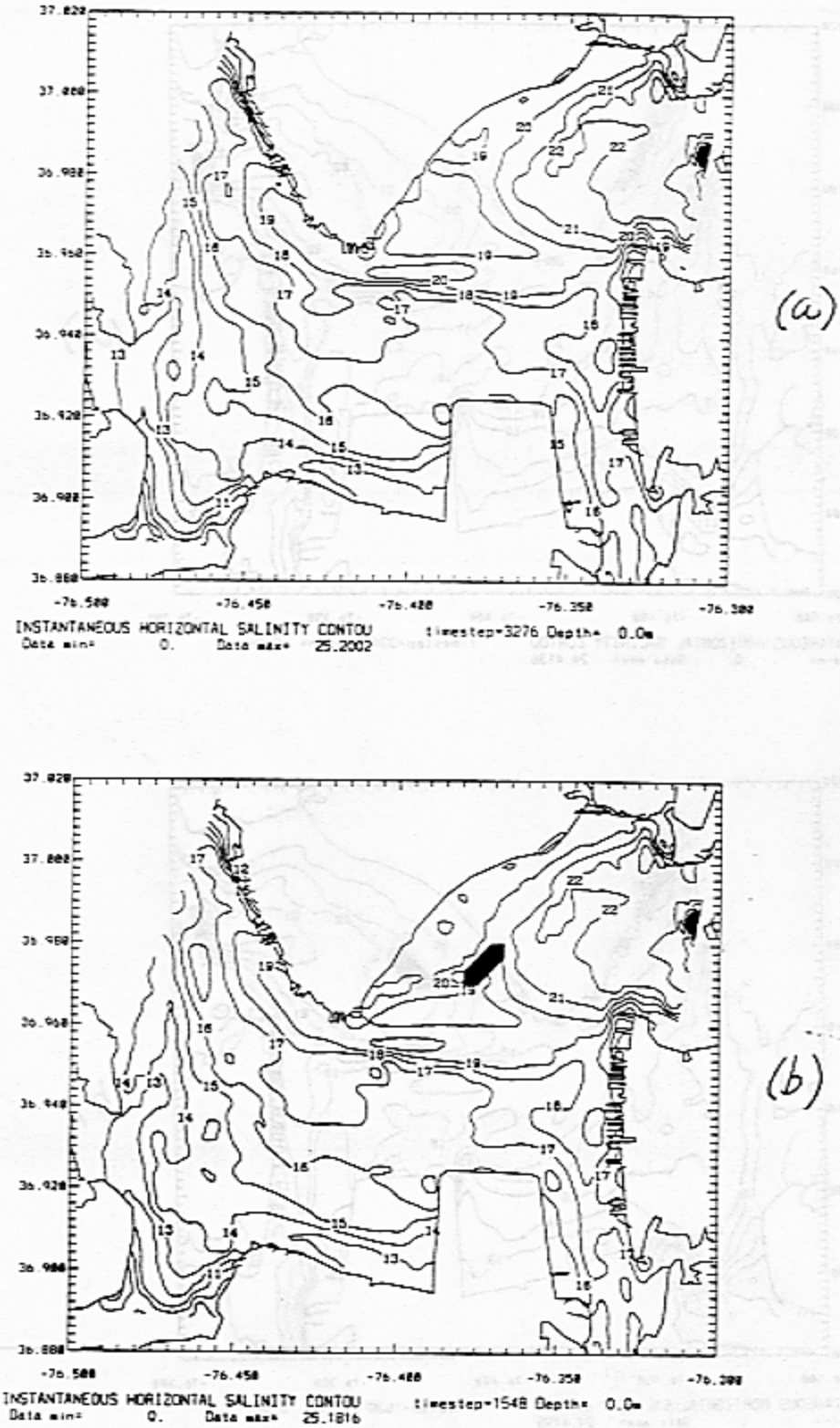
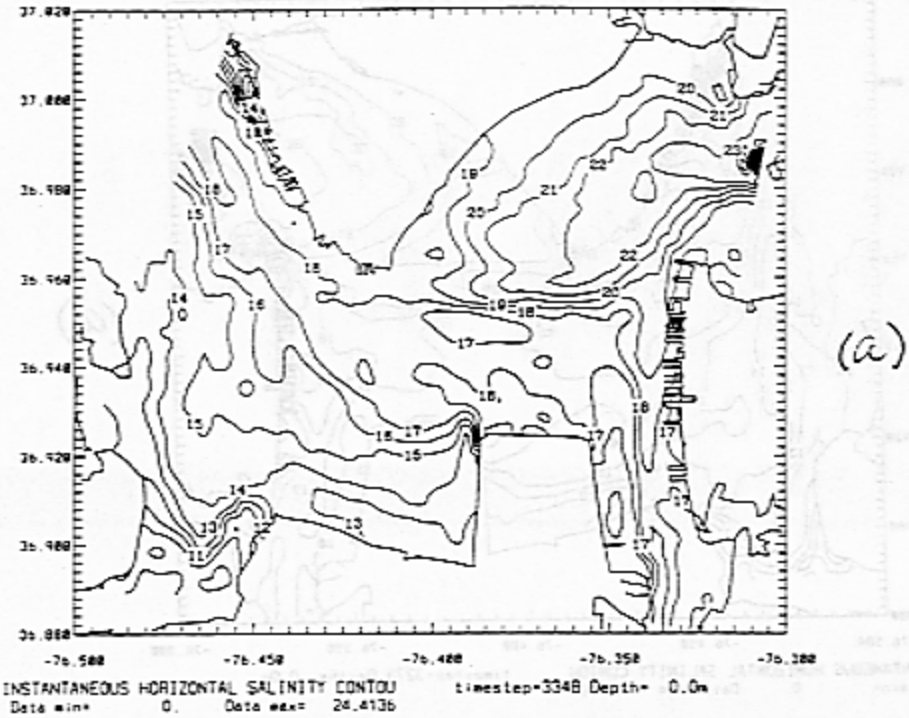
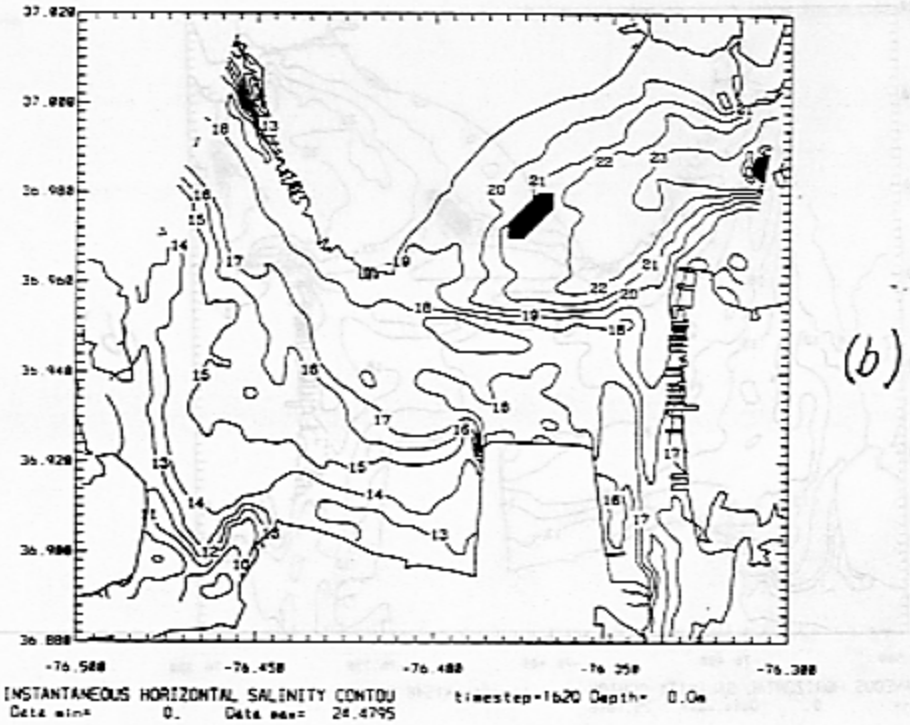


Figure 27 Instantaneous surface salinity at hour 7, for the base (a) and island 1 (b) configurations.

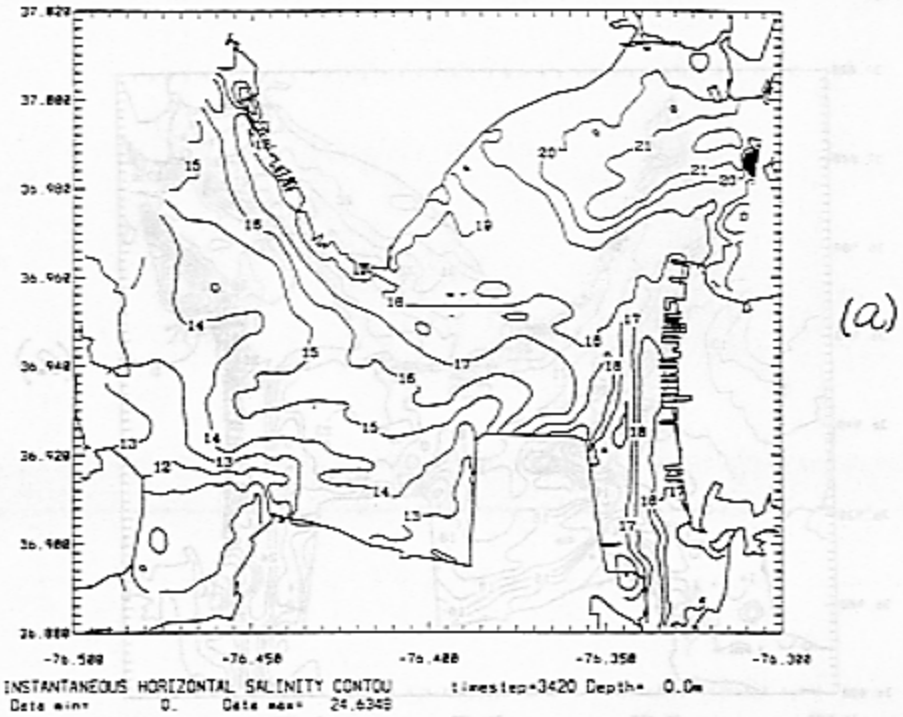


(a)



(b)

Figure 28. Instantaneous surface salinity at hour 9, for the base (a) and island 1 (b) configurations.



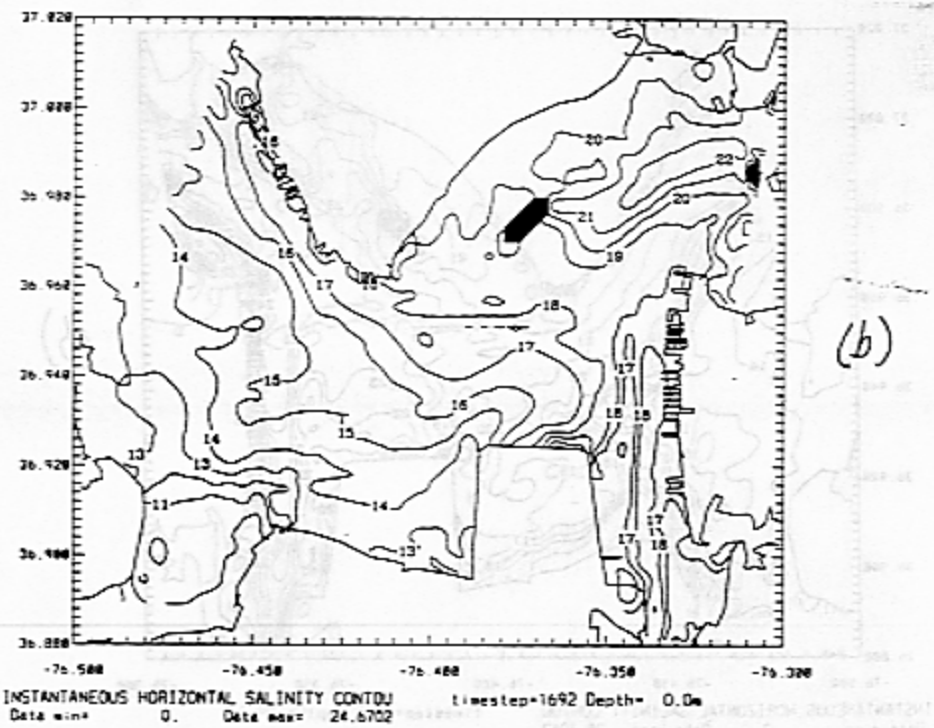


Figure 29. Instantaneous surface salinity at hour 11, for the base (a) and island 1 (b) configurations.

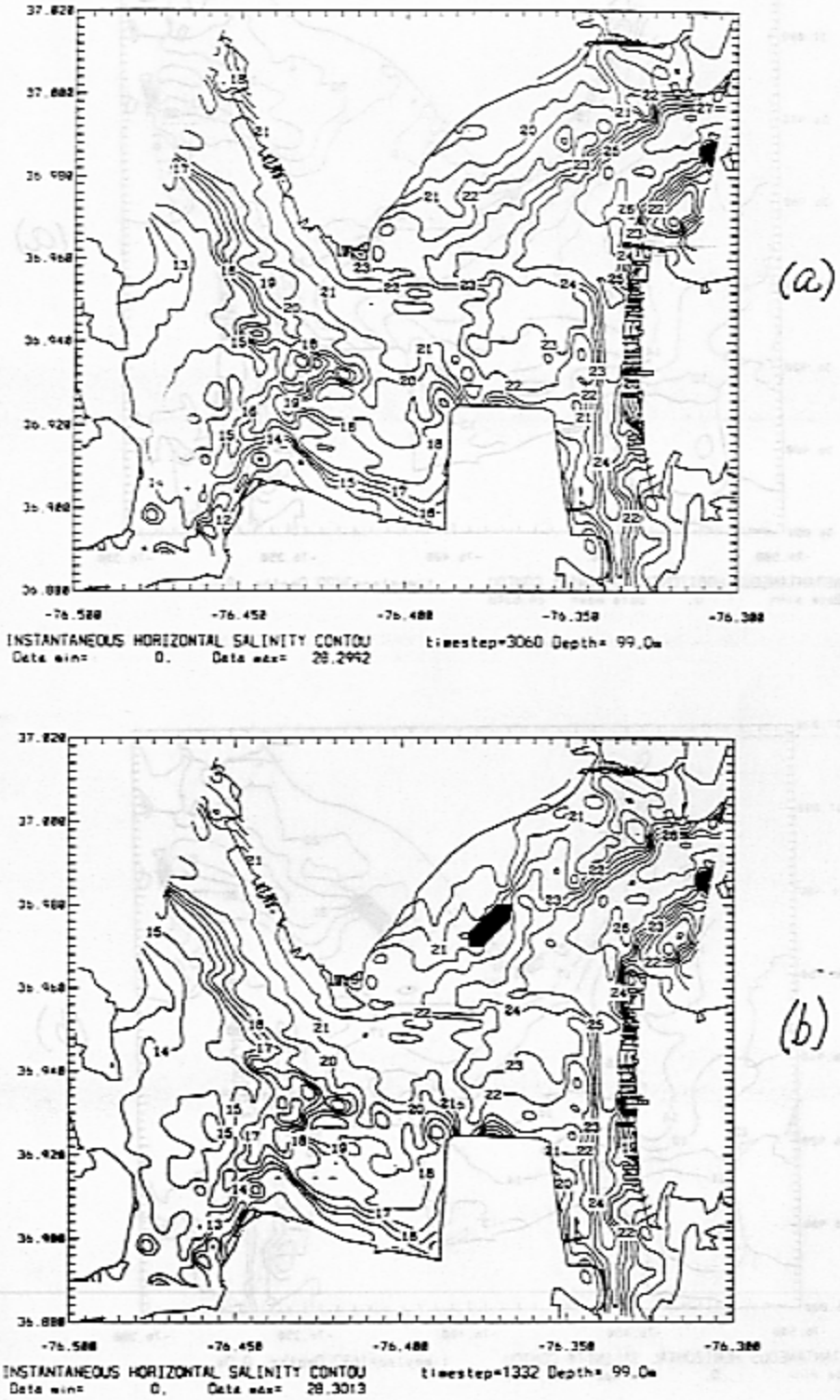
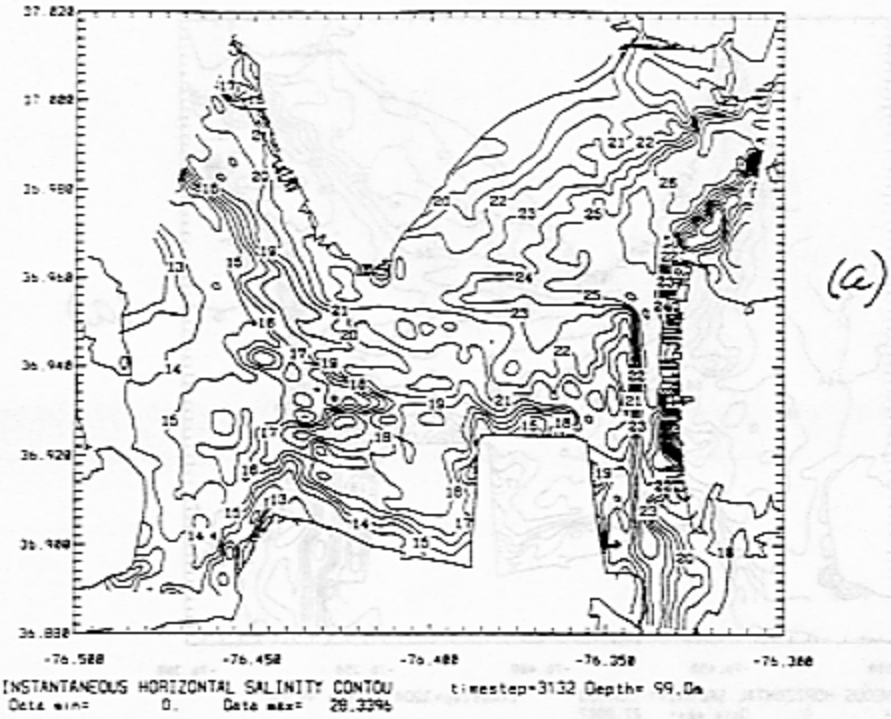


Figure 30. Instantaneous bottom salinity at hour 1, for the base (a) and island 1 (b) configurations.



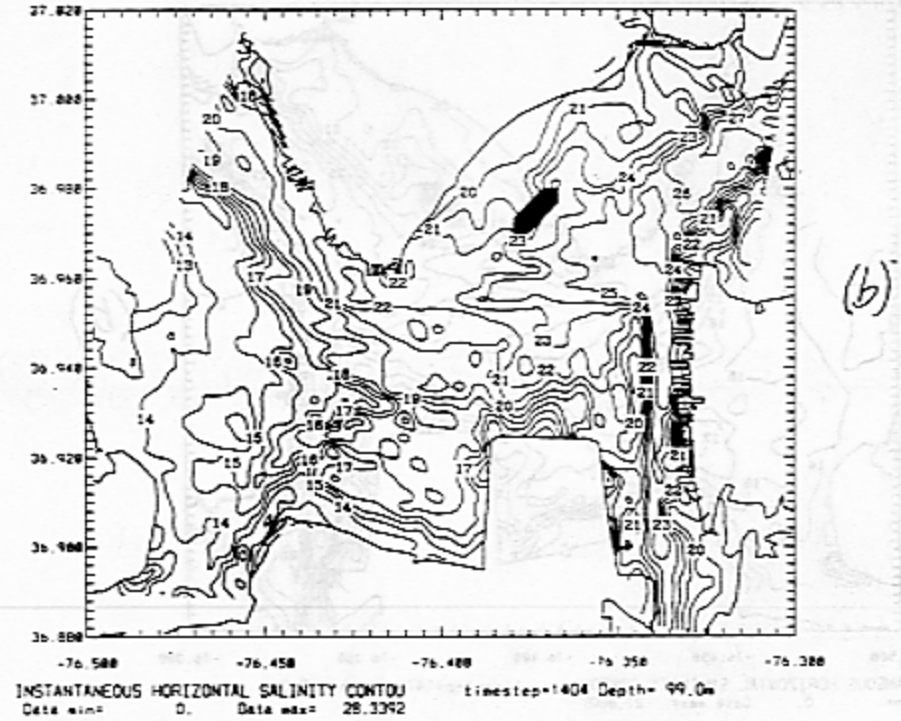
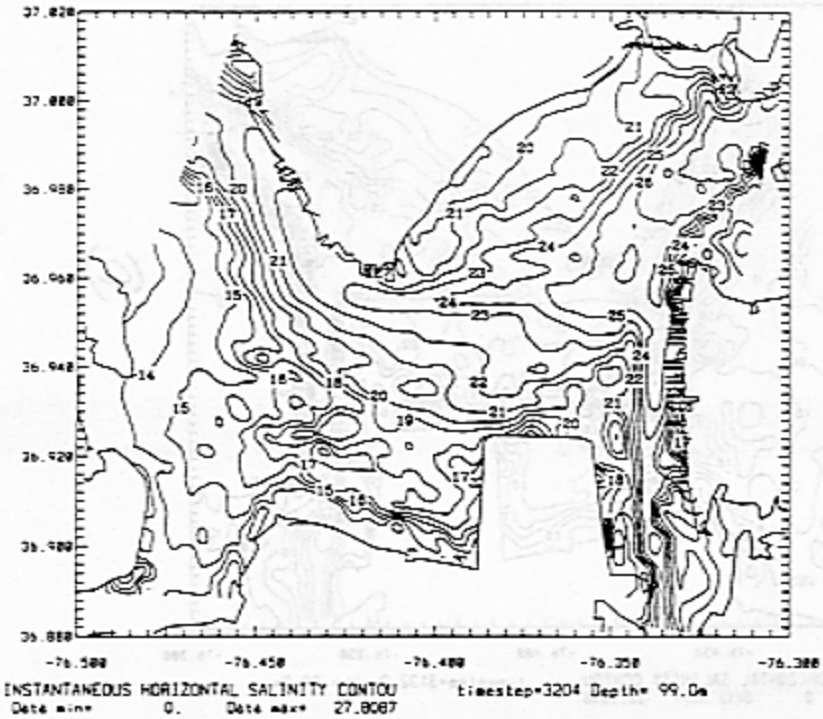


Figure 31. Instantaneous bottom salinity at hour 3, for the base (a) and island 1 (b) configurations.



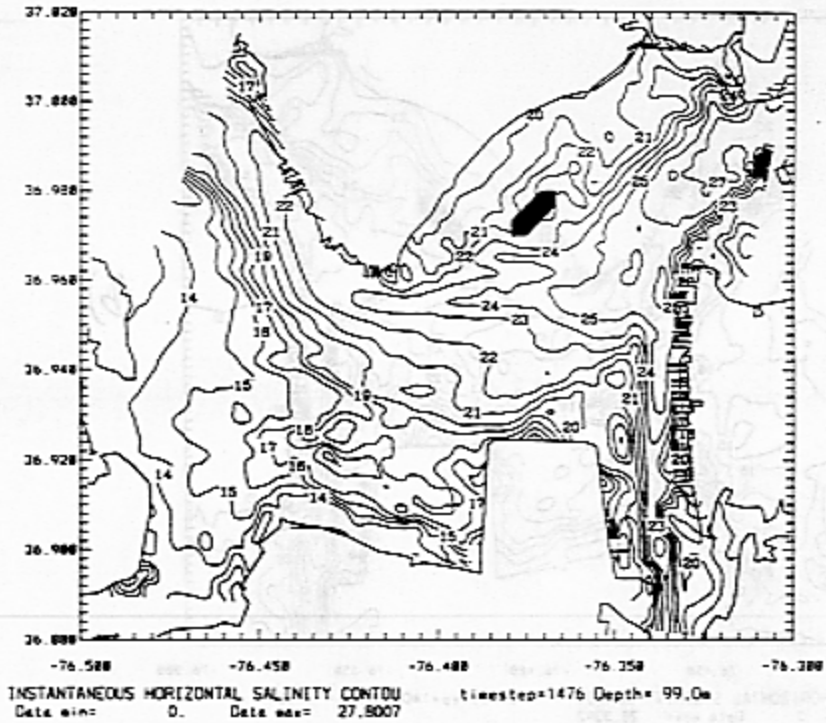
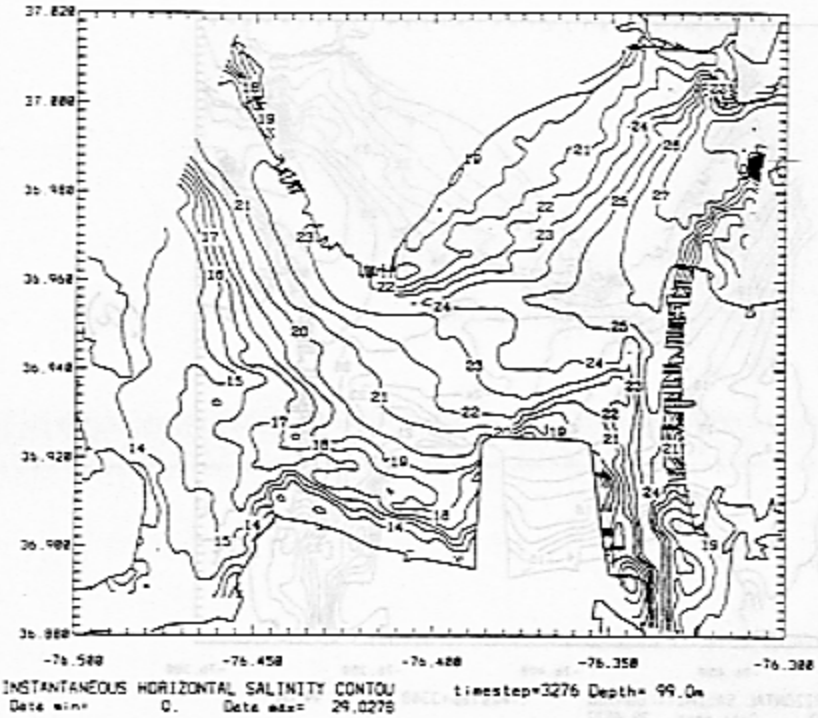


Figure 32. Instantaneous bottom salinity at hour 5, for the base (a) and island 1 (b) configurations.



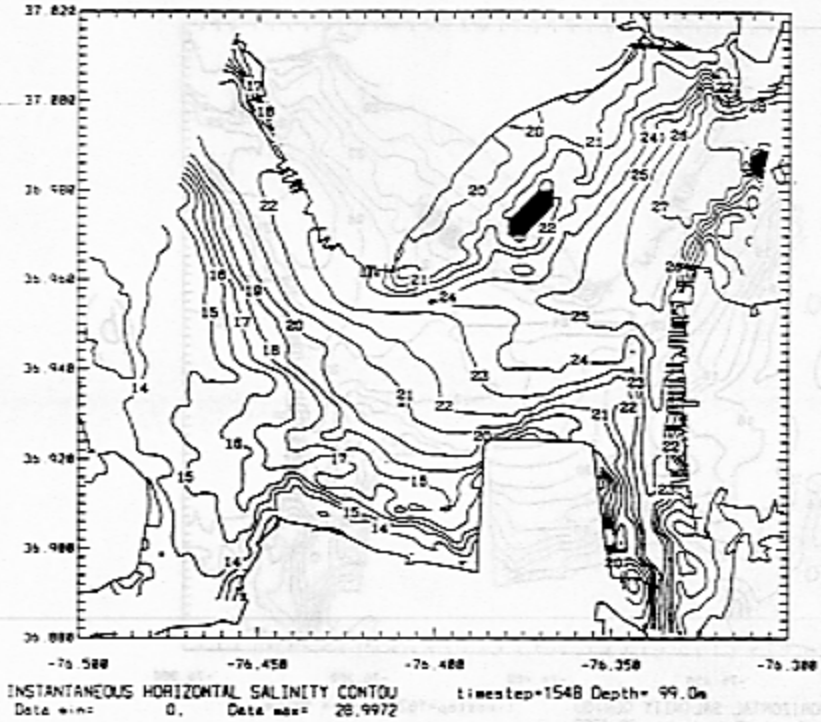


Figure 33. Instantaneous bottom salinity at hour 7, for the base (a) and island 1 (b) configurations.

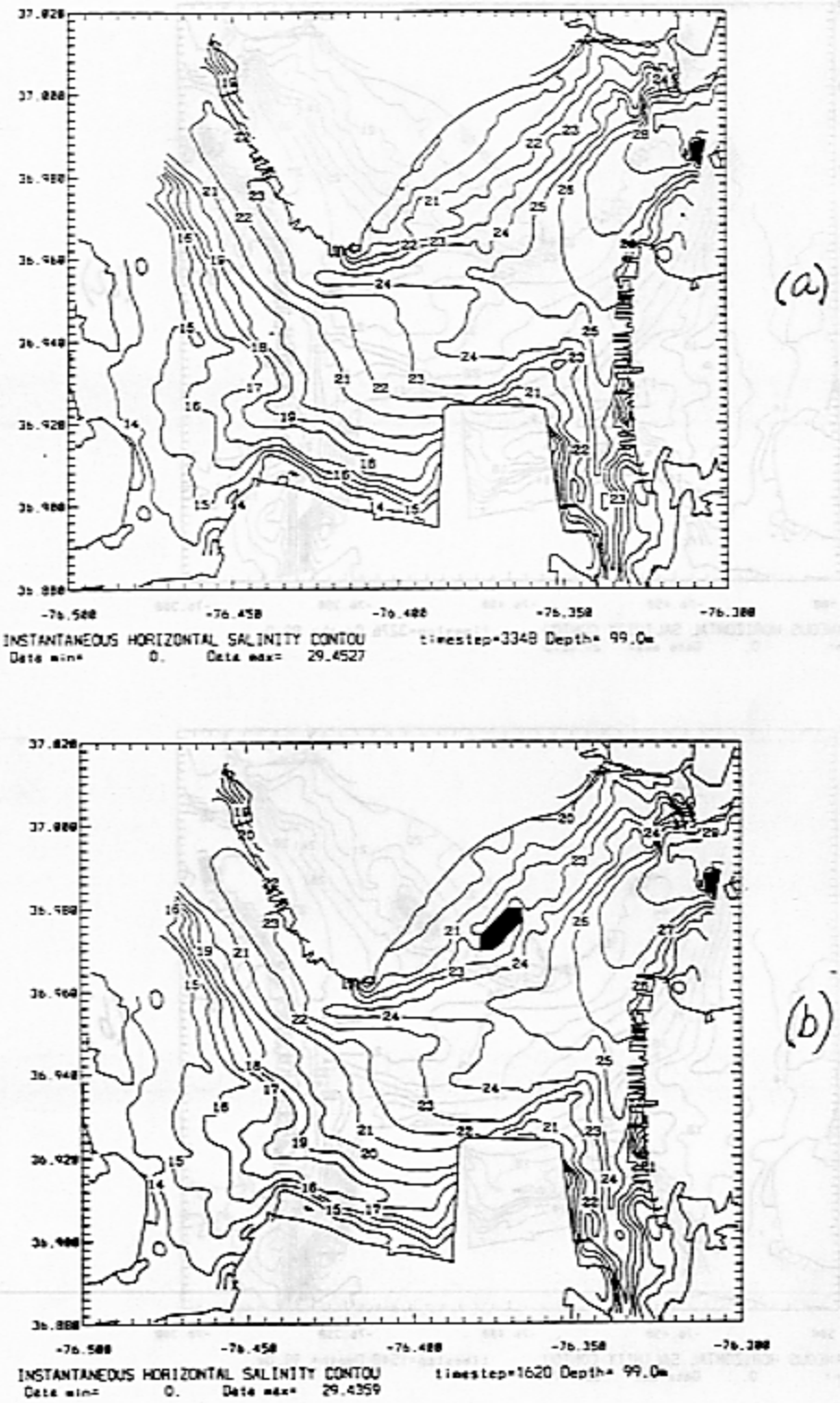


Figure 34. Instantaneous bottom salinity at hour 9, for the base (a) and island 1 (b) configurations.

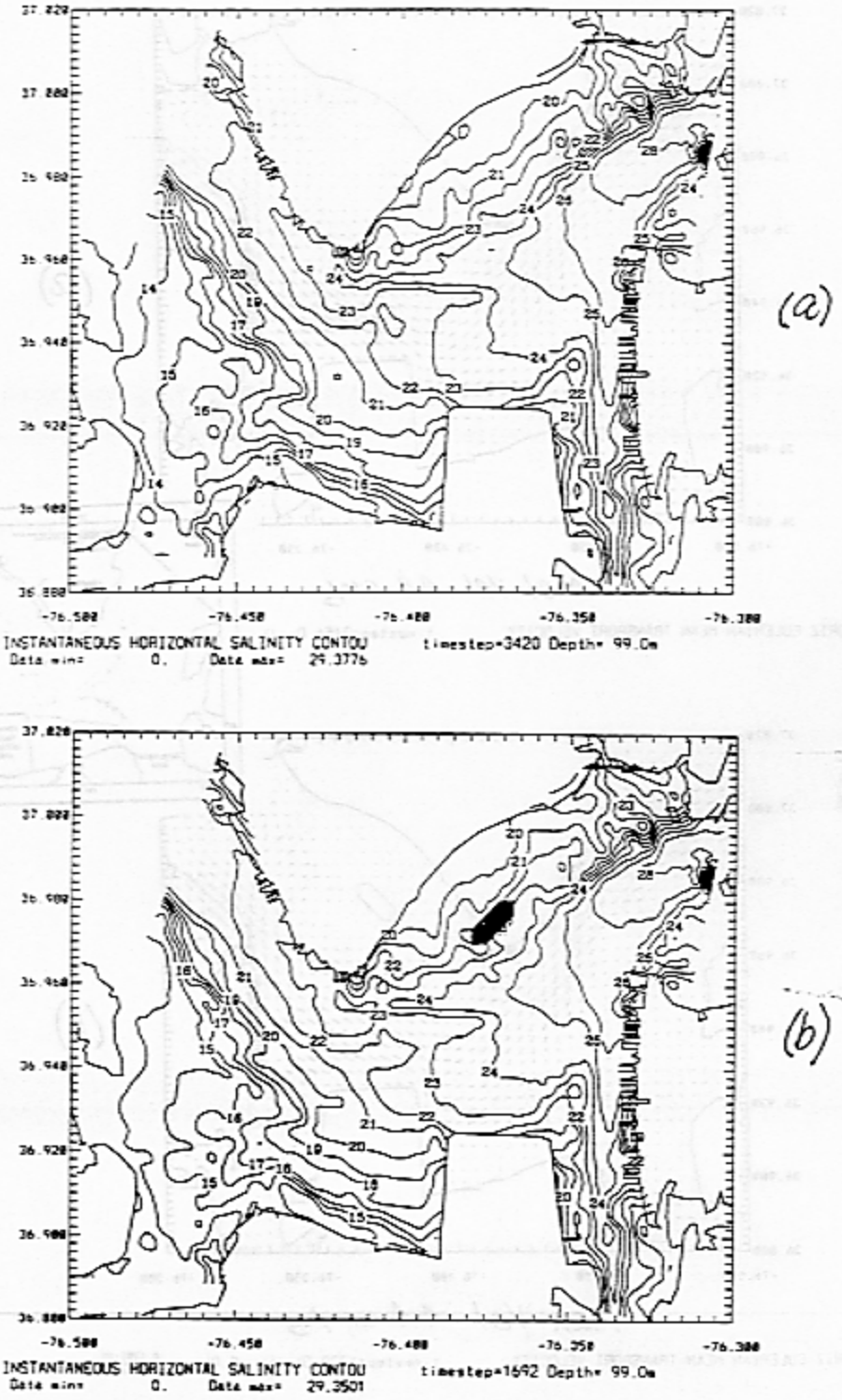


Figure 35. Instantaneous bottom salinity at hour 11, for the base (a) and island 1 (b) configurations.

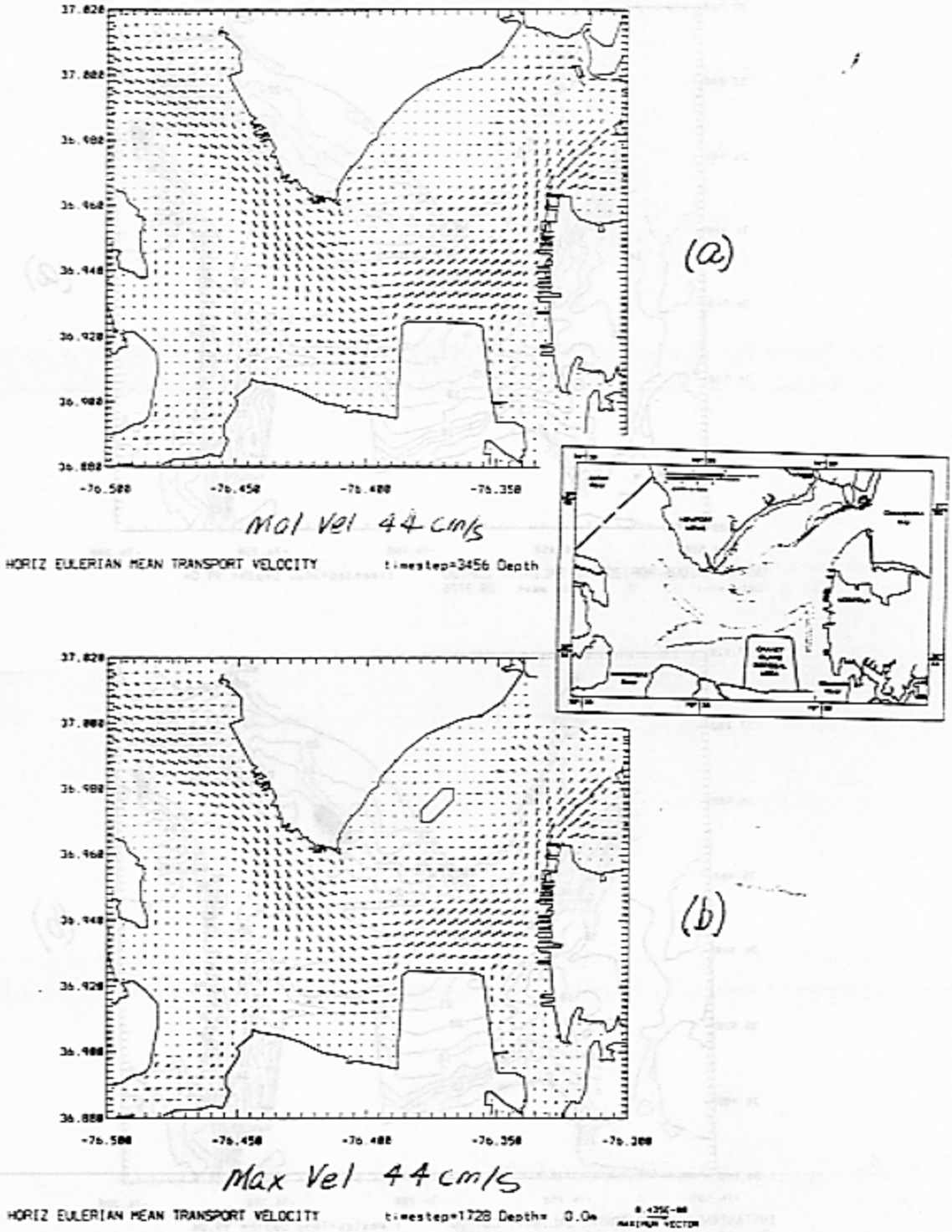
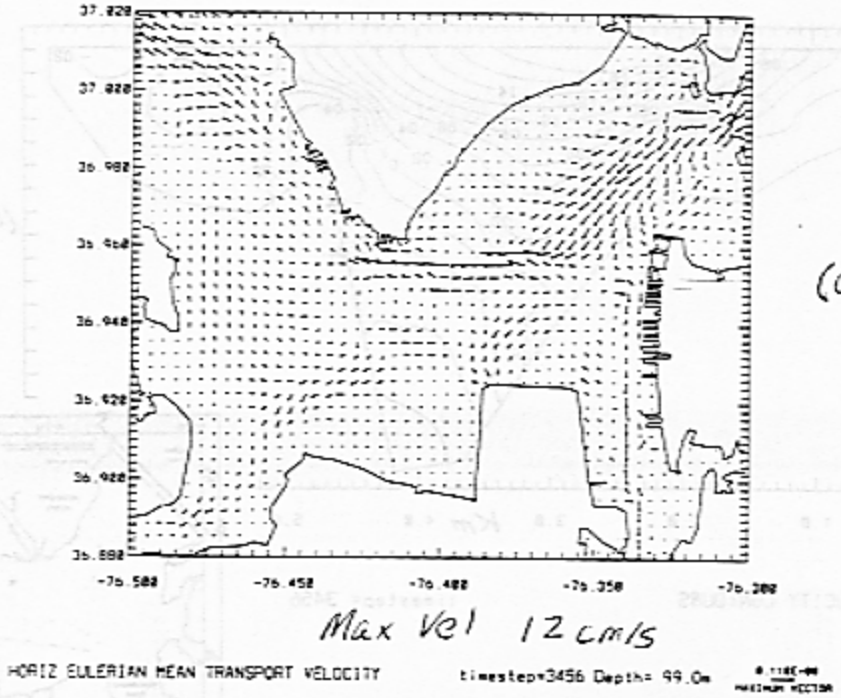


Figure 36. Tidally averaged surface velocities (m/s), for the base (a) and island 1 (b) configurations.



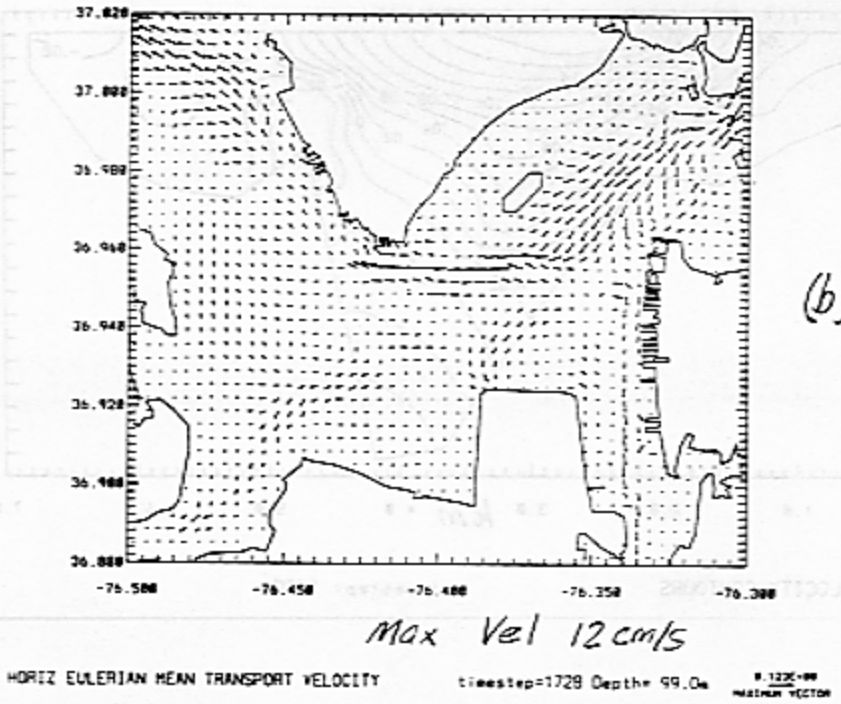


Figure 37. Tidally averaged bottom velocities (m/s), for the base (a) and island 1 (b) configurations.

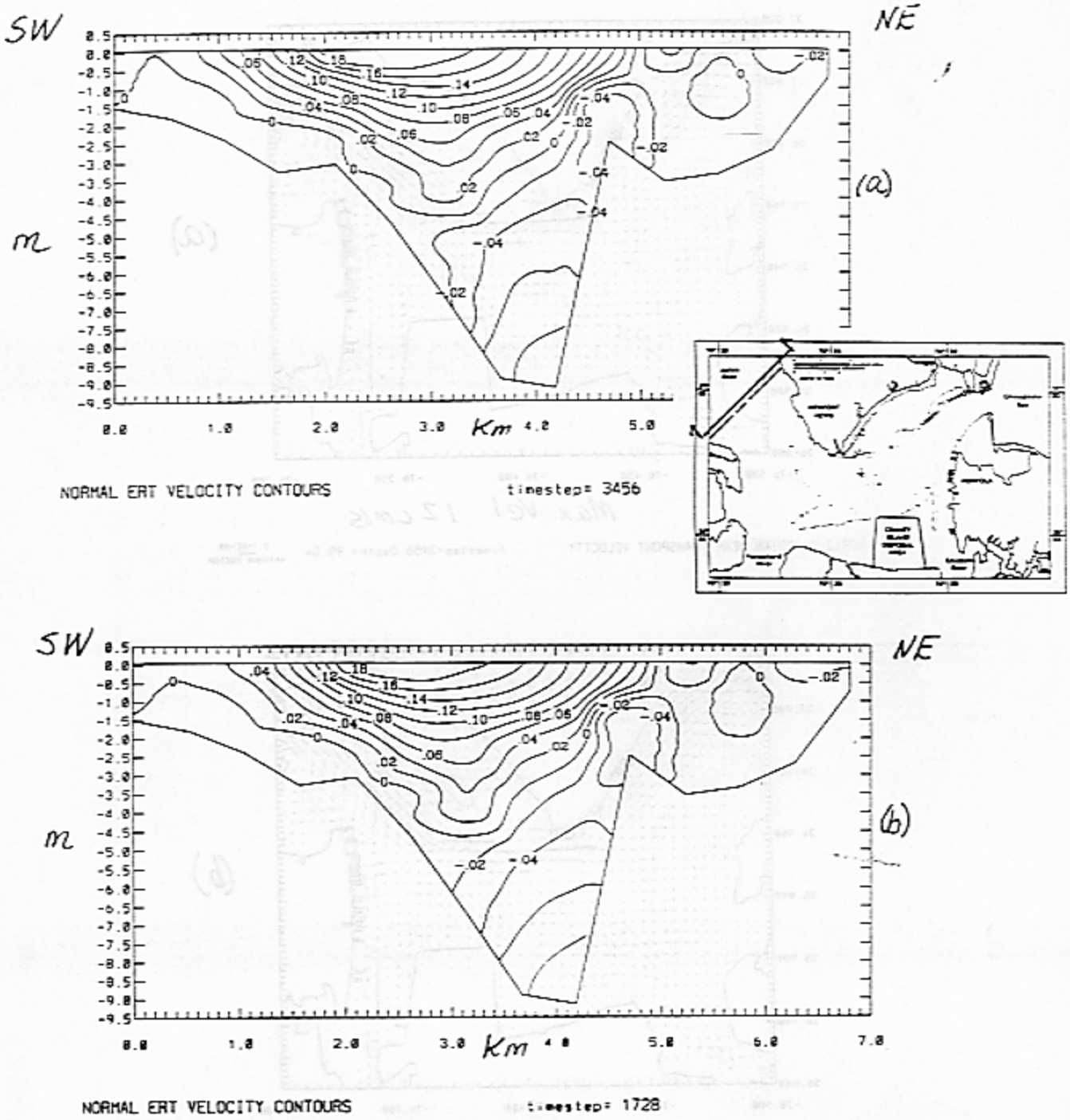


Figure 38. Tidally averaged normal velocities (m/s) over a southwest to northeast section at the James R, for the base (a) and island 1 (b) configurations.

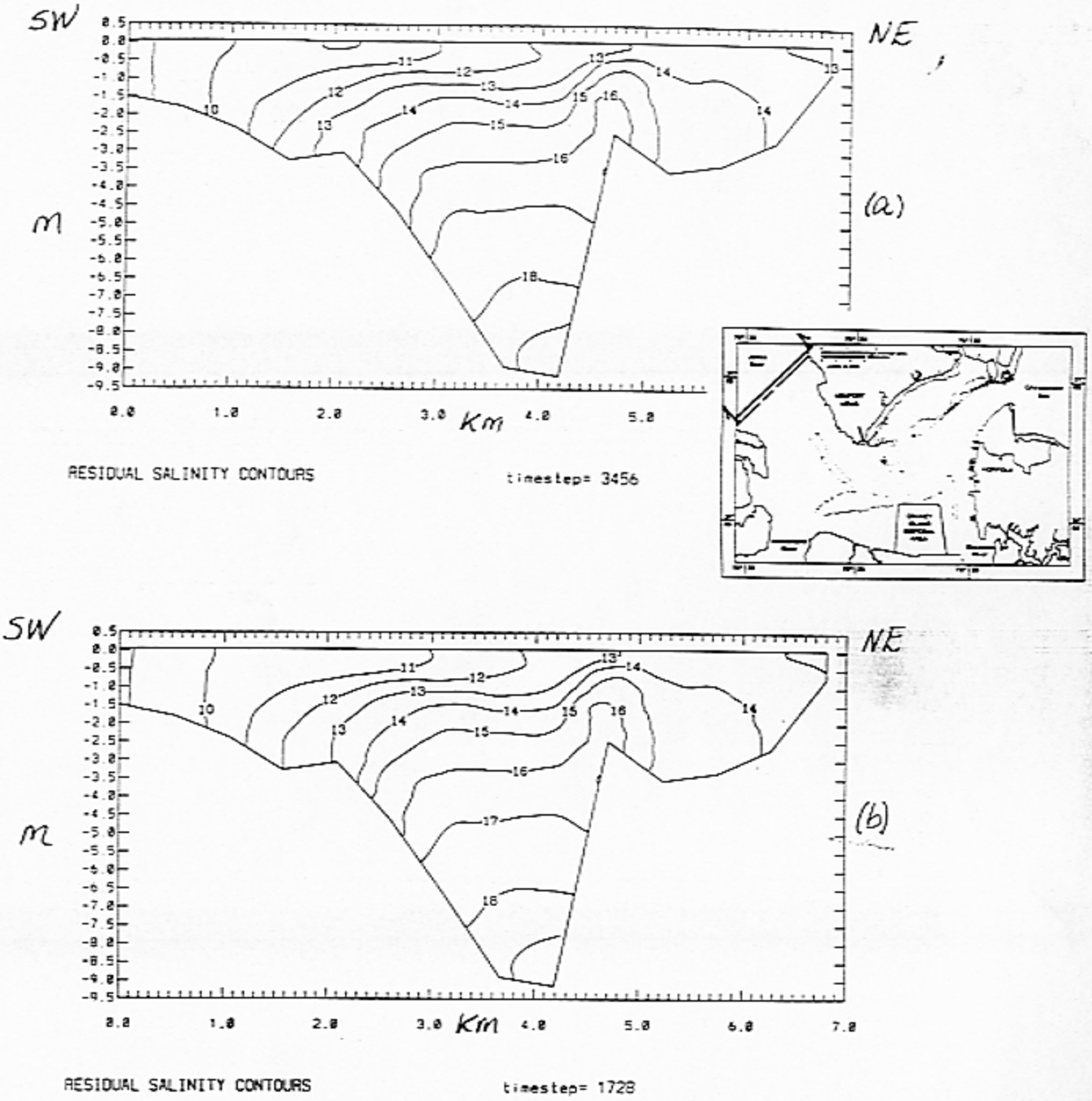


Figure 39. Tidally averaged salinity over a southwest to northeast section at the James R, for the base (a) and island 1 (b) configurations.

NUMERICAL MODEL EVALUATION OF PROPOSED DREDGED MATERIAL ISLAND OFFSHORE OF RAGGED ISLAND WILDLIFE MANAGEMENT AREA (LOWER JAMES RIVER)

prepared by

U.S. Army Engineer District, Norfolk
Norfolk, Virginia 23510-1096

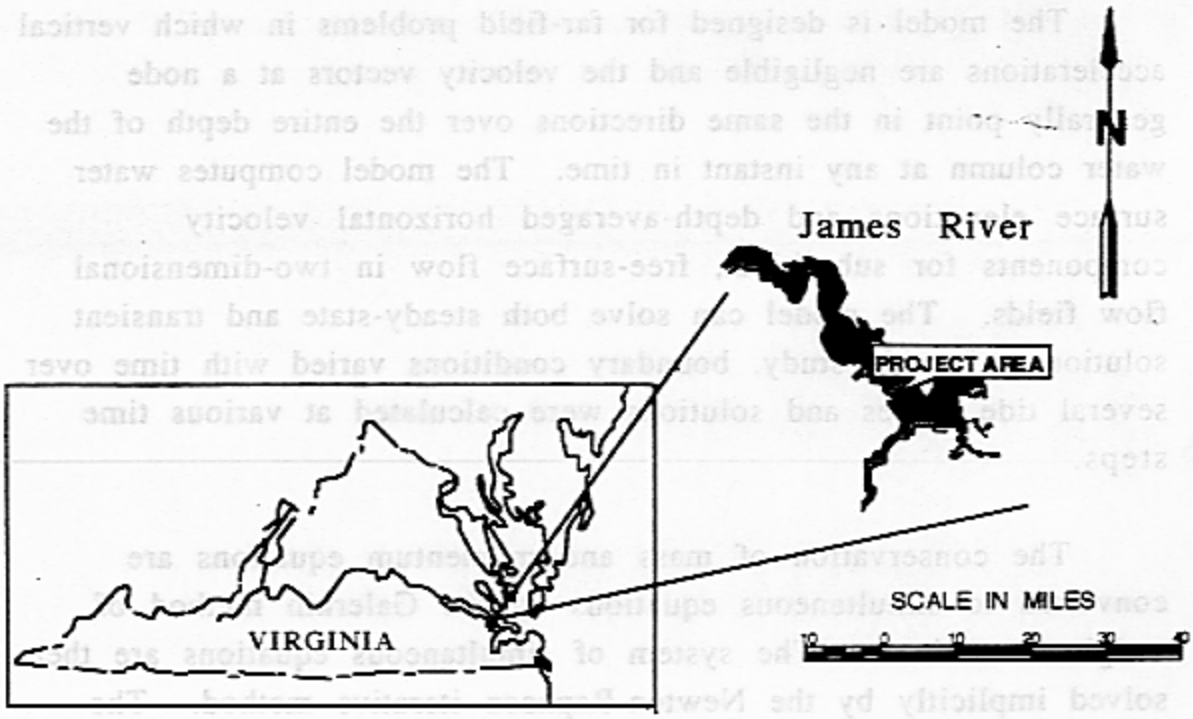
EVALUATION OF PROPOSED DREDGED MATERIAL ISLAND USING TABS-2 HYDRONAMIC MODELING SYSTEM

INTRODUCTION

Background

Several dredged material placement alternatives are being investigated by the Norfolk District, Corps of Engineers in the Lower James River. They include, but are not limited to: (1) offshore placement, (2) placement in a deep trough at the entrance to Hampton Roads harbors, and (3) creation of islands in the Chesapeake Bay. Island creation is proposed for two possible sites in the Lower James River, Ragged Island and Hampton Flats. This study investigates the hydrodynamic effects of an island proposed for the Ragged Island site (see figure 1 & plate 14).

Figure 1. General Location Map



An assessment of the impact of an island on circulation in the lower James River was performed as a preliminary planning level task. The primary objectives were to assess general changes in circulation and currents in the vicinity of the island and within the entire lower James River estuary.

NUMERICAL MODELING APPROACH

The Numerical Model

The Corps of Engineers numerical modeling system, Open-Channel Flow and Sedimentation, TABS-2 was used in this investigation. The primary code used was the Two-Dimensional Model for Free Surface Flows (RMA-2V version 4.28). This code employs the finite element method to solve the Reynolds form of the Navier-Stokes equations of turbulent flow. Friction is calculated with the Manning's equation and eddy viscosity coefficients are used to define turbulence characteristics.

The model is designed for far-field problems in which vertical accelerations are negligible and the velocity vectors at a node generally point in the same directions over the entire depth of the water column at any instant in time. The model computes water surface elevations and depth-averaged horizontal velocity components for subcritical, free-surface flow in two-dimensional flow fields. The model can solve both steady-state and transient solutions. In this study, boundary conditions varied with time over several tide cycles and solutions were calculated at various time steps.

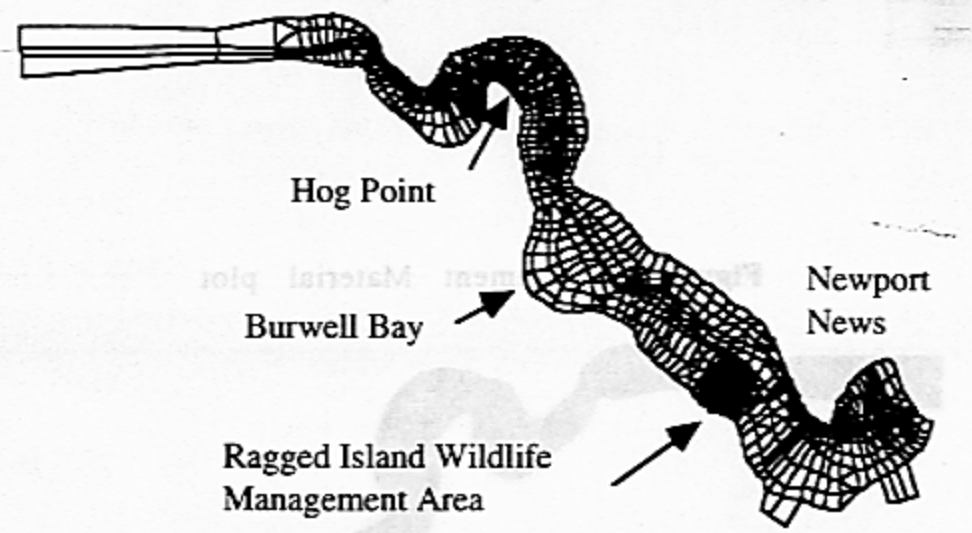
The conservation of mass and momentum equations are converted to simultaneous equations by the Galerkin method of weighted residuals. The system of simultaneous equations are then solved implicitly by the Newton-Raphson iterative method. The solution is achieved using a front-type matrix solver that assembles

a portion of the matrix and solves that portion before assembling the next portion of the matrix.

James Lower River Computational Mesh

The bathymetric data for the computational mesh were digitized from NOAA coastal charts 12248 (March 1992) and 12245 (June 1984). A triangulation algorithm in FastTabs version 2.06 was used to generate and edit the mesh that contains 4000 nodes and 1300 elements as shown in figure 2 (see Plate 1 for more detail). The upstream boundary location was artificially extended to the west, away from the Hog Point tide station (see Figure 4), to allow for more water storage between the upstream boundary and Hog Point. This modification produced reasonable water surface elevations at the Hog Point tide station and was far enough away from the area of interest to impact the study results.

Figure 2. Computational Mesh



Boundary Conditions

The two dynamic boundary conditions used for the model were located at the upstream end near Jamestown Island and at the downstream end near Sewells Point in the Hampton Roads Harbor. The upstream boundary condition used 8500 c.f.s as the average inflow for the simulation period from 26 May 1993 to 31 May 1993.

This value was based on U.S.G.S. water resources data collected on the James River at Richmond. The downstream boundary condition used tide data from Sewells Point reference tidal station (Latitude 36° 57', Longitude 76° 20') generated from the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, 1993 Tide Tables.

Model Parameters

The elements of the model were divided into 5 material types based on depth and location as shown in figure 3. The model verification resulted in a final set of model parameters representing Manning's n values and eddy viscosities. These values were selected from a range of realistic values and adjusted to provide an optimum comparison of the model's computed water levels and currents to values contained in published 1993 NOAA tide tables. Table 1 lists the material types with the hydraulic parameters.

Figure 3. Element Material plot

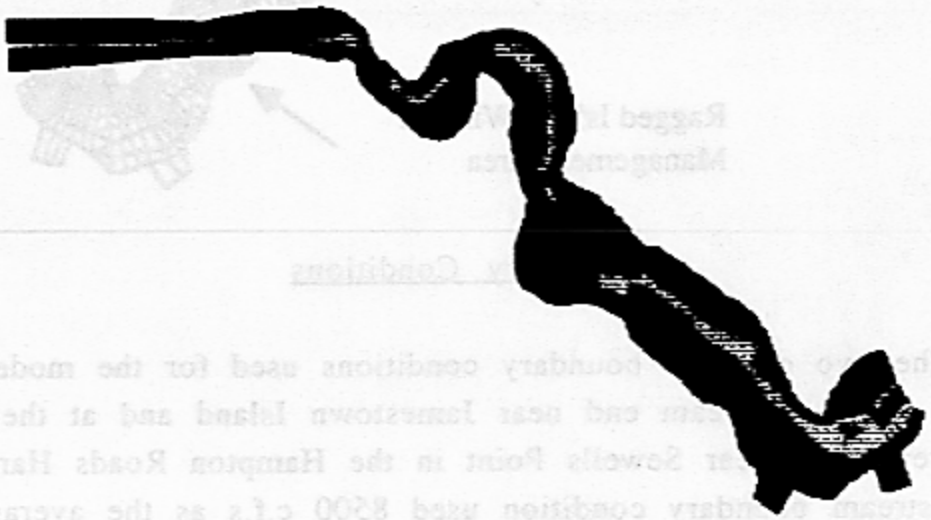


Table 1. Model Parameters

Material Number	Eddy Viscosity lb-sec/ft^2	Manning's n
1	250	0.03
2	300	0.03
3	450	0.02
4	550	0.02
5	350	0.02

Verification

The verification data were obtained from four tidal and four current stations along the James River as shown in figure 4. Station positions are listed in table 2. Verification of the model was carried out by comparing water levels and current velocities from the model to the predicted tide levels and current velocities. Initial simulations ran for 140 hours, however due to computer time and disk space limitations computer runs were scaled back to 40 hours. The "spin-up" time for the model occurred within three simulation hours.

As shown in plate 2, after adjustments were made to the model parameters, the modeled water surface elevations were in close agreement in phase and amplitude with the predicted tide levels. The maximum amplitude difference at peak tide was about 0.15 feet at Burwell Bay and about 0.20 feet at maximum ebb. All of the phase shifts at the tide stations were less than 15 minutes.

The tidal current velocities published in the NOAA tables are listed only as maximum flood or ebb. The modeled and predicted current velocities are shown in plate 3. With the exception of Burwell Bay, the values were in relatively close agreement. Discussions with Dr. John Hamrick from the Virginia Institute of Marine Science confirmed that the modeled velocities at Burwell Bay

are reasonable. Plates 4 and 5 provide the model velocity contour plots for maximum flood and maximum ebb at Newport News for the existing (no island) conditions. The velocity magnitudes ranged from 0 to 2.5 ft/s for the entire mesh.

Figure 4. Tide and Current Locations

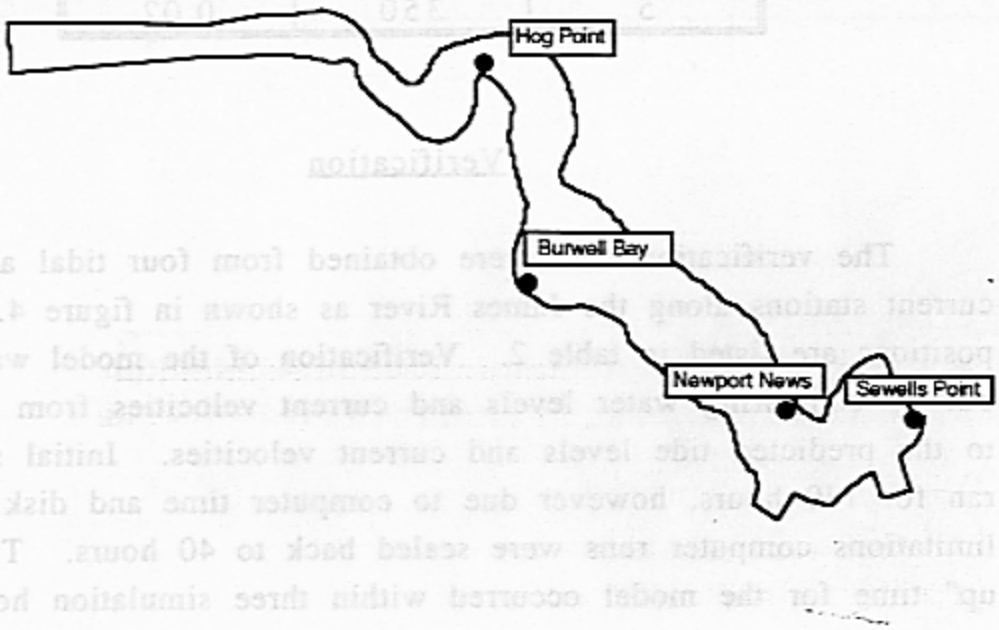


Table 2. Tide Station Positions

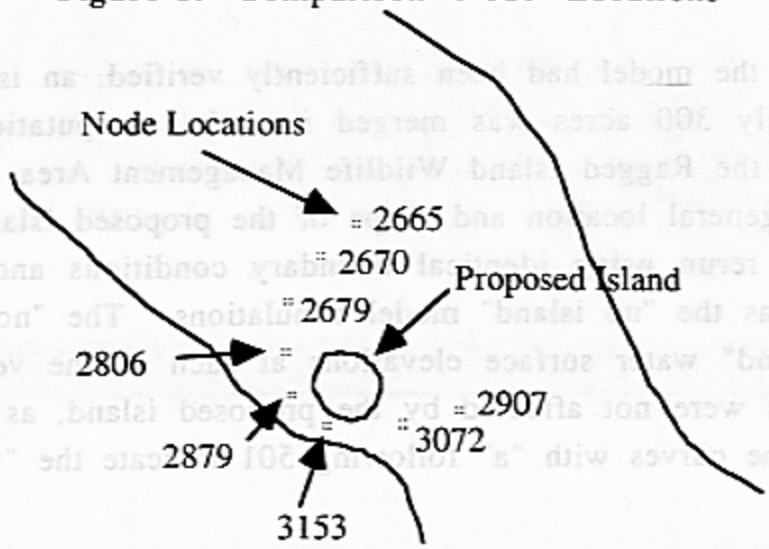
Station Number	Location	Latitude	Longitude
2519	Hampton Roads	36° 57'	76° 20'
2543	Newport News	36° 58'	76° 26'
2551	Burwell Bay	37° 03'	76° 40'
2555	Hog Point	37° 12'	76° 41'

MODEL RESULTS

Once the model had been sufficiently verified, an island of approximately 300 acres was merged into the computational mesh offshore of the Ragged Island Wildlife Management Area. Plate 6 shows the general location and shape of the proposed island. The model was rerun using identical boundary conditions and hydraulic parameters as the "no island" model simulations. The "no island" verses "island" water surface elevations at each of the verification tide stations were not affected by the proposed island, as shown in plate 7. The curves with "a" following 501 indicate the "with island" condition.

Eight nodes in the vicinity of the island were selected to compare tidal velocities (figure 5). As shown in plates 8 and 9, velocities were changed slightly by the presence of the proposed island. During maximum flood and maximum ebb, the island has an effect of reducing the velocities upstream and downstream of the island by about 0.2 ft/s. The area between the island and the mainland experienced an increase in velocity of about 0.3 ft/s. Plates 10 and 11 show the velocity contours at maximum flood and maximum ebb in the vicinity of the proposed island. Plates 12 and 13 are velocity vector plots of the circulation patterns around the island for maximum flood and ebb.

Figure 5. Comparison Node Locations



CONCLUSIONS

The RMA-2V model was successfully verified to published tide and current data for the simulation period. The comparisons of the computed water surface elevations and velocities to predicted data in the verification process were very good. Based on model results, the presence of a proposed island had no effect on the water surface elevations and only a slight effect on the local current velocities. The dominant erosional process in the vicinity of Ragged Island is by wave action. A slight increase in current velocities between the island and mainland is not expected to increase the existing shoreline erosion since wave protection provided by the island would offset the effects of slightly increased current velocities.

References

FastTABS Hydrodynamic Modeling Users Reference Manual and Appendices A and B. 1993, Brigham Young University, Engineering Computer Graphics Laboratory, Provo, Utah and U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Heltzel, Samuel B., and Granat, Mitchell A. 1988 (April). "Lower James River Circulation Study Virginia, Evaluation of Craney Island Enlargement Alteratives," Technical Report HL-88-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lin, Hsin-Chi J., and Martin, William D. 1989 (June). "Newport News Channel Deepening Study, Virginia," Technical Report HL-89-12, Hydraulics Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thomas, W. A., and McAnally, W. H., Jr. 1985 (Aug). "User's Manual for the Generalized Compuer Program System; Open -Channel Flow and Sedimentation, TABS-2, Main Text and Appendices A through O," Instructional Report HL-85-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Tide Tables 1993, High and Low Water Predictions, East Coast of North and South America, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Tidal Current Tables 1993, Atlantic Coast of North America, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

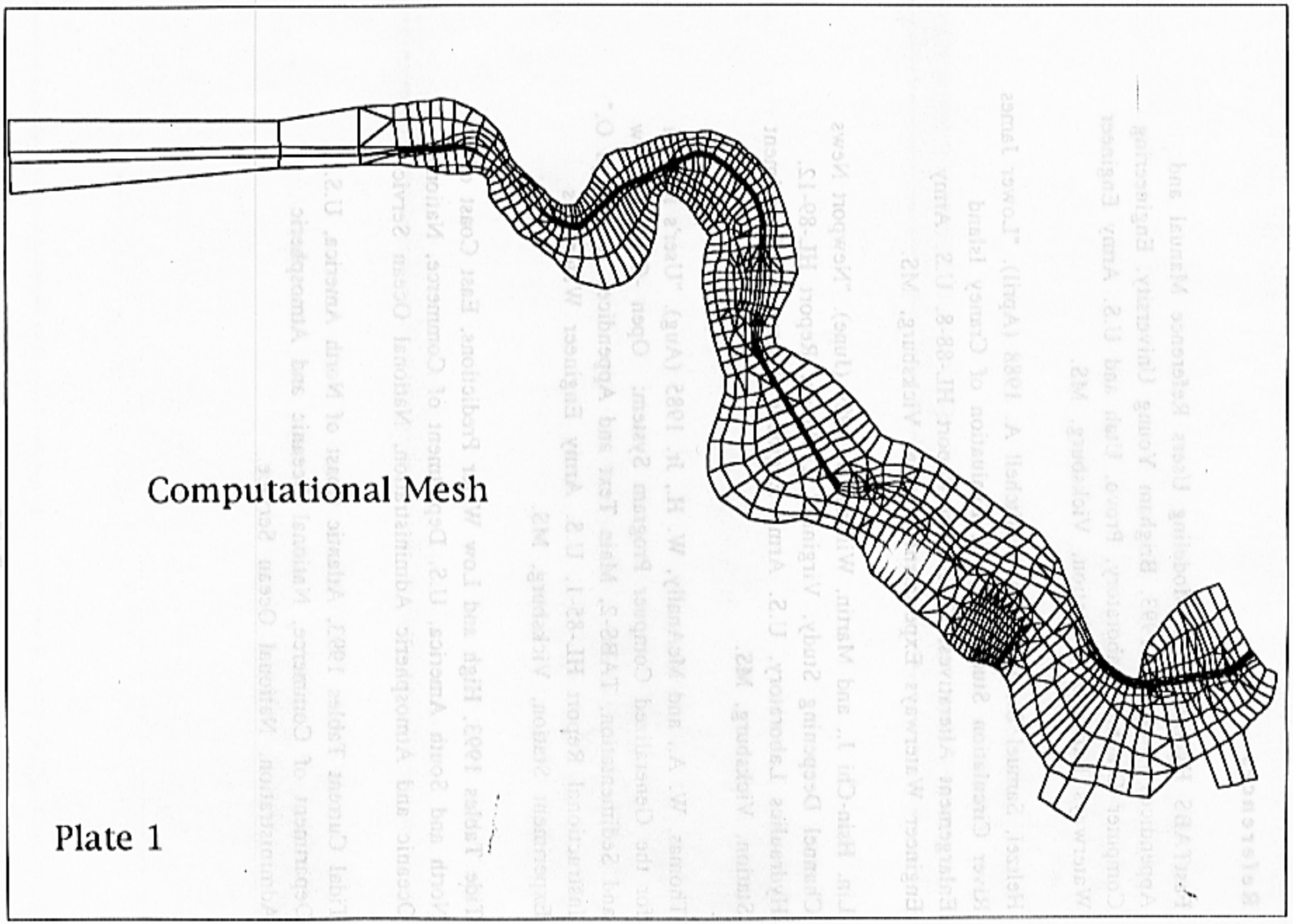
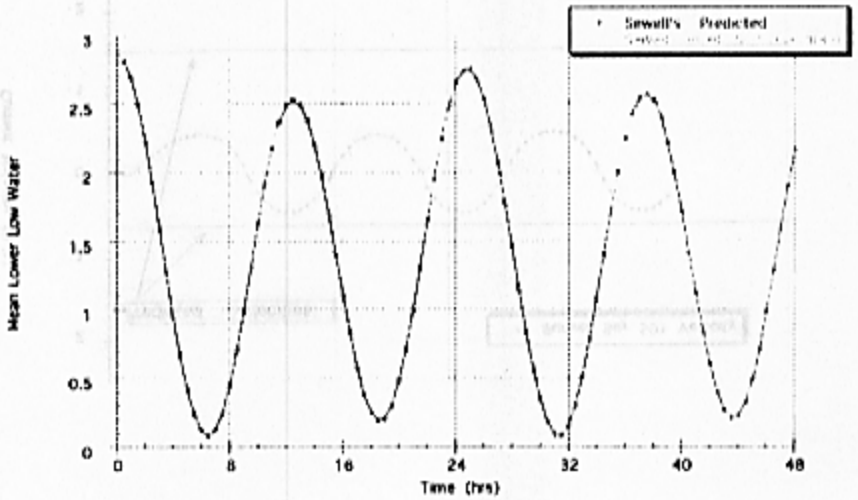
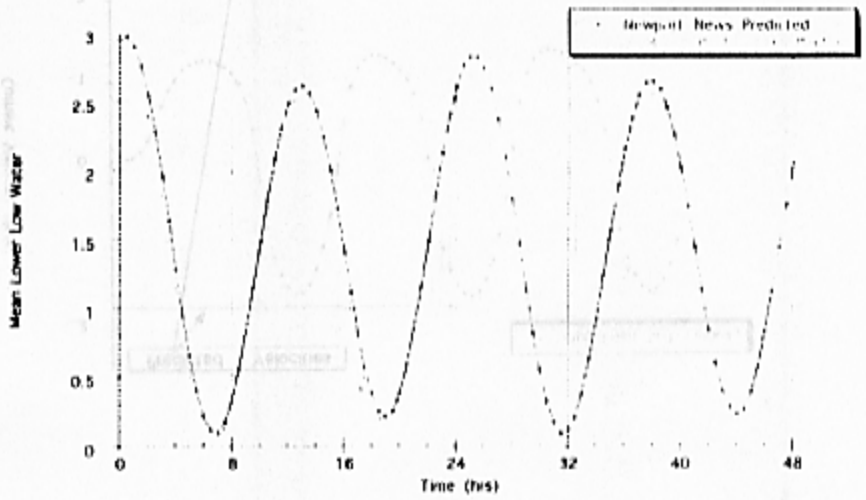
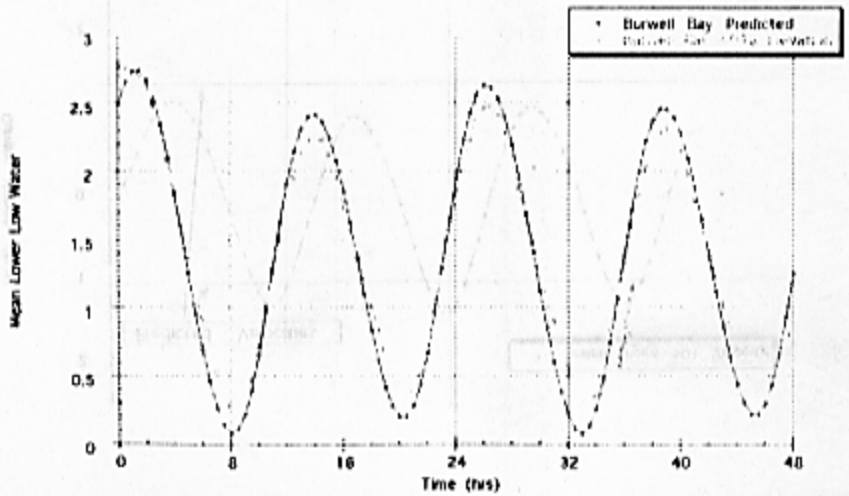


Plate 1

Modeled vs Predicted Tide Elevations







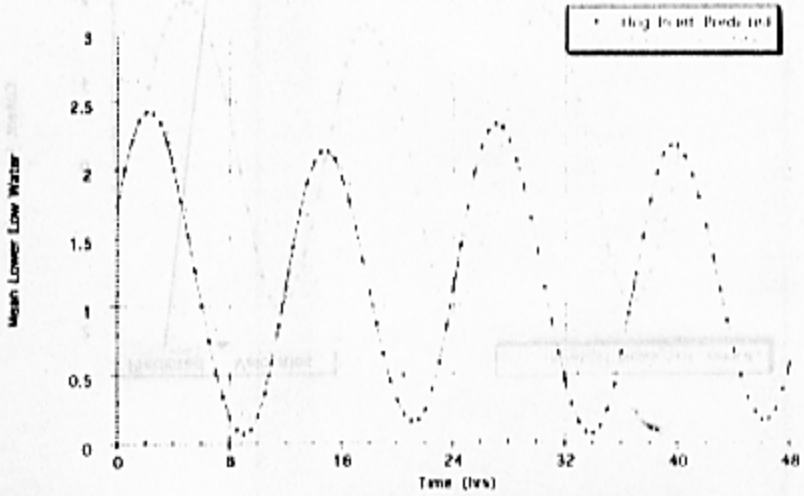
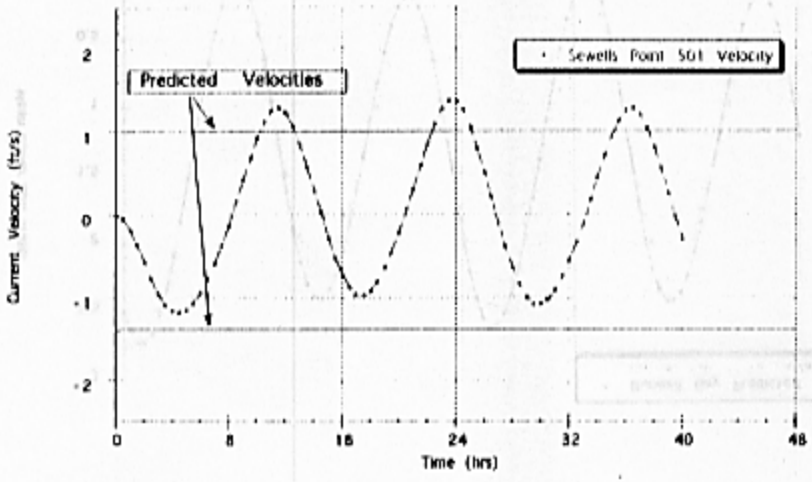
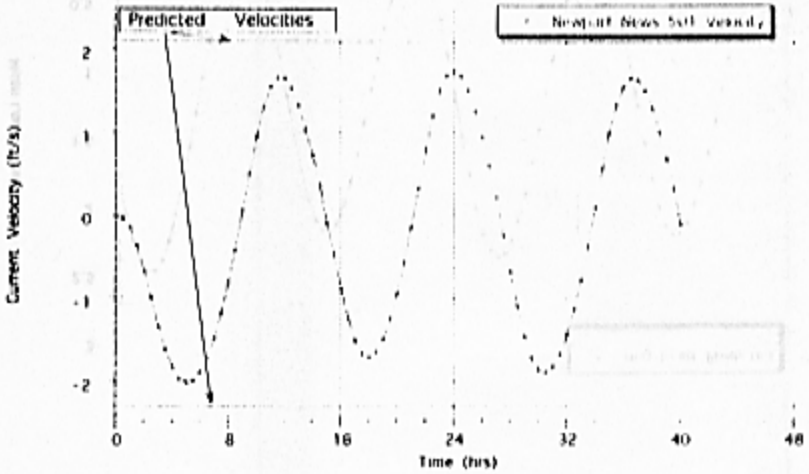
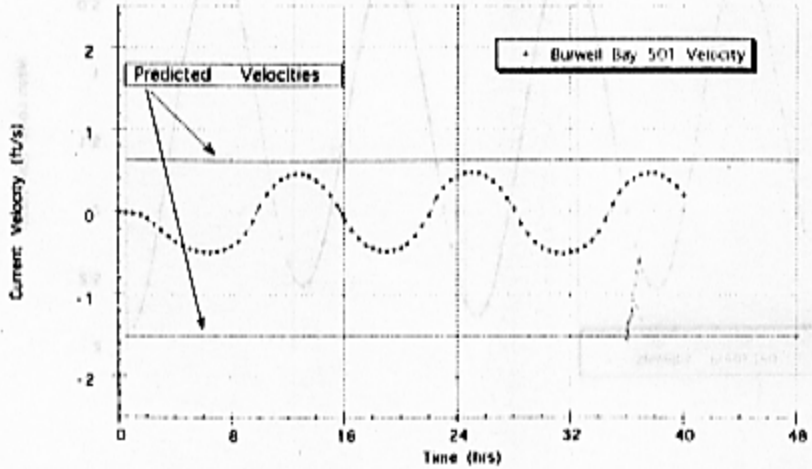


Plate 2

Modeled vs Predicted Maximum Tidal Currents







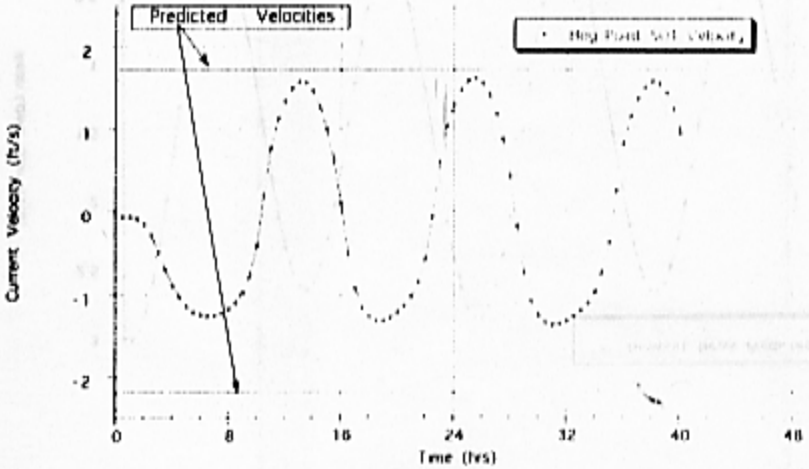


Plate 3

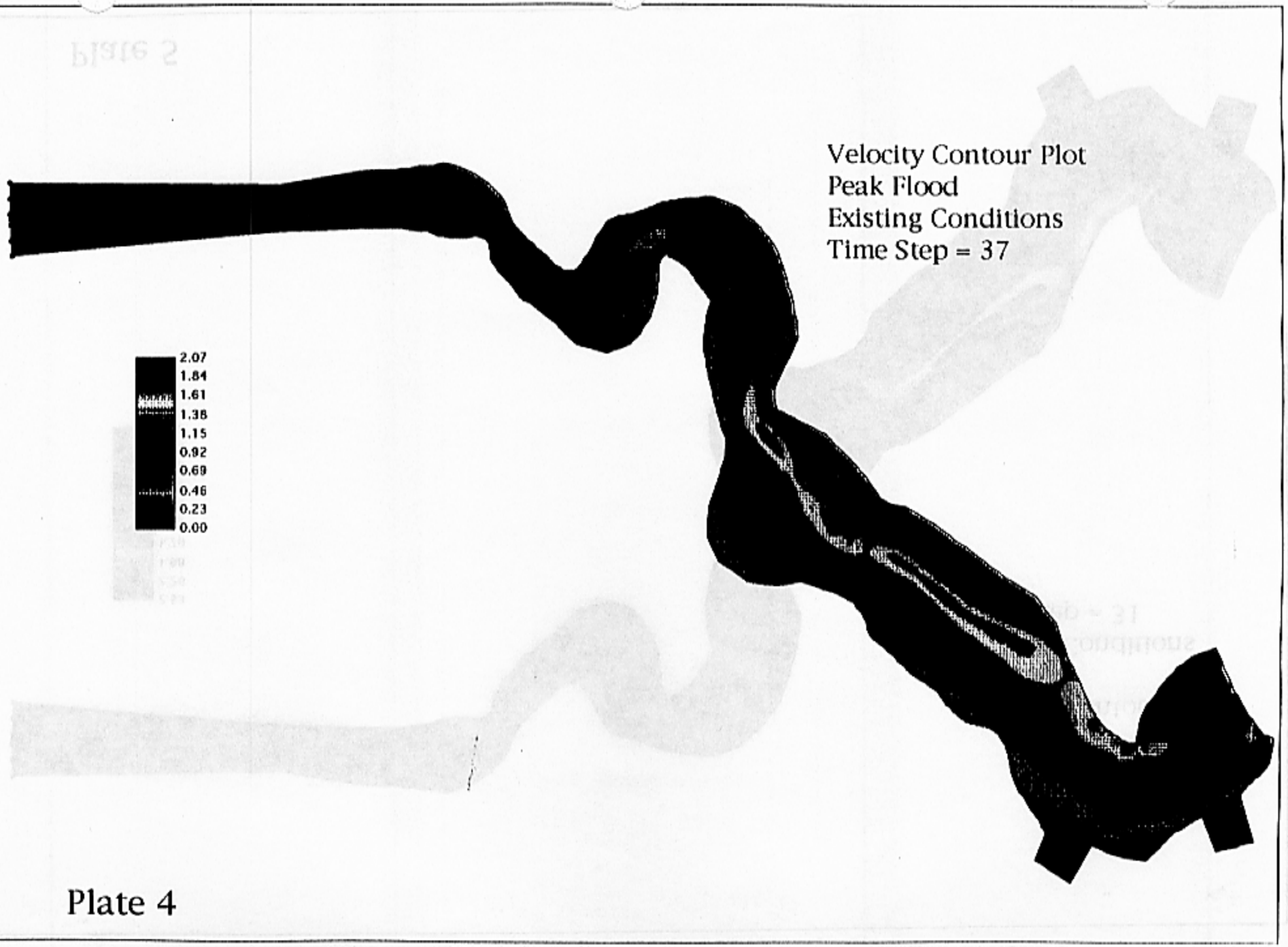
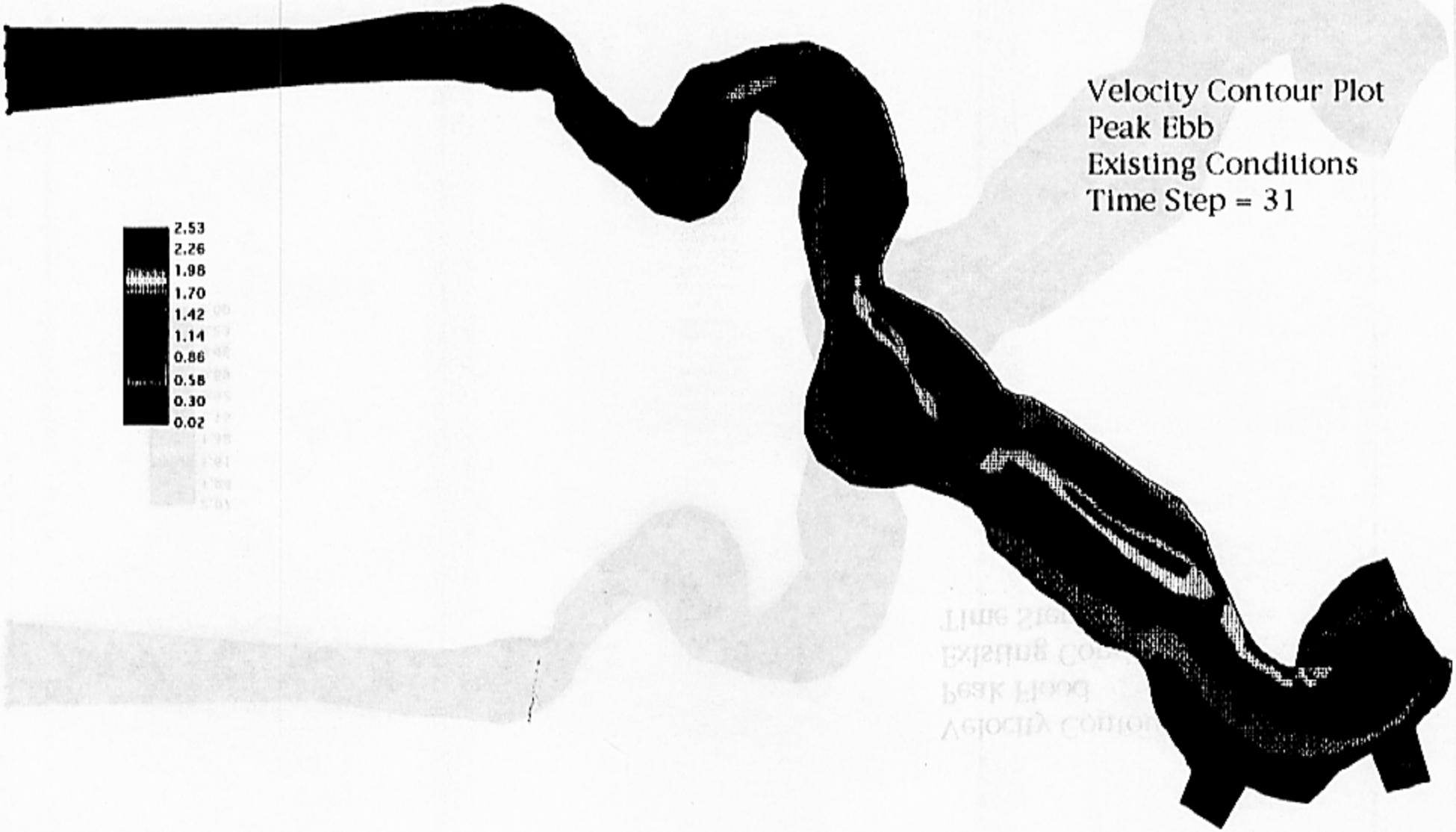

Velocity Contour Plot
Peak Flood
Existing Conditions
Time Step = 37
2.07
1.84
1.61
1.38
1.15
0.92
0.69
0.46
0.23
0.00

Plate 4



Velocity Contour Plot
Peak Ebb
Existing Conditions
Time Step = 31

Plate 5

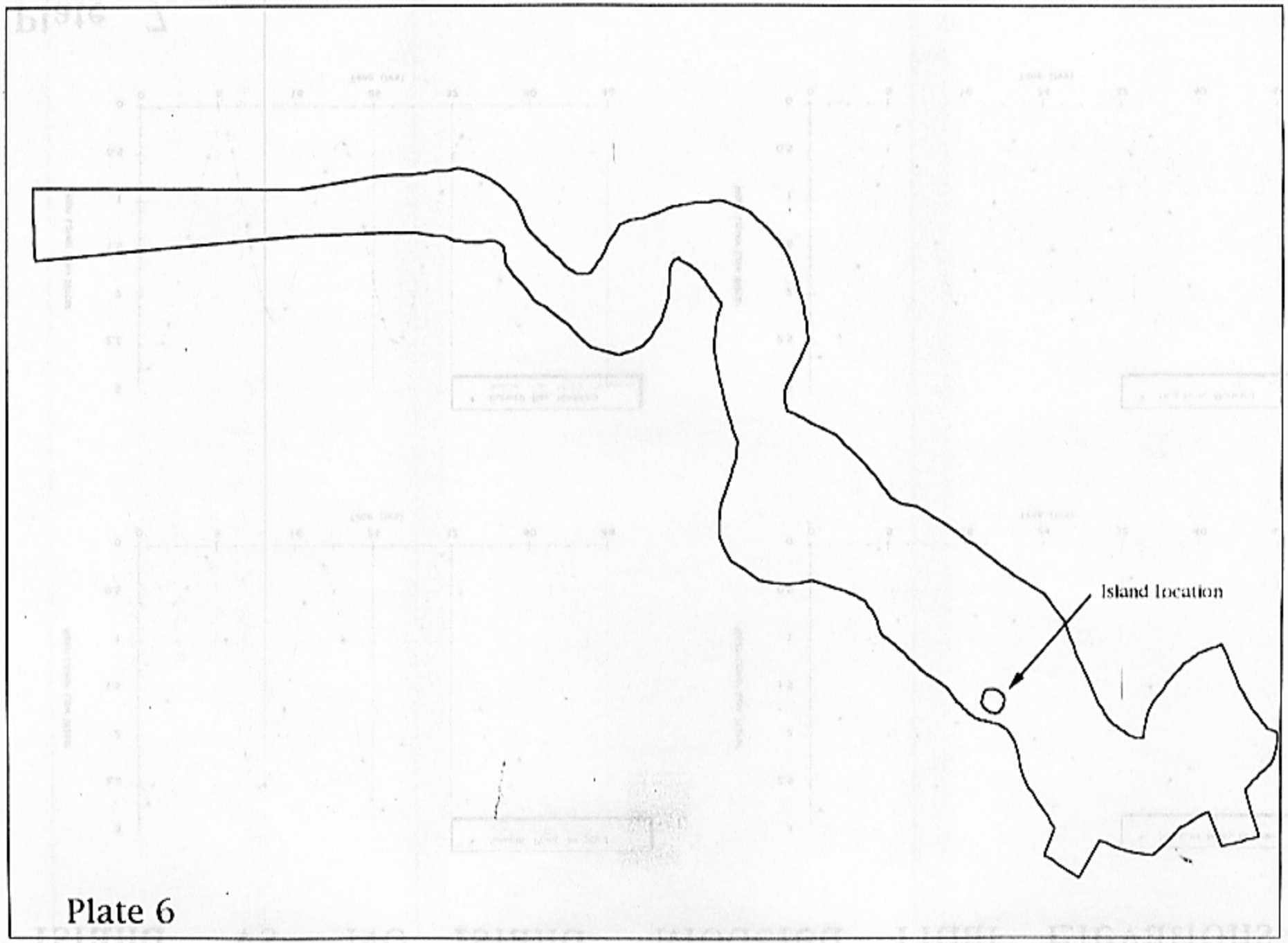
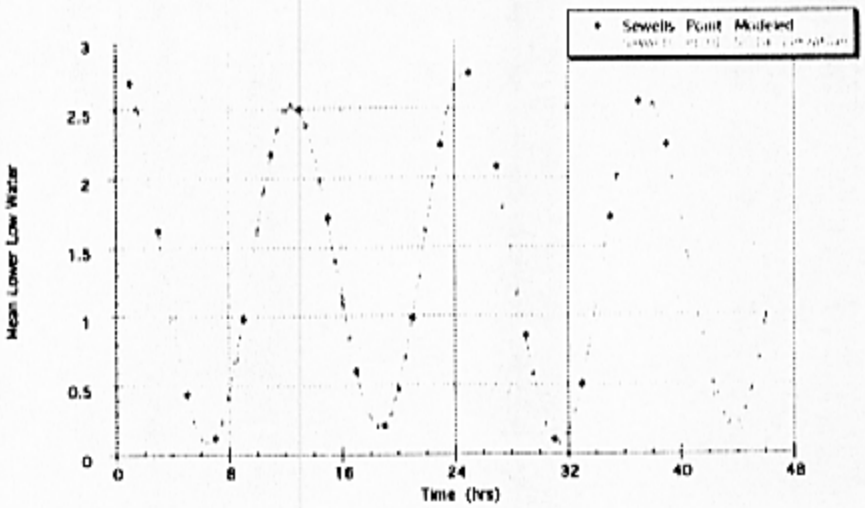
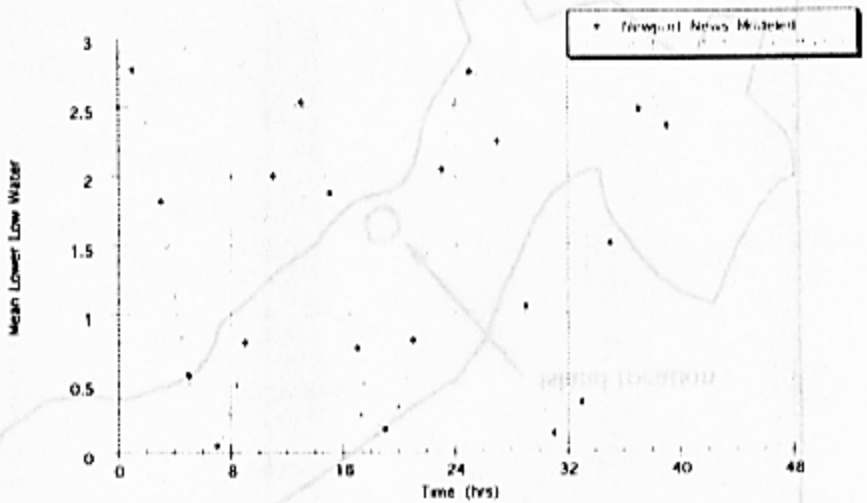
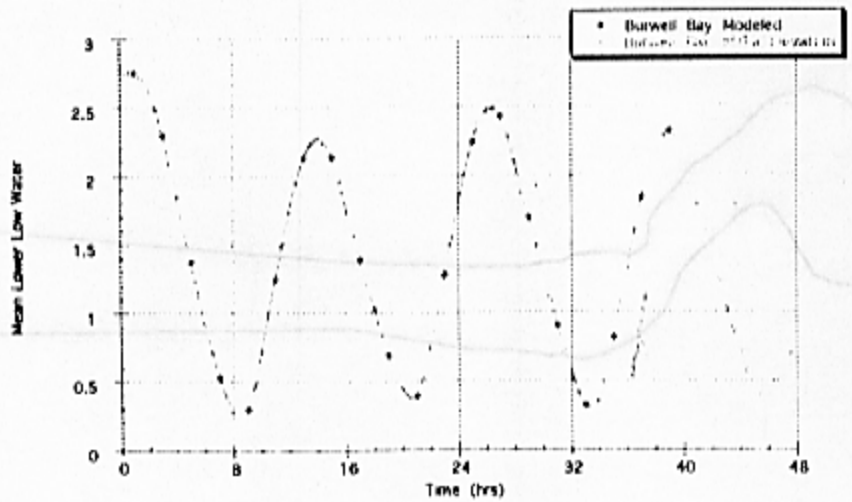


Plate 6

"Island" vs "No Island" Modeled Tidal Elevations







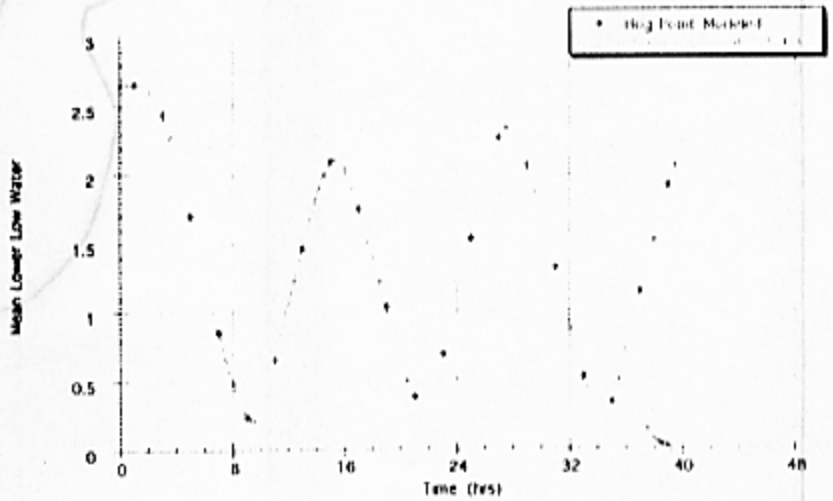


Plate 7

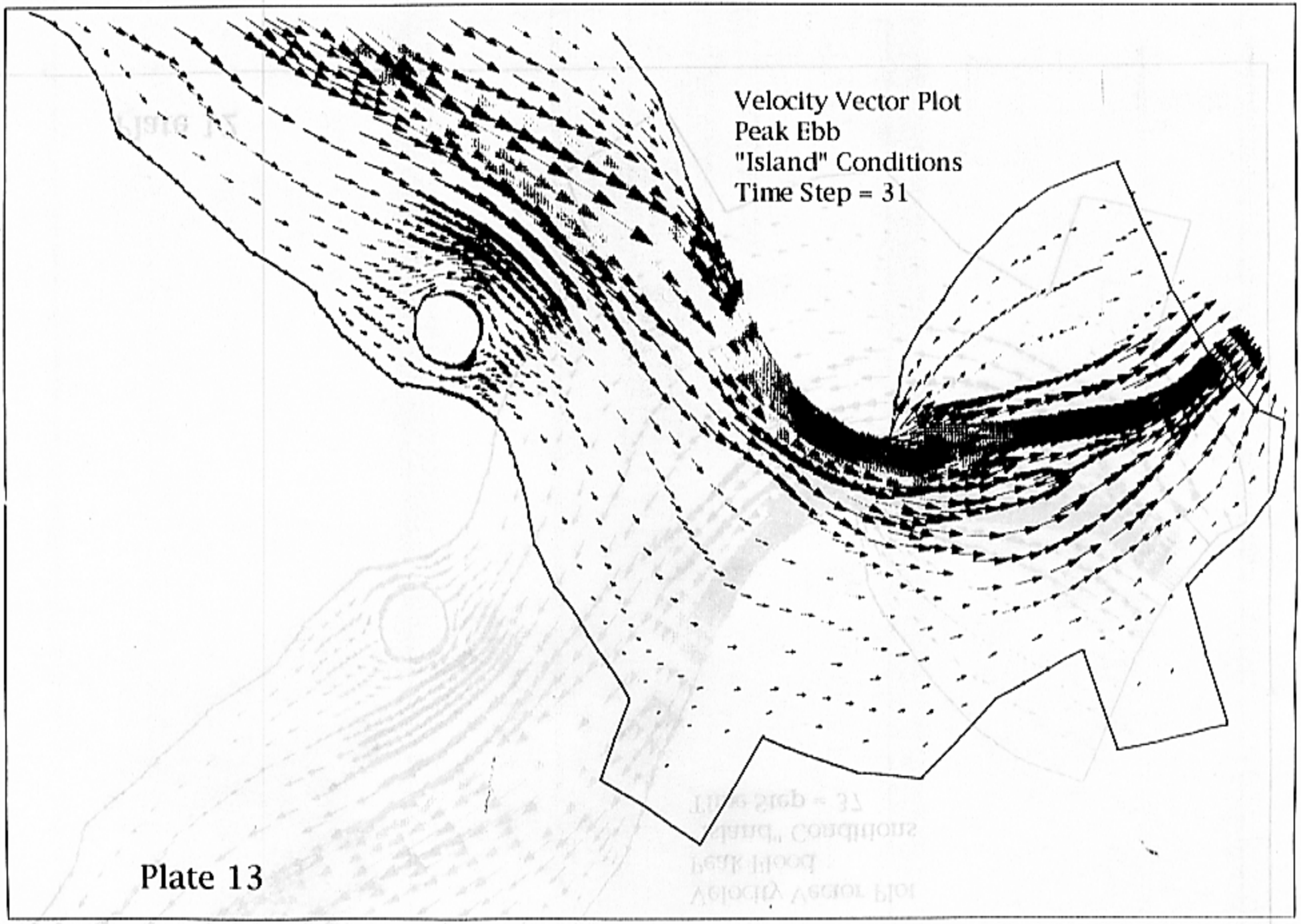

Velocity Vector Plot
Peak Ebb
"Island" Conditions
Time Step = 31

Plate 13

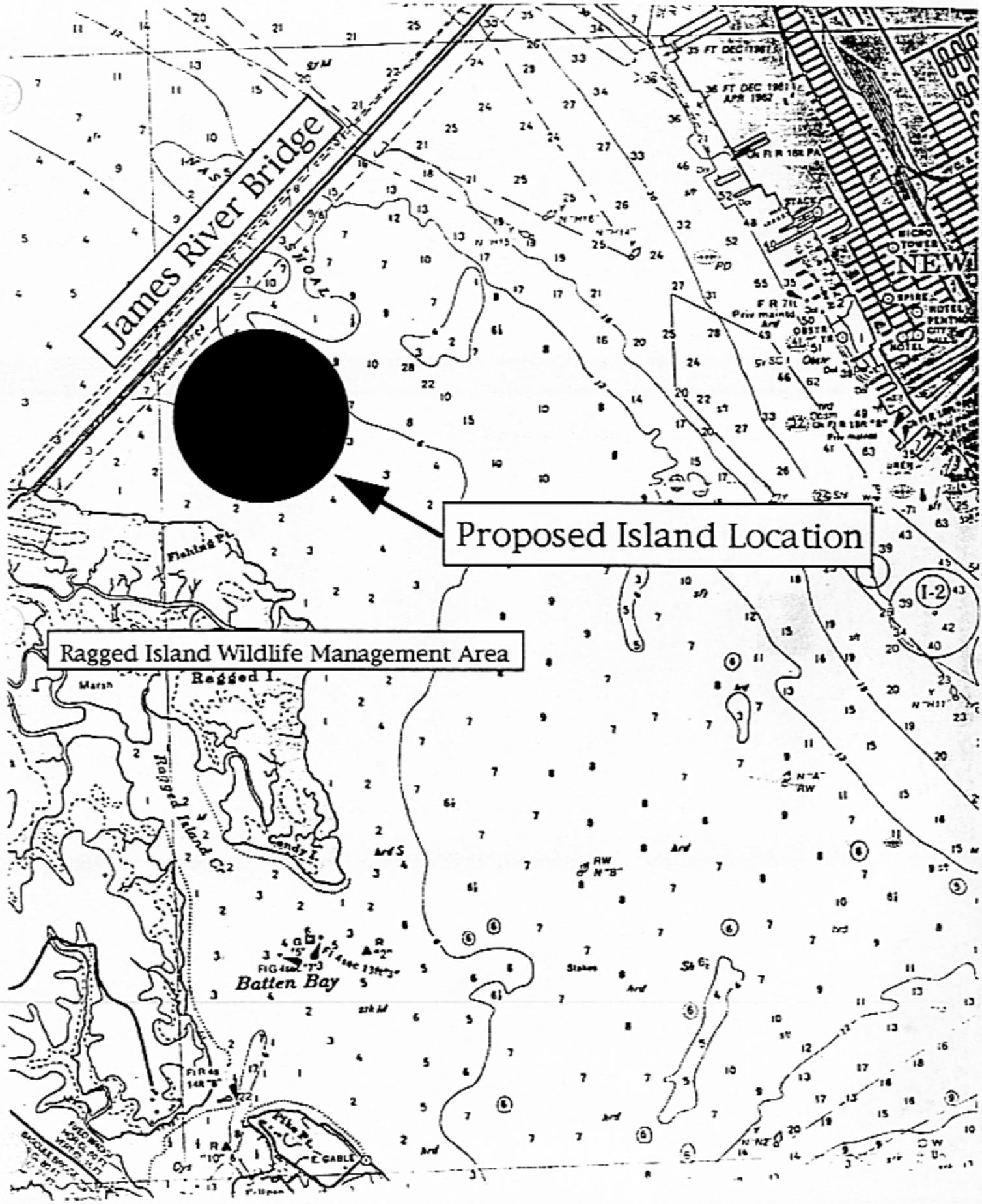

James River Bridge
Proposed Island Location
Ragged Island Wildlife Management Area
Ragged I.
Batten Bay
Fishing Pt.
Ragged Island Cr.
Candy I.
Marsh
NEW
I-2

Plate 14

APPENDIX C

U.S. FISH AND WILDLIFE SERVICE

REPORTS

Lower Chesapeake Bay Dredged Material Beneficial Uses Study
Norfolk Harbor and Channels, Virginia
Initial Project Management Plan

U.S. Fish and Wildlife Service
Annapolis Field Office

Prepared By:
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1825 Virginia Street
Annapolis, MD 21401

Under Supervision of:
John P. Wolflin, Supervisor
Annapolis Field Office

Prepared For:
Department of the Army
Norfolk District, Corps of Engineers
Planning Division
Environmental Analysis Branch

Abstract

Lower Chesapeake Bay Dredged Material Beneficial Uses Study
Norfolk Harbor and Channels, Virginia
Initial Project Management Plan
U.S. Fish and Wildlife Service Investigation

John W. Gill
August 1990

This report provides planning aid information to assist the Norfolk District, Corps of Engineers (Planning Division, Environmental Analysis Branch), in assessment and development of an Initial Project Management Plan to select conceptual projects in the study area. Projects incorporate beneficial uses of dredged material, and focus on Chesapeake Bay island habitat protection and enhancement in support of resource needs documented for the lower Bay. Seven candidate sites are screened through a fatal flaw analysis, and narrowed down to 3 projects meriting further investigation, with an additional project proposed for consideration after construction and assessment of other similar projects. Projects meriting further investigation include: 1) Ragged Island Wildlife Management Area Wetland/Habitat Creation and Erosion Control; 2) Wetland Creation Adjacent to Craney Island Dredged Material Disposal Area, and 3) Eastern Shore of Virginia National Wildlife Refuge Habitat and Visual Screen/Berm Creation. An outline listing studies required for these projects is provided. The project meriting investigation once the technique of creating designed habitats with dredged material is deemed successful is Plum Tree Island National Wildlife Refuge Wetland/ Habitat Creation and Erosion Control.

LOWER CHESAPEAKE BAY DREDGED MATERIAL BENEFICIAL USES STUDY
NORFOLK HARBOR AND CHANNELS, VIRGINIA
INITIAL PROJECT MANAGEMENT PLAN
U.S. FISH AND WILDLIFE SERVICE INVESTIGATION

August 1991

BACKGROUND

In the Chesapeake Bay, the Army Corps of Engineers (Norfolk and Baltimore Districts) is responsible for maintenance and associated dredged material management planning for over 160 navigation channels. In most cases, non-Federal interests are responsible for, and bear all cost for, acquisition of the necessary lands, easements, rights-of-way, and retaining dikes associated with disposal operations. Of the many economic, engineering, and environmental considerations associated with dredging projects, disposal of dredged material can be the most problematic.

In order to understand the magnitude of the problem, it is only necessary to look at major channel maintenance and deepening requirements over the next 20 years. These larger Chesapeake Bay projects will generate over 200 million cubic yards of material. The 200 million cubic yard figure is particularly worrisome when considering most of the existing open-water and diked containment disposal sites will reach capacity within the next five years. In addition to disposal requirements of larger projects, numerous small navigation projects will generate dredged material. Smaller projects can present disposal problems which far exceed their volumetric contribution.

Present day environmental awareness, within the government and private sectors, has prompted a reevaluation of traditional disposal methods of dredged material management. For small and large dredging operations, dredged material disposal options are becoming limited. Environmental concerns with traditional methods include:

- Wetland impacts.
- Water quality impacts associated with contaminants, nutrients, and turbidity.
- Material movement out of the area of initial deposition.
- Indirect and direct impacts to resources such as shellfish, submerged aquatic vegetation (SAV), and fish.
- Loss of valuable upland areas (in terms of natural resource value) for disposal site conversion.

Some of the problems associated with dredged material disposal relate to the way dredged material is viewed. In the past, dredged material was viewed as a waste by-product of navigation projects. Therefore, planning emphasized disposal in the cheapest, most efficient manner. However, if dredged material is viewed as a potential resource, new disposal options and "Public Interest" values may become available.

INTRODUCTION

The Norfolk District, Army Corps of Engineers, and the Virginia Port Authority have expressed an interest in investigating potential beneficial uses of dredged material in the Virginia portion of Chesapeake Bay. In this regard, an interagency work group (Appendix 1) convened to discuss lower bay dredged material beneficial uses. The work group mandate was to outline beneficial use options for future consideration as projects. Alternative projects would then be further evaluated (through a fatal flaw analysis) as candidate proposals. Ideas and products generated by the work group would ultimately be incorporated into the development of an Initial Project Management Plan (IPMP) to study beneficial uses and management of dredged material in lower Chesapeake Bay and Norfolk Harbor.

The following candidate sites and/or applications represent alternative projects (requiring further fatal flaw analysis) developed during the work group process:

- Wetland/habitat creation along eroding James River shoreline (lower end of river).
- Wetland/habitat creation at Windmill Point (site of previous beneficial use attempt).
- Wetland/habitat creation and erosion control adjacent to existing islands within the area of dredged material transport consideration (e.g., Ragged Island Wildlife Management Area proposal by the Applied Marine Research Laboratory of Old Dominion University).
- Oyster bar mound creation in James River and/or ocean side of Virginia's Eastern Shore.
- Island creation/enhancement in the inland bay area of Virginia's Eastern Shore.
- Fish structure, stable berm, or feeder berm creation.
- Island/wetland/habitat creation along eroding sections of Fisherman Island National Wildlife Refuge (NWR).
- Contaminated harbor/river bottom capping with clean dredged material.
- Borrow pit reclamation and wetland/habitat creation.
- Dredged material dewatering, storage, and rehandling area for future use in construction (Craney Island could be assessed for this function).
- "Deep Trough" disposal.
- Thin layering of material (less than 12 inch deposit) over large expanses of bay bottom.

PROGRAM MANAGEMENT PLAN

The Norfolk District, Army Corps of Engineers (Corps), has requested the Annapolis Field Office, U. S. Fish and Wildlife Service (Service), to assist in the preparation of an Initial Project Management Plan (IPMP) assessing beneficial use of dredged material opportunities in the lower Chesapeake Bay. The primary focus of the Service IPMP investigation is to identify potential island restoration\enhancement sites within the geographic boundaries previously defined as the economical hauling distance (Figure 1). The objective is to meet identified lower bay resource needs through the application of beneficial use of dredged material. Potential sites identified are further analyzed for obvious fatal flaws (preliminary assessment using existing resource information to determine presence of resources, or high probability of negative impact, which would preclude further consideration of a site). Examples of fatal flaws would be presence of submerged aquatic vegetation beds, shellfish grounds, anadromous fish breeding or nursery areas, or other important natural resource considerations. Also discussed is the ecological logic used to choose or eliminate sites. For those sites which merit further investigation (lacking fatal flaws and meeting identified lower bay resource needs), a draft Scope of Studies (SOS) is provided.

Upon completion of the IPMP document, mutually selected projects will be more thoroughly pursued, in terms of requisite studies and design. The details of required scopes of work during this proceeding study phase will be developed at the end of the IPMP preparation.

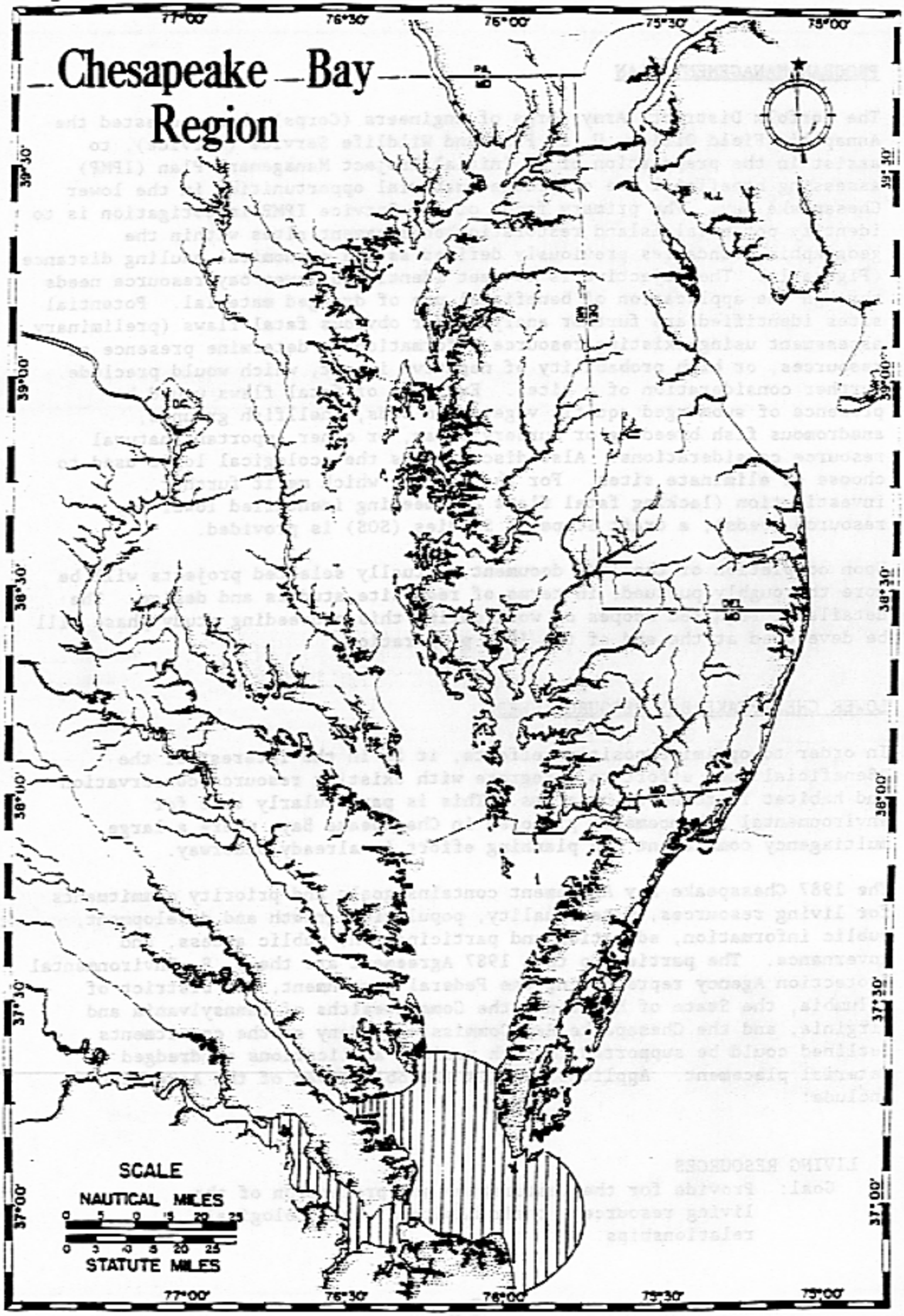
LOWER CHESAPEAKE BAY RESOURCE NEEDS

In order to optimize positive effects, it is in the interest of the "Beneficial Use" effort to integrate with existing resource conservation and habitat improvement programs. This is particularly true for environmental enhancements proposed in Chesapeake Bay, where a large multiagency commitment and planning effort is already underway.

The 1987 Chesapeake Bay Agreement contains goals and priority commitments for living resources, water quality, population growth and development, public information, education and participation, public access, and governance. The parties to this 1987 Agreement are the U. S. Environmental Protection Agency representing the Federal government, the District of Columbia, the State of Maryland, the Commonwealths of Pennsylvania and Virginia, and the Chesapeake Bay Commission. Many of the commitments outlined could be supported through various applications of dredged material placement. Applicable goals and objectives of the Agreement include:

- LIVING RESOURCES
  - Goal: Provide for the restoration and protection of the living resources, their habitats, and ecological relationships.

Figure 1. Economic hauling distance boundary.



Objectives:
- Restore, enhance, protect, and manage SAV.
- Protect, enhance, and restore wetlands, coastal sand dunes, forest buffers, and other shoreline and riverine systems important to water quality and habitat.
- Conserve soil resources and reduce erosion and sedimentation to protect bay habitat.
- Develop bay-wide fisheries management strategies and develop complementary state programs and plans to protect and restore the finfish and shellfish stocks of the bay, especially the freshwater and estuarine spawners.
- Provide for the restoration of shellfish stocks in the bay, especially the abundance of commercially important species.
- Restore, enhance, and protect waterfowl habitat.

o WATER QUALITY

Goal: Reduce and control point and nonpoint sources of pollution to attain the water quality condition necessary to support the living resources of the bay.

Objectives:
- Evaluate and institute, where appropriate, alternative technologies for point source pollution control, such as biological nutrient removal and land application of effluent to reduce pollution loads in a cost-effective manner.
- Reduce the levels of nonpoint source pollution.
- Manage sewage sludge, dredged spoil, and hazardous wastes to protect the bay system.

o POPULATION GROWTH AND DEVELOPMENT

Goal: Plan for and manage the adverse environmental effects of human population growth and land development in the Chesapeake Bay Watershed.

Objectives:
- Consult with local government representatives in the development of Chesapeake Bay restoration and protection plans and programs.
- Assure that government development

projects meet all environmental requirements.

- Promote, among local, state, and Federal governments, and the private sector, the use of innovative techniques to avoid and, where necessary, mitigate the adverse impacts of growth.

o PUBLIC INFORMATION, EDUCATION, AND PARTICIPATION

Goal: Promote greater understanding among citizens about the Chesapeake Bay system, the problems facing it, and the policies and programs designed to help it, and foster individual responsibility and stewardship of the bay's resources.

Goal: Provide increased opportunities for citizens to participate in decisions and programs affecting the bay.

o PUBLIC ACCESS

Goal: Promote increased opportunities for public appreciation and enjoyment of the bay and its tributaries.

Objectives:

- Improve and maintain access to the bay, including public beaches, parks, and forested lands.
- Improve opportunities for recreational and commercial fishing.
- Secure shoreline acreage to maintain open space, and provide opportunities for passive recreation.
- Secure necessary acreage to protect unique habitat and environmentally sensitive areas.

o GOVERNANCE

Goal: Support and enhance the present comprehensive, cooperative, and coordinated approach toward management of the Chesapeake Bay System.

Goal: Provide for continuity of management efforts and perpetuation of commitments necessary to ensure long-term results.

CHESAPEAKE BAY ISLANDS

In Chesapeake Bay, islands are preferentially selected by many migratory bird species as nesting/production areas. Numerous species of wading birds, shore birds, waterfowl [including one of the North American Waterfowl Management Plan emphasis species, the American black duck (Anas

rubripes)], and endangered species such as the bald eagle (Haliaeetus leucocephalus), are either dependent on, or exhibit a preference toward, island sites. Additionally, many Chesapeake islands include beach habitat components which are heavily used by nesting northern diamondback terrapins (Malaclemys terrapin), as well as migratory birds. Although similar habitat conditions and vegetative communities may occur on the mainland, isolation, lack of human disturbance, and fewer predators make islands desirable. Species lists for select islands are provided in the appendices.

Throughout the bay, island habitats are rapidly being lost to erosion. The significance of the problem can be seen by comparing historical island acreages with present acreages on one section of Maryland's Eastern Shore -- from Eastern Neck Island just north of the Chesapeake Bay Bridge, south to Barren Island located west of the Hooper Island complex. Historically (mid-1800's), this area included 35 islands with a total cumulative footprint acreage of approximately 55,500 acres. By the 1940's, 12 islands had been completely lost to erosion, and the footprint acreage of the remaining islands had been reduced to approximately 45,000 acres. More than 10,500 acres of valuable fish and wildlife habitat had been lost in less than 100 years. Much of this loss was to estuarine wetlands.

The habitat loss associated with island erosion is exacerbated by subsidence, exponential growth in human population, and urban expansion throughout Chesapeake Bay mainland areas. Living resources are more restricted in terms of potential habitat, and what habitat remains is being negatively affected. Both quantity and quality are becoming limiting habitat factors. This scenario is particularly worrisome because new islands, for the most part, are not being formed.

At present, Chesapeake Bay islands are erosional features formed when a peninsula is bisected, and the shoreline retreats inward, leaving the remaining landmass offshore. With much of the present Chesapeake shoreline developed, and erosional areas protected by bulkheads and revetments, fewer areas have island-forming potential. Of course erosion is also severely impacting islands. All of these factors suggest protection of existing islands is becoming more critical.

CANDIDATE SITES

As a starting point, seven sites were selected for further consideration through the IPMP effort. Selections were based on geographic boundaries defined by the Corps as the economic hauling distance, review of existing resource information, identified resource needs for the Lower Chesapeake Bay, and applicable candidate sites generated by the interagency work group. For each site, a preliminary, conceptual project design was developed (or had been previously provided) for fatal flaw analysis.

The cost to implement any of the seven projects was not considered, either as an initial selection criteria, or in prioritizing recommended projects for further consideration. The cost to implement recommendations may be

significant and/or more expensive than more conventional methods of dredged material management. It is the position of the Service that dredged material management should produce short- and long-term environmental benefits in addition to maintenance of adequate ship channels. Many of these benefits may be hard to quantify in an economic sense.

Figure 2 shows location for the candidate sites and the following IPMP proposals:

A. Wetland Creation and Erosion Control at the Western Side of the Eastern Shore Approach Causeway to the Chesapeake Bay Bridge Tunnel

B. Eastern Shore of Virginia NWR Habitat and Visual Screen/Berm Creation

C. Fisherman Island NWR Wetland/Habitat Creation and Erosion Control

D. Plum Tree Island NWR Wetland/Habitat Creation and Erosion Control

E. Ragged Island Wildlife Management Area (WMA) Wetland/Habitat Creation and Erosion Control

F. Hog Island WMA Wetland/Habitat Creation and Erosion Control

G. Wetland Creation Adjacent to Craney Island Dredged Material Management Area

In addition to the seven candidate proposals, two other sites merit consideration. Both sites exhibit considerable wildlife habitat value and/or potential, however, are outside of the economic hauling boundary. Navigation projects separate of the IPMP effort could be assessed regarding the use of these sites for beneficial use application. The sites and preliminary concept proposals are:

H. Wetland Creation and Erosion Control on the West Side of Watts Island

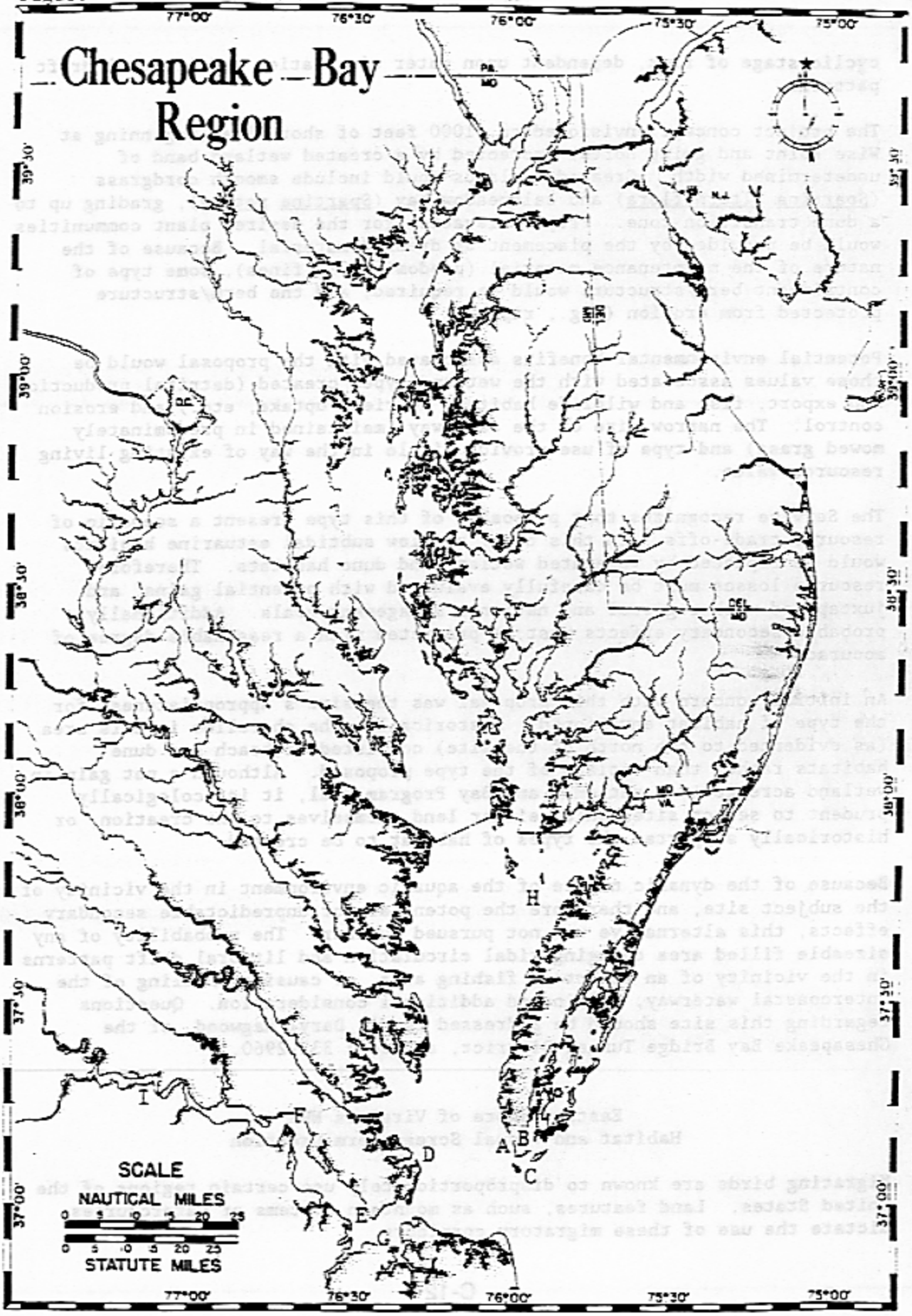
I. Wetland/Habitat Creation at the Previously Used Beneficial Use Site Off Windmill Point

PROJECT DESCRIPTIONS AND ASSESSMENTS

Wetland Creation and Erosion Control at the Western Side of the Eastern Shore Approach Causeway to the Chesapeake Bay Bridge Tunnel

The western shoreline of the eastern shore approach causeway to the Chesapeake Bay Bridge Tunnel exhibited erosion in the past. According to Eastern Shore of Virginia NWR staff, presently the mean high water mark is at the toe of the existing protective revetment, whereas historically there was a narrow sandy beach and dune in between. More recently (per bridge tunnel staff), sand has begun to accrete. Apparently, the area is in a

Figure 2. Candidate site locations.



cyclic stage of flux, dependent upon water circulation and littoral drift patterns.

The project concept envisioned ca. 1000 feet of shoreline (beginning at Wise Point and going north) protected by a created wetland band of undetermined width. Created wetlands would include smooth cordgrass (Spartina alterniflora) and saltmeadow hay (Spartina patens), grading up to a dune transition zone. Proper elevation for the desired plant communities would be provided by the placement of dredged material. Because of the nature of the maintenance material (predominately fines), some type of containment berm/structure would be required, and the berm/structure protected from erosion (e.g., riprap).

Potential environmental benefits associated with the proposal would be those values associated with the wetland types created (detrital production and export, fish and wildlife habitat, nutrient uptake, etc.) and erosion control. The narrow size of the causeway (maintained in predominately mowed grass) and type of use provide little in the way of existing living resource value.

The Service recognizes that proposals of this type present a scenario of resource trade-offs. In this case, shallow subtidal estuarine habitats would be replaced by vegetated wetland and dune habitats. Therefore, resource losses must be carefully evaluated with potential gains, and juxtaposed with regional and national management goals. Additionally, probable secondary effects must be predicted with a reasonable degree of accuracy.

An initial concern with this proposal was the site's appropriateness for the type of habitat envisioned. Historically, the shoreline in this area (as evidenced to the north of the site) consisted of beach and dune habitats rather than wetland of the type proposed. Although a net gain in wetland acreage is a national and Bay Program goal, it is ecologically prudent to select sites which either lend themselves to the creation, or historically supported the types of habitat to be created.

Because of the dynamic nature of the aquatic environment in the vicinity of the subject site, and therefore the potential for unpredictable secondary effects, this alternative was not pursued further. The probability of any sizeable filled area changing tidal circulation and littoral drift patterns in the vicinity of an important fishing area, or causing shoaling of the intercoastal waterway, eliminated additional consideration. Questions regarding this site should be addressed to Mr. Daryl Hagwood, of the Chesapeake Bay Bridge Tunnel District, at (804) 331-2960.

Eastern Shore of Virginia NWR
Habitat and Visual Screen/Berm Creation

Migrating birds are known to disproportionately use certain regions of the United States. Land features, such as mountain systems or watercourses, dictate the use of these migratory corridors.

Two prominent land features of the mid-Atlantic coast are the south-facing peninsulas terminating at Cape May, New Jersey, and Cape Charles, Virginia. Southward migrating birds are "funneled" to the tips of these peninsulas. Additionally, there is a reluctance for migrators to cross barriers of open water (such as the Chesapeake Bay) until suitable weather conditions are present. This serves to concentrate birds, often in immense numbers, at the water's edge. These factors together provide for continental prominence of Northampton County, Virginia, and Eastern Shore of Virginia NWR, as a staging and concentration area for eastern North American migratory birds during fall migration (see Appendix 2 for species list).

The significance of this area is widely known to bird watchers, bird banders, biologists, and conservationists. The woodlands of the Cape Charles area are probably the most important focal point or staging area for raptor and passerine southward migration on the eastern coast of the United States (Hill, J. M., 1984, Master's Thesis, George Mason University). However, it is less widely known that many of North America's woodland species that use this area are declining in numbers (The Virginia Natural Heritage Program, 1988, Report on the Bayside and Kiptopeke Beach of the Eastern Shore of Virginia in Northampton County). Reasons for the declines are poorly documented, but are probably combinations of several factors including: fragmentation of nesting habitat, tropical deforestation, increased cowbird nest-parasitism (due to North American deforestation), and loss of habitat (Ehrlich, P. R., D. S. Dobkin, and D. Wheye, 1988, The Birder's Handbook, Simon and Schuster, Inc.).

The decline of neotropical migrant birds emphasizes the national importance of carefully managing the migratory bird habitats of Cape Charles and the Atlantic flyway, and educating the public about forest fragmentation and its long term effects. The realization of this need was reason, in part, for the establishment of the Eastern Shore of Virginia NWR.

In fulfillment of its environmental education objectives, the Refuge is building a visitors center complete with educational displays and outdoor created habitats. The hope is to attract recreational Chesapeake Bay users, and leave them with an understanding of the Bay's bounty, problems, and how human actions can hurt or help. In order that this expected intensive use of the Refuge does not impact more sensitive wildlife areas, the Refuge wishes to visually separate the visitor center area.

Refuge staff are in the process of creating an earthen berm to act as a visual screen between the visitor area and more sensitive wildlife areas. Once created, the berm would be vegetated with trees and shrubs, replacing the existing fallow farm field with indigenous forest. Dredged material could be used relatively easily for this purpose.

A rounded, trapezoidal hill approximately 30 feet high, with a top width of 55 feet, a footprint width of 150 feet, and an overall minimum length of 650 feet is envisioned. Although the refuge has some capability to create such a feature, at present, trucks for hauling and fill material are in short supply.

The main environmental and logistical concern with this candidate proposal would be the location of the area to pump or off-load dredged material. Presumably, area is available in the vicinity of Wise Point. Whether there is adequate space for any kind of significant storage volume would need to be determined. There already exists a refuge access road to Wise Point, which could be used to transport material to the berm creation site.

Based on this preliminary assessment, the Eastern Shore of Virginia NWR Habitat and Visual Screen/Berm Creation candidate merits further investigation. Questions and coordination regarding this candidate should be addressed to Mr. Sherman Stairs, Refuge Manager, Eastern Shore of Virginia NWR, at (804) 331-2760; mailing address:

Refuge Manager
Eastern Shore of Virginia National Wildlife Refuge
RFD #1, Box 122 B
Cape Charles, Virginia 23310

Fisherman Island NWR Wetland/Habitat Creation and Erosion Control

Fisherman Island NWR was established in 1969 to serve as a breeding ground and nursery for the many species of shore and water birds that use the site in great numbers (Appendix 2). The island is a satellite refuge to the Eastern Shore of Virginia NWR. Species that breed on the island include:

- American oystercatcher (Haematopus palliatus)
- royal tern (Sterna maxima)
- gull-billed tern (Gelochelidon nilotica)
- common tern (Sterna hirundo)
- roseate tern (Sterna dougallii)
- least tern (Sterna albifrons)
- Forster's tern (Sterna forsteri)
- black skimmer (Rynchops niger)
- laughing gull (Larus atricilla)
- willet (Catoptrophorus semipalmatus)
- clapper rail (Rallus longirostris)
- American black duck (Anas rubripes)
- mallard (Anas platyrhynchos)
- gadwall (Anas strepera)
- red-breasted merganser (Mergus serrator)
- green heron (Butorides striatus)
- black-crowned night heron (Nycticorax nycticorax)
- yellow-crowned night heron (Nyctanassa violacea)
- brown pelican (Pelecanus occidentalis)
- osprey (Pandion haliaetus)

The island is crescent-shaped, with a circumferential distance of about 6 miles (approximately 1000 acres in size). The outer margin of the crescent

is wide sandy beach, grading up to protective sand dunes, and then grading down to expansive salt marsh which makes up the majority of available habitat. Aside from a few scattered trees and shrubs on the eastern two-thirds of the island, most forested sites are confined to a small section north of the Bay Bridge Tunnel.

At the extreme northeast side of the island, fronting on Smith Inlet and opposite Smith Island, new and extensive offshore bars and shoals are forming (Buckley, P. A., and F. G. Buckley, undated, Hofstra University, The Birds of Fisherman Island National Wildlife Refuge). Some of these bars are becoming uncovered during spring low tides. In general, the island appears to be eroding at the northwest shoreline, and building up on the northeast side. Presently, shallows extend in all directions far offshore, with shallows and sandbars uncharted due to the frequent changes in position.

As with the Bridge Tunnel Approach Causeway candidate, initially Fisherman Island was considered for erosion control and wetland/habitat creation potential. Like the Bridge Tunnel site, Fisherman Island is not truly eroding, but is migrating due to circulation patterns and littoral drift. Again, this is an area of complex currents, where predicting changes associated with a large area of fill would be difficult. Even if probable effects could be modeled with an acceptable degree of accuracy, covering existing sandy substrates with finer silts and clays would be inadvisable. Additionally, waters surrounding the area support heavy recreational fishing. In terms of the islands existing high habitat value, and fish and wildlife utilization, the "If it isn't broken don't fix it" conclusion was drawn. Therefore, this alternative was not pursued further. Questions regarding the site should be addressed to Mr. Sherman Stair, at the Eastern Shore of Virginia NWR.

Plum Tree Island NWR Wetland/Habitat Creation and Erosion Control

Plum Tree Island NWR consists of 3,275 acres of salt marsh habitat situated on a peninsula of land formed by the York River to the north and the James River to the south. It is approximately five miles long and two miles wide at its longest and widest points. Plum Tree is bisected by nine major creeks and innumerable smaller guts or inlets. The entire area is affected by tidal flux, with most of the area affected daily. The area is noteworthy for providing habitat to numerous waterfowl, wading birds, waterbirds, shorebirds, fish, and aquatic furbearers (Appendix 3). Although previously used by the Air Force as a bombing range, the habitats seem relatively pristine in terms of appearance and ecological functions.

Plum Tree shorelines are characterized by sandy beaches, or exposed peat associated with wetland communities. Where sandy beaches occur, typically they grade up to small dune areas (50-100 feet wide), which then grade down to high marsh (saltmeadow hay) or low marsh (smooth cordgrass). Some of the dune sites are receding landward due to erosion. The Virginia Institute of Marine Science (VIMS) defines severe erosion as any shoreline

segment that exceeds two feet erosion per year. Two locations (Appendix 4) on Plum Tree meet this criteria: 1) the entire north shore, from Cow Island to Marsh Point, and 2) the southeast shore from Plum Tree Point to the mouth of Fire Pine Creek. The significance of the problem can be seen by an existing pier, previously connected to the island, which now is 100 yards offshore.

Waters surrounding the area are sandy bottom shallows (e.g., Poquoson Flats), much of which supports extensive beds of eelgrass (Zostera marina). Both shallow water areas and deeper waters further offshore are heavily fished by commercial (crab pots, gill net, clam tong) and recreational users. Water clarity in the island vicinity is good, and may also indicate good water quality.

Noteworthy, in addition to the areas migratory bird value, refuge staff (Mr. Gary Andres) has observed the following:

- From June through September, large schools of spot (Leiostomus xanthurus) and Atlantic croaker (Micropogonias undulatus) feed on minnows and crustaceans transported by the wetland creeks.
- From early August into September 1989, a large pod (40-50) of Atlantic bottlenose dolphins (Tursiops truncatus) consistently fed over the flats from Drum Point to Plum Tree Point.
- Large sea turtles were spotted in the Back River and above the flats off Plum Tree Point, from late July to early September.
- The observation tower on the south end of the refuge has been visited by the Federally endangered peregrine falcon (Falco peregrinus).

The candidate proposal envisions the creation of an island, oriented parallel to the shoreline, to serve as an offshore breakwater. Some type of containment berm would be built and protected with riprap, and the dredged material placed within. After dewatering, a mixture of upland and wetland habitats would be created by grading and planting. If possible, considering the type of material, intertidal wetlands would be established on the Plum Tree Island side of the created island, grading up to high marsh, transition zone, and upland. The location and size of the created habitat would be dictated by the regulatory/review community, and the Back Bay NWR manager. Presumably, the island would be sited in an area where providing a lower wave energy climate on the landward side could increase (or allow establishment of) eelgrass beds.

As previously discussed, waters surrounding Plum Tree are considered very valuable. Dr. Herb Austin of the VIMS, who was contacted in regard to the area's value, rated the area very high for recreational fishing for croaker, spot, striped bass (Morone saxatilis), sea trout (Cynoscion nebulosus), and weakfish (Cynoscion regalis). He also felt the proposal could enhance the fisheries value of the area. Mr. Tony Watkinson of the Virginia Marine Resource Commission spoke of the areas value to crabbers,

gill netters, and clammers. His opinion was the area is too valuable to experiment with because of significant potential resource tradeoffs.

Theoretically, this candidate proposal has the potential to protect an existing valuable resource area, enhance the areas value for fish and wildlife, and (depending on the size of the project) provide significant dredged material placement capacity. The proximity of Plum Tree Island NWR to several Federal channels is obviously an additional benefit to the site. However, because of the surrounding waters high value, Plum Tree may not be the best place to experiment. Refuge staff also expressed this concern, particularly for any sizeable proposal.

Plum Tree Island NWR Wetland/Habitat Creation and Erosion Control candidate merits further investigation. However, one of the other, similar, candidates recommended for investigation should be built first. After adequate follow-up studies are conducted on the first island creation, and deemed a success, this candidate could be revisited. Questions and coordination regarding this candidate should be addressed to Mr. Anthony Leger, Refuge Manager, Back Bay NWR, at (804) 721-2412; mailing address:

Refuge Manager
Back Bay National Wildlife Refuge
P.O. Box 6286
Virginia Beach, VA 23456

Ragged Island Wildlife Management Area (WMA)
Wetland/Habitat Creation and Erosion Control

Ragged Island WMA was established to preserve habitat for wildlife, and provide recreational opportunities to the citizens of Virginia. Predominately, habitats are comprised of smooth cordgrass (Spartina alterniflora) marshes and stands of loblolly pine (Pinus taeda), with little in the way of upland and/or non-tidal communities. From a potential dredged material transport perspective, the location close to the main Hampton Roads Harbor Reach and Newport News shipping channel is appealing.

The WMA is situated adjacent to a shoal area (average 1-3 ft. MLW) exhibiting turbidity problems from James River sediment loadings, and wind-directed waves and currents. Apparently, sediment is stirred up regularly, creating cloudy water conditions most of the year. These wave energies have the additional effect of causing serious erosion along the northern and eastern shorelines.

The Applied Marine Research Laboratory (AMRL) of Old Dominion University is recommending Ragged Island WMA be investigated as a potential habitat creation and restoration area using dredged material. AMRL contends that although the area presently supports a large variety of wildlife species, few species actually breed there. The number of species that could use the area for breeding, feeding, and resting could be significantly increased by adding additional habitat types (e.g. uplands and freshwater). Additionally, the existing shallow water area and shoreline could be

improved by reducing wave energy and combating shoreline erosion. In this regard, AMRL has developed a conceptual habitat restoration/creation proposal based on beneficial uses of dredged material (Appendix 5).

Proposed is a series of five islands forming half of a semicircular breakwater beginning just below the James River Bridge, and ending offshore of Candy Island. Islands will be created by placing dredged material inside a containment berm. The landward facing edge of the created islands would approximately follow the -6 foot MLW contour. Channelward facing island shorelines (west, north, and east faces) would be protected with riprap. Three of the islands are proposed to be approximately 1000 feet in length by 250 feet in width. The two main islands would be constructed to be approximately 300 and 550 acres. The combined acreage for all proposed islands would be 870 acres, with a capacity to accommodate up to 17 million cubic yards of dredged material. The island configuration would also create a 800-1000 acre shallow water embayment between the WMA and back side of the islands. The reduced wave climate created should significantly minimize shoreline erosion on Ragged Island. Theoretically, by providing lower wave energies, water clarity within the created embayment would improve, thereby enhancing the site's ability to establish and support SAV.

Once dredge material placement and dewatering were complete, various habitat types would be created through grading and planting. AMRL is proposing the creation of tidal and nontidal wetlands, shallow water ponds, and various upland habitats including forest. Tidal wetlands would be positioned on the embayment side of created islands. Also proposed is the establishment of SAV in created ponds, and creation of American oyster (Crassostrea virginica) reefs within the shallow water embayment.

In terms of potential resource tradeoffs associated with conversion of existing aquatic habitat, AMRL states there is a commercial crabpot fishery for blue crabs (Callinectes sapidus) in the area. There are no longer any productive oyster beds in this zone (per AMRL), and no commercial clamming is conducted within the impact zone (probably due to shallow water depth rather than absence of clams). The area receives seasonal use by some recreationally and commercially important finfish for foraging (including anadromous species), however is not considered by AMRL to be a significant nursery area. Purportedly, SAV has not existed in the shallow water zone in recent years, and stands little chance of survival there given present wave energy and turbidity conditions. It should be stressed that all of this information requires field verification.

Existing resource information on the Ragged Island proposal site is inadequate to perform a fatal flaw analysis. At the same time, the proposal conceptually has considerable merit in terms of potential resource benefits and proximity to navigation projects. As such, Ragged Island WMA Wetland/Habitat Creation and Erosion Control candidate merits further investigation. The first step of the investigation should be baseline data collection at the site to determine potential resource tradeoffs or conflicts. Of particular interest is the sites value to crabs and shellfish, finfish (particularly anadromous species), and commercial/recreational users. Provided fatal flaws are lacking (based on

a consensus of the regulatory/review community), the next requisite analysis should be to determine expected changes to current and littoral drift patterns.

Based on the character of the maintenance dredged material (predominately silty material), the proposal should probably be modified to include containment treatment and riprap for all sides of the islands. Additionally, the proposal could be scoped down to a demonstration acreage, or sequenced with follow-up studies before each new island construction.

Questions and coordination regarding this candidate should be addressed to Mr. Donald Schwab, Ragged Island WMA Manager, at (804) 934-1577; mailing address:

P.O. Box 847
Suffolk, VA 23434

and Mr. Robin Bedenbaugh of AMRL, at (804) 683-4195; mailing address:

Old Dominion University
Applied Marine Research Laboratory
1034 W 45th St.
Norfolk, Va 23529-0456

Hog Island Wildlife Management Area
Wetland/Habitat Creation and Erosion Control

At present, information is being acquired on this site. If the resource information on this candidate indicates further investigation is merited, this section will be provided as an addendum. At present, the site's distance from the Federal shipping channels (at the upstream end of the economic hauling boundary) could be assessed in terms of transport logistic/economic considerations.

Wetland Creation Adjacent to Craney Island
Dredged Material Disposal Area

The Craney Island disposal area is a 2,500-acre confined dredged material disposal facility located near Norfolk, VA. It is the site which receives dredged material from the Hampton Roads area, including the Federal channels for Norfolk Harbor and associated projects (including contaminated material). The site has been in continuous use since construction in the mid-1950's.

In 1981, the Craney Island Management Plan (CIMP) was developed by the U.S. Army Engineer Waterways Experiment Station to extend the useful life of the site for disposal of maintenance material from nearby shipping/harbor channels. The goals of the CIMP included maximization of storage capacity, dewatering and densification of dredged material, and maintenance of

acceptable water quality effluent. The end result of the CIMP was a proposed 2,500-acre westward expansion of the site for dredged material containment, including contaminated harbor materials.

The Site Operations and Monitoring Report for Craney Island Disposal Area; 1980-1987, summarizes the expected impacts of the expansion as follows:

> "The major impact of constructing an expansion to Craney Island on the natural environment would be the loss of an extensive amount of estuarine bottom land. The Plan B westward extension of Craney Island would include about 2,500 acres of estuarine bottom land being irrevocably transferred to a disposal site eventually destined to become dry land. The designated area would be impounded by a levee system. Along the northern margin, the levee would be in waters of depths of 12 to 15 feet. The area becomes more shallow toward the natural shoreline. About one-third of this site is presently in water between one and three feet deep. The bottom generally consists of a dark sandy, mud which emits a strong hydrogen sulfide odor when brought to the surface. Within the substrate are mainly polychaete worms and mud snails, with scattered hydroids present. Migrant species of significance include the blue crab and invertebrates common to the diets of the local fish. If this site were covered with dredged materials, bottom fauna would be destroyed. Migrant crabs, fish, and invertebrate species would be forced to other locales in the area. There is a lack of active recreational fishing in the area; however, the site supports a rather large commercial shad fishery in March and April. Numerous crab pots are also common along the central and outer margins. There are no significant oyster or hard shell clam resources with this area which would be directly affected by the proposed westward expansion."

The 1991 Virginia House Committee on Chesapeake and Its Tributaries found these impacts unacceptable considering the type of use proposed, and passed House Bill No. 1478. Section A of the Bill states:

> "No agency of the Commonwealth, including the Virginia Port Authority, shall have the authority to expand the Craney Island Disposal Area northward or westward or beyond it present capacity or to cause activities which will result in such expansion of the Craney Island Disposal Area. In addition, no state funds shall be expended for any activities which will result in the expansion of Craney Island northward or westward or beyond it's present capacity as a disposal area for material dredged from any site, including Hampton Roads Harbor."

At the time candidates were being developed, House Bill No. 14788 did not exist.

This candidate proposal recommended expanding Craney Island through wetland creation, interspersed by shallow water, tidal ponds. Direction of the expansion, and size of the habitats to be created would be determined by an interagency team. Wetland/tidal pool communities such as those preferred

by shorebirds, wading birds, and waterfowl were envisioned. The only upland conversion associated with the concept would be the containment berm. Additionally, only material suitable for ocean disposal would be used. Although House Bill No. 1478 was promulgated assuming a proposed dredged material disposal/upland type expansion, as written it appears to preclude beneficial use of dredged material at this location (of the wetland creation type) as well.

Interestingly, House Bill No. 1478 also contains section C. which states:

> "Prior to the disposal of any dredged material either at an ocean area or on Craney Island Disposal Area, the Virginia Port Authority shall investigate and consider the availability of beneficial uses of the dredged material. The Virginia Port Authority shall consult with State and Federal agencies to ensure the environmental acceptability of any beneficial use. When such environmentally acceptable beneficial use is available, the Virginia Port Authority shall pursue such use."

Section C could be interpreted to support a wetland creation candidate at Craney Island.

Wetland creation adjacent to Craney Island Disposal Area merits further investigation, at least in terms of the application of House Bill No. 1478. If the Bill does not preclude further consideration, baseline data already collected at the site could be used for a fatal flaw analysis, and a consensus among the review agencies/groups on the acceptability of the candidate proposal. Questions and coordination regarding this candidate should be addressed to Mr. Robert V. Ogle, Chief, Planning Division, Norfolk District, Corps of Engineers, at (804) 441-7390; mailing address:

> Department of the Army
> Norfolk District, Corps of Engineers
> Fort Norfolk, 803 Front Street
> Norfolk, VA 23510-1096

PROJECTS OUTSIDE OF THE ECONOMICAL HAULING BOUNDARY

Although outside of the area covered by the IPMP effort, two sites are recommended for beneficial use of dredged material consideration. Other navigation projects located within reasonable proximity to these sites could be used. Because of the considerable wildlife value exhibited, or the potential value which could be realized, these sites are highly recommended for investigation by the appropriate branch of the Norfolk District, Corps of Engineers.

Wetland Creation and Erosion Control on the West Side of Watts Island

Watts Island is located on the Virginia eastern shore side of the Chesapeake Bay, just off the mouth of Pocomoke Sound, in Accomack County.

The island is privately owned, is approximately 2 miles long, and appears to be exhibiting significant erosion. Approximately 80% of the island is estuarine wetland, with the remainder supporting upland forest. Because , extensive eelgrass beds occur in the shallow waters on the east side of the island, and not on the west (per VIMS, 1989 Distribution of SAV in the Chesapeake Bay), presumably erosion is worse on the western side. However, the western shoreline is characterized by dunes, and the eastern side is undercut clay bank and marsh peat. Shallow water bottom types are clay on the west, and sand on the east. The clay bottom type was another factor in the assumption erosion was worse on the western side. The island itself is made of clay.

The island is particularly valuable as production habitat for migratory birds (Appendix 6). At least 6 species of colonial waterbird nest on the island, as well as black duck, shorebirds, American oystercatcher, osprey, and presumably rails. The island contains several old bald eagle nests, and would most certainly constitute good future eagle nesting habitat based on the location and isolation. Many of the species find not only excellent nesting habitat, but also an interspersion of various habitat types which provide various requirements necessary for broods, cover, sanctuary, feeding, pairing, etc. Habitats available are particularly appealing because of the apparent lack or few numbers of mammalian predators. In addition to production, wetlands on the island and surrounding bay waters receive high wintering waterfowl use.

Many of the eastern shore islands supporting forest in Chesapeake Bay are comprised of predominately clay material. It appears (from preliminary field review) that as island shorelines recede inward from erosion, newly exposed shallow water bottoms are composed of the hard clay parent material. This is believed to be the case on the western side of Watts. The subaqueous area which was formerly island fastland has been referred to as the island's "historic footprint". Because of the hard clay makeup, island historic footprints may be less productive than surrounding silt or sand bottom types. For this reason, historic island footprints can be preferred areas for wetland/habitat creation. Conversion to other habitats has less probability for negative impact or significant resource tradeoff (e.g., trading fish for ducks).

The conceptual proposal for Watts Island is identical to another conceptual proposal being discussed for Poplar Island, in the Maryland portion of Chesapeake Bay (Appendix 7). A containment berm would be built along the western historic footprint. Dredged material would be pumped or transported to the site, and deposited within the berm to designed elevation. Most of the area would be converted to low marsh and high marsh, interspersed with tidal ponds and guts. The remainder of created habitat and berm would support transition habitat, such as switch grass (Panicum virgatum), and upland forest. Significant dredged material placement capacity is available, considering the size of the western shore historic footprint.

Although no large shipping channels occur close to Watts Island, several small local navigation channels requiring maintenance occur nearby, such as

the channel at Onancock Creek. Often, small navigation projects can present dredged material placement problems, particularly on the eastern shore of Virginia, because of the lack of suitable upland disposal sites., Even though a Watts candidate would have a high initial (berm construction) cost, Watts could solve the recurring problem associated with lack of acceptable placement sites. Logistically, Watts Island proximity to these local channels must be assessed in terms of transportation cost.

If the Corps is interested in further fact finding in regard to Watts, Ms. Jean Watts of the Chesapeake Bay Foundation could be contacted at (804) 622-1964 for the number and address of the private landowner.

Wetland Habitat Creation
at the Previously Used Beneficial Use Site
Off Windmill Point

In 1974 the Corps built a dredged material island approximately 20 acres in size off Windmill Point in the James River, downriver from Hopewell, Virginia. A temporary sand dike was created, then filled with silty maintenance dredged material. Very rapidly (one growing season), the site naturally colonized into a dense cover of arrow arum (Peltandra virginica), pickerelweed (Pontederia cordata), and arrowhead (Sagittaria latifolia). Physically, the site remained relatively stable for 9 years, up to 1983. River floods then compromised the dike, allowing erosion to become significant. As of 1989, the island consisted of two smaller islands connected by an expanse of shallow water and mud flat. Most of the marsh had been washed out.

This Corp project was part of a long term monitoring effort described in Technical Report D-89-1, Long Term Monitoring of Eleven Corps of Engineers Habitat Development Field Sites Built of Dredged Material, 1974-1987, by Mary C. Landin, James W. Webb, and Paul L Knutson, of the Corps Waterway Experiment Station. Appendix 8 contains the Windmill Point project description and assessment. In summary, the project was very successful except for inadequate consideration of dike erosion potential. With a redesign to address erosion, another attempt at wetland creation on this site merits investigation.

SCOPE OF STUDIES

The following outline represents studies required to develop plans, construct, and monitor a project such as the Ragged Island, Plum Tree Island, or Craney Island candidates. This outline was developed by a multiagency team working on the previously discussed Poplar Island concept proposal in Maryland.

I. **Engineering**

- Bathymetric/topographic surveying and mapping.

- Coastal engineering.
  - Collect and analyze tide, wind, and current data.
  - Analyze aerial photography.
  - Conduct wave and current studies.
  - Determine littoral drift patterns/sediment dispersion.
  - Determine dredged material transport and placement.
  - Determine dredged material placement capacity.
- Geotechnical engineering.
  - Review existing data.
  - Prepare drilling plan.
  - Conduct subsurface exploration and laboratory analysis.
  - Conduct consolidation and stability analysis.
- Design requirements.
  - Design short term and long term containment cell sequence and siting.
  - Determine construction access.
  - Prepare preliminary design.
  - Estimate design quantities.
- Cost estimates.
  - Prepare construction cost estimate (includes costs for transportation and placement).
  - Calculate average annual cost.
  - Estimate operation and maintenance costs.
- Identify critical path of activities and sequencing to accomplish first/demonstration project.

II. Environmental

- Coordinate with appropriate agencies/groups.
- Review existing baseline information.
  - Aquatic ecology.
  - Terrestrial ecology
  - Threatened and endangered species.
  - Water quality.
  - Sediment characteristics.
- Collect field baseline information for data gaps in existing information.
- Determine time-of-year restrictions for construction.

- Conduct preliminary hazardous and toxic waste site assessment.
- Assess existing habitat value.
- Develop habitat design/enhancement plan.
- Develop monitoring plan.
- Describe future with and without project conditions.
- Assess post-construction habitat value.
- Develop environmental mitigation plan.

III. **Cultural**

- Coordinate with appropriate agencies/groups.
- Perform Phase I literature search, site file search, and field survey (if required).
- Assess impacts (Findings of Effects).
- Prepare Section 106 Report/MOA.

IV. **Benefit Analysis**

- Establish baseline conditions for project area.
- Determine commercial and recreational users.
- Determine living resource benefits.
- Determine water quality benefits.
- Determine impact(s) on commercial and recreational users.

V. **Plan Formulation (for both demonstration and long term)**

- Formulate alternatives.
- Establish evaluation criteria.
- Analyze alternatives (comparison matrix).
- Select preferred alternative.

VI. **Demographics**

- Determine current use.

VII. **Real Estate**

- Determine ownership.
- Secure land easement, ownership, and rights-of-way.

VIII. **Risk Assessment**

- Assess and quantify containment failure consequences.
- Determine non-targeted consequences (cumulative loss of small amounts of contained material).
- Determine other.

IX. **Public Involvement**

- Designate lead for coordination.
- Hold public hearings.
- Develop program for public education.

X. **Study Management**

- Develop funding and task schedule for feasibility study.
- Schedule development of demonstration project and long term project.
- Identify critical path sequence
- Assign tasks and monitor progress of tasks.
- Convene meetings as required.

XI. **Report Preparation**

- Prepare main report/integrated NEPA document.
- Prepare Notice of Intent.
- Prepare Record of Decision.

- Prepare Notice of Availability.
- Prepare DEIS/FEIS.
- Prepare Finding of No Significant Impact (where applicable).

Lower Chesapeake Bay Dredged Material Beneficial Uses Study
Norfolk Harbor and Channels, Virginia
Initial Project Management Plan:

Natural Resource Concern Screening for Four Alternatives
Located in the Lower Section of the James River

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Department of the Army
Norfolk District, Corps of Engineers
Planning Division
Environmental Analysis Branch

Abstract

Lower Chesapeake Bay Dredged Material Beneficial Uses Study
Norfolk Harbor and Channels, Virginia
Initial Project Management Plan:

Natural Resource Concern Screening for Four Alternatives
Located in the Lower Section of the James River

John W. Gill
Michael J. Klebasko
June, 1992

This report provides planning aid information to assist the Norfolk District, Corps of Engineers (Planning Division, Environmental Analysis Branch), in assessment and development of an Initial Project Management Plan to select conceptual projects in the study area. Projects incorporate beneficial uses of dredged material for purposes of wetland/habitat construction, and focus on lower James River island habitat protection and enhancement. Concept selection is based on resource needs documented for the lower Chesapeake Bay, as enumerated in the Chesapeake Bay Agreement. Four candidate sites and conceptual proposals are screened through a fatal flaw analysis. The four site proposals are: 1) Fringe Wetland Creation Around Craney Island Dredged Material Disposal Area; 2) Ragged Island Wildlife Management Area Wetland/Habitat/Island Construction and Erosion Control; 3) Mulberry Island Wetland/Habitat/Island Construction and Erosion Control; and 4) Hog Island Wildlife Management Area Wetland/Habitat/Island Construction and Erosion Control. Of the four sites considered, Craney Island and Ragged Island conceptual proposals appear to minimize resource tradeoffs to the greatest extent. Of these two preferred alternatives, the Ragged Island proposal has the most potential to benefit fish and wildlife resources, and the habitats they are dependent upon.

Key Words: dredged material, beneficial use, wetland/habitat construction, erosion control

LOWER CHESAPEAKE BAY DREDGED MATERIAL BENEFICIAL USES STUDY
NORFOLK HARBOR AND CHANNELS, VIRGINIA
INITIAL PROJECT MANAGEMENT PLAN:

U.S. FISH AND WILDLIFE SERVICE
NATURAL RESOURCE CONCERN SCREENING FOR FOUR ALTERNATIVES
LOCATED IN THE LOWER SECTION OF THE JAMES RIVER

June, 1992

BACKGROUND

In 1990, the Norfolk District, Army Corps of Engineers (Corps), produced a study for the Virginia Port Authority (Port) assessing various alternative means of replacing the Craney Island Dredged Material Disposal Facility. As the remaining capacity at Craney Island is limited, alternative sites must be made available to handle approximately 4,000,000 cubic yards of dredged material annually. The study concluded that two primary options existed: expansion of Craney Island, and barge hauling suitable material 75 miles to an ocean placement site.

The 1991 Virginia House Committee on Chesapeake and Its Tributaries found impacts associated with expanding Craney Island unacceptable, and passed House Bill No. 1478. Section A of the Bill states:

> "No agency of the Commonwealth, including the Virginia Port Authority, shall have the authority to expand the Craney Island Disposal Area northward or westward or beyond it's present capacity or to cause activities which will result in such expansion of the Craney Island Disposal Area. In addition, no state funds shall be expended for any activities which will result in the expansion of Craney Island northward or westward or beyond it's present capacity as a disposal area for material dredged from any site, including Hampton Roads Harbor."

This Committee decision left the Port with an ocean disposal primary option (and associated hauling expense), and a study recommended complementary option. The complementary possibility was to explore means to use as much suitable dredged material for beneficial purposes as possible, in order to minimize use of the primary option. Although it is unlikely that all material could be used beneficially, beneficial use could potentially cut down transport costs while enhancing the environment (e.g., wetland/habitat creation). Virginia Port Authority requested the Corps to follow up the 1990 study with a comprehensive study of ways to beneficially use dredged material.

As a first step to the study process, an interagency work group (Appendix 1) convened to outline potential beneficial uses of dredged material for future consideration as projects. Alternatives were evaluated through group discussion, with the following candidate concept proposals (within a given distance from navigation projects) suggested for review:

- Wetland/habitat creation along sections of eroding James River shoreline.

- Wetland/habitat creation at Windmill Point

- Island wetland/habitat creation and erosion control adjacent to, or, offshore of, existing islands (e.g., Ragged Island Wildlife Management Area proposal by the Applied Research Laboratory of Old Dominion University).

- Oyster bar mound creation in James River and/or ocean side of Virginia's Eastern Shore.

- Island creation/enhancement in the inland bay area of Virginia's Eastern Shore.

- Fish structure, stable berm, or feeder berm creation.

- Island/wetland/habitat creation along eroding sections of Fisherman Island National Wildlife Refuge (NWR).

- Contaminated harbor/river bottom capping with clean dredged material.

- Borrow area reclamation and wetland/habitat creation.

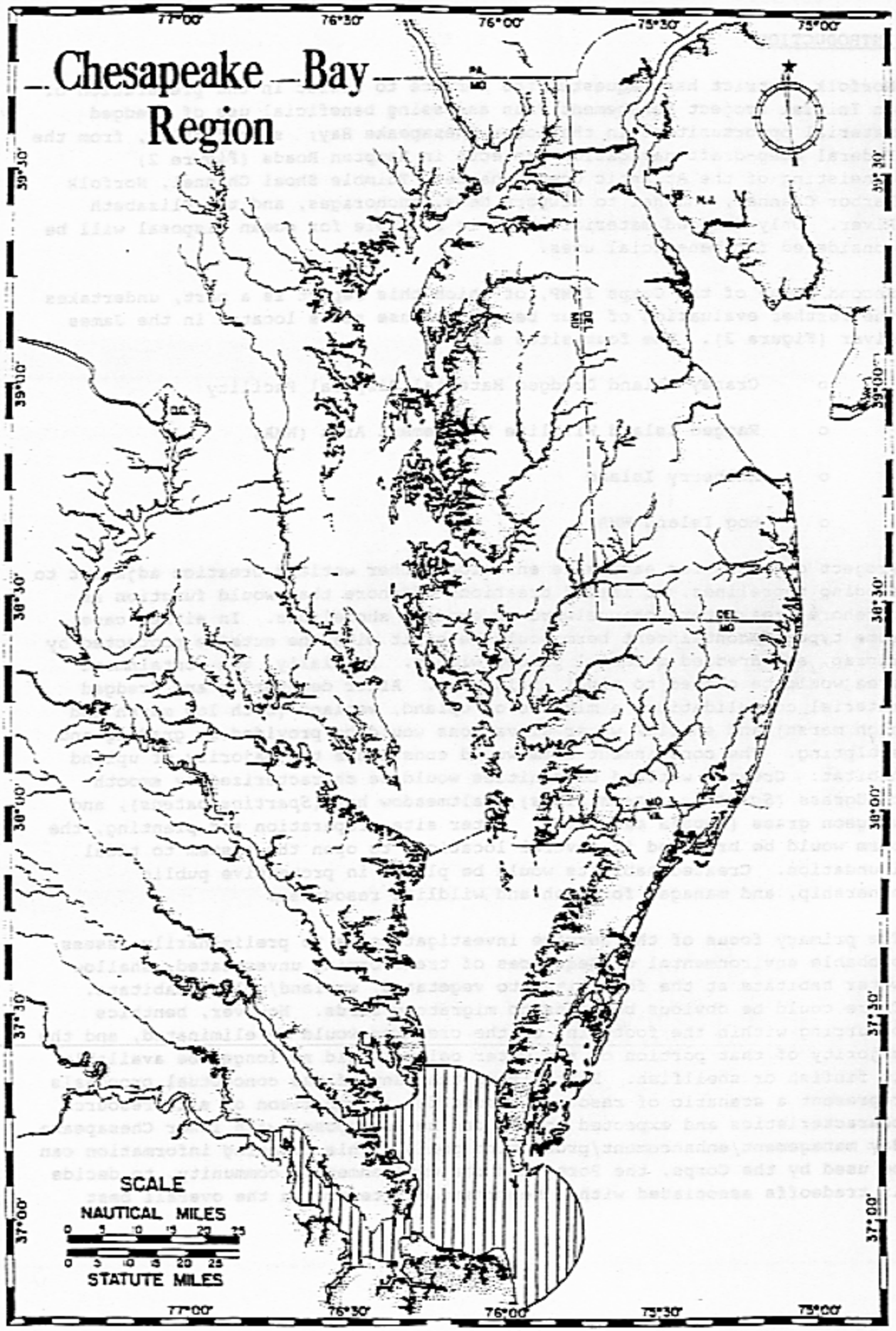
- Dredged material dewatering, storage, and rehandling area for future use in construction (Craney Island could be assessed for this function).

- Wetland fringe creation around Craney Island.

At the request of the Corps, the Annapolis Field Office, U.S. Fish and Wildlife Service (Service), analyzed sites and concepts developed by the interagency workgroup (U.S. Fish and Wildlife Service, 1991) in order to narrow down the list to those potential projects meriting further consideration. Proposals were reviewed in terms of meeting identified (through the Chesapeake Bay Agreement) lower bay resource needs, were located within the Corps defined economic hauling distance (Figure 1), and lacked significant natural resource "fatal flaws". Examples of fatal flaws would be presence of submerged aquatic vegetation (SAV) beds, shellfish grounds, anadromous fish breeding or nursery areas, or other commercial, recreational, or ecological considerations.

The planning aid information provided in the Service's report was incorporated into first phase development of a Corps Initial Project Management Plan (IPMP) assessing beneficial use opportunities in the lower bay. First phase IPMP analysis recommended further evaluation for four potential beneficial use of dredged material sites. Second phase of the IPMP will assess which of the four sites should be studied with the available study funds, and which also appear to have the greatest potential for implementation from environmental, engineering, and economic perspectives. The Corps envisions a comprehensive 3-year investigation of IPMP recommended sites.

Figure I. Economic Hauling Distance Boundary.



INTRODUCTION

Norfolk District has requested the Service to assist in the preparation of, an Initial Project Management Plan assessing beneficial use of dredged material opportunities in the lower Chesapeake Bay; specifically, from the Federal deep-draft navigation projects in Hampton Roads (Figure 2) consisting of the Atlantic Ocean Channel, Thimble Shoal Channel, Norfolk Harbor Channel, Channel to Newport News, anchorages, and the Elizabeth River. Only dredged material which is suitable for ocean disposal will be considered for beneficial uses.

Second phase of the Corps IPMP, of which this report is a part, undertakes the further evaluation of four beneficial use sites located in the James River (Figure 3). The four sites are:

- Craney Island Dredged Material Disposal Facility
- Ragged Island Wildlife Management Area (WMA)
- Mulberry Island
- Hog Island WMA

Project concepts for each site envision either wetland creation adjacent to eroding shorelines, or island creations offshore that would function as offshore breakwaters channelward of eroding shorelines. In either case, some type of containment berm would be built with the outside protected by riprap, and dredged material placed within. Initially, the containment area would be closed to tidal influences. After dewatering and dredged material consolidation, a mixture of upland, wetland (both low marsh and high marsh) and shallow water elevations would be provided by grading and sculpting. The containment berm would constitute the majority of upland habitat. Created wetland communities would be characterized by smooth cordgrass (*Spartina alterniflora*), saltmeadow hay (*Spartina patens*), and widgeon grass (*Ruppia maritima*). After site preparation and planting, the berm would be breached in several locations to open the system to tidal inundation. Created habitats would be placed in protective public ownership, and managed for fish and wildlife resources.

The primary focus of the Service investigation is to preliminarily assess probable environmental consequences of transforming unvegetated, shallow water habitats at the four sites to vegetated, wetland/upland habitats. There could be obvious benefits to migratory birds. However, benthics occurring within the footprint of the creation would be eliminated, and the majority of that portion of the water column would no longer be available to finfish or shellfish. Recognizing that any of the conceptual proposals represent a scenario of resource tradeoffs, a comparison of site resource characteristics and expected losses can be juxtaposed with lower Chesapeake Bay management/enhancement/protection goals. This planning information can be used by the Corps, the Port, and the environmental community, to decide if tradeoffs associated with a recommended site are in the overall best

interest of Chesapeake Bay living resources. Any selected site(s) would be investigated under a Corps proposed 3-year study.

Figure 2. Federal Deep Draft Navigation Projects.

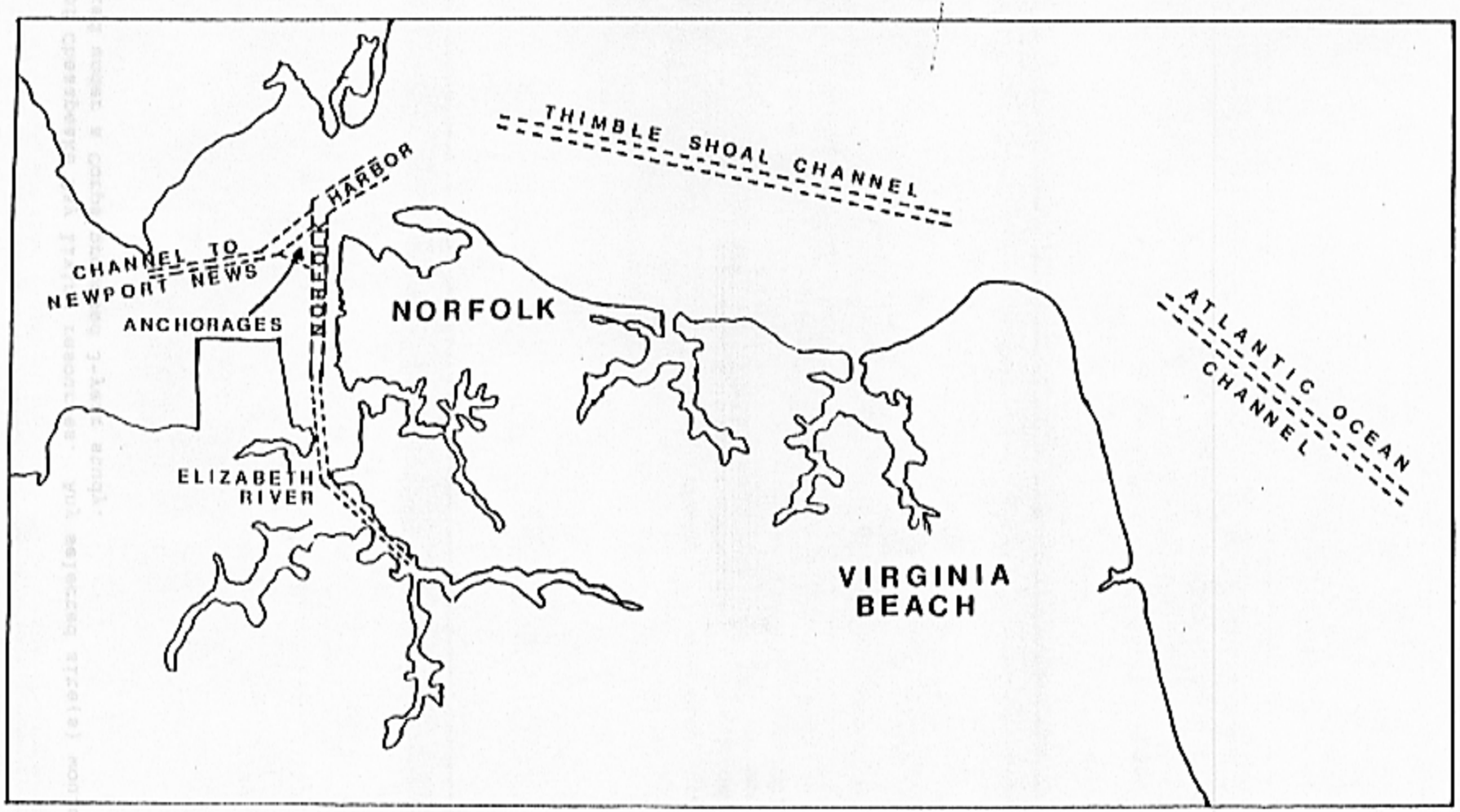
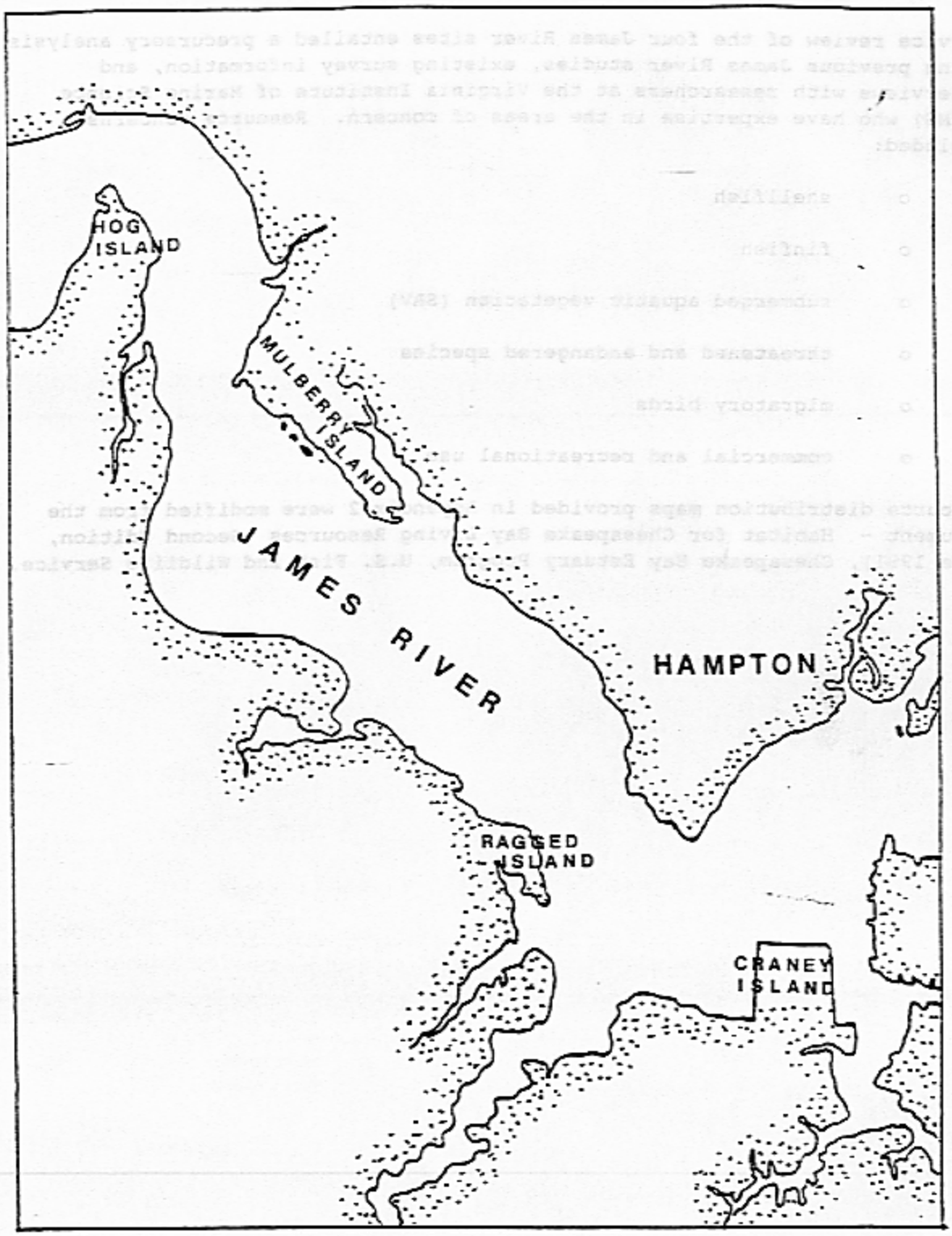


Figure 3. Four Beneficial Use of Dredged Material Sites.



Service review of the four James River sites entailed a precursory analysis using previous James River studies, existing survey information, and interviews with researchers at the Virginia Institute of Marine Science (VIMS) who have expertise in the areas of concern. Resource concerns included:

- shellfish
- finfish
- submerged aquatic vegetation (SAV)
- threatened and endangered species
- migratory birds
- commercial and recreational use

Resource distribution maps provided in Appendix 2 were modified from the document - Habitat for Chesapeake Bay Living Resources (Second Edition, June 1991), Chesapeake Bay Estuary Program, U.S. Fish and Wildlife Service.

STUDY SITES

Specific locations of the various site proposals have yet to be determined. The concepts assume locations in shallow water (generally water depths less than -7 feet at mean low water [MLW]), in areas exhibiting the most severe erosion. Except for Craney Island, wetland fringe creations and island creations were initially considered at all sites. In order to optimize positive effects to migratory birds (in terms of production habitat), the Service recommends creating islands in lieu of fringe wetland establishment. Although similar habitat conditions and vegetative communities may occur on the mainland, isolation, lack of human disturbance, and fewer predators make islands more desirable. Islands must be sited far enough offshore to minimize predator and human intrusions from the mainland. Because the project purpose envisioned at Craney Island is different, fringe wetland creation is considered.

CRANEY ISLAND

As previously discussed, Virginia House Bill No. 1478, Section A, prevents any agency from expanding the Craney Island Disposal Area. Interestingly, the Bill also contains Section C which states:

> "Prior to the disposal of any dredged material either at an ocean area or on Craney Island Disposal Area, the Virginia Port Authority shall investigate and consider the availability of beneficial uses of the dredged material. The Virginia Port Authority shall consult with State and Federal agencies to ensure the environmental acceptability of any beneficial use. When such environmentally acceptable beneficial use is available, the Virginia Port Authority shall pursue such use."

Prior to passage of House Bill No. 1478, the concept of a fringe wetland creation around the existing disposal facility was discussed. The wetland width would be determined by the interagency team, with input from the public. The concept assumes limited dredged material placement capacity because of the relatively narrow fringe of wetland which would be constructed. Before the site could seriously be considered, a contaminant assessment would be performed to determine the potential of attracting wildlife into a contaminated area (e.g., the existing disposal facility).

AFFECTED RESOURCES AND ENVIRONMENTAL CONSEQUENCES

Resources of the project area are discussed in a Service Planning Aid Report to the Corps (U.S. Fish and Wildlife Service, 1989). The report details resources of both deep and shallow water areas surrounding Craney Island, therefore discussions include species which may not use the shallow water areas under consideration for this proposal. The reader is referred to the document for an overview of resources at the site.

The concept objective is to provide some fish and wildlife habitat, while creating an aesthetically-pleasing buffer around the site. An additional benefit could come from the nutrient/contaminant uptake capability of a created wetland.

The conceptual proposal was included in the event House Bill No. 1478 is politically interpreted to allow such a beneficial use. Obviously, a proposal to environmentally enhance Craney Island would require public involvement and government assurance that the project would constitute enhancement rather than expansion of the facility. Because this concept provides the Port with very limited capacity, there would not be a long term benefit for dredged material placement.

RAGGED ISLAND WILDLIFE MANAGEMENT AREA

The Applied Marine Research Laboratory (AMRL) of Old Dominion University has proposed a habitat creation/erosion control project based on the beneficial use of dredged material at Ragged Island WMA. The original proposal envisioned a series of five islands forming an arc-shaped breakwater, beginning just below the James River Bridge, and ending offshore of Candy Island. Islands would be created by placing dredged material inside a containment berm, with the berm protected by riprap. The landward shoreline of the created islands would approximately follow the -6 mean low water (MLW) contour. Three of the islands were proposed to be approximately 1000 feet in length by 250 feet in width. The two main islands would be constructed to be approximately 300 and 550 acres. The combined acreage for all proposed islands would be 870 acres, with an approximate capacity to accommodate up to 17 million cubic yards (mcy) of dredged material. The island configurations would also create a 800 to 1000 acre shallow water, protected embayment between the WMA and the back sides of the islands. The reduced wave climate created in the embayment should significantly reduce erosion on Ragged Island. AMRL theorizes that the lowered wave energy could improve water clarity of the embayment to allow for reestablishment of SAV.

Once dredged material placement and dewatering were complete, various habitat types would be created through grading and planting. AMRL is proposing the creation of tidal and nontidal wetlands, shallow water ponds, and various upland habitats including forest. Tidal wetlands would be positioned on the embayment side of created wetlands. Also proposed is the establishment of SAV beds in created ponds, and the construction of eastern oyster (*Crassostrea virginica*) reefs within the embayment.

Presently, a scoped down version of the AMRL proposal is under consideration. Rather than 5 islands, a one-island demonstration project (of appropriate demonstration size) would be constructed in the downriver vicinity of the James River Bridge. The completed project could then be assessed for feasibility and desirability of expanded application.

AFFECTED RESOURCES AND ENVIRONMENTAL CONSEQUENCES

Due to the oyster disease organisms MSX (*Haplosporidium nelsoni*) and dermo (*Perkinsus marinus*), there are presently no significant oyster populations in the James River downriver from Days Point (Mann, pers. comm.), and little if any commercial harvest of oysters around Ragged Island. However, much of the surrounding shoal area is in private oyster lease, and areas outside of the shoal are designated public oyster grounds (Baylor Grounds). Although these areas are currently unproductive, the footprint of any island constructed would constitute a loss of potential oyster habitat should future remedies be found for the oyster diseases. There does not appear to be good shell bottom (bar) within the area of project consideration. Assuming a small demonstration project, hydrodynamic changes to the James River would not be expected, and no changes in bivalve larval transport patterns would occur (should this site be selected for the 3 year study, hydrodynamic modeling would evaluate these assumptions).

Although shallows around Ragged Island could provide potential soft shell clam (*Mya arenaria*) habitat, most likely densities are low (Mann, pers. comm.). Likewise, hard clam (*Mercenaria mercenaria*) numbers are expected to be low, with the clams tending to be in deeper waters channelward of the proposal (Mann, pers. comm.).

Summer use of the shallows by male and female blue crabs (*Callinectes sapidus*) is considered high (Lipscius, pers. comm.). Both feeding and molting habitat are provided. Crabs are not distributed around Ragged Island during the wintering period. Because of the wide distribution of blue crabs throughout Chesapeake Bay during the summer months, Ragged Island would not be considered critical habitat. The conceptual island proposal should constitute feeding and molting habitat (e.g. intertidal wetlands and channels), and the creation of a protected tidal, shallow water embayment could enhance the existing shallows molting value (Lipcius, pers. comm.). Crab potting is done off Ragged Island, although, depending on the specific siting of the project, not necessarily in the area of consideration (e.g. might be to shallow for work boats). At this time it should be assumed commercial crab harvest within the footprint of a created island would be displaced.

In addition to the commercial crabbing in the vicinity of Ragged Island, 2 haul seines are fished from the WMA for striped bass (*Morone saxatilis*) and spotted sea trout (*Cynoscion nebulosus*) in the early spring (Colvocoresses, pers. comm.). Most haul seining is done from Fishing Point, which is downriver of potential conflicts with the proposal. Stake gill nets in the vicinity are set in deeper waters, channelward of areas being considered for island construction. Most recreational fishing is also associated with dropoffs and deeper waters, outside of shallow waters under consideration.

At present, SAV beds are not found in the James River, presumably because of high sediment loads and poor water clarity. Shallows surrounding Ragged Island do constitute potential habitat (assuming future improvement in water quality) for eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). Although an island project would create protected, tidal, shallow water areas, without water quality improvements throughout the James River watershed, recolonization by SAV is not assumed. This assessment is contrary to project benefits enumerated by the AMRL. SAV establishment is more likely in nontidal ponds proposed for the project.

Generally, unvegetated, shallow water flats around Ragged Island would not be expected to provide critical habitat for commercially or recreationally important fish species (Colvocoresses, pers. comm.). This is not to say the shallows are not used by foraging fish. That portion of the water column taken up by the created upland segment of the proposal would no longer be available to finfish. Species and numbers of fish collected by VIMS Summer Beach Seine Survey - Data for lower James River stations, 1989-91, are shown in Table 1.

Tidal wetland and channel habitats constructed as part of the proposal would be available to fishes, and would provide additional detrital input,

forage fish habitat, and structure for epifaunal attachment. Riprap protecting the constructed island would also be of benefit (and an attraction) to fish species associated with structure.

Table 1: VIMS Summer Beach Seine Survey -- Data for lower James River stations, 1989-91.

Fishes captured by species --

		n	occurrences
ATLANTIC SILVERSIDE	(Menidia menidia)	3836	56
BAY ANCHOVY	(Anchoa mitchilli)	2987	30
ATLANTIC MENHADEN	(Brevoortia tyrannus)	650	11
SPOT	(Leiostomus xanthurus)	624	35
WHITE MULLET	(Mugil curema)	577	23
STRIPED MULLET	(Mugil cephalus)	545	23
GIZZARD SHAD	(Dorosoma cepedianum)	451	23
STRIPED BASS	(Morone saxatilis)	338	61
WHITE PERCH	(Morone americana)	262	31
ATL. THREAD HERRING	(Opisthonema oglinum)	178	7
THREADFIN SHAD	(Dorosoma petenense)	124	4
ATLANTIC CROAKER	(Micropogonias undulatus)	116	19
STRIPED KILLIFISH	(Fundulus majalis)	115	11
STRIPED ANCHOVY	(Anchoa hepsetus)	85	17
ROUGH SILVERSIDE	(Membras martinica)	70	15
BLUEFISH	(Pomatomus saltatrix)	56	17
ATLANTIC NEEDLEFISH	(Strongylura marina)	28	10
CREVALLE JACK	(Caranx hippos)	28	8
SOUTHERN KINGFISH	(Menticirrhus americanus)	27	5
TIDEWATER SILVERSIDE	(Menidia peninsulae)	15	7
SPOTTAIL SHINER	(Notropis hudsonius)	13	4
MUMMICHOG	(Fundulus heteroclitus)	8	5
SILVER PERCH	(Bairdiella chrysoura)	7	3
HARVESTFISH	(Peprilus alepidotus)	3	1
SUMMER FLOUNDER	(Paralichthys dentatus)	3	2
WHITE CATFISH	(Ictalurus catus)	3	3
BLUE CATFISH	(Ictalurus furcatus)	2	2
BLUEGILL	(Lepomis macrochirus)	2	2
BLUEBACK HERRING	(Alosa aestivalis)	2	2
CHANNEL CATFISH	(Ictalurus punctatus)	2	2
NORTHERN PUFFER	(Sphoeroides maculatus)	2	1
PERMIT	(Trachinotus falcatus)	2	2
SPANISH MACKEREL	(Scomberomorus maculatus)	2	2
WEAKFISH	(Cynoscion regalis)	2	1
ATLANTIC SPADEFISH	(Chaetodipterus faber)	1	1
AMERICAN EEL	(Anguilla rostrata)	1	1
BLUE RUNNER	(Caranx crysos)	1	1
BL.CHEEK TONGUEFISH	(Symphurus plagiusa)	1	1
COBIA	(Rachycentron canadum)	1	1
GOLDEN SHINER	(Notemigonus crysoleucas)	1	1
HOGCHOKER	(Trinectes maculatus)	1	1
INSHORE LIZARDFISH	(Synodus foetens)	1	1
LADYFISH	(Elops saurus)	1	1
SPOTTED SEATROUT	(Cynoscion nebulosus)	1	1
TOTAL		11175	60

Federally listed threatened and endangered species that may be found in the lower reaches of the James River include:

piping plover (*Charadrius hiaticula*)
bald eagle (*Haliaeetus leucocephalus*)
peregrine falcon (*Falco peregrinus*)
shortnose sturgeon (*Acipenser brevirostrum*)
Atlantic loggerhead turtle (*Caretta caretta*)
Atlantic green turtle (*Chelonia mydas*)
Atlantic hawksbill turtle (*Eretmochelys imbricata*)
Atlantic leatherback turtle (*Dermochelys coriacea*)
Atlantic Ridley turtle (*Lepidochelys kempi*)

With the exception of the peregrine falcon and piping plover, all are considered transients and should not be affected by an island creation.

The peregrine falcon is known to consistently forage in the vicinity of Craney Island, where a concentration of its major prey base (shorebirds and waterfowl) occur (U.S. Fish and Wildlife Service, 1989). The piping plover nests on the existing disposal facility. Because of the close proximity to Craney Island, and habitat which can support a similar prey base, Ragged Island could be used by the falcon. The island proposal may also create additional plover nesting habitat. If Ragged Island is selected for further study, a full assessment of the impacts of island creation would be required under Section 7(a)(2) of the Endangered Species Act.

Ragged Island presently supports a diverse assemblage of avifauna, and is particularly important to shorebirds, waterbirds (and waders), and waterfowl (Schwab, pers. comm.). The island and surrounding shallows primarily provide forage and resting habitat. Nesting habitat is somewhat limited for upland nesters due to the minor proportion of uplands on the area. The shallow water habitat displaced by an island creation would constitute a forage or resting habitat loss primarily to diving ducks, seaducks, and piscivorous species (terns, osprey, etc.). The Service's Midwinter Waterfowl Survey for the area covering the lower James River is provided in Table 2. Because this habitat type, and the benthic assemblage it supports, is widely distributed along the river, the proposed island site would not be deemed critical (Diaz, pers. comm.).

Most other aquatic oriented, avian species using the area are associated with shoreline, beach, or wetland habitats, and should be positively affected or unaffected by the proposal. Resting habitat for the diving ducks could be improved through the creation of a protected embayment. Generally, a wetland and upland island creation would benefit avian species, and the addition of island upland habitat would provide upland nesting sites which are proportionately scarce. Based on the conceptual Ragged Island proposal, Virginia Department of Game and Inland Fisheries (VDGIF) supports the idea (Schwab, pers. comm.).

Table 2. Midwinter Waterfowl Surveys for Virginia Segment 1 (James River from Hampton roads to U.S. Route 17 Bridge), 1973 to 1989. (Source: U.S. Fish and Wildlife Service)

Species	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Mallard	5	50	300	50		71	60	97	271	500	100	700	175	137	137	517	102
Black Duck		250	tr*		30	216	100	163	185	300	tr	300	42	51	11	110	73
Gadwall		55					1510		6				25				
Widgeon		700		11		35	160		133	600	300	100	100	34	65	85	16
Green Winged Teal							1500	40						12			
Shoveler		350					3150	360		400							
Pintail		10					2	50		400	200	100					
Wood Duck											tr		50				
Total Dabblers	5	1370	300	61	30	322	6482	710	595	2200	600	1200	392	234	213	712	191
Redhead		15			100					100							
Canvasback	180	775	700	590		1536	1231	1690	1414	1500	2800	1200	1684	749		1327	150
Scaup			200	130		1072	35	17		100		200	75	15		365	
Ringneck								297	30	700		100		400		125	
Goldeneye	10	10	tr	9	50	22	1182		4	200	tr	tr	28	3	35	10	24
Bufflehead	35	45	tr	14	40	215	353	149	235	300	100	200	128	53	33	37	173
Ruddy Duck		300	200	100		100	162	100	103			100	20	5			
Total Divers	225	1145	1100	843	190	2972	2963	2253	1786	2900	2900	1800	1935	1225	68	1864	347
Scoter				23		89		38	29	300	tr			31		1	
Oldsquaw				73	150	12	5	50	163	300	100		71	7	16		
Total Seaducks				96	150	101	5	88	192	600	100		71	38	16	1	
Merganser		2	tr		100	19	10	3	71	800	200	200	125	6	44		19
TOTAL DUCKS	230	2517	1400	1000	470	3414	9460	3054	2644	6500	3800	3200	2523	1503	341	2610	557
Brant										800		200					
Snow Goose												200					
Canada Goose		400				249	114	363	309	300	100	1900	700	225	337	1736	2500
TOTAL GEESE		400				249	114	363	309	1100	100	2300	700	225	337	1736	2500
Whistling Swan												tr			2		
Coot							100				100				500		
GRAND TOTAL	230	2917	1400	1000	470	3663	9674	3417	2953	7600	4000	5500	3220	1728	1180	4346	3057

*tr = trace

MULBERRY ISLAND

Mulberry Island is part of the Fort Eustis Military Reservation. Like Ragged island, the area is predominately tidal marsh characterized by smooth cordgrass. Unlike Ragged Island, numerous upland islands and ridges are interspersed throughout emergent wetlands. Mulberry Island is also bisected by tidal creeks and guts to a greater extent than observed at Ragged.

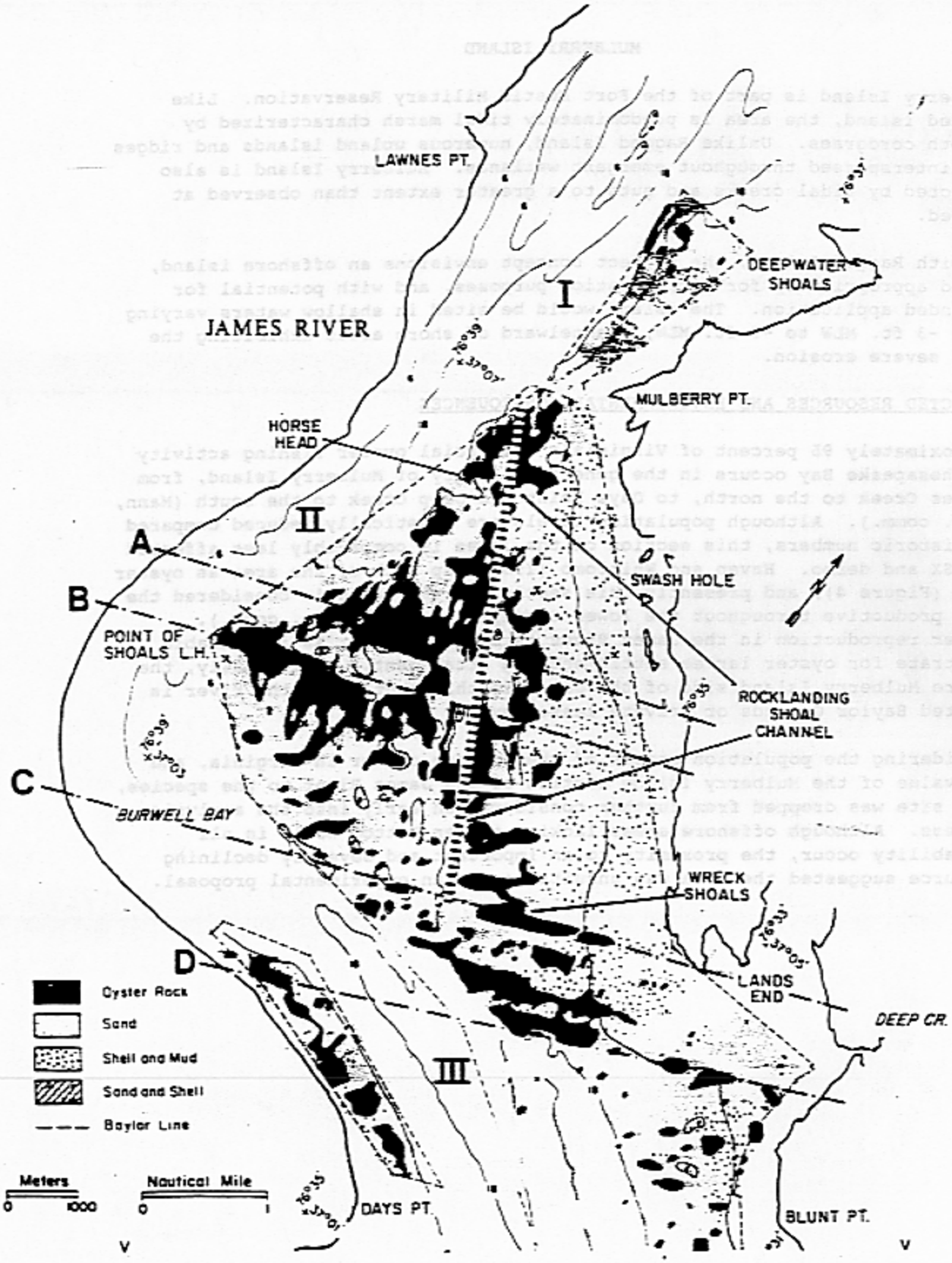
As with Ragged Island, the project concept envisions an offshore island, sized appropriately for demonstration purposes, and with potential for expanded application. The island would be sited in shallow waters varying from -3 ft. MLW to -9 ft. MLW, channelward of shore areas exhibiting the most severe erosion.

AFFECTED RESOURCES AND ENVIRONMENTAL CONSEQUENCES

Approximately 95 percent of Virginia's commercial oyster fishing activity in Chesapeake Bay occurs in the general vicinity of Mulberry Island, from Lawnes Creek to the north, to Days Point and Deep Creek to the south (Mann, pers. comm.). Although population levels are drastically reduced compared to historic numbers, this section of the James is comparably less affected by MSX and dermo. Haven and Whitcomb (1983) map much of the area as oyster reef (Figure 4), and presently this section of the James is considered the most productive throughout the lower Chesapeake (Mann, pers. comm.). Oyster reproduction in the James River is centered here, as is suitable substrate for oyster larvae settlement and attachment. Additionally, the entire Mulberry Island side of the James in this section of the river is charted Baylor Grounds or private leased oyster ground.

Considering the population status of the eastern oyster in Virginia, and the value of the Mulberry Island section of the James River to the species, this site was dropped from further consideration early into the analysis process. Although offshore areas lacking oyster bottom would in all probability occur, the proximity to an important and severely declining resource suggested the area was unsuitable for an experimental proposal.

Figure 4. Oyster Reefs.



Oyster reefs and other bottom types in the James River, VA. Shown are areas I, II, and III separated by the clear lines and transects A, B, C, and D. Mud bottoms within the bounds of the Baylor areas are unstippled. (Source: Haven and Whitcomb 1983)

HOG ISLAND WILDLIFE MANAGEMENT AREA

Hog Island WMA, located just upstream from Fort Eustis Military Reservation, is managed primarily for wintering waterfowl and other wetland dependent species of fish and wildlife. Unlike Ragged Island WMA, Hog Island is staffed, and contains several impoundments which are manipulated for moist soil management purposes. The area includes tidal marshes similar to those found at Mulberry Island, nontidal impoundments, and upland agricultural fields. Shoreline erosion appears worst in areas around Hog Point, and along the western shoreline. Hog Island is located near the upstream limit of what the Corps has designated as the "economic hauling distance".

The concept for Hog Island is an offshore breakwater-type island (demonstration size), located offshore of the western shoreline, in waters varying from -9 ft. MLW to -11 ft. MLW. The island would be sited channelward of severely eroding areas in the vicinity of Hog Point.

A series of riprap, offshore but close to inshore, breakwaters have already been constructed along the shoreline of the management area, and seem to be functioning. The breakwaters were constructed as part of the Chesapeake Bay Shoreline Erosion Study (1990) conducted jointly by the Norfolk District Corps, the Virginia Division of Soil and Water Conservation, and the VIMS. These structures appear to be trapping sand (with varying degrees of success), in stabilized tombolo (sand spit) depositional patterns. The present island creation proposal would be located to benefit shorelines lacking this protection.

It was recognized from the start that the economics of transporting material this far upriver would limit Hog Islands attractiveness to the Corps and Port. This additional cost will have to be balanced against environmental gains (e.g. erosion control) and resource tradeoffs.

AFFECTED RESOURCES AND ENVIRONMENTAL CONSEQUENCES

From a commercial and recreational fisheries perspective, Hog Island would be considered a poor choice compared to the other three alternatives (Colvocoresses, pers. comm.). Conflicts with commercial haul seiners, gill netters, and pound netters would be of primary concern, with additional potential opposition from recreational fishermen. Much of the fish harvest takes place in water depths under consideration for island siting.

Although probably in conflict with harvest interests, theoretically, island creation would not constitute a significant loss of critical habitat to the commercial species of concern: catfish, spot, croaker, striped bass. That portion of the bottom and water column taken up by created upland and high marsh habitats would be unavailable, however, created intertidal wetlands and protective riprap would provide structure and associated communities. These newly available habitats should be attractive to forage fish and their predators.

Resource tradeoffs for other living resources of concern (e.g. shellfish, crabs, SAV, migratory birds, and other finfish) would be similar to that suggested for Ragged Island WMA. Benefits would be to species associated with protected shallow water, wetlands and/or upland nesting habitat, or those species using areas presently eroding. Conversion would occur to aquatic habitats which are widely distributed.

During some years, Hog Island WMA supports an active bald eagle nest (Schwab, pers. comm.). Apparently, another nest occurs on the opposite side of the river, with the same eagle pair alternating in different years which nest is used (Schwab pers. comm.). If Hog Island is selected for further study, a full assessment of the impacts of island creation would be required under Section 7(a)(2) of the Endangered Species Act. Except for occasional transients, other Federally-listed threatened or endangered species should not be affected.

SUMMARY

Of the four sites considered, Craney Island Dredged Material Disposal Facility and Ragged Island WMA appear to minimize resource tradeoffs to the greatest extent when compared to the other two sites. In part, Craney Island is preferred because of alterations associated with the disposal facility which have already occurred at this site. Resource benefits associated with the Craney Island proposal would include water quality improvement, fish and wildlife habitat creation, and aesthetic improvement. Resource benefits associated with the Ragged Island proposal would include erosion control, and fish and wildlife habitat protection and creation. Of the two preferred concepts, Ragged Island has the most potential to benefit fish and wildlife resources. This is due in large part to the areas surrounding, relatively undeveloped landscape, existing fish and wildlife habitat value exhibited, and the ongoing habitat loss to erosion.

REFERENCES

Colvocoresses, J.A. 1992. Personal Communication. Virginia Institute of Marine Science, The College of William and Mary. Gloucester Point, VA.

Diaz, R.J. 1992. Personal Communication. Virginia Institute of Marine Science, The College of William and Mary. Gloucester Point, VA.

Habitat Requirements for Chesapeake Bay Living Resources. 1991. Appendix Maps. Chesapeake Bay Estuary Program, U.S. Fish and Wildlife Service. Annapolis, MD.

Haven, D.S. and J.P. Whitcomb. 1983. The Origin and Extent of Oyster Reefs in the James River, Virginia. Contribution No. 1199 from the Virginia Institute of Marine Science, The College of William and Mary. Gloucester Point, VA 23062.

Lipcius, R.N. 1992. Personal Communication. Virginia Institute of Marine Science, The College of William and Mary. Gloucester Point, VA.

Mann, R. Personal Communication. Virginia Institute of Marine Science, The College of William and Mary. Gloucester Point, VA.

Schwab, D. Personal Communication. Virginia Department of Game and Inland Fisheries. Richmond, VA.

U.S. Army Corps of Engineers. 1990. Chesapeake Bay Shoreline Erosion Study, Feasibility Report. Baltimore and Norfolk Districts, North Atlantic Division, with the State of Maryland and the Commonwealth of Virginia. Baltimore, MD.

U.S. Fish and Wildlife Service. 1989. Planning Aid Report on the Norfolk Harbor and Channels, Virginia, Long-Term Disposal Study (Inner Harbor). Virginia Field Office. White Marsh, VA.

U.S. Fish and Wildlife Service. 1991. Lower Chesapeake Bay Dredged Material Beneficial Uses Study, Norfolk Harbor and Channels, Virginia, Initial Project Management Plan. Annapolis Field Office. Annapolis, MD.

APPENDICES

APPENDIX 1

INTERAGENCY WORKGROUP MEMBERS
LOWER CHESAPEAKE BAY BENEFICIAL USES OF DREDGED MATERIAL

INTERAGENCY WORK GROUP MEMBERS
LOWER BAY DREDGED MATERIAL BENEFICIAL USES

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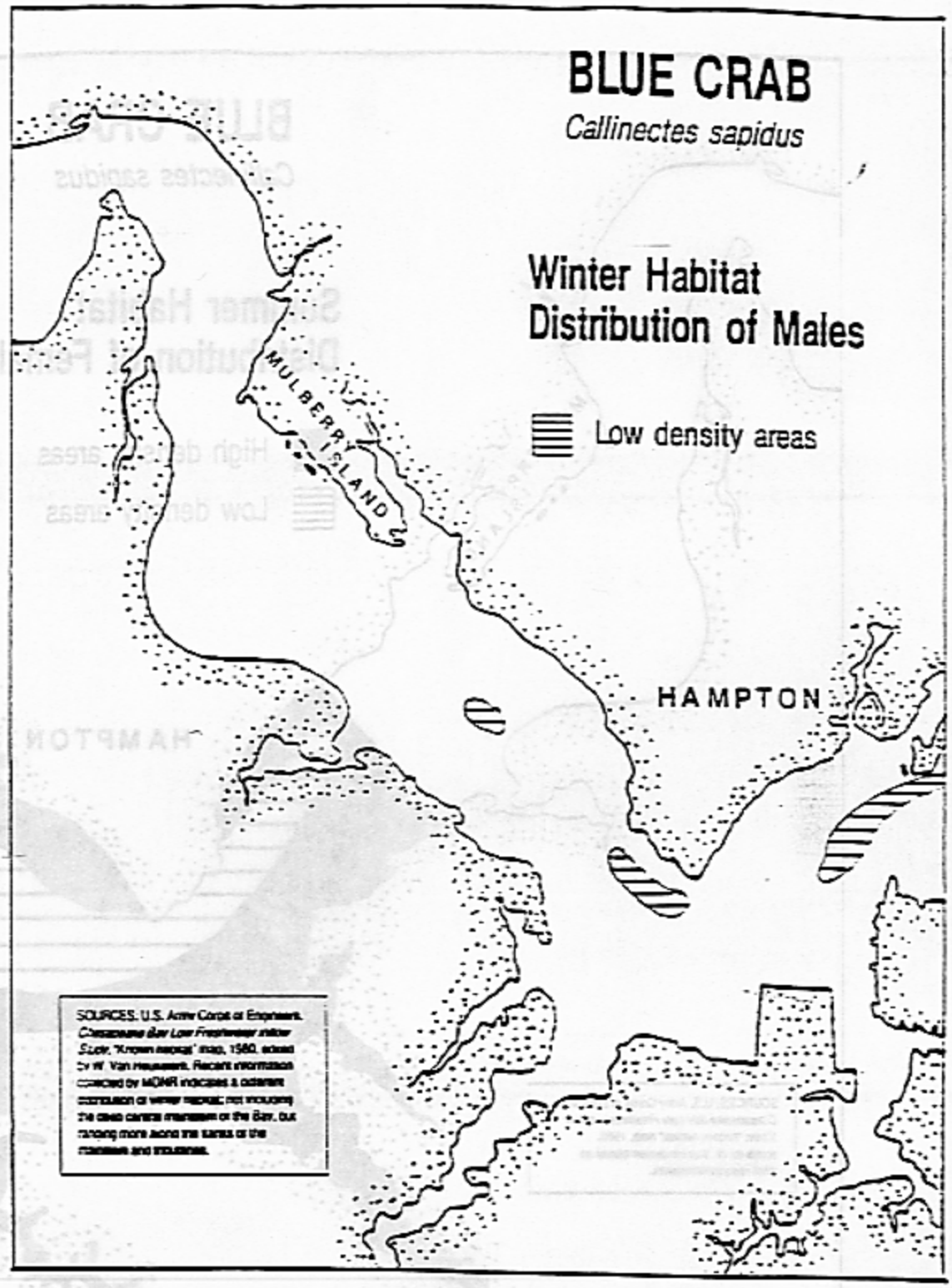
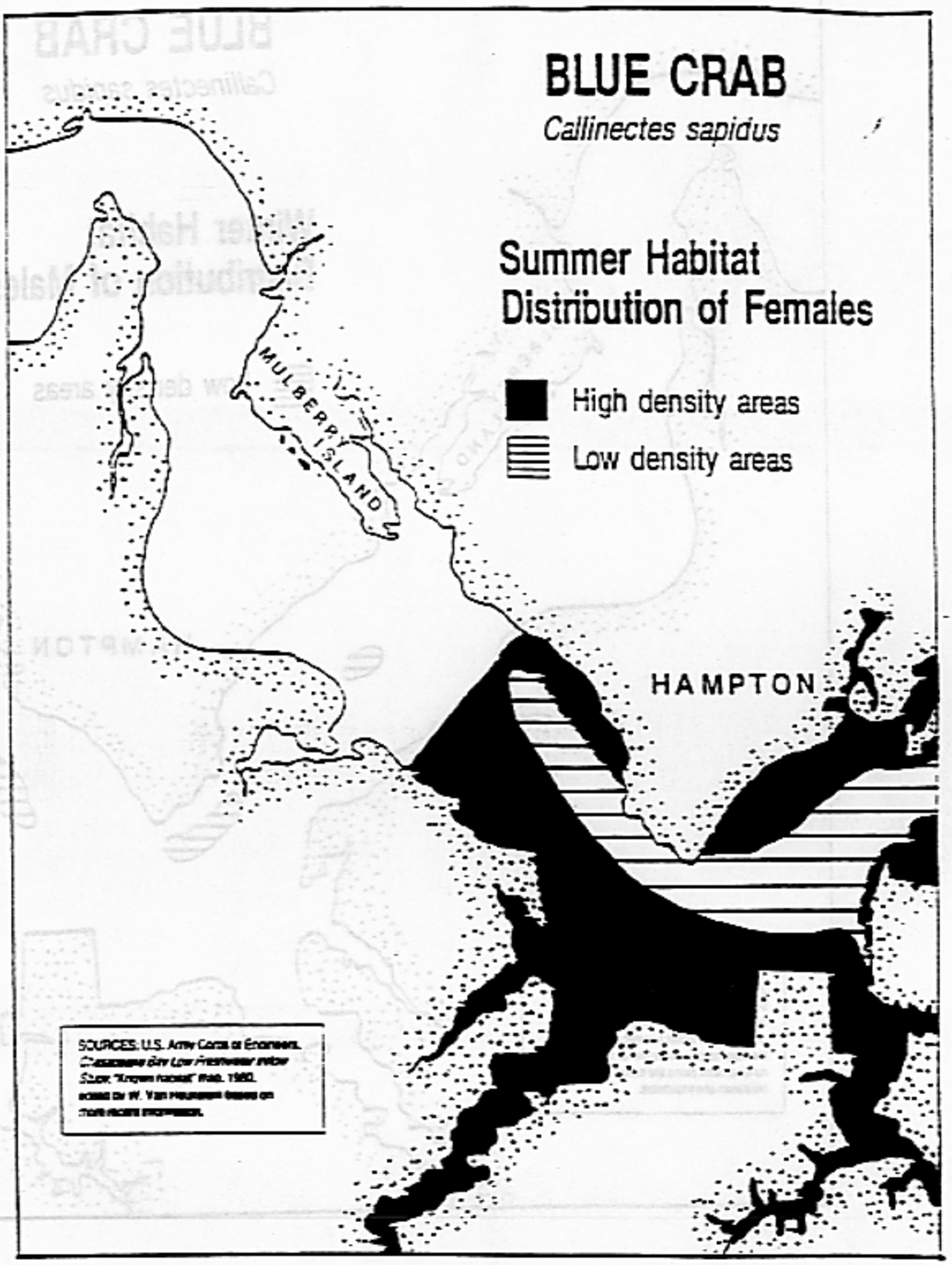
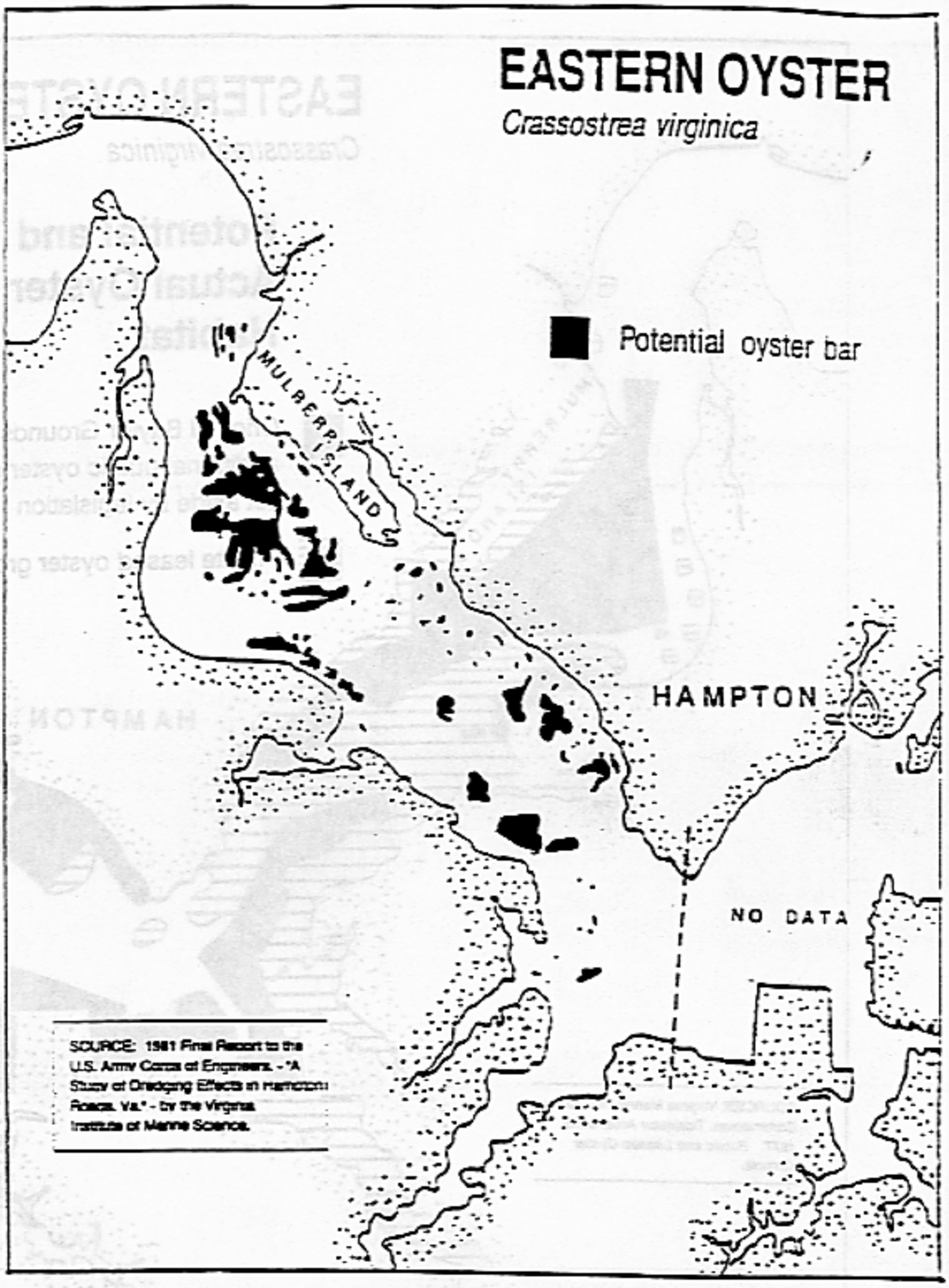
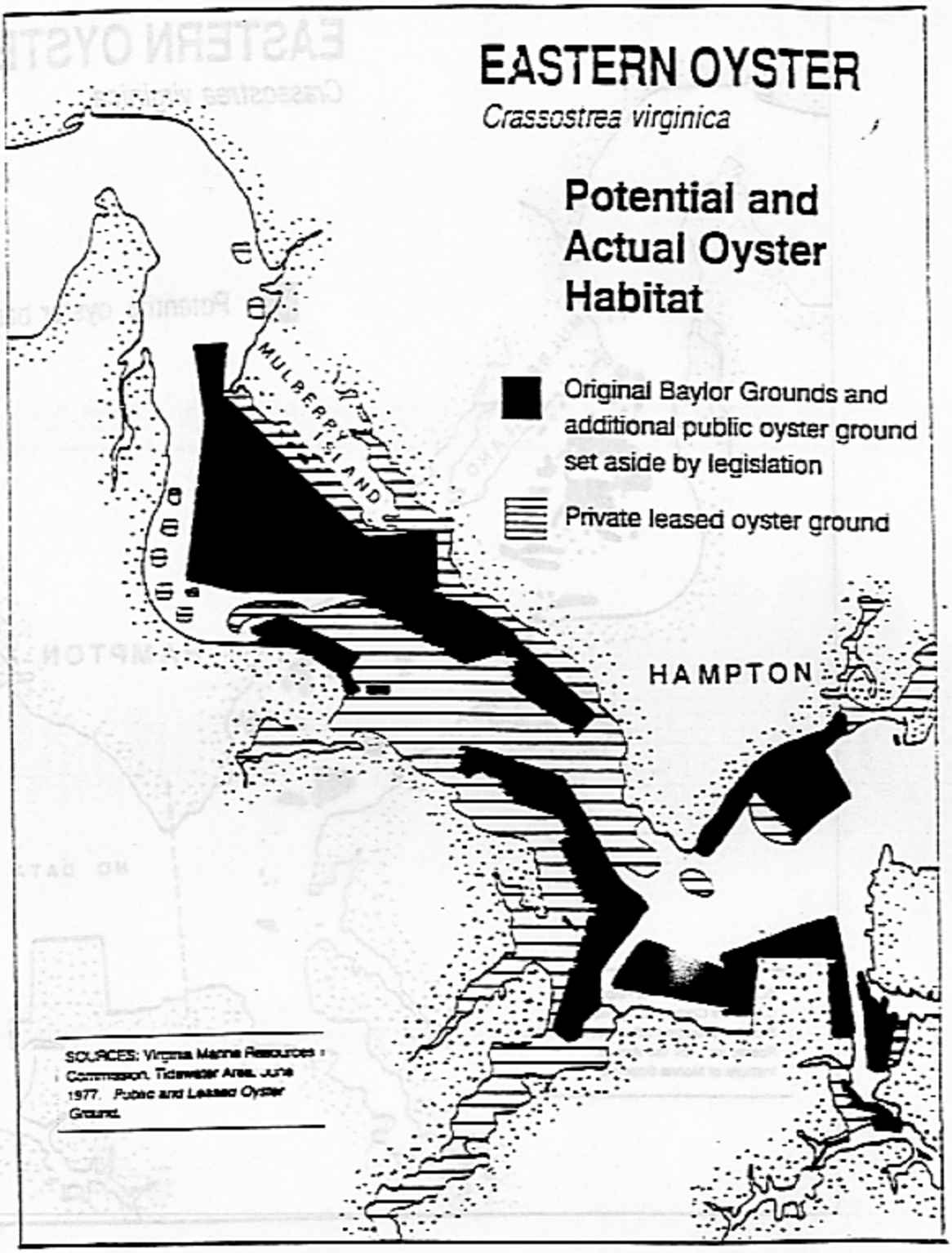
APPENDIX 2

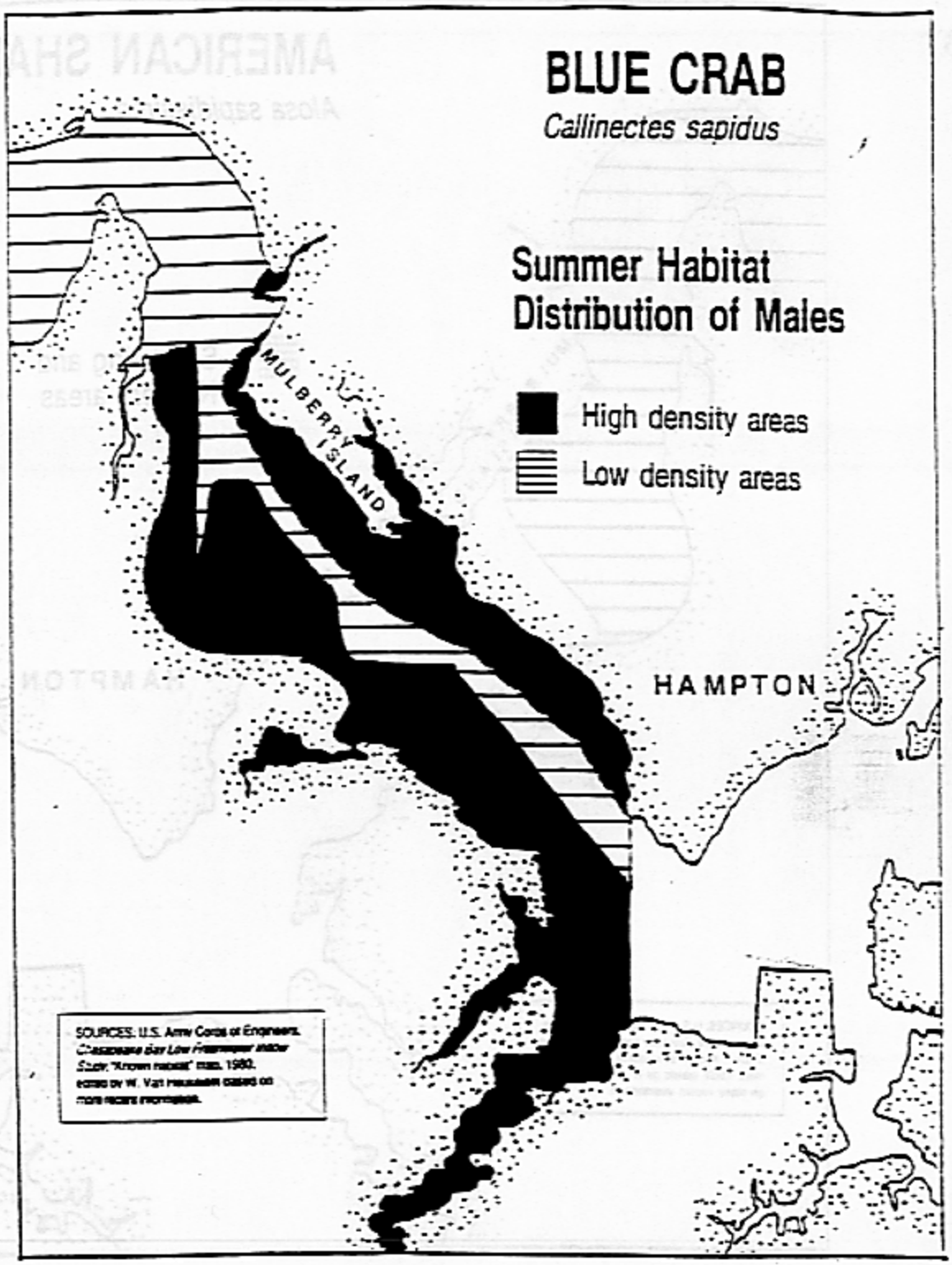
LIVING RESOURCE DISTRIBUTION MAPS

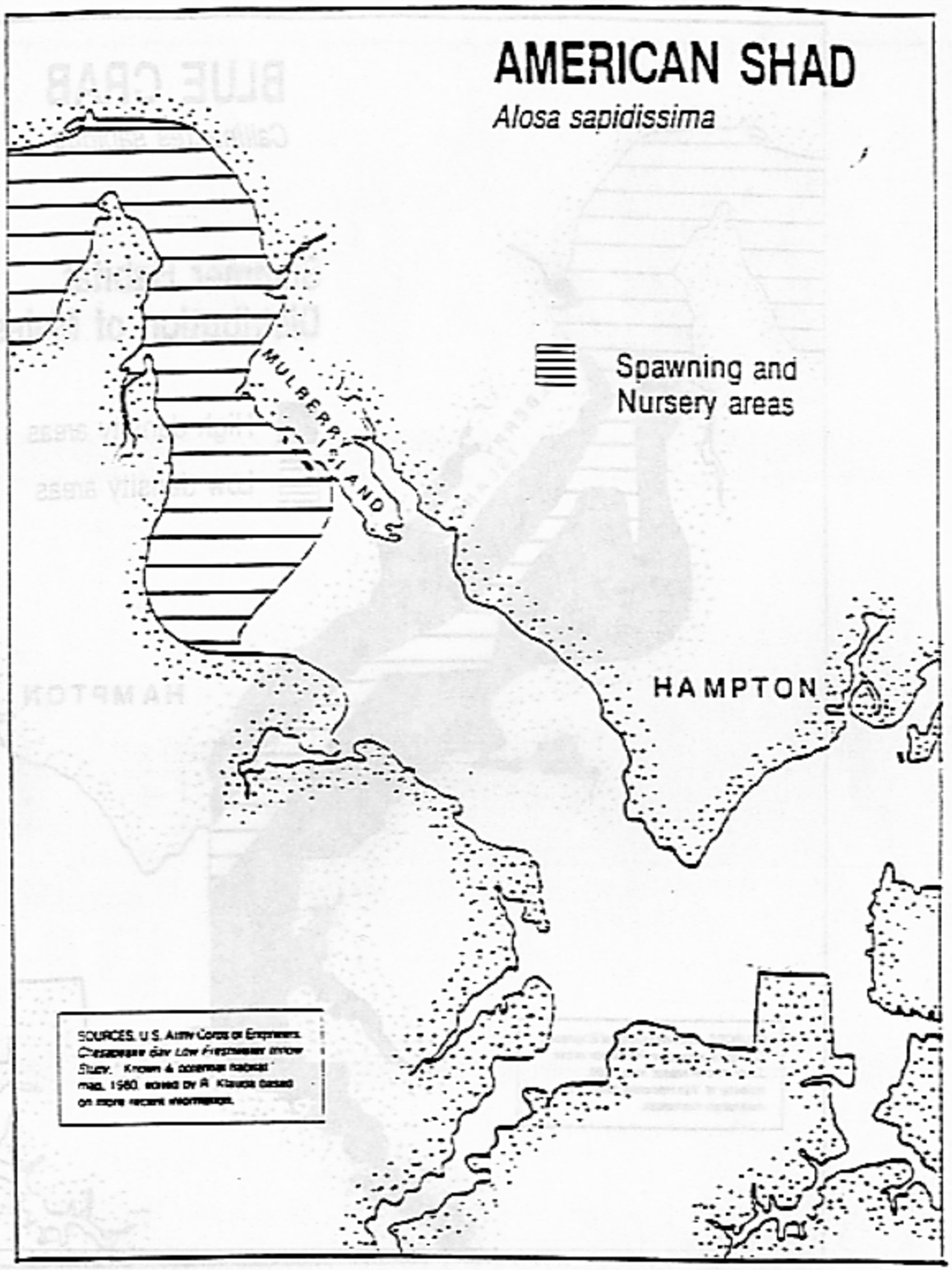

BLUE CRAB
Callinectes sapidus
Winter Habitat
Distribution of Males
Low density areas
MULBERRY ISLAND
HAMPTON
SOURCES: U.S. Army Corps of Engineers, Chesapeake Bay Low Freshwater Inflow Study, "Known habitat" map, 1980, edited by W. Van Heuseleer. Recent information collected by MDNR indicates a different distribution of winter habitat; not including the deep central mainstem of the Bay, but ranging more along the sands of the mainstem and tributaries.

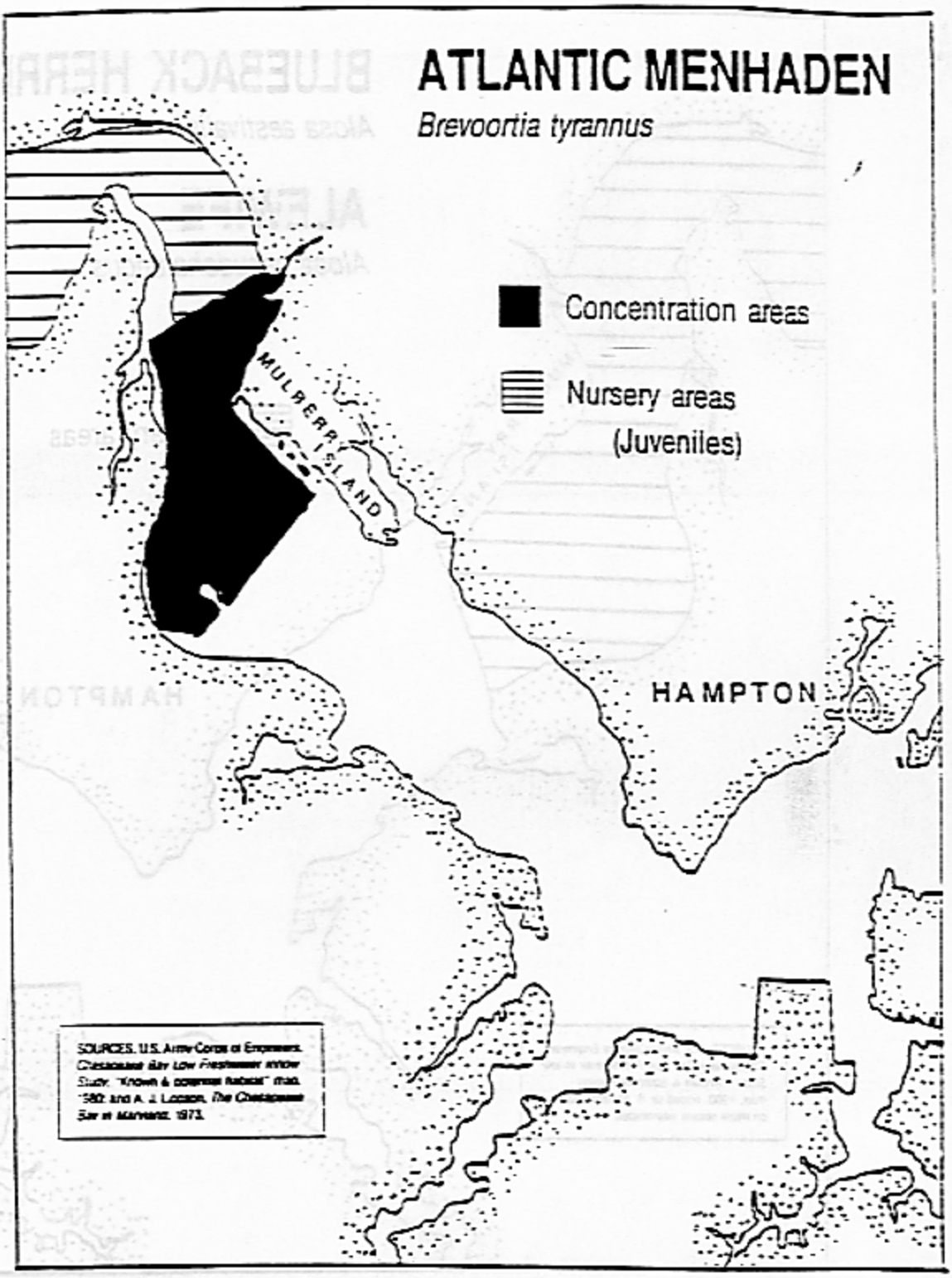

BLUE CRAB
Callinectes sapidus
Summer Habitat
Distribution of Females
High density areas
Low density areas
MULBERRY ISLAND
HAMPTON
SOURCES: U.S. Army Corps of Engineers.

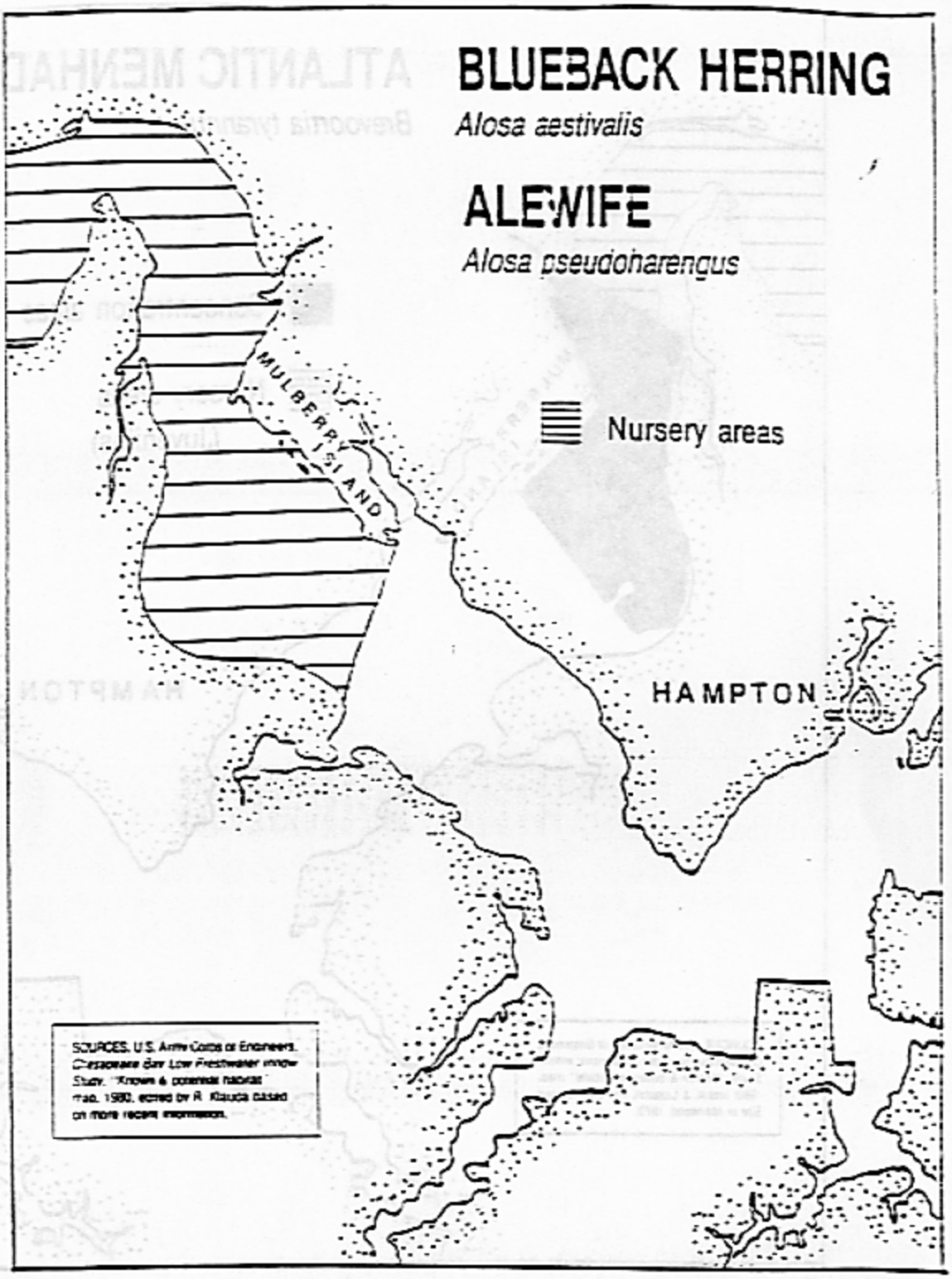

EASTERN OYSTER
Crassostrea virginica
Potential oyster bar
MULBERRY ISLAND
HAMPTON
NO DATA
SOURCE: 1981 Final Report to the U.S. Army Corps of Engineers - "A Study of Dredging Effects in Hampton Roads, Va." - by the Virginia Institute of Marine Science.

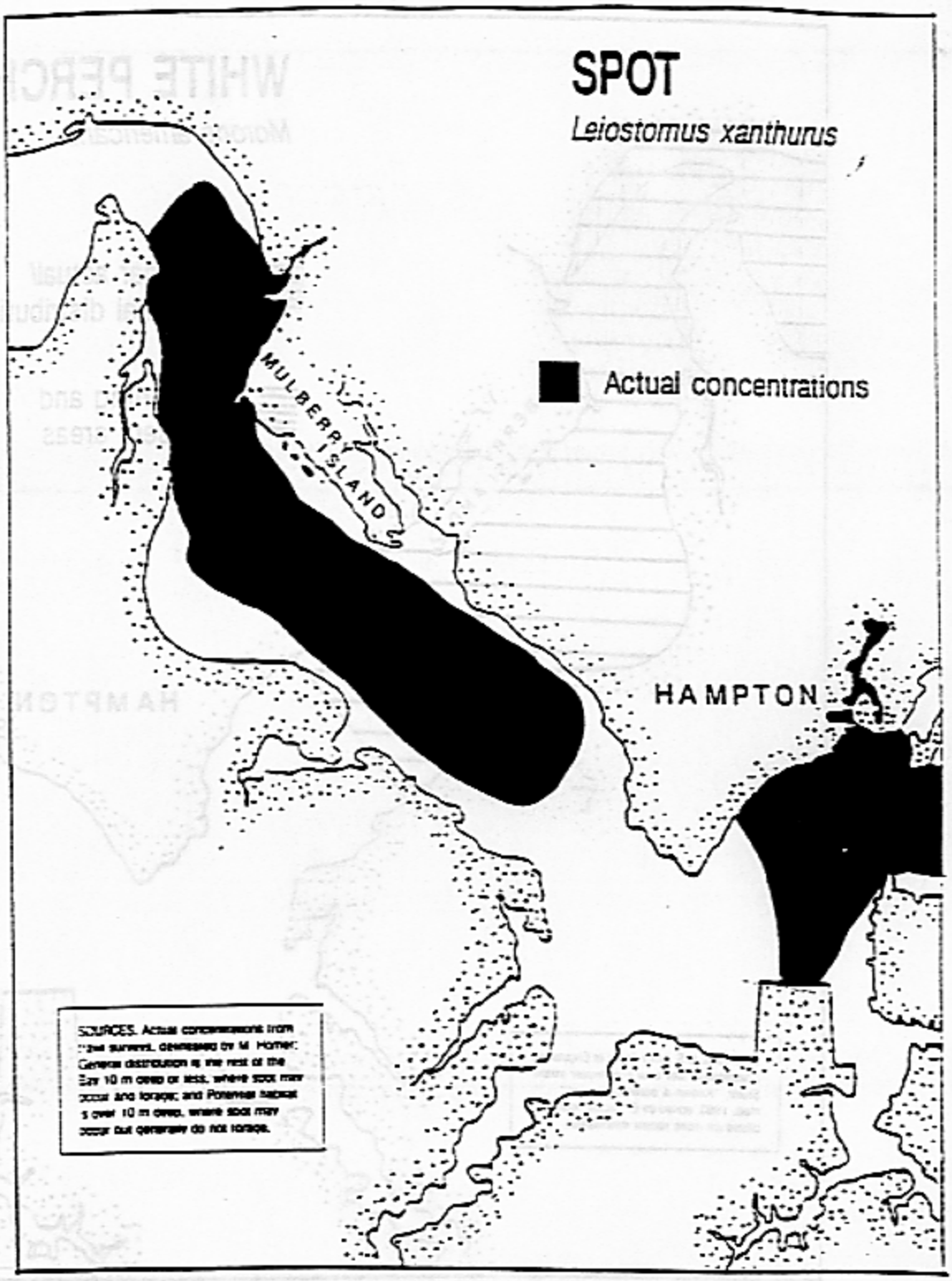

EASTERN OYSTER
Crassostrea virginica
Potential and Actual Oyster Habitat
Original Baylor Grounds and additional public oyster ground set aside by legislation
Private leased oyster ground
MULBERRY ISLAND
HAMPTON
SOURCES: Virginia Marine Resources Commission. Tidewater Area. June 1977. Public and Leased Oyster Ground.

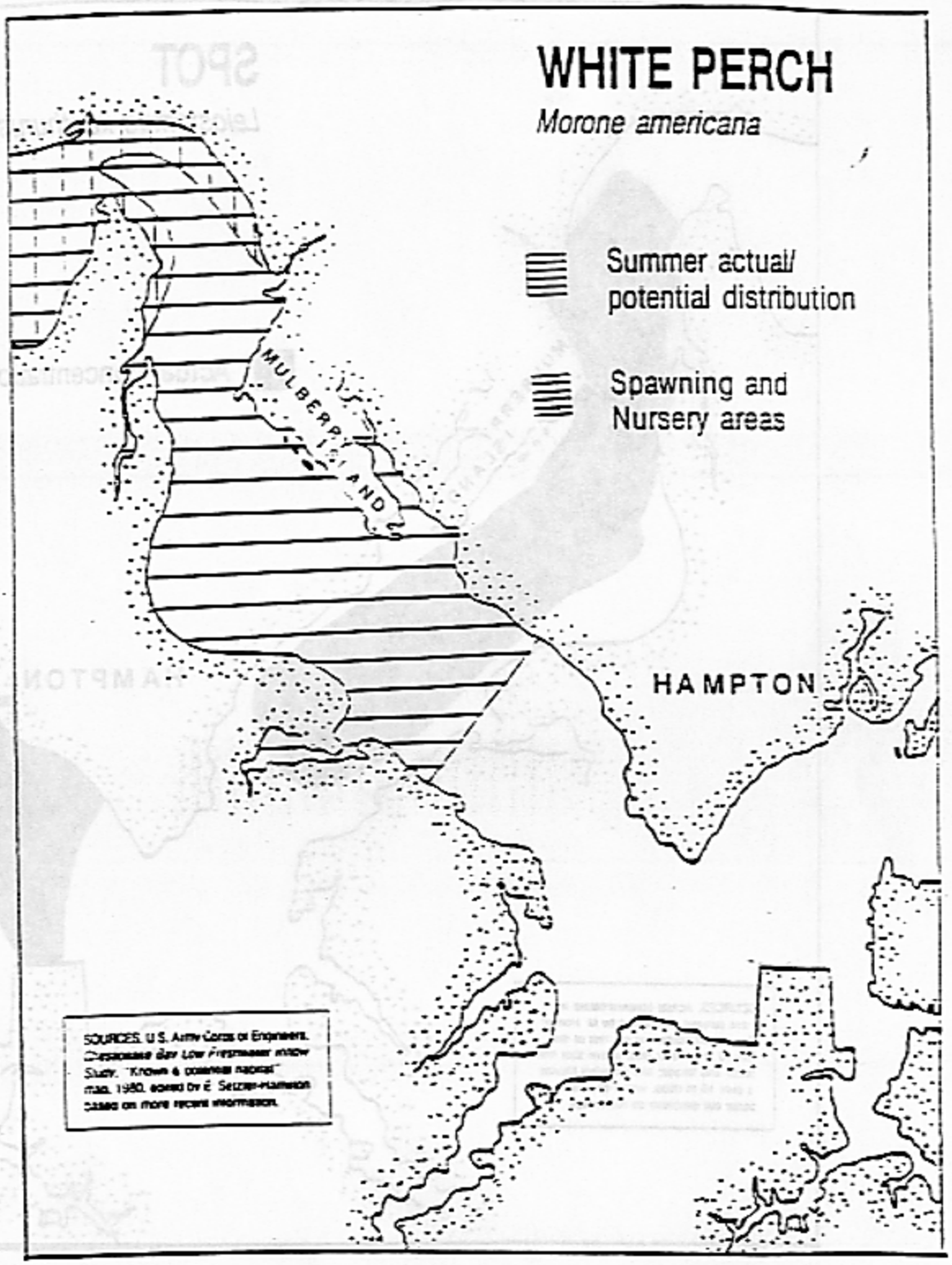

BLUE CRAB
Callinectes sapidus
Summer Habitat Distribution of Males
High density areas
Low density areas
MULBERRY ISLAND
HAMPTON
SOURCES: U.S. Army Corps of Engineers.

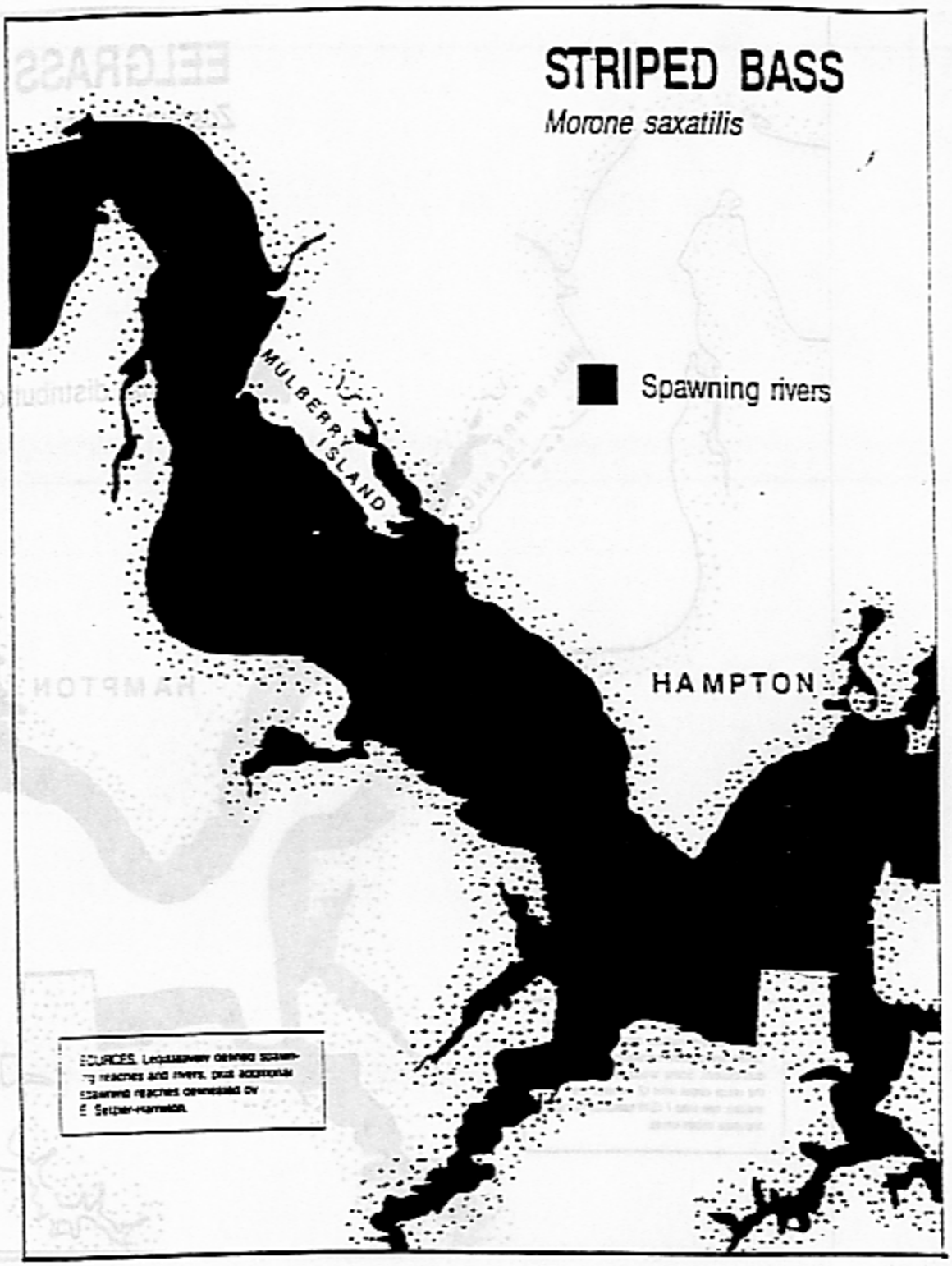

AMERICAN SHAD
Alosa sapidissima
Spawning and
Nursery areas
MULBERRY ISLAND
HAMPTON
SOURCES. U.S. Army Corps of Engineers.
Chesapeake Bay Low Freshwater Inflow
Study. Known & potential habitat
map, 1980, edited by R. Klauda based
on more recent information.

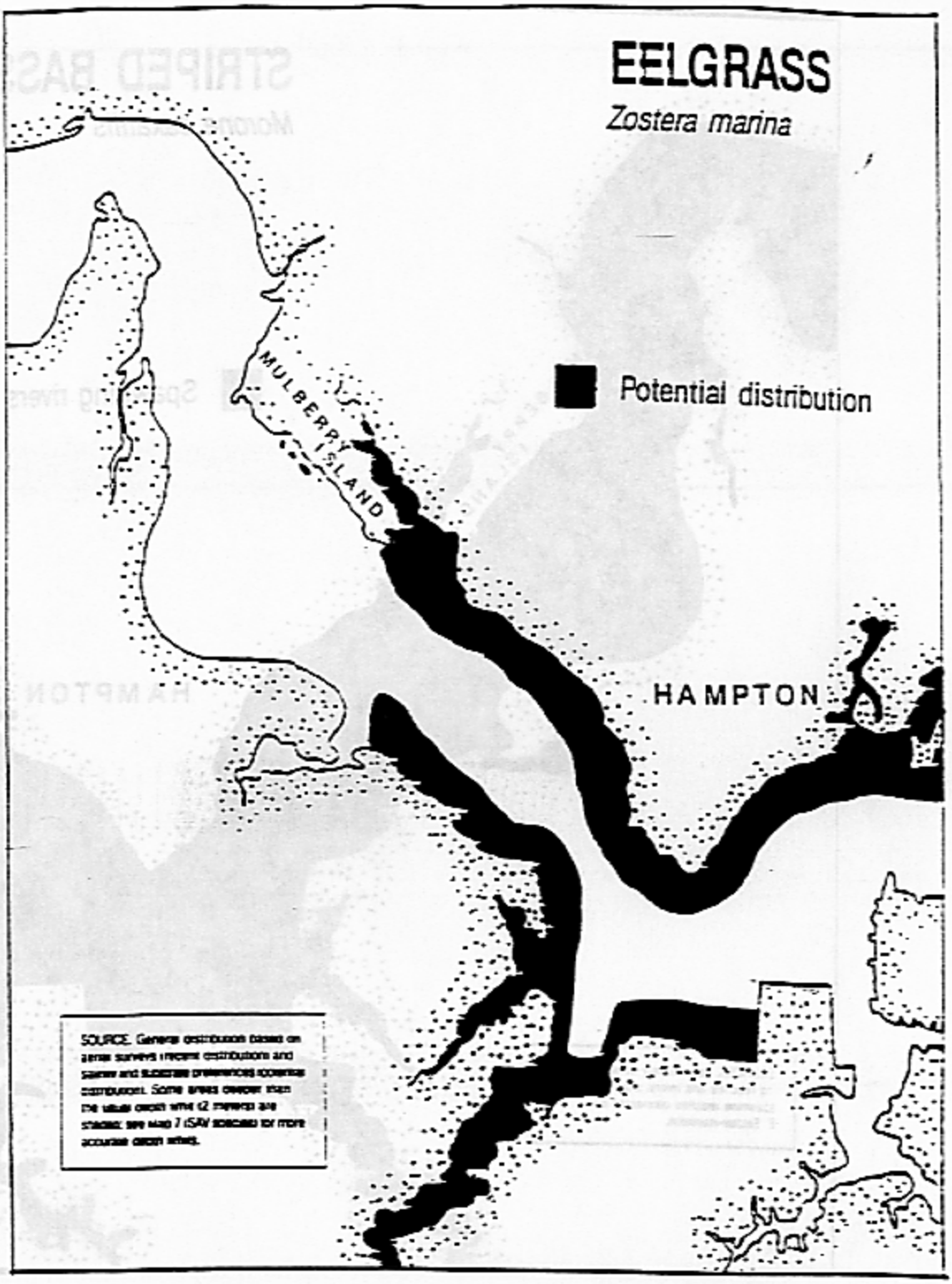

ATLANTIC MENHADEN
Brevoortia tyrannus
Concentration areas
Nursery areas
(Juveniles)
MULBERRY ISLAND
HAMPTON
SOURCES: U.S. Army Corps of Engineers, Chesapeake Bay Low Freshwater Inflow Study, "Known & potential habitat" map, 1980; and A. J. Lodson, The Chesapeake Bay in Maryland, 1973.

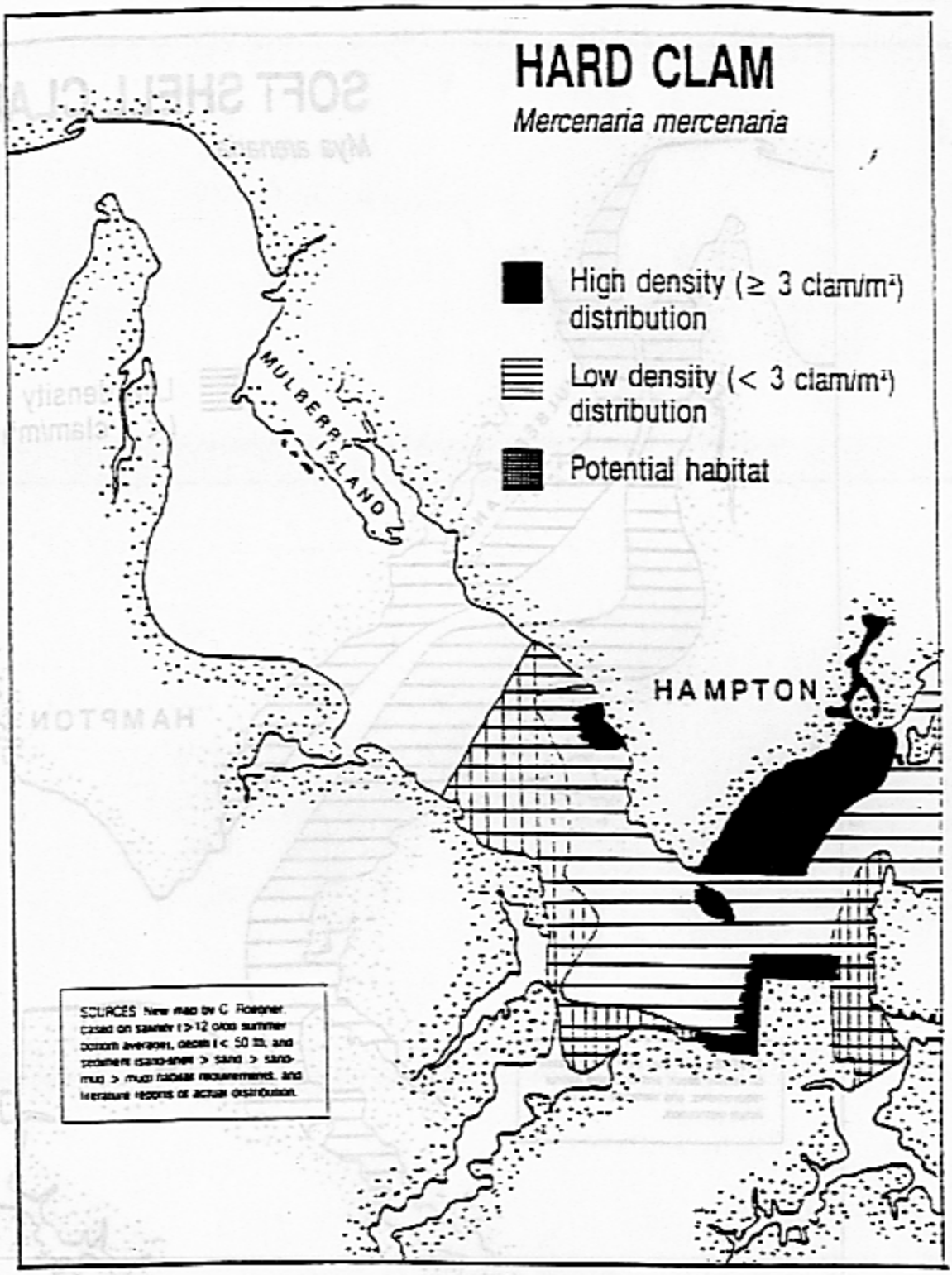

BLUEBACK HERRING
Alosa aestivalis
ALEWIFE
Alosa pseudoharengus
Nursery areas
MULBERRY ISLAND
HAMPTON
SOURCES. U.S. Army Corps of Engineers. Chesapeake Bay Low Freshwater Inflow Study. "Known & potential habitat" map. 1980, edited by R. Klauda based on more recent information.

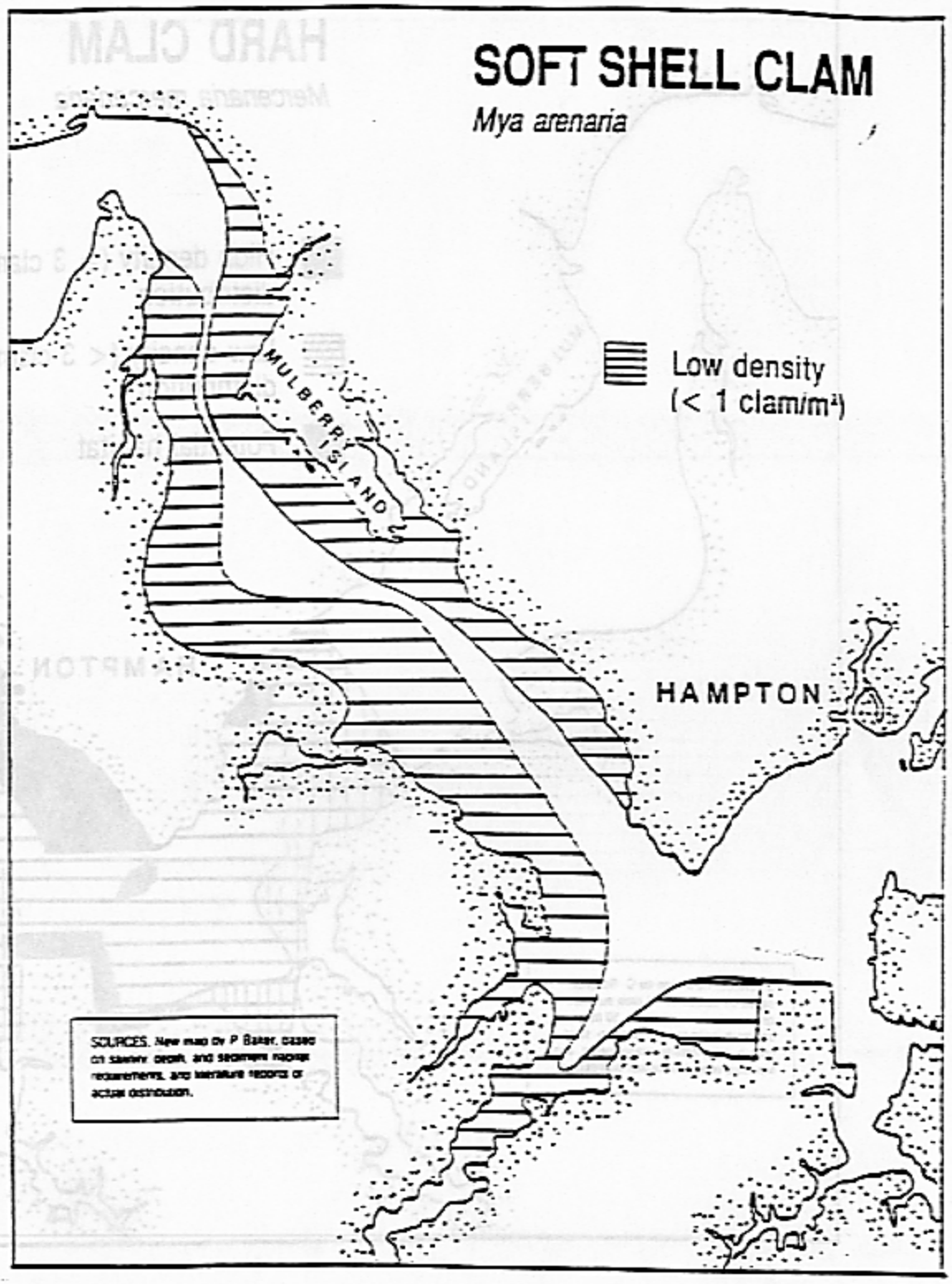

SPOT
Leiostomus xanthurus
Actual concentrations
MULBERRY ISLAND
HAMPTON
SOURCES. Actual concentrations from trawl surveys, compiled by M. Homer. General distribution is the rest of the Bay 10 m deep or less, where spot may occur and forage; and Potential habitat is over 10 m deep, where spot may occur but generally do not forage.


WHITE PERCH
Morone americana
Summer actual/ potential distribution
Spawning and Nursery areas
MULBERRY ISLAND
HAMPTON
SOURCES: U.S. Army Corps of Engineers, Chesapeake Bay Low Freshwater Inflow Study, "Known & potential habitat" map, 1980, added by E. Setzler-Hamilton based on more recent information.


STRIPED BASS
Morone saxatilis
Spawning rivers
MULBERRY ISLAND
HAMPTON
SOURCES: Legislatively defined spawning reaches and rivers, plus additional spawning reaches delineated by E. Setzler-Hamilton.


EELGRASS
Zostera marina
Potential distribution
MULBERRY ISLAND
HAMPTON
SOURCE: General distribution based on aerial surveys (recent distributions and salinity and substrate preferences (potential distribution). Some areas deeper than the usual depth limit (2 meters) are shaded; see Map 7 (SAV species) for more accurate depth limits.


HARD CLAM
Mercenaria mercenaria
High density (≥ 3 clam/m²) distribution
Low density (< 3 clam/m²) distribution
Potential habitat
MULBERRY ISLAND
HAMPTON
SOURCES: New map by C. Roegner, based on salinity (>12 o/oo summer bottom averages, depth (< 50 ft), and sediment (sand-shell > sand > sand-mud > mud) habitat requirements, and literature reports of actual distribution.


SOFT SHELL CLAM
Mya arenaria
Low density
(< 1 clam/m²)
MULBERRY ISLAND
HAMPTON
SOURCES. New map by P. Baker, based on salinity, depth, and sediment habitat requirements, and literature records of actual distribution.

Final

APPENDIX D

MITIGATION

BANK EVALUATION

MITIGATION BANKING

Introduction

Mitigation banking is a form of compensatory mitigation used to address activities having a negative impact on wetlands. The Section 404(b)(1) Guidelines of the Clean Water Act present a set of environmental standards and criteria to be addressed before permits for wetland impacts are granted. The guidelines allow compensatory mitigation only after an analysis of all practical alternatives in order to, primarily, avoid the impact or , at second best, to minimize the impact. Mitigation can occur through restoration of a historic, but non-functional, wetland, through creation of a wetland from upland or through the enhancement of certain functions of a degraded wetland. Whenever possible,up-front, on-site, in-kind mitigation is preferable. Up-front mitigation ensures that the wetland is functioning at targeted levels before the proposed impact begins. On-site and in-kind mitigation is designed to reduce the loss of specific wetland types and functions that are unique and ecologically valuable to the local landscape. Mitigation banking is intended to aggregate smaller wetland impacts by restoring, creating or enhancing larger wetland mitigation bank sites. By its nature, mitigation banking is an off-site but up-front form of mitigation that may or may not be in-kind.

Wetland Mitigation Banking

Wetland mitigation banking was formally defined by the U.S. Fish and Wildlife Service (FWS) in 1981 as "habitat protection or improvement actions taken expressly for the purpose of compensating for unavoidable, necessary losses from specific future development actions". The bank accumulates mitigation credits based on benefits accrued from the compensation project. Withdrawals, in the form of debits, can be made from this account on a predefined ratio of exchange to fulfill compensatory mitigation requirements. The value of credits and debits must be assessed by a standard methodology. Several methodologies have been developed such as the FWS's Habitat Evaluation Procedure (HEP) and the Army Corps of Engineer's Wetland Evaluation Technique (WET) which utilizes habitat units for exchange. In other cases, the exchange ratio may be acreage based.

Both public and private concerns establish mitigation banks, often for their own uses. Banks sponsored by permit applicants, such as large public and private concerns, often work by the credit and debit systems of habitat units or other currency units. Mitigation fee banks, offer credits for sale to fulfill permitting processes . Costs are based on acquisition, enhancement, planning, construction, management, monitoring and typically, an additional 10% of project costs to cover administrative expenses (Short. 1988).

The details of mitigation banking should be formally defined in a Memorandum of Agreement (MOA) between sponsors of the bank and the appropriate local, state and federal permitting and commenting agencies. The MOA is a legally binding contract protecting the interests of the bank sponsor, developers and government agencies. The MOA should clearly state the location of the mitigation site, the details of mitigation, the targeted results, the valuation system used to define the worth of credits and debits, how the credits are to be used, and the long-term maintenance and monitoring programs of the mitigation site (Riddle and Denninger. 1985)

Advantages

Wetland mitigation banking offers several advantages as a form of compensatory mitigation. Both economic and ecologic benefits accrue due to the spatial and temporal scale of mitigation banking. The banking system can streamline the permitting process. The legally binding nature of the MOA's can be used to ensure long-term success. Mitigation banking also provides opportunities for effective and environmentally sensitive regional habitat and land-use management.

Economic and Ecologic Benefits of Scale - Large, contiguous tracts of wetlands can be developed at a lower cost per acre relative to numerous small mitigation projects. Cost are saved by the consolidation of planning, management and financial resources. The potential for successful mitigation is much higher than piecemeal projects since the banking operator generally has a higher level of expertise. Wetland value and function can be enhanced at larger scales whereas small mitigation projects may contribute less due to their discontinuous nature and lower success rate (Anderson and Rockel. 1991). In addition,

mitigation banking calls for full attainment of wetland function and value at the mitigation site prior to the withdrawel of credits. The a priori nature of mitigation banking allows accrual of benefits before any impacts are realized.

Streamlining the Permitting Process - Mitigation banking can streamline the permitting process for both the developer and permitting agencies. Permitting agencies are assured of adequate mitigation compliance and long-term maintenance. In return, this gives developers more certainty in project development (Heagerty and Concannon. 1988). Developers can buy or use existing credits with greater certainty and in a shorter time which has the potential to reduce the permitting period from 3-5 years to months (Anderson and Rockel. 1991). Developers can rely on the bank operators to ensure long-term success thus relieving themselves of this responsibility. Banking can also aid the planning process for development since mitigation costs can be determined up-front.

Long-Term Success - The assurances built into an MOA improve the outlook for long-term success. Small mitigation efforts often fail because the project goals were not clearly determined or stated, many projects were never completed or even initiated, the technical means of mitigation was not completely developed or understood and long-term management did not occur (Redmond. 1992, McCort et al. 1988). These issues are commonly addressed in the properly developed MOA.

Comprehensive Planning - Mitigation banks can be easily incorporated into regional habitat and land use management plans such as Special Area Management Plans or Habitat Conservation Plans (Lewis. 1992, Marsh and Acker. 1992)). Particular wetland functions and values can be optimized by targeting potential banking sites with hydrologic and ecologic factors favorable to mitigation. Habitat diversity can be maintained and historical losses of particular wetland types can be regained with careful planning (Eliot. 1985). A whole-system watershed approach can be utilized in concert with mitigation banking to address environmental issues in the face of anticipated development. Additionally, exchange ratios with greater than equal replacements and the production of large-scale high quality wetlands over

smaller tracts of questionable success can increase both the quality and quantity of wetland habitats.

Disadvantages

Wetland mitigation banking does provide for low-cost, high-quality mitigation, but there are disadvantages inherent in this process as well. The off-site and, often, out-of-kind mitigation that occurs in banking may be detrimental to local ecosystem function. Potential for abuse exists. Institutional problems must be dealt with and the economics of banking may constrain its widespread use.

Inadequate Compensation - The unavoidable off-site nature of a mitigation bank results in the loss of site-specific wetland functions that may not be adequately compensated for. Watershed effects may not be fully addressed if compensation occurs outside of the impacted region In many instances, out-of-kind replacement also occurs. For example, emergent wetlands are often created to replace other wetland types, such as bottomland hardwood swamps, because they are easier and less expensive to create (Marsh and Acker. 1992). The methodologies used for habitat assessment are often called into question (Riddle. 1988). Conservationists fear that wetland permits are being bought for inadequate, out-of-kind and off-site mitigation and that the ecosystem benefits of the off-site mitigation don't outweigh the on-site losses.

Abuse - The ease of mitigation banking for the developer may create increased pressure for off-site mitigation. There may be less emphasis given to careful project planning in attempts to avoid or minimize on-site impacts (Short. 1988). The concept of buying mitigation credits gives the impression, that wetland permits can be bought for a price, downplaying the need for adequate compensation.

Institutional Problems - The MOA requires full participation and agreement between all the Federal, State and Local agencies involved in the permitting and regulatory process. The process may become politically mired when policy conflicts occur between different governmental levels. Mitigation banking is still young. These agencies must develop the expertise and acquire the statutory

powers to manage wetland mitigation banks.if mitigation banking is to become mandatory public policy

Economics - A certain amount of risk is incurred by the bank developer, regardless if the credits are to be utilized in-house or offered for purchase (King. 1992). Since up-front and successful mitigation is required, years may elapse before any return on investment is perceived. To compound the risk, success of the bank can not always be guaranteed. Depending on the type of mitigation required, restoration costs per acre can range from $70 to $230,000 above land acquisition costs (Anderson and Rockel. 1991). Certain activites, such as land excavation are responsible for elevating restoration costs. Land aquisition costs may be equally expensive, particularly if the land to be purchased happens to be economically valuable to development. These costs over time could translate to a 5-6 fold increase on investment and must also consider long-term maintenance and management costs. If mitigation credits carry too high of a price, the scope of mitigation banking may be limited to large public and private concerns.

Current State of Wetlands Mitigation Banking

Wetland mitigation banks have been developed and maintained with varying degrees of success in many states (Anderson and Rockel. 1991). Most of the bank sponsors are State agencies which, in many cases, retain exclusive use of the banks. Fewer banks are administered and used by private concerns. The Clinton Administration's statement of wetlands policy ("Protecting America's wetlands: a fair, flexible and effective approach" August 24, 1993), endorses the use of mitigation banking as a valid method of compensation, only when on-site mitigation is not feasible, under the Section 404 regulatory programs. The use of mitigation banking will be encouraged, particularly when it is incorporated into advanced land-use management plans for watersheds, by the provision of financial and technical support. Given the appropriate constraints, wetland mitigation banking can be an effective tool, both protecting and enhancing the Nation's wetlands and by accommodating the needs of development.

Recommendations

The appropriate and successful application of wetland mitigation banking relies on its judicial use and the development of a sound MOA. As dictated by Section 404(b)(1) Guidelines, off-site mitigation should only be employed after all other alternatives have been exhausted. Mitigation banking is not meant to be a panacea for mitigation requirements. Successful mitigation can be ensured through a legally binding MOA. Many mitigation efforts fail due to poor design and lack of long-term monitoring and maintenance (Redmond. 1992). Assurances should be built into the MOA guaranteeing that specific mitigation objectives, in terms of desired wetland function and value, have been met prior to use of the bank. Adequate monitoring and maintenance programs should be specified to ensure continued success. Protocols for habitat valuation and credit exchange should be precisely defined and agreed upon by all entities involved to avoid costly misunderstandings and inadequate exchanges. In addition, mitigation banking could be utilized as an effective tool when integrated with regional comprehensive land use management plans. Wetland benefits can be maximized at the watershed ecosystem level while providing for future development needs.

Wetands can be constructed using dredged material. The cost of constructing wetlands in this manner is often more expensive than more commonly used placement alternatives such as ocean placement or confined upland placement (such as Craney Island Dredged Material Management Area). However, if these constructed wetands can be used as mitgation banks the increased costs would be offset, dredged material could be used beneficially, and important wetland habitat could be restored. Used prudently, mitigation banks hold promise as future beneficial use projects.

Literature Cited

Anderson, R. and R. DeCaprio. 1992. Banking on the Bayou. National Wetlands Newsletter 14(1):10.

Anderson, R. and M. Rockel. 1991. Economic valuation of wetlands: Discussion paper #065. American Petroleum Institute, Washington, D.C.

Clinton Administration. 1993. Summary of "Protecting American's Wetlands: a Fair, Flexible and Effective Approach", August 24, 1993.

Dunham, F.O. 1985. Mitigation banking: A State perspective, p. 257-259. In J.A. Kusler and P (Eds.), Proceedings of the National Wetland Assessment Symposium. Association of State Wetland Managers, Inc., New York.

Eliot, W. 1985. Implementing mitigation policies in San Francisco Bay, p. 920-940. In O.T. Magoon, H. Converse, D. Miner, D. Clark and L. Thomas Tobin (Eds.), Coastal Zone '85. American Society of Civil Engineers, New York.

Ford, K.E. and K.A. Glatzel. 1989. Wetlands mitigation banking: Prospects for the State of Washington, p. 1230-1241. In O.T. Magoon, H. Converse, D. Miner, L. Thomas Tobin and D. Clark (Eds.), Coastal Zone '89. American Society of Civil Engineers, New York.

Heagerty, D.D. and M.O. Concannon. 1988. Mitigation banking: Investments for public and private benefits, p. 325-326. In J. Zelazny and J.S. Feirabend (Eds.), Wetlands: Increasing our Wetland Resources. National Wildlife Federation, Washington, D.C.

King, D.M. 1992. Avoiding another taxpayer bailout. National Wetlands Newsletter 14(1):11-12.

Kruczynski, W.L.1990 Options to be considered in preparation and evaluation of mitigation plans, p.555-570. In J.A. Kusler and M.E. Kentula (Eds.), Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.

Kruczynski, W.L. 1990. Mitigation and the Section 404 program: A perspective, p. 549-554. In J.A. Kusler and M.E. Kentula (Eds.), Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.

Kusler, J. 1992. The mitigation banking debate. National Wetlands Newsletter 14(1):4.

Kusler, J. 1993. Wetlands wish list. National Wetlands Newsletter 15(2):11-12.

Lewis III, R.R. 1990. Wetlands restoration/creation/enhancement terminology: Suggestions for standardization, p. 417-419. In J.A. Kusler and M.E.

Kentula (Eds.), Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.

Lewis, R.R. 1992. Why Florida needs mitigation banking. National Wetlands Newsletter 14(1):7.

Marsh, L.L. and D.R. Acker. 1992. Mitigation banking on a wider plane. National Wetlands Newsletter 14(1): 8-9.

McCort, W.D., L.C. Lee and G.R. Wein. 1988. Mitigating for large-scale wetland loss: A realistic endeavor?, p. 359-367. In J.A. Kusler, M.L. Quammen and G. Brooks (Eds.). Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Inc., New York.

McCrain, G.R. 1991. Highways and pocosins in North Carolina: An overview. Wetlands 11:481-488.

McVoy, G.R. 1988. Advantages of open water/emergent wetlands for mitigation and a holistic approach to banking, p. 289-293. In J.A. Kusler, M.L. Quammen and G. Brooks (Eds.). Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Inc. New York.

Redmond, A. 1992. How successful is mitigation? National Wetlands Newsletter 14(1):5-6.

Riddle, E.P. 1988. Mitigation banks: Unmitigated disaster or sound investment?, p. 353-358. In J.A. Kusler, M.L. Quammen and G. Brooks (Eds.). Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Inc. New York.

Riddle, E.P. and M.F. Denninger. 1985. Coastal wetlands mitigation banks: The California State Coastal Conservancy experience, p. 260-264. In J.A. Kusler and P. Riexinger (Eds.). Proceedings of the National Wetland Assessment Symposium, Association of State Wetland Managers, Inc., New York.

Salveson, D. 1990. Wetlands: Mitigating and regulating development impacts. The Urban Land Institute, Washington, D.C.

Schonholtz, R. 1988. San Joaquin Marsh Mitigation program: An example of urban wetland management on a large scale, p. 336-339. In J.A. Kusler, S. Daly and G. Brooks (Eds.), Proceedings of the National Wetland Symposium: Urban Wetlands. Association of State Wetland Managers, Inc., New York.

Sheehy, D.J. and S.F. Vik. 1989. Extending mitigation banking beyond wetlands, p. 1242-1253. In O.T. Magoon, H. Converse, D. Miner, L.

Thomas Tobin and D. Clark (Eds.), Coastal Zone '89. American Society of Civil Engineers, New York.

Short, C. 1988. Mitigation banking. U.S. Fish Wildl. Serv. Biol. Rep. 88(41). 103 pp.

Tettemer, J.M. 1988. Mitigation banking: Our best chance for long-term wetlands preservation and management, p. 350-352. In J.A. Kusler, M.L. Quammen and G. Brooks (Eds.). Proceedings of the National Wetland Symposium: Mitigation of Impacts and Losses. Association of State Wetland Managers, Inc. New York.

APPENDIX E

VIRGINIA INSTITUTE OF MARINE SCIENCE

REPORT TO GENERAL ASSEMBLY OF VIRGINIA

DECEMBER 1992

BENEFICIAL USES OF DREDGED MATERIALS IN HAMPTON ROADS, VIRGINIA

VIRGINIA INSTITUTE OF MARINE SCIENCE

A Report to the Governor and General Assembly of Virginia

December 1992

PREFACE

This report is submitted pursuant to House Joint Resolution No. 150 of the 1992 Session of the General Assembly:

HOUSE JOINT RESOLUTION NO. 150

Requesting the Virginia Institute of Marine Science to conduct a study on the alternate uses and application of dredged spoils from the Hampton Roads Harbor.

***WHEREAS**, the 1991 Session of the General Assembly passed House Bill 1478, which prohibited the expansion of Craney Island and directed the appropriate state agencies to investigate and study the cost and availability of beneficial uses of dredged materials; and*

***WHEREAS**, such investigation and study should occur before disposal capacity is met; now, therefore, be it*

***RESOLVED** by the House of Delegates, the Senate concurring, That the Virginia Institute of Marine Science (VIMS) be requested to conduct a study on the alternative uses and applications of dredged spoils from the Hampton Roads Harbor, including environmental, economic and social impacts of any alternative.*

***VIMS** shall be assisted by Old Dominion University, the State Water Control Board, the Virginia Port Authority and the Virginia Marine Resources Commission.*

***VIMS** shall submit its findings and recommendations to the Governor and the 1993 Session of the General Assembly in accordance with the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.*

✦ ✦ ✦ ✦

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In many respects this report reflects the efforts of the Beneficial Uses Workgroup, an interagency group formed in 1990 by the Corps of Engineers in partnership with the Virginia Port Authority.

Corps of Engineers reports provided much of the background material for the study. Particularly important source materials were, General Design Memorandum 1, Norfolk Harbor and Channels, Virginia, June 1986, and Norfolk Harbor and Channels, Virginia: Long-term Disposal (Inner Harbor), Draft Information Report, June 1990.

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EXECUTIVE SUMMARY

SCOPE OF STUDY. In keeping with the understood legislative intent this report addresses those uses of dredged materials wherein benefits may accrue to living estuarine and/or waterfowl resources, and to beach nourishment with suitable material. Specifically, focus was placed on habitat modification or creation through utilization of dredged material from Hampton Roads Harbor in association with the current project to deepen and maintain the shipping channels.

BACKGROUND. The Norfolk Harbor and Channels Project, authorized by the U. S. Congress in 1986 (Public Law 99-662), enables a sequenced deepening of the approach and inner harbor channels in order to ensure current and future competitiveness of the Commonwealth's port system in Hampton Roads. With construction of an outbound channel of 50 foot depth, the first phase of the project has been completed. Completion of additional project elements will depend upon port needs and, most significantly, upon provision for disposal areas for the material dredged.

Within the Inner Harbor (the channel network inside the Hampton Roads Bridge Tunnel) the total project will generate, over 50 years, about 250 million cubic yards of dredged material. Of this amount about 26 million cubic yards is due to construction of deeper channels and anchorages. Most of the material will derive from maintenance of the project depth. To date, materials dredged from the inner harbor have been placed in the Craney Island Disposal Area, a 2,500 acre site in the Hampton Roads contiguous to the City of Portsmouth. That site is projected to be filled by 1997. In 1990, the Corps of Engineers proposed expansion of Craney Island as the most economical means to provide a long-term (50 years) general use disposal area for the Hampton Roads. In 1991, the General Assembly passed House Bill 1478 (Code 62.1-132-20) prohibiting the expenditure of state funds to expand the capacity of Craney Island. That option precluded, the requirement remains with the Commonwealth to provide suitable disposal area(s). Meanwhile, the Corps of Engineers is investigating means to extend the useful life of Craney Island via geotechnical methods and/or administrative processes to restrict use of the site to contaminated materials which are unsuitable for ocean disposal. Ocean disposal, a more costly option, is available for disposition of those materials deemed suitable.

BENEFICIAL USES OF DREDGED MATERIALS. Based upon initiatives taken by the Corps of Engineers in 1971 there is increased recognition that dredged materials may have environmentally beneficial uses. Within the past three years several federal environmental advisory/management agencies have joined with the Corps of Engineers in agreements to encourage and enable various marine habitat restoration goals using dredged materials. Several such projects have been completed or are pending in the Maryland portion of the Chesapeake Bay.

In 1990 the Corps of Engineers, in partnership with the Virginia Port Authority, initiated an interagency workgroup to examine beneficial use options for materials dredged from the inner harbor. Several options have been proposed and reviewed as to feasibility which include creation of islands for wetland and waterfowl habitat, oyster bar restoration, and fisheries habitat enhancement. This report has utilized those interim findings.

Disposal of dredged materials in the estuarine and marine environment always involves tradeoffs in natural resource values. Therefore, beneficial uses of dredged material must be pursued within the framework of carefully defined resource management goals, rather than as incidental benefits accrued as part of a solution to a disposal dilemma.

While there is potential for environmentally positive uses of dredged material for habitat creation or modification, there remains considerable uncertainty as to whether created habitat functions in all respects as its natural counterpart. This uncertainty should not discourage pursuit of beneficial uses, but it does caution against presumed success. Only through properly documented projects will the uncertainty be reduced.

CONCLUSIONS AND RECOMMENDATIONS.

1. Need for Commonwealth Program in Long-Range Dredged Material Management Planning. Over the long-term there could be substantial benefits to the Commonwealth in environmentally beneficial uses of dredged material. The issue must be addressed on a long-term, Commonwealth-wide basis. The issue is substantially broader than the question of coping with the disposal of materials from Hampton Roads. Options for beneficial use of dredged material from navigation projects should be considered in the context of a long-term dredged material management plan. Long-term planning is required because the analysis of alternatives is time consuming, and should a candidate beneficial use option emerge, the administrative processing time for consideration under Federal programs is substantial.

   While the Corps of Engineers routinely operates with extended planning and analysis for project development and maintenance, the Commonwealth resource management and advisory agencies do not operate along comparable time-lines. Rather, these agencies work with the Corps on a consultative basis in the later stages of planning, generally after a subset of disposal alternatives have been determined. In order for the Commonwealth to take better advantage of the potential of beneficial uses of dredged material, the appropriate state agencies need to engage in long-range planning.

   RECOMMENDATION: The appropriate resource management, advisory, and economic development agencies of Virginia should join together to draft a long-term dredged material management plan, which includes consideration of beneficial uses, for subsequent review by the Executive and the Legislative branches. Elements considered in the draft plan should include:

   a. Establishment of goals, objectives, and mechanisms for long-term dredged material planning for Federal navigation projects in the Commonwealth.

   b. Identification of resource management goals and objectives which can be supported by appropriate beneficial use and general impact mitigation strategies.

   c. Determination of strategies for effective interagency cooperation between state, federal and local governments in program implementation.

d. Initiation of a generic evaluation framework to guide review of specific projects with respect to management objectives and resource trade-offs associated with beneficial uses of dredged material.

e. Examination of potential funding mechanisms to meet non-Federal cost sharing requirements for beneficial uses.

f. Examination of potential State policy issues.

g. Determination of additional agency resources required to execute a long-term dredged material management program.

2. Limitations of Beneficial Uses for Inner Harbor Dredged Materials. Beneficial uses of dredged material for habitat creation or modification should not be viewed as a strategy to replace ocean disposal or to significantly relieve the pressure for a confined disposal site for Inner Harbor dredged materials. However, habitat creation could serve in a limited way to augment these means of disposal. This view of limited application is held because:

a. Within the inner harbor approximately 250 million cubic yards of dredged material will be generated over a 50 year term. Of the beneficial use options reviewed, creation of islands for varied wetland and/or waterfowl habitat utilizes the largest volume of dredged material per unit area. Conservatively, a 1,000 acre island would utilize about 16 million cubic yards. There are a limited number of suitable sites, a number insufficient to accommodate the volume of material to be generated.

b. Construction of an island for creation of wetland and waterfowl habitat necessitates constructing dikes with sandy material in order to contain the fine-grained silts and clays pumped to fill the site. The channels and anchorages to be dredged in the inner harbor contain a limited supply of suitable dike material. This further constrains the number and scale of such habitat creation. While additional sand material could be obtained from borrow sites external of the channels, additional costs and resource trade-offs at the borrow site would come into play.

c. The cost of habitat development which requires multiple or special handling is significantly greater than ocean disposal, even if the site is within a distance equivalent to the ocean disposal site. Preliminary cost analysis by the Corps of Engineers for island habitat creation indicates a cost factor of about 1.5 to 2 relative to ocean disposal at the Dam Neck Ocean Disposal Site. Those estimates exclude costs associated with planning studies, the cost ramifications of potential seasonal disposal restrictions which could be imposed, and post-disposal shaping of the habitat, planting, and monitoring. Comparisons with the somewhat more distant Norfolk Disposal Site, yet to be designated, would presumably be somewhat more favorable.

RECOMMENDATION: In spite of the limitations noted, it is recommended that evaluations continue on the more promising options for habitat creation or modification. Viewed over the long-term such applications could be an important testing ground to evaluate the utility of such beneficial uses. Of the beneficial use options reviewed, three emerge as candidates for further evaluation:

- Development of islands in the lower James River-Hampton Roads for varied wetland and/or waterfowl habitat.

- Development of oyster reef habitat in the lower James River, and

- Application of dredged material, in thin layers, for benthic habitat enhancement for target finfish species in the lowermost portion of the Chesapeake Bay.

i. Island Creation for Wetland/Waterfowl Habitat

- **Adjacent to Ragged Island Wildlife Management Area.** This site has received initial screening by the Beneficial Uses Workgroup. Substantial further evaluations will be required. Construction at this site would expand the scale of existing habitat, and with suitable design could reduce ongoing shoreline erosion.

- **Adjacent to West Side Craney Island.** While the site may have potential for habitat development, the first step necessary is a determination whether such development would violate the intent of House Bill No. 1478. Substantial further evaluations will be required to assess resource tradeoffs and on potential impacts on flow patterns in the Hampton Roads-lower James River.

ii. Oyster Reef Habitat in the Lower James River. The oyster beds of the lower James River have been critically important to the Virginia oyster industry. Restoration of the oyster stocks is a critical need. Evaluation of a pilot-scale oyster reef restoration project is warranted. Site evaluation should be undertaken in the vicinity of Wreck Shoal-Point of Shoals. Relief created with sandy dredged material should be covered with shell cultch for oyster settlement. While the site should be held as a no-harvest sanctuary, the larvae generated from oysters spawning at the site would support the oyster bottoms open to harvest.

iii. Benthic Habitat Enhancement with Thin Layer Application of Dredged Material. Such application is not recommended within the areas of the Inner Harbor or lower James River. However, sites within the southernmost sector of the Chesapeake Bay should be evaluated as to whether dredged materials from the Thimble Shoals Channel or the Inner Harbor channels would be suitable to achieve enhancement of the benthic habitat with respect to targeted finfish species. This strategy is not to be construed as endorsement of open-water disposal. Rather, it is intended as an experimental pursuit to assess the potential as a limited strategy.

I. Scope of Study

Pursuant to the request advanced in House Joint Resolution No. 150 by the 1992 General Assembly *(See Preface)*, this report addresses beneficial uses of dredged material associated with the deepening of navigation channels in Hampton Roads Harbor and subsequent project maintenance. Particular focus is placed on material derived from channels in the Inner Harbor, that portion of the waterway system west of the Hampton Roads Bridge Tunnel *(Figure 1)*. However, issues associated with long-term disposal of dredged materials must be viewed in the context of the entire Norfolk Harbor and Channels project, particularly as they relate to placement of material at ocean sites and the need for contained sites to accommodate materials unsuitable for ocean disposal. Moreover, issues associated with maintenance of navigation channels extend throughout the Commonwealth and the general issue of placement of dredged material must be viewed as a perpetual challenge.

The Corps of Engineers defines beneficial uses of dredged material as, "All productive and positive uses of dredged material, which cover broad use categories ranging from fish and wildlife habitat development, to human recreation, to industrial/commercial uses" *[1]*. Examples include:

- Beach nourishment, shoreline stabilization and erosion control.
- Habitat development or manipulation for aquatic and upland biota.
- Various reclamation projects such as port and industrial development.

Indeed, a review of past disposal activities in Virginia would provide illustrations of the above examples. Moreover, it is Commonwealth policy that priority consideration should be given to use of suitable dredged materials (sand) for nourishment of beaches *(Code of Virginia, 10-1-704)*.

In keeping with the understood legislative intent, this report considers a more restrictive definition of beneficial uses of dredged material. In addition to beach nourishment, focus is placed on those uses from which benefits may accrue to living marine resources. Thus, particular attention is given to habitat development and manipulation.

II. Port of Hampton Roads

A. Economic Impact. As the Commonwealth's greatest port complex, Hampton Roads plays a crucial role in the local and state economy. The Port is the largest export center for coal in the United States with rail shipments from Virginia, West Virginia, Kentucky and Tennessee. With respect to United States waterborne foreign commerce, the tonnage handled in 1990 at Hampton Roads exceeded any other port in the United States *[2]*. Using employment, payroll and tax revenues resulting from industries that are required at the port or attracted to the port as measures of economic impact, a recent study *[3]* found the total economic impact of the Port in 1988 resulted in about 112,000 jobs, payroll of $2,262 million, and state tax revenues of $260 million.

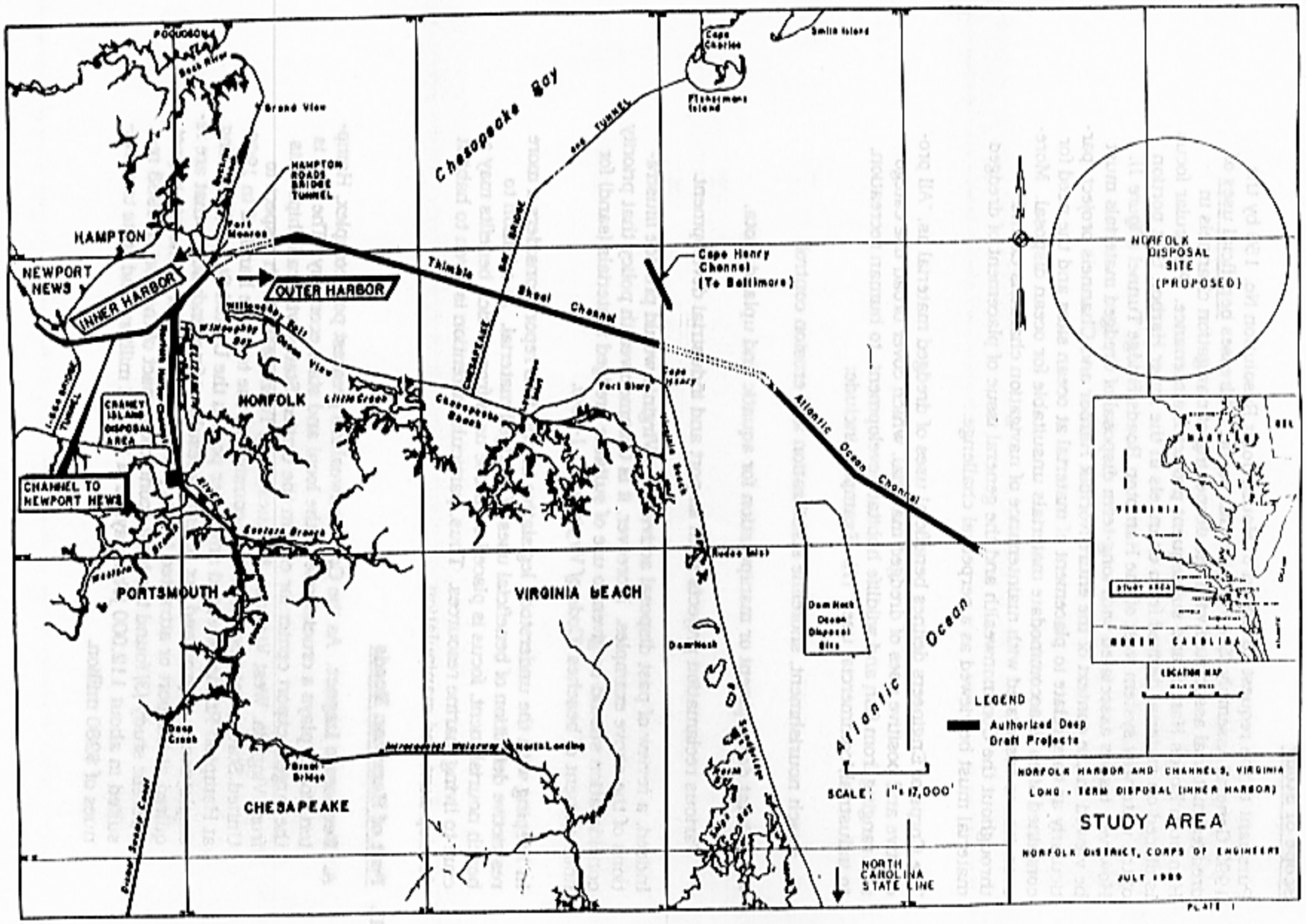

FIGURE 1. Norfolk Harbor and Channels, Virginia, with disposal areas. Reproduced from Reference 5. Figure scale, 1 inch equals approximately 30,200 feet.

The growth of the Hampton Roads port complex is linked to the ability to maintain adequate water depths in the waterways servicing the port facilities. Ships, particularly bulk carriers, have become larger in response to lower, per unit, transportation costs *[4]*. Consequently, there has been a continuing pressure for deeper access channels.

B. **Brief History of Dredging and Disposal in Hampton Roads.** The earliest federally sponsored dredging, in 1876, authorized channel deepening in the southern and eastern branches of the Elizabeth River *[5,6]*. More generalized deepening to 40 foot depth of the access channels, including Thimble Shoals Channel, was authorized during the period 1917-1927. In 1965, channel deepening to 45 foot depth was authorized for the Thimble Shoals, Newport News, and the Norfolk Harbor Channels *(Figure 1)* with somewhat lesser depths within the Elizabeth River.

Earlier disposal practices included placement of dredged material within Hampton Roads, the lower James River and within the southernmost Chesapeake Bay. During the period of about 1920 to 1939 substantial volumes of dredged material were placed, unconfined, in the immediate vicinity of Craney Island. Construction of a contained site at Craney Island was authorized in 1946. The earliest utilization of ocean disposal occurred in the 1950s. Use of the Dam Neck Ocean Disposal Site began during 1967 with the deepening of the Thimble Shoals Channel to 45 feet.

III. Norfolk Harbor and Channels Project, Deepening to Fifty-five Feet

A. **Authorization and Description.** The Water Resources Development Act of 1986 (Public Law 99-662) authorized deepening the channels leading to, and within, the Hampton Roads port complex. Project authorization includes, in addition to various anchorages, the following channel elements (see *Figure 1* for locations):

Channel	Channel Depth	
	Current Status	Authorized
Atlantic Ocean Channel	Undredged	60 Feet
Thimble Shoals Channel	50/45 Feet	55 Feet
Norfolk Harbor Channel	50/45 Feet	55 Feet
Channel to Newport News	50 Feet	55 Feet
Elizabeth River and		
Lower Southern Branch	40 Feet	45 Feet
Middle Southern Branch	35 Feet	40 Feet
Upper Southern Branch	35 Feet	35 Feet

The project is planned as sequential elements. The first element, 50 foot depth outbound channels in Thimble Shoals and Norfolk Harbor and 50 foot depth, full width, in Newport News Channels, has been completed. Subsequent elements are construction of outbound channels to 55 foot depth followed by 50 foot and 55 foot inbound channels.

B. **Cost-sharing**. In May . 1986. the Commonwealth entered into a Local Cooperation Agreement with the Department of the Army for participation in cost-sharing. The agreement covers project costs for the construction of the 50 foot outbound lanes of the Thimble Shoal and Norfolk Harbor Channels and full width deepening of the Newport News Channel. Costs to the Commonwealth include 50 percent of the new construction plus 50 percent of incremental cost of maintenance over that of the 45 foot depth. To this end the General Assembly of Virginia appropriated $26 million dollars effective 1 July 1986.

IV. Dredged Material Disposal Requirements

A. **Responsibility**. Under the Water Resources Development Act of 1986 the local project sponsor is responsible for the provision of suitable disposal areas. The Army Corps of Engineers performs the required engineering and other studies, and determines the lowest cost disposal option which determines the basis for cost-sharing negotiations. The cost of construction of a contained disposal site is the responsibility of the non-Federal sponsor. Two disposal sites have been utilized in construction of the first phase of the current deepening project. Dam Neck Ocean Disposal Site (DNODS) and Craney Island Disposal Area (CIDA), a general purpose contained site *(Figure 1)*. In addition, the Corps of Engineers has requested designation of another ocean disposal area, the Norfolk Disposal Site.

B. **Current and Pending Disposal Sites.**

1. Norfolk Disposal Site (Pending). The Norfolk District requested the U. S. Environmental Protection Agency to designate this site for suitable material from the Norfolk Harbor and Channel Project. The site *(Figure 1)* is located about 45 miles from Craney Island and is approximately 50 square nautical miles in area. That request was based upon an extensive set of investigations and an Environmental Impact Statement.

2. Dam Neck Ocean Disposal Site (DNODS). DNODS, a site 37 miles from Craney Island, has been used since 1967 for new and maintenance work in the Thimble Shoals and Cape Henry Channel. In 1977, the EPA provided interim site designation and final EPA designation in March, 1988. In contrast to the Norfolk Disposal Site several federal and state environmental resource agencies have expressed continuing concerns regarding the use of DNODS for disposal of very fine-grained sediment (silts and clays) from portions of the Thimble Shoals and Inner Harbor channels. These concerns address questions of sediment stability, water quality and potential disruption of spawning, nursery, and migration of important finfish and crabs in the Baymouth region *[7]*. The U.S. Environmental Protection Agency, Region III, has conducted monitoring studies during the period 1986 to 1992. The Corps of Engineers estimates the remaining (1990) DNODS capacity, as designated, to be about 63 million cubic yards (MCY).

3. Craney Island Disposal Area (CIDA)

a. History. Authorized by the River and Harbor Act of 1946, construction of the Craney Island Disposal Area began in 1954 and closure of dikes was completed in early 1957 *[5]*. As originally authorized, the area of CIDA was some 2,500 acres *(Figure 1)* with a compound levee at elevation to 18 feet above mean low water (MLW). The expected disposal life was estimated at 20 years with a capacity of 96 million cubic yards (MCY) at 18 feet elevation. With compaction of the underlying marine clays that capacity has been exceeded. By 1980 about 130 MCY of material had been deposited with an average fill elevation of about 15 feet mean low water (MLW).

Recognizing the limited remaining life of CIDA, the Norfolk District, in 1979, initiated studies for a disposal management plan to extend its useful life. Based upon a projection of 5 MCY per year of maintenance dredging that study estimated a limited life of 19 years (from 1980) without steps to increase capacity. With the management plan proposed and the same projected annual disposal of 5 MCY the lifetime could be increased by 17 years. The management plan included compartmentalization of the retention area to accelerate consolidation and raising the internal dikes to +30 feet MLW. The plan was fully implemented in late 1984.

Based upon the experience gained from management plan implementation between 1984 and 1987 the CIDA lifetime was revised downward with the estimate that the site will be filled to 30 foot elevation by the year 2000. The life expectancy was further reduced by placement in CIDA of some 6 MCY of material from deepening the 50 foot outbound channels of the inner harbor. A 1989 Corps of Engineers report *[5]* estimates the CIDA will be filled by 1997.

Between 1957 and August 1987 (prior to the current channel deepening project) approximately 167 MCY of dredged material have been placed into CIDA. The sources of materials are distributed as follows:

	Volume (MCY)	%Total
Corps of Engineers		
Navigation Channels	120.4	72
Other Federal Interests	23.1	14
State and Commercial Interests	23.3	14
	166.8	100

Due to compaction of underlying strata, and implementation of a disposal management plan, the capacity and useful life of CIDA has very substantially exceeded the original design estimates of 96 MCY and 20 years (ca 1977).

b. Current Status and Projected Life of Craney Island Disposal Area. As noted above, the current operational estimate is that CIDA will be filled by year 1997 to 2000 depending upon usage rates. The Corps of Engineers is currently investigating means to further ex-

tend CIDA useful life. One means under evaluation is the use of vertical drains placed through the deposited dredged materials and into the underlying strata to further dewater and consolidate the deposits. Also under consideration is a proposal to limit CIDA use to only those materials unsuitable for ocean disposal. The Corps investigations are evaluating both the capacity and environmental issues involved with restricted use. The initial results of these studies will be available in 1993 *[8]*.

C. **Alternative Disposal Plans Considered by Corps of Engineers.** Recognizing the finite useful life of CIDA both the Corps of Engineers and agencies of the Commonwealth have, over the past twenty years, investigated alternatives. Various options have most recently been examined by the Corps in conjunction with planning the current deepening project. Using a planning time-frame of fifty years, the Corps *[6]* examined:

1. Within the Inner Harbor
   a. Increasing the elevation of Craney Island
   b. Extraction of material from Craney Island
   c. Expanding the area of Craney Island
   d. Contained sites in Willoughby Bay, on Hampton Flats, and on Ragged Island
   e. Disposal alongside of channels
2. Contained Sites in Chesapeake Bay
   a. Horseshoe Shoal area off Buckroe Beach
   b. Ocean View
   c. Eastward of Chesapeake Bay Bridge-Tunnel
3. Inland Sites
   a. Suffolk (Dismal Swamp)
   b. Abandoned borrow pits by truck haul
   c. Abandoned mining site by rail haul
4. Ocean Sites (with use of the existing CIDA for Unsuitable Material)
   a. Dam Neck Ocean Disposal Site
   b. Norfolk Disposal Site
   c. Pipeline to sea

d. Capping unsuitable material at sea

Based upon combinations of environmental, construction feasibility, and cost factors, and significant resistance from the various localities, expansion of the Craney Island site was found to be the least cost alternative.

Corps policy is to use the least costly, environmentally acceptable alternate for Federal projects. It is the least cost plan which is used by the Corps in determining non-Federal cost-sharing should the local sponsor opt for a more costly alternative.

The Corps advanced six plans for expansion of Craney Island which involved either northward, westward expansion or combinations of the two. The plan ultimately recommended involved northward and westward expansion of 2,500 acres to provide a site sufficient to service the 50 year requirement for the inner harbor *(Figure 2)*.

In 1991, the Virginia General Assembly passed House Bill No. 1478 (Code 62.1-132.20, Appendix 1) which prohibits expenditures of state funds for expansion of Craney Island.

D. Need for Contained Disposal Area for Contaminated Dredged Material. Under the current regulatory framework, dredged materials are classified as to whether they pose a significant threat to aquatic organisms in open ocean disposal areas. The materials deemed unsuitable for ocean disposal require disposal in a contained site. The criteria for ocean disposal suitability are established by the EPA and Corps of Engineers. The criteria should be expected to vary through time as more meaningful test protocols are developed. Virtually all large ports, including Hampton Roads, contain contaminated sediment in the dredged materials *[9]*. The requirement for contained disposal area (s) must be viewed as perpetual.

In 1977, the U.S. EPA and the Army Corps of Engineers developed a manual, "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters *[10]* for use in the implementation of Section 103 of Public Law 92-532, the Marine Protection, Research and Sanctuaries Act of 1972. The manual contains technical guidance on chemical, physical, and biological procedures to determine the acceptability of dredged material for ocean disposal.

During the period 1979-1983 studies of the inner harbor channels were conducted by Old Dominion University for the Norfolk District, Corps of Engineers, in accordance with the above referenced manual. Based upon these the Corps has estimated that about 18 percent (4.67 MCY) of the new work in the Inner Harbor would require contained disposal. These materials are in the Elizabeth River and/or Southern Branch. About 8.2 percent of the projected 50 year maintenance work (17.7 MCY) are projected to require contained disposal. Retrospective application of the study results by the Corps permitted estimation of the amount of material placed into CIDA that was unsuitable for ocean disposal. Approximately 8.2 percent (3.7 MCY) of the material placed during 1978 through 1987 was unsuitable for ocean disposal. These materials were derived from the channels of the Elizabeth River system. It is important to note that materials from the New-

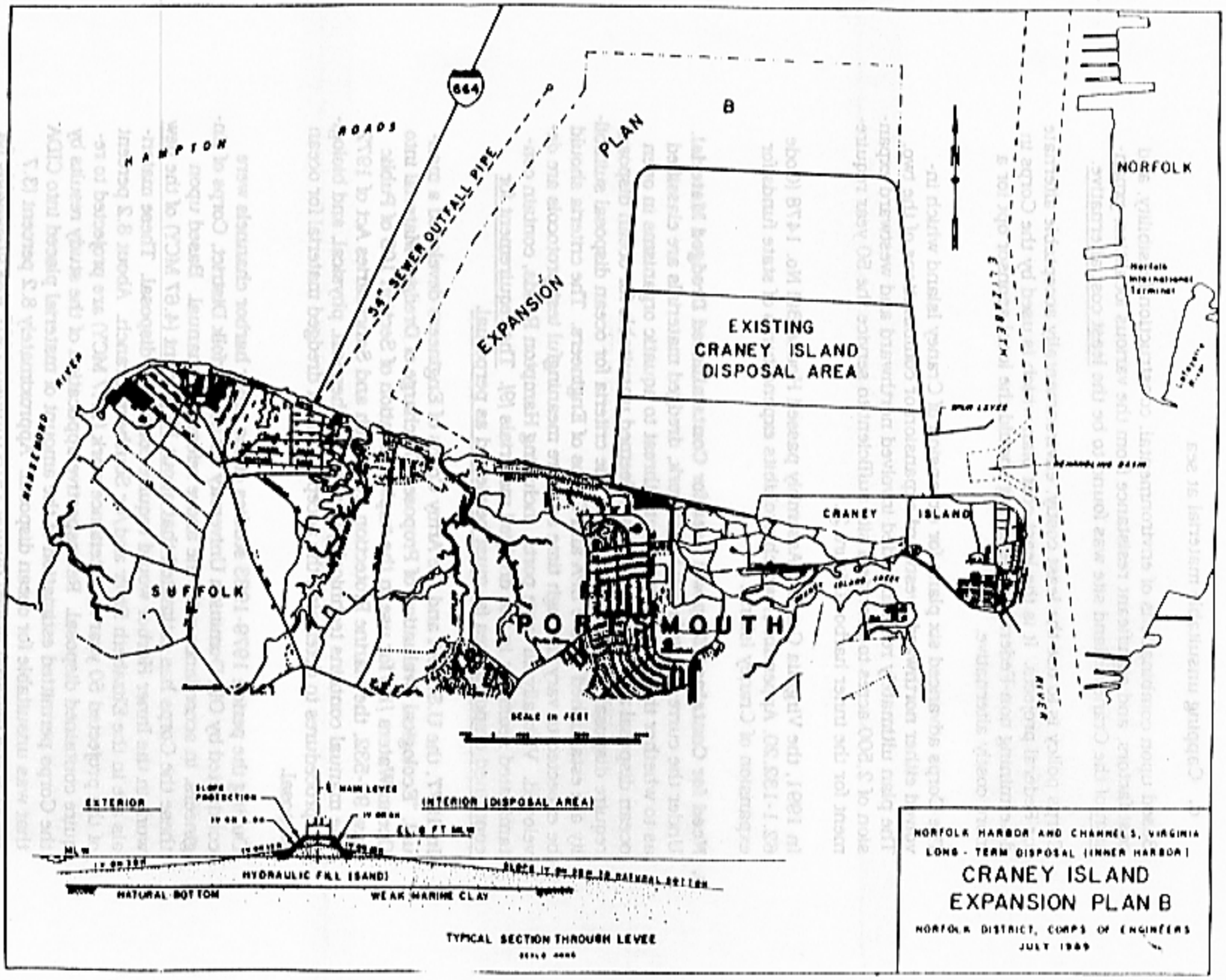

FIGURE 2. Craney Island Expansion Plan B. Reproduced from Reference 5.

port News Channel and the Norfolk Harbor Channel were found suitable for ocean disposal.

In 1991 the EPA and Corps of Engineers issued a revision of the 1977 Manual entitled "Evaluation of Dredged Material Proposed for Ocean Disposal. Testing Manual" *[11]*. The procedures and criteria of the revised manual are generally viewed as more comprehensive than the earlier requirements. Additional investigations in accordance with the revised manual will be conducted in 1994 with results expected in 1995-1996 *[12]*. The results of these investigations will determine the revisions of the current projections of dredged material volumes that require confined disposal.

The above referenced testing manual addresses ocean disposal; that is, disposal external of the Chesapeake Bay. The EPA and Corps of Engineers also have under development and review, a manual that pertains to inland waters which would include the Chesapeake Bay and fresh waters. Application of these procedures and criteria will likely further condition open water disposal in the Chesapeake Bay and tributaries.

V. Beneficial Use of Dredged Material

A. National Level. Although the coinage of the term "beneficial use" is relatively recent, the utilization of dredged material for construction purposes has been common practice for many decades, particularly as fill material in land reclamation for port and industrial development. Such was the case in the historical development of the Hampton Roads area *[13]*.

Increased recognition of the ecological value of many open water areas historically used as disposal sites has constrained former disposal practice such that increasing innovation is required in managing disposal activity. Under the Congressional authority of the River and Harbors Act of 1970, the U.S. Army Engineer Waterways Experiment Station (WES) initiated the Dredged Material Research Program (DMRP). This program included wide-ranging studies to gain a more definitive understanding of the environmental impact associated with dredging and disposal, and to develop new or improved dredged material disposal practices *[14]*. The DMRP gave considerable attention to habitat development and other potential productive uses.

Use of suitable dredged materials for beach nourishment was formally promulgated at the federal level in Section 933 of the Water Resources Development Act of 1976 (PL 94-587). Upon request of a state, such utilization is authorized if deemed in the public interest. In such cases the state is required to pay 50 percent of the increased cost associated with project modification.

Section 1135 of the Water Resources Development Act (WRDA) of 1986 (PL99-662) and extension under WRDA 1990 (see Appendix 2) allows the Army Corps of Engineers to modify the operation or maintenance of existing dredging projects for "the purposes of improving the quality of the environment in the public interest." Local sponsors are required to provide 25 percent of the project modification costs.

In 1989, the U. S. Departments of Interior and Army formed a cooperative agreement addressing waterfowl habitat conservation. Particular attention is given to opportunities for Corps of Engineers civil works projects to advance the goals of the North American Waterfowl Management Plan.

In 1991 a cooperative agreement was finalized between the National Oceanic and Atmospheric Administration (NOAA) and the Department of the Army (DOA) for a program to restore and create fish habitat *(Appendix 3)*. Although not restricted to habitat development using dredged materials, those opportunities are expressly recognized. The cooperative agreement resulted from a pilot study at six sites, four of which involved dredged material *[15]*. Two sites were in Maryland, one involving oyster bar restoration and the other, creation of topography for submerged aquatic vegetation.

Additional beneficial use authorization was recently passed in the Water Resource Development Act of 1992. Title II, Section 204 (Appendix 4) authorizes projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands in connection with authorized construction, operation and maintenance of navigation projects. Non-Federal interests are required to provide 25 percent of the construction cost, and 100 percent of operation and maintenance costs. Appropriations not to exceed $15 million dollars annually were authorized. No funds were appropriated for fiscal year 1993.

Section 204 (1992) differs from Section 1135 (1986) in that applicability of Section 204 is not restricted to existing projects. Moreover, Section 204 specifically references aquatic and ecologically related habitats.

B. **Chesapeake Bay.** One of the Chesapeake Bay Program goals is habitat restoration and enhancement. Policies have been adopted for the protection and enhancement of submerged aquatic vegetation and wetlands. More recently, the Bay Program Living Resources Subcommittee has embarked upon development of an Aquatic Reef Habitat Plan to address enhancement of oyster habitat. Selected dredged materials may have a role in oyster reef restoration.

In addition to such baywide efforts, both Maryland and Virginia have participated in projects involving beneficial use of dredged material.

1. Maryland. In 1991 the Governor's Task Force on Dredged Material Management *[16]* submitted its report and recommendations on actions to meet both short and long-term needs. It was recommended that beneficial uses, including beach nourishment and habitat development, should be a high priority. With respect to habitat development, four recent or ongoing projects are particularly noteworthy:

   - Black Duck Habitat at Bodkin Island. Bodkin Island, in Eastern Bay, was a significant black duck brood and nesting area. In 1847, the island area was 50 acres; by 1984 it had been reduced to less than one acre due to wave erosion *[17]*. Using 45,000 to 60,000 cubic yards (CY) of dredged material from the Chester River project, the island is to be enlarged to approximately 5 acres. The design includes a combination of upland bird nesting

The option screening process has incorporated several decision elements:

- Construction feasibility
- Consistency with resource needs as identified in the Chesapeake Bay Agreements
- Location with respect to economic hauling distance established by the Corps of Engineers *(Figure 3)*.
- "Fatal flaw" analyses

The economic hauling distance is essentially the mileage equivalent to the distance from the inner harbor to the Dam Neck Ocean Disposal Site, currently the only designated ocean disposal site. This criterion was invoked because hauling material to greater distances would likely be more costly than disposal at the currently designated ocean site. The analysis applies the questions: 1) would significant natural resources be directly or indirectly impacted, and 2) do current policies or attitudes concerning potential impacts to commercial fishery or recreation values render the proposition untenable. Thus, the "fatal flaw" analysis has been a pragmatic, ad hoc, application of contemporary natural resource management policy and opinion. The options have not been cast against specific Commonwealth resource management objectives that might be supported by the beneficial use of dredged material.

Wetland-Upland Habitat

Following preliminary screening of several candidate sites for wetland-upland habitat by the U. S. Fish and Wildlife Service, four sites in the James River were raised as candidates that might be constructed from materials suitable for ocean disposal:

- Area adjoining the west side of Craney Island.

The concept has been to create a wetland fringe. This prospect is held in abeyance until it is determined whether such action might violate the requirements of House Bill 1478(1991) with respect to increasing the capacity of Craney Island.

- Habitat Island adjacent to Mulberry Island.

The concept is to create an island with varied habitat characteristics offshore of Mulberry Island, an area of predominantly tidal marsh. This site was deemed unsuitable because, 1) much of the near shore bottom is charted as public (Baylor Grounds) or private leased oyster grounds, 2) the area is one of the few remaining productive oyster ground areas in the James River, and 3) the site is relatively distant from the Inner Harbor, the source of the dredged material.

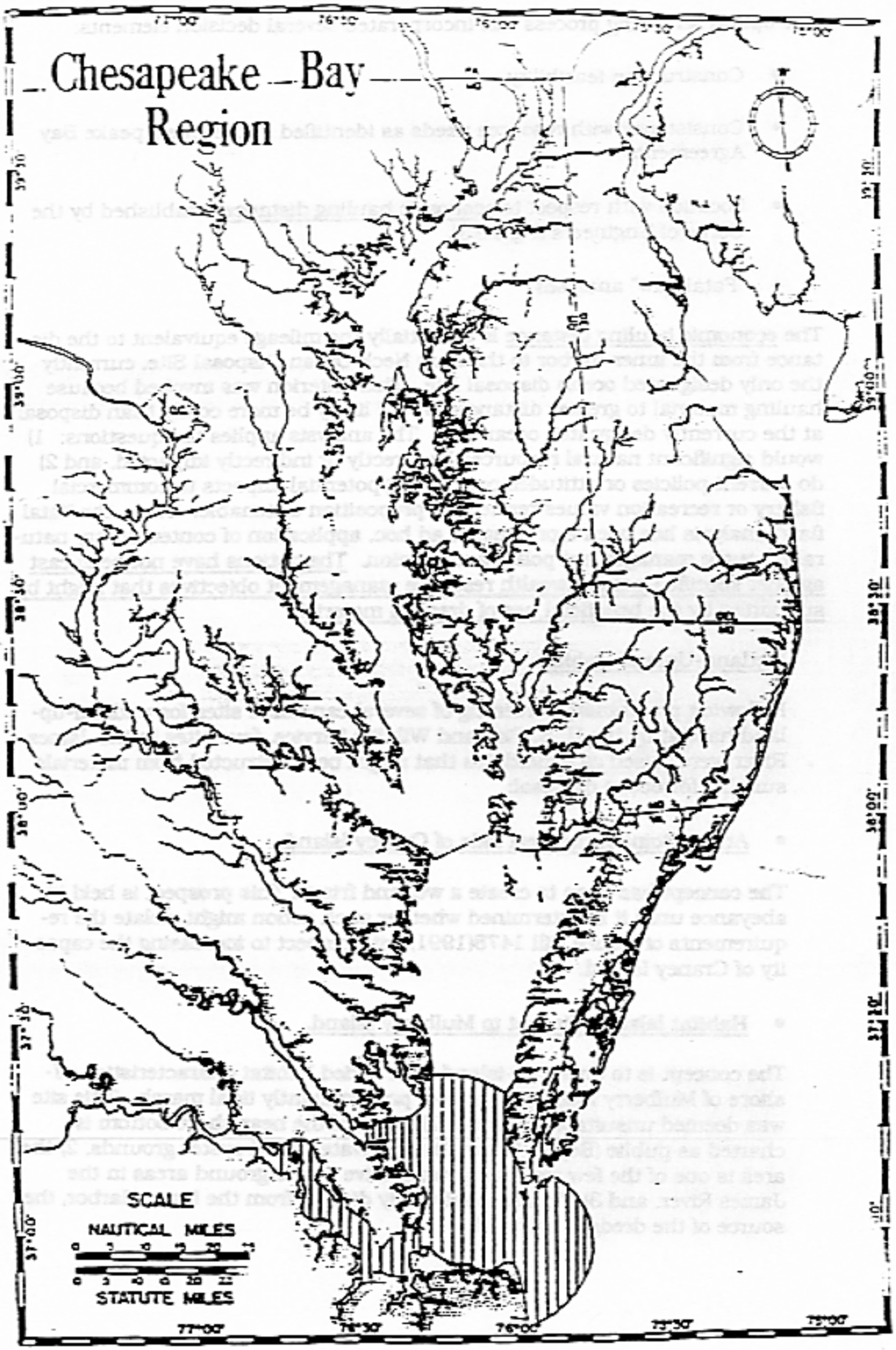

FIGURE 3. Economic Hauling Distance Boundary.
Reproduced from Reference 21.

- Habitat island adjacent to Hog Island Wildlife Management Area (WMA)

The Hog Island WMA is managed principally for migrating waterfowl and other wetland dependent species. One of several potential benefits could be protection of the presently eroding shoreline. However, there is concern that conflicts would arise with commercial and recreational fishing interests. Moreover, the site is located at the limit of the Corps of Engineers designated economic hauling distance.

- Habitat island adjacent to Ragged Island WMA.

The Applied Marine Research Laboratory (AMRL) of Old Dominion University has proposed a mixed habitat/erosion control project composed of five islands (870 acres) with the channelward berm protected by riprap *(23)*. After initial consolidation, the contained material would be shaped and planted to create various habitat types, tidal and nontidal wetlands, shallow water ponds and various upland habitats. This project is discussed further in Section VI. C. 2.

Oyster Bar Restoration.

In the absence of harvesting, natural oyster bars grow vertically as larvae from successive years settle and grow, and eventually bury the older oysters. Bathymetric maps of the James River in the 1870s indicated oyster "reefs" which were exposed at low water *(Figure 4)*. Decades of harvesting activity with the consequent loss of shell material have resulted in the virtual elimination of these features. Restoration of natural oyster habitat has been endorsed by the Blue Ribbon Oyster Panel of Virginia and by the Chesapeake Bay Program.

Reconstruction of oyster reef substrate using dredged materials requires application of granular material (sand) to form a steep mound which then is covered with shell to stabilize the topography and to induce natural oyster settlement. At present there are few productive areas in the James River due to incursions of prevalent oyster diseases. However, this option for beneficial use is worthy of further evaluation, particularly in the areas with lower disease mortalities.

Fishery Reefs. The Virginia Marine Resources Commission has, since 1974, conducted an Artificial Reef Program to enhance recreational fishing within the lower Bay and Bay-mouth regions. In addition to sunken vessels, concrete igloo-like structures have been emplaced. Encrusting biota on surfaces of the reef structure serve as food for smaller fish which in turn attract larger predators. Dredged materials fail to provide comparable attributes and are thus unsuitable for this use.

"Thin-Layer" Application of Dredged Material. The fauna living within and on the bottom sediments (the benthic community) are a crucial component of the aquatic food chain as they directly and indirectly serve as food sources for finfish and crustaceans. The species composition, abundance, and diversity within the benthic community are controlled to a significant degree by sediment grain size characteristics, salinity, and water depth. Re-

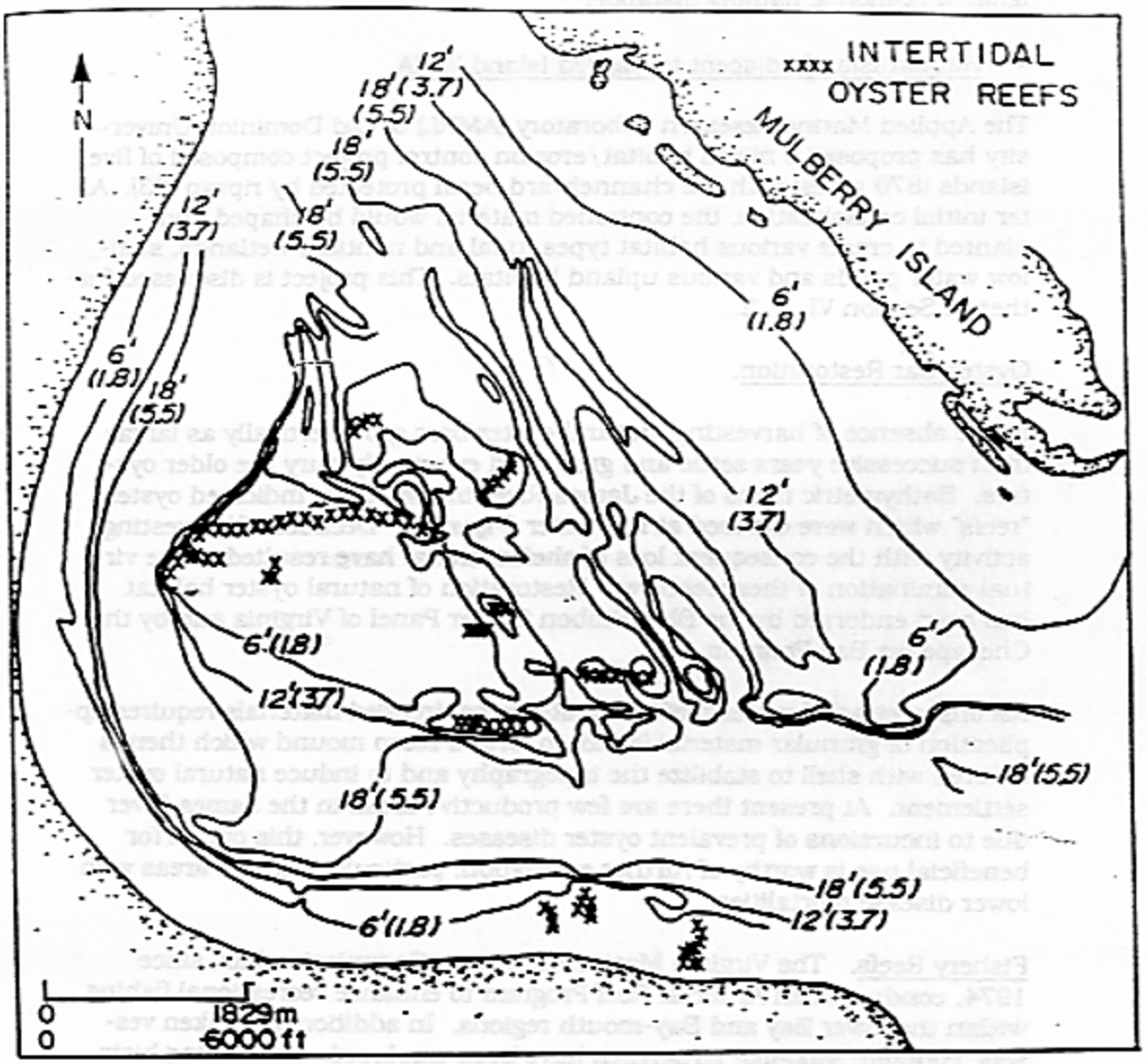

FIGURE 4. **Intertidal Oyster Reefs, Wreck Shoal and Burwell Bay, James River, 1870. Based on U.S.C.S. Sheet No. 1179A. Depth contours in feet (meters). Reproduced from Reference 24.**

source values differ between various benthic communities and within a given benthic community depending upon the level of ecological succession.

Given a clear resource management objective with respect to identifying the target population(s) (usually finfish or crabs) to be supported, dredged material might be used to enhance benthic resource value by changing the characteristics of the sediment or by mimicking a natural disturbance to induce early successional stages. Two alternative strategies pertain:

- Matching sediment materials. This strategy applies when the sediment characteristics of the dredged material closely match those of the native sediments. Although application of the dredged material smothers the *in situ* fauna, during early re-colonization many more individuals occupy the substrate which increases, at that time, the habitat value to the target fisheries population. Within a few years the original community would become re-established. In this strategy the "benefit" is short-lived. Successive thin layer applications may reinstill the benefit. However, this approach is limited since significant depth changes are not desirable. This application should not be interpreted to mean designation of an unlimited open-water disposal strategy.

- Changing substrate characteristics. The characteristics of the native sediment may be changed by application of dissimilar sediment materials. By careful selection of the contrasting materials, the resultant benthic community could be managed to provide an enhanced habitat value to support selected target populations.

The strategies noted above focus on direct food chain-support role of the benthos. However, the benthos has additional roles in ecosystem function which may condition beneficial use strategies. For example, benthic nutrient cycling characteristics should be considered when benthic resource value is evaluated. It is to be noted that these strategies must be considered as experimental in nature. The Corps of Engineers advises (1992) that until such demonstration projects have been thoroughly documented they must be considered as "potential" beneficial uses *[25]*.

A "thin-layer" site was considered on Horseshoe Shoal parallel to the Thimble Shoal Channel. The site (4 nautical miles by 1 nautical mile with 1 foot fill depth) was envisioned to accommodate about 4 million cubic yards (MCY) of Thimble Shoals Channel dredged material. Due to uncertainties regarding the ability to achieve a uniform layer, and potential disruption of the crab fishery, the proposition has been dropped from further consideration.

Deep Trough-Partial Filling. Eastward of the Hampton Roads Bridge-Tunnel, the approach to the Inner Harbor is a deep channel. A channel of approximately 1.67 million square yards has depths of 90 feet or more. One proposal under consideration is to deposit about 5 MCY of Inner Harbor material which would fill the hole to minus 82 ft. depth *[22]*.

Hydrodynamic modeling studies are being conducted by the Corps of Engineers to evaluate whether the material would be subject to scour and transported into the adjacent channels which are maintained at project depths.

As well, evaluations will be required as to potential effects on salinity patterns within the lower James River. This option accrues no known environmental benefits.

VI. Analysis of Beneficial Use Options in Inner Harbor and Lower Bay

A. Decision Processes - Resource Tradeoffs. All dredged material emplacement results in modification to existing habitats. Such emplacement may result in an incidental biological value for selected species. However, the new habitat may be of less value than the displaced habitat. Thus, habitat development or modification always involves tradeoffs in resource values. As noted by

Lunz *et al [26]*, "The general ecological management objective of habitat development with dredged material would be to maintain or increase the distribution, abundance, and/or biomass of target animal populations and their support populations. Support populations may be plants, animals or both." The identification of target populations must be guided by ecological principles. Such target populations may be selected on the basis of their status of regional commercial, recreational, or ecological significance. In many cases of habitat development target species are the plant and animal populations which support the resources at higher levels in the food chain.

In the formulation of resource management policy guiding habitat development attention must be given to the physical and biological factors extant in local settings. Estuaries, in particular, are characterized by appreciable gradients in physical, chemical, and biological characteristics. Consequently, similar habitats in different parts of an estuary may have significantly different resource values relative to a given habitat development objective. Additional major factors which must be considered in evaluating displaced and developed habitats include *[26]*:

1. Extent of the existing habitat. Within a given zone of an estuary certain types of habitats may cover a small area. Displacement of such limited habitats which may be critical to non-target and support resources should be avoided. For example, submerged aquatic vegetation, being light dependent, is able to grow only in shallow water (two meters or less). Within the Chesapeake Bay and tributaries this depth zone is limited.

2. Successional sequence of developed habitat. After final emplacement of dredged material additional time is required before biological benefits accrue. Moreover, the biological benefits may change over time due to successional changes as the system ages. The planning strategy must take into account which successional stage is targeted and the value of that stage relative to the displaced habitat.

3. Functional characteristics of existing and planned habitats. While a developed habitat may have the physical appearance of a natural system it may not function like a natural system. Planning for a developed habitat should incorporate current scientific understanding to maximize the likelihood of achieving intended function. The physical scale of the habitat developed may also influence functional effectiveness.

For example, a number of wetland development projects have be dertaken but relatively few have been documented to function as ral systems". Thus, habitat development requires careful plannir design, post installation studies and monitoring to determine whe functional objectives are achieved. Ecological modeling will play a creasingly significant role in such planning and evaluation process

4. Cumulative Effects. One of the most challenging questions facing ec system analysts is how much of a given natural habitat is needed in a aquatic ecosystem to achieve optimum conditions. For many aquatic habitats this question cannot be answered with certainty. The question naturally follows as to how much new, developed habitat is sufficient to support the identified target species. While not easily answered, the question must be posed. As noted by Lunz *et al* [26], "Managers and environmental planners need to evaluate existing information and fill in gaps before habitat development becomes a routine choice of dredged material disposal."

Options for beneficial uses of dredged material should be considered in the context of a long-term dredged material management plan. Long-term planning is required because the analysis of alternatives is time consuming and, should a candidate beneficial use option emerge that is appropriate for consideration under the aforementioned Federal programs, substantial time is needed for administrative processing. The Corps of Engineers submits its funding requests for channel maintenance projects two or more years ahead of planned operation. Thus, an alternatives analysis initiated five years before planned operation would likely be required. Projects involving new construction require still longer lead times.

While the Corps of Engineers routinely operates with extended planning and analysis for project development and maintenance, the Commonwealth resource management and advisory agencies do not operate along comparable time-lines. Rather, these agencies work with the Corps on a consultative basis in the later stages of planning, generally after a subset of disposal alternatives have been determined.

In order for the Commonwealth to take better advantage of the potential of beneficial uses of dredged materials, the appropriate state agencies need to engage in long-term planning. Four important steps need to be taken:

1. There needs to be a determination whether additional policy is required to utilize dredged material for aquatic habitat development or modification. Current Commonwealth policy is limited to the use of suitable dredged material for beach nourishment.

2. Resource management goals and objectives which might be supported by appropriate beneficial use strategies must be identified and articulated.

3. A mechanism for long-term planning involving beneficial uses of dredged material needs to be established.

4. A generic decision-making framework needs to be formalized. Each navigation project could then be evaluated in a consistent manner with regard to case specific resource-tradeoff issues.

With such planning elements in place, the Commonwealth could then form a more comprehensive partnership with the Corps of Engineers for systematic evaluation of potential beneficial uses which are consistent with Commonwealth resource management objectives.

B. **Characteristics of Inner Harbor Dredged Materials; Limitations for Beneficial Uses**. Of the approximately 250 million cubic yards (MCY) of dredged material generated from completion of the inner harbor most, about 225 MCY, would be derived from channel maintenance. Over the 50 year project planning period, (1990-2040) average annual maintenance is expected to exceed 4 MCY. Most of the material removed through channel maintenance is fine-grained sediment (silt and clay). The volume of sandy material is relatively small. Of the Inner Harbor channels only the Newport News Channel contains significant volumes of sand. Completion to the project design depth (57 feet, 55 feet plus 2 feet margin) would provide a total of approximately 1.7 MCY. Overdredging to 70 feet would provide approximately 6 MCY. Aside from the Newport News Channel, other channel segments would provide relatively small volumes of sandy materials.

The characteristics of the dredged material impose some limitations on the types and scale of beneficial use for habitat development or modification. To create an island for varied wetland and waterfowl habitat necessitates construction of dikes with sandy material to contain the fine-grained silts and clay pumped into the site. The relatively limited volumes of sandy materials available constrains the number and/or scale of such habitat construction. While additional sand material could be obtained from borrow sites external of the channels, additional costs and resource tradeoffs at the borrow site would come into play.

C. **Options**. In all of the options discussed below, the dredged material is assumed to be that deemed suitable for ocean disposal (i.e., not contaminated).

1. Beach Nourishment. Within the entirety of the 55 foot project three channel segments will yield substantial amounts of sandy materials. They are the Atlantic Ocean Channel, the eastern most portion of the Thimble Shoals Channel, and the Channel to Newport News. Other segments contain smaller pockets of suitable material. The Corps of Engineers has conducted several studies *[27]* with respect to utilization of materials from the Atlantic Ocean Channel for beach nourishment in the City of Virginia Beach, and for materials from the eastern section of Thimble Shoals Channel on the beaches of the Cities of Norfolk and Hampton.

The Channel to Newport News would yield approximately 1.7 MCY of sandy materials when completed to a depth of 57 feet and up to 6 MCY if overdredged to a depth of 70 feet. Corps of Engineers evaluation of the material indicates the sand materials are too fine for beach nourish-

ment. However,the material is suitable for construction of dikes for containment of fill.

2. Island Creation for Wetland/Waterfowl Habitat. Over the past century appreciable wetland and waterfowl habitat has been lost through natural erosion processes. The use of dredged material for replacement habitat has substantial potential. However, there are significant issues associated with such development. In particular, resource tradeoffs involving the displaced habitat need to be fully assessed. Also, while some types of habitat structure may be successfully shaped, there remains substantive debate whether or when all of the functional aspects of such habitats are achieved.

   Two design aspects warrant particular attention. Such habitats should be constructed either in proximity to similar natural habitat to achieve scale affects, or be of such substantial scale to fully realize potential habitat objectives. Secondly, the constructed habitat should be protected from erosive forces by armoring the dikes or berms exposed to wave and/or tidal current forces.

   Subaqueous bottoms are the property of the Commonwealth. The Code of Virginia (28.2-1201A) also provides that "All islands which rise by natural or artificial causes from lands which are in common under 28.2-1200 shall remain in public ownership and continue as a common."

   Application to James River/Hampton Roads. Based upon the current levels of analysis two candidate sites emerge for further evaluation.

   - Habitat expansion at Ragged Island as proposed by ODU offers several clear benefits. First, the project is proposed to be constructed adjacent to an existing state-managed resource area, and to be eventually incorporated into that managed resource area. Secondly, the project is of such substantial scale and in such close proximity to an existing managed natural resource area that likelihood of the project achieving desired habitat objectives is improved. Thirdly, the project is not only designed to protect itself from erosive forces, but to protect the remaining natural shoreline of the adjacent management area as well. However, as originally proposed at 870 acres (*Figure 5*), there is substantial excursion onto public oyster grounds (Baylor Grounds). Due to prevalence of oyster diseases, there is no commercial oyster production from these beds. It may be possible to include new oyster beds in the project design. Nonetheless, Article II, Section 3, of the Constitution of Virginia reserves to the General Assembly the authority to remove bottom areas from Baylor Grounds. The project layout, as proposed, extends an appreciable distance over the shallow flank of the river. This extension may significantly interrupt the lower James River circulation thought to control oyster larvae transport. Three-dimensional hydrodynamic modeling must be utilized to examine the appropriate design of the site.

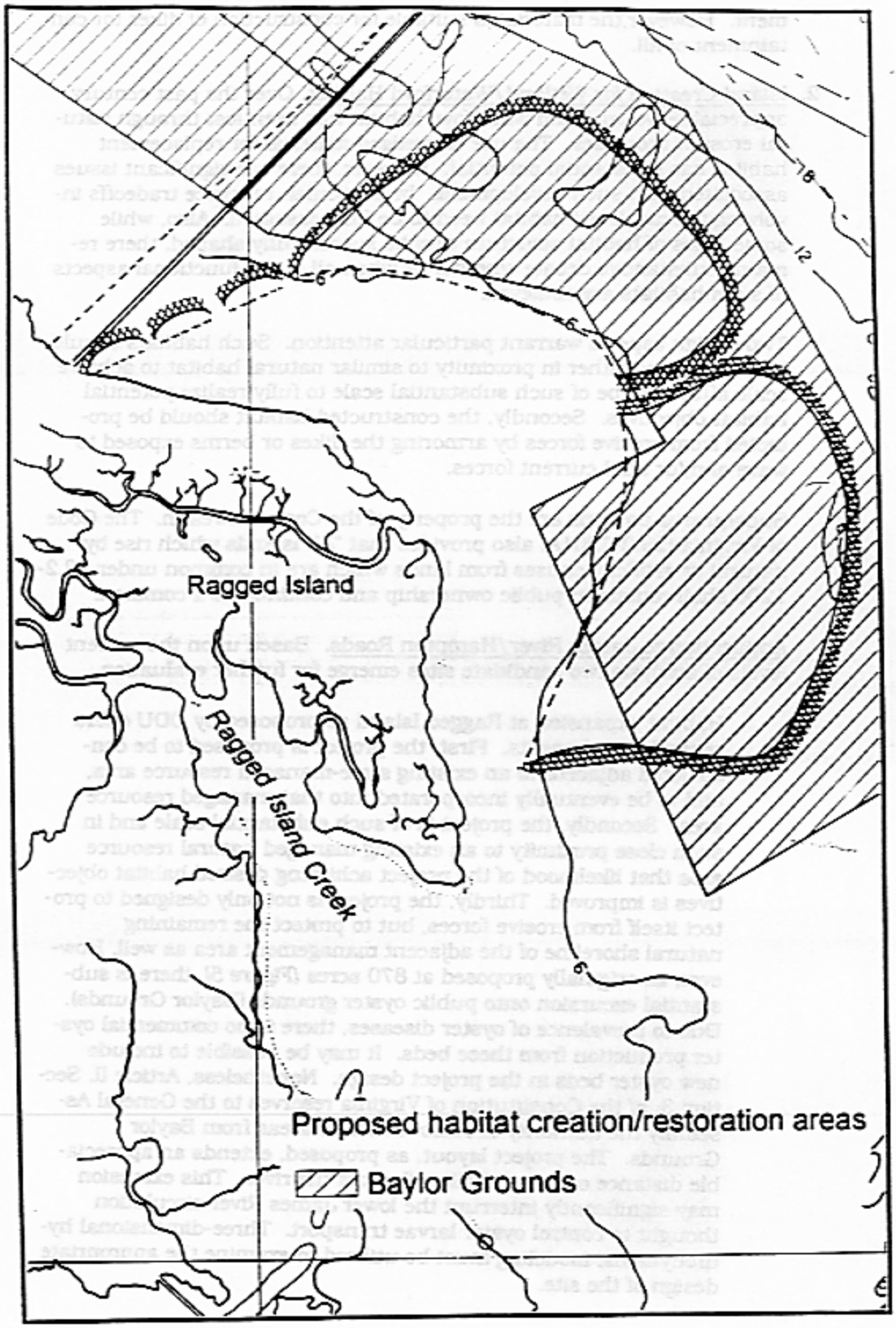

FIGURE 5. Proposed Habitat Creation Area Off Ragged Island, James River. Reproduced from Reference 23.

- The area west of, and adjacent to, Craney Island should also be viewed as a viable site for habitat development. Preliminary evaluation suggests the benthic resource tradeoffs may be acceptable. However, an interpretation of law arising from House Bill 1478 *(Code 62.1-132.20)* will be required to determine whether such habitat development would violate legislative intent. Even with a permissive interpretation, several additional steps will be required in the environmental evaluation. These include a more comprehensive analysis of the resource tradeoffs, and three-dimensional hydrodynamic modeling to determine whether such habitat development would adversely impact the circulation of the lower James River. It must also be determined whether waterfowl attracted to the habitat would be adversely exposed to contaminated sediment placed on Craney Island, an area likely to be incorporated in their range of utilization.

3. Oyster Bar Restoration. In the past, natural oyster reefs were widespread throughout the Chesapeake Bay and tributaries. Over several centuries of harvesting these reefs have been depleted. In more recent decades the prevalence of oyster diseases, combined with continued harvest, and perhaps degraded water quality, has further depleted the oyster stocks. In addition to any commercial significance oyster reefs have important roles in the function of the estuarine system. In sufficient numbers, oysters may be significant in maintenance of water quality due to filter feeding with resultant removal of material in the water column, which may also achieve a favorable shift in the planktonic food chain *[28]*. Moreover, the faunal assemblage associated with the oyster reef may be important as spawning, nursery and feeding habitat for species supporting finfish and crabs. Recognizing the ecological significance of oyster reefs the Chesapeake Bay Program Executive Council recommended the development of an Aquatic Reef Habitat Plan. Suitable dredged material can be used for oyster reef development when a cap of oyster shell is added to provide a substrate suitable for oyster larvae settlement.

   James River Application. Restoration of the James River oyster populations is crucial. Given the current prevalence of oyster diseases the most logical location for development of oyster reefs from dredged materials is in the vicinity of Wreck Shoal and Point of Shoals where infection levels are lower than downriver areas. Developed reefs should be treated as sanctuary areas since the goal is to restore natural habitat. Although not open to harvest, such reefs would serve as sources of larvae to those areas open to harvest. Pending demonstrated success with the initial efforts and reduction in disease intensity, additional reefs could be developed downriver.

4. Submerged Aquatic Vegetation Habitat (SAV).

   SAV is dependent upon water column light penetration for photosynthesis. Under current water quality conditions suitable light penetration is limited to less than two meters (mean low water) during the growing season. Thus, SAV habitat is limited to relatively shallow water. SAV habitat area could be increased by filling selected areas to appropriate

depth. This has recently been demonstrated by a pilot study in Maryland *[15]*.

James River Application. In decades past there were substantial SAV beds in the lower James River. At present only a small bed remains on Hampton Flats. The reason for this limitation is not clear although ambient turbidity is probably implicated. In the absence of restoration in the existing habitat, construction of additional habitat area is not recommended.

5. Application of Dredged Materials to Enhance Benthic Habitat.

The conceptual framework for benthic habitat modification is discussed in Section V. This strategy is not deemed suitable within the Lower James River or Inner Harbor area due to space restrictions and the potential impacts on oyster beds of the Lower James.

However, there are areas within the lower Chesapeake Bay where this strategy may have limited potential. Further evaluation is warranted.

6. Creation of Shoals for Fisheries Enhancement.

Fishes tend to congregate around structures and bottom areas with topographic relief. Under suitable circumstances dredged materials could be used to create topography. In 1988 a massive dredged material mound of fine-grained sediments was constructed near Mobile Bay, Alabama. The site covered 2.5 square miles with elevation up to 20 feet. Post-disposal studies indicated rapid colonization by a diverse benthic fauna which provided a forage base for local fish populations *[29]*.

The southern portion of the Chesapeake Bay has substantial sand shoal topography. The southern portion of the Bay has moderately strong tidal currents and experiences significant wave action from the Bay mouth and within the Bay. These hydrodynamic forces constantly shape and remold the shoals. Most of the dredged materials from the Inner Harbor and Thimble Shoals Channel are soft, fine-grained sediments. Such materials would be more susceptible to erosion and resuspension. Given the likely physical instability and the fact that there already is substantial bottom topography, the creation of additional topography is contraindicated.

7. Filling Deep Holes. While this option does not satisfy the conditions of beneficial uses as defined in this report, the option is discussed because of potential adverse impacts to the ecosystem, particularly as deep topography may be seasonally important finfish habitat. Deep holes are known to provide critical winter habitat for striped bass, white perch and other species in the less saline portions of the Bay and tributaries *[30]*. The significance of deeper topography in the more saline portions of the Bay is poorly understood due to the paucity of finfish survey data in the deep holes. However, it is well documented that fish congregate around structures and topographic relief features. Deep water habitat is highly limited in the Virginia portion of the Bay

and tributaries *(Figure 6)*. Given what is known about finfish utilization of deep water habitat in less saline portions of the Bay and tributaries, and what remains unknown about utilization of deep water habitat in the higher salinity areas, placement of dredged materials in deep holes should be discouraged.

D. **Cost Estimates**. The cost estimates presented herein were prepared by the Army Corps of Engineers, Norfolk District for the aforementioned Beneficial Uses Workgroup *[20]*. Since the scenarios treated have not been subjected to an advanced design and engineering analysis the estimates must be considered as very preliminary. Nevertheless, the Corps of Engineers indicates that the estimates are useful for cost comparisons between the various beneficial use scenarios and disposal at Dam Neck Ocean Disposal Site (the only designated ocean disposal site), which is the only alternative given the limited remaining capacity of Craney Island.

Dredging and disposal costs are determined by a number of factors. Distance to the disposal site is a significant factor as is the accessibility of the site. Since mobilization and demobilization costs are significant, the size (volume) of the project is a substantive factor. Disposal operations that require multiple handling of the dredged material or other special handling are more costly. For the purposes of these estimates, the Corps of Engineers used a bucket dredge with scow hauling when disposal distance and site characteristics precluded use of hopper dredge or direct hydraulic pipeline discharge.

Table 1 portrays estimated costs of the beneficial use options discussed in Section V. While dollar values are shown they are included only to establish the order of magnitude of expected cost. However, the cost ratios which compare "beneficial use" options to ocean disposal are particularly relevant. Because of the requirements of multiple or special handling involved with habitat creation such as wetland/upland islands, the costs are substantially greater than ocean disposal. In the case of island habitat the cost per acre is appropriately cast as the incremental cost between ocean disposal and habitat creation rather than the full cost. For the case of island creation adjacent to Ragged Island the relative values are $118K per acre for 1025 acres, $135K per acre for 200 acres, and $220K per acre for 50 acres.

Several factors could influence more refined estimates. Advanced engineering processes may change the storage capacity of the islands, thereby changing the individual storage capacities, and the comparative scale costs.

Relative to other habitat creation or modification "thin layer" application to enhance benthic resource value has a near neutral cost ratio. This case reflects the opportunity to use a short distance hydraulic pipeline discharge. Cases involving greater distances would exhibit a less favorable cost ratio.

Only in the case of disposal in the deep trough east of the Hampton Road Bridge Tunnel does the cost ratio reflect disposal at less cost than ocean disposal. As noted earlier this option offers no known environmental benefit. The option is "beneficial" only with respect to cost.

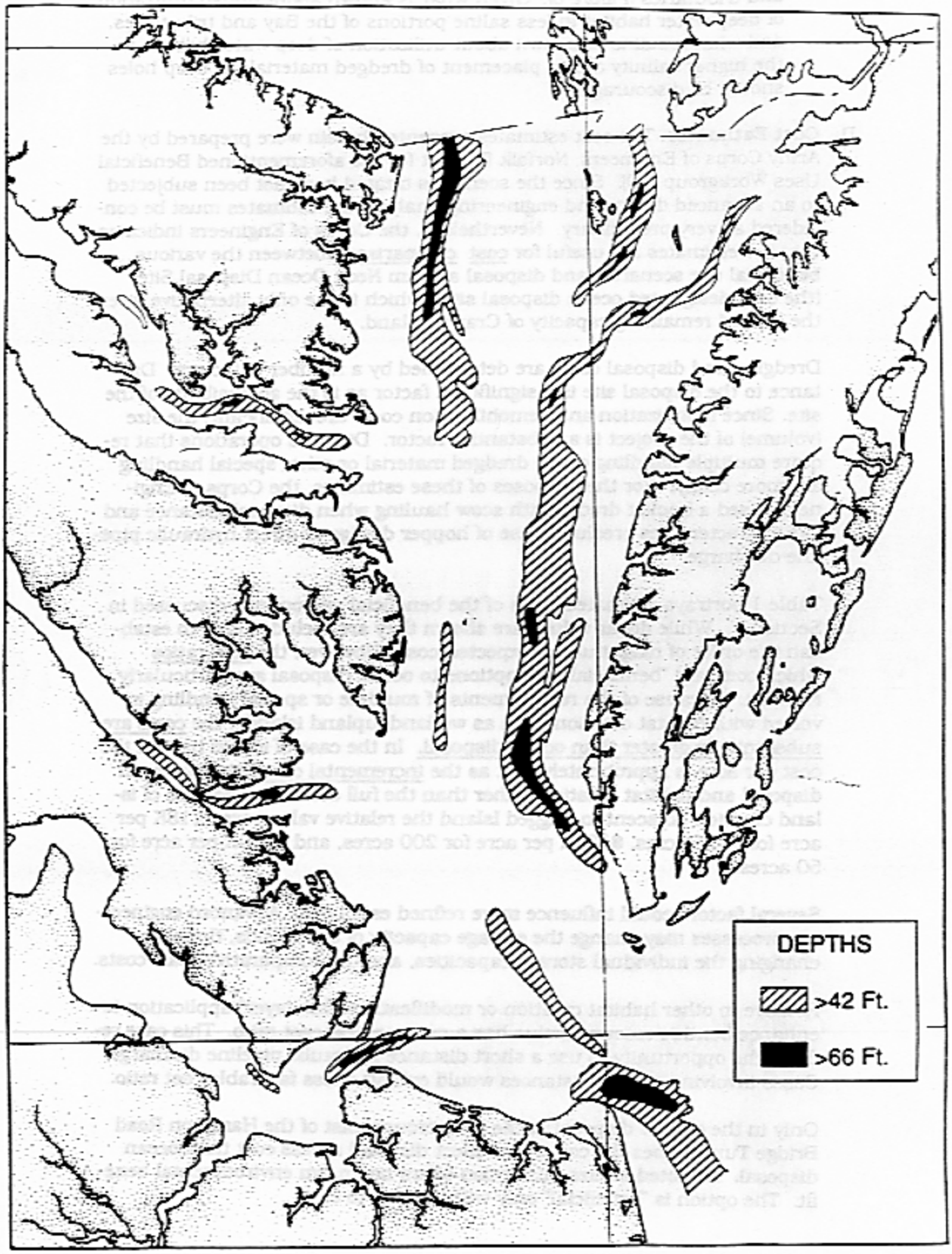

FIGURE 6. Deep Water Areas (Excluding Navigation Channels) Within the Lower Chesapeake Bay and Tributaries.

TABLE 1: COST COMPARISONS BETWEEN BENEFICIAL USE OPTIONS AND DISPOSAL AT DAM NECK OCEAN DISPOSAL SITE

(Based on Army Corps of Engineers Estimates)

OPTION	LOCATION	MATERIAL VOLUME (MCY)	OPTION COST	OPTION COST PER CY	DNODS COST PER CY	+ PER CY COST RATIO
1025 Acre Island	Ragged Island	16.3	*$243,230,000	$14.92	$ 7.51	2.0
200 Acre Island	Ragged Island	5.7	*$ 69,784,000	$12.35	$ 7.50	1.6
50 Acre Island	Ragged Island	1.9	*$ 25,252,000	$13.47	$ 7.50	1.8
46 Acre Wetland	Mulberry Island	0.34	$ 5,356,000	$15.57	$ 7.60	2.0
8 Acre Oyster Reef	Point of Shoals	0.03	**$ 344,000	$22.68	$16.61	1.4
Thin Layer 3443 Acres	Thimble Shoals	5.5	$ 45,375,000	$ 8.25	$ 7.29	1.1
Fish Habitat 2 Berms 0.8 Acre	Lower Bay	0.009	***$ 125,000	$14.50	$ 7.82	1.8
Disposal in Deep Trough	East of Hampton Roads Bridge Tunnel	5.1	$ 34,784,000	$ 6.82	$ 7.75	0.9

\+ COST RATIO = $\frac{\text{Alternate Disposal Option}}{\text{Disposal Cost at DNODS}}$ DNOS = Dam Neck Ocean Disposal Site

* Cost includes riprap, excludes costs of shaping habitat, planting at habitat, and monitoring costs.

** Estimate based on option as part of larger dredging project; cost reflects equipment limitations.

*** Estimate based on option as part of larger dredging project.

The cost estimates presented in *Table 1* do not include costs associated with site planning studies or those of post-disposal shaping of the habitat, planting, and monitoring. As well, cost factors would likely increase if there were seasonal disposal restrictions imposed.

Finally, it is noteworthy that the cost comparisons are cast in terms of ocean disposal at the Dam Neck Ocean Disposal Site. Comparisons with disposal at the, somewhat more distant, Norfolk Disposal Site would presumably be more favorable.

E. **Funding Mechanisms for Beneficial Uses.** Ultimately, the distribution of costs for beneficial uses of dredged materials would be determined by negotiation between the Corps of Engineers and the Virginia Port Authority via local cost-sharing agreements. In particular, an interpretation of Section 1135 of WRDA 1986 (PL99-662) as amended will be required as it pertains to the discussed beneficial use projects associated with the Norfolk Harbors and Channels Project *[31]*. It appears that Section 204 of WRDA 1992 would apply since it is not restricted to projects existing at the time of enactment. Another avenue for funding larger beneficial use projects is by project specific authorization in civil works program legislation.

F. **Regulatory Process.** Any of the envisioned scenarios for beneficial use of dredged material will undergo environmental review mandated by federal, state and local law. The degree of scrutiny and the governmental levels involved will be a function of the size and scope of the proposal as well as the number and type of aquatic resources expected to be adversely affected. The degree of scrutiny can be predicted to be high under almost any scenario involving the James River because of the multiple uses practiced in the river and the wide-ranging unique resources involved.

The James River receives multiple waste loads from sewage treatment plants, thermal effluents, point source industrial effluents and significant dredging disruptions due to the presence of numerous shipping channels, military bases and shipping terminals including coal and container cargo.

At the same time, the James supports summer crab pot fisheries, a significant commercial hard clam fishery, the oyster seed beds, public oyster grounds (Baylor) and private leases, significant sports and commercial fin fisheries, spawning grounds for various estuarine organisms and a number of rare and endangered birds, turtles and other species. Large areas of vegetated and nonvegetated wetlands (mud flats) occupy the lateral margins of the river and its tributaries. This multiplicity of factors will make any environmental review quite complicated, sensitive, and time-consuming.

Once a plan or plans are developed for a beneficial use scenario, the first step will be the development of an Environmental Assessment (EA) and/or Environmental Impact Statement (EIS) as required under the National Environmental Policy Act (NEPA) which includes consideration of economics, alternatives, and impacts of not doing the project. Depending on the scope and significance of the natural resources impacted, much time may be required in conducting studies to determine the degree of significance and methods of impact avoidance. The first step in the process involves a scop-

ing procedure wherein all regulatory and advisory agencies, as well as the general public, define the type and scope of information necessary and the issues involved with the proposal. Once the studies are completed and required information has been collected, a draft Environmental Assessment or Impact Statement is produced and circulated for comment. These comments are collected and incorporated into the draft document which is circulated as a Final Draft. This then becomes the primary decision-making and informational tool in the permit review process involving the three basic levels of government (See *Figure 7* which incorporates the proposed Department of Environmental Quality).

Federal permit review is carried out under the authority of Section 404 of the Clean Water Act, as amended, Section 103 of the Marine Protection, Research and Sanctuaries Act (MPRSA), and the Fish and Wildlife Coordination Act. The latter requires the sponsoring agency to give equal weight to environmental issues and mandates coordination with the National Marine Fisheries Service (NMFS), the Fish and Wildlife Service (F&WS), and other federal agencies as well as state resource and advisory agencies. Section 404 involves evaluation of dredging and filling operations in navigable waters of the United States, including wetlands. A Section 404(b)(1) evaluation is performed to assess the water quality related impacts associated with dredging and filling. Section 103 of MPRSA specifies that all proposed operations involving the transportation and dumping of dredged material into ocean waters have to be evaluated to determine the potential environmental impact of such activities. Also invoked at this point are the provisions of the Endangered Species Acts (state and federal) and the Marine Protection, Research and Sanctuaries Act. This review will involve a practicable alternatives analysis, wetlands and other special aquatic site review, mitigation-compensation review and water quality impact assessment. Also analyzed are impacts to human health, aquatic life and wildlife, and in addition, aquatic ecosystem diversity, productivity and stability. Consideration is also mandated for historical, recreation, aesthetic and economic values of the aquatic system.

Concurrent to the Section 404 review, the state and local review process takes place, involving as many as four permits or certifications. If the proposal is federally sponsored, a local wetlands permit may be required if tidal wetlands are involved. Additionally, a permit is required for encroachment on state-owned subaqueous land which entails a full public interest review by the Virginia Marine Resources Commission staff, with the assistance of the Virginia Institute of Marine Science, and final action taken at public hearing by the VMRC commissioners. The Virginia Water Protection Permit involves review of water quality impacts by the staff of the Water Control Board to include non-tidal wetlands impacts. This permit serves the same function and enhances the effectiveness of the 401 Certification delegated under the Clean Water Act. The fourth state action required for federally sponsored projects involves a Federal Consistency determination to ensure that the proposal is consistent with Virginia's Coastal Resources Management Plan. This determination is made within the proposed Department of Environmental Quality, assuming current agency responsibilities are maintained.

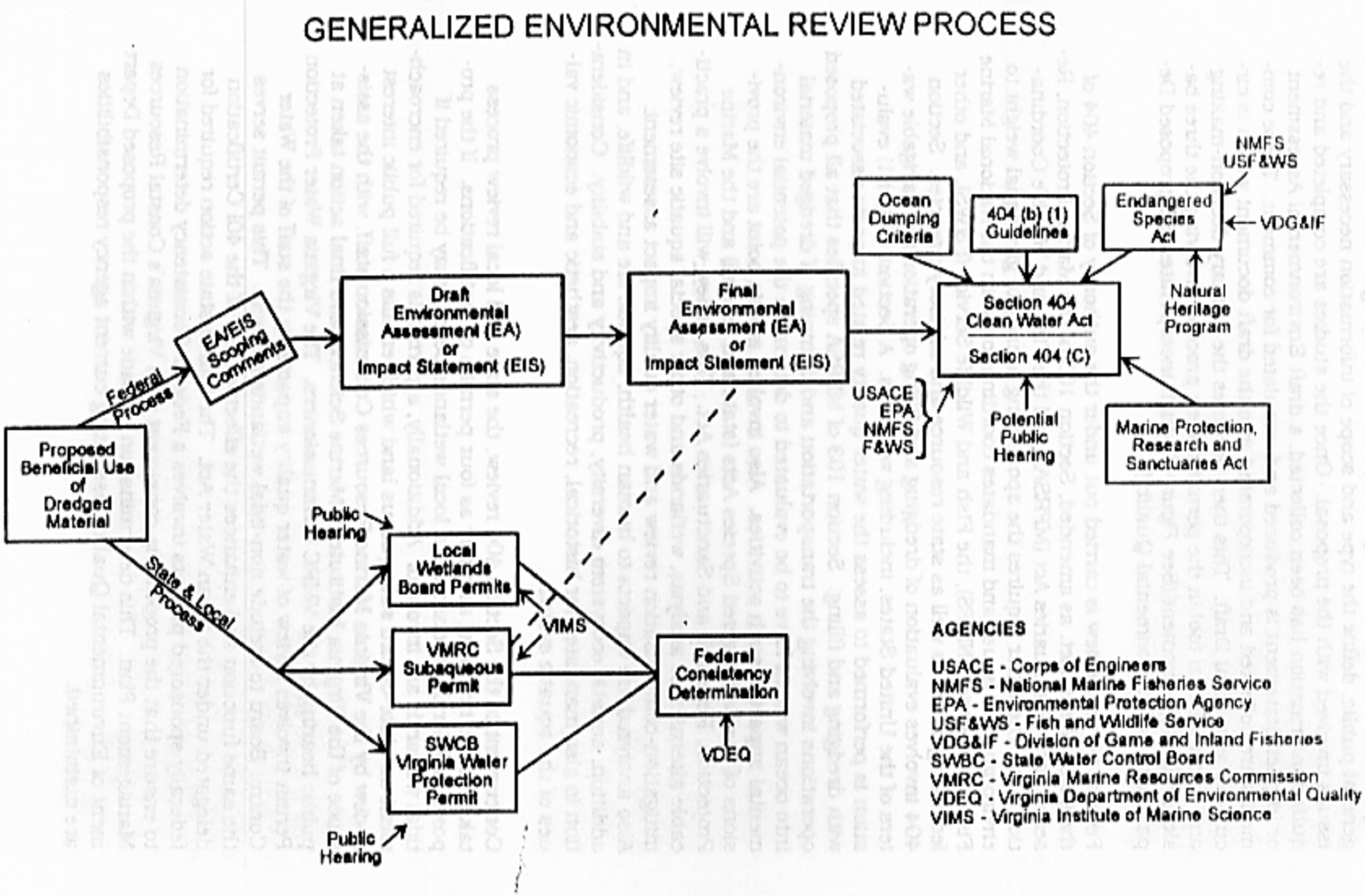

FIGURE 7. Generalized Environmental Review Process.

Once all permits and certificates have been issued the proposal may proceed. It should be noted that failure to receive any one of the approvals dooms the proposal: all are required. Each permit may also include its own modifications and permit conditions intended to minimize adverse environmental impacts.

VII. Conclusions and Recommendations

A. **Need for Commonwealth Program in Long-Range Dredged Material Management Planning.** Over the long-term there could be substantial benefits to the Commonwealth in environmentally beneficial uses of dredged material. The issue must be addressed on a long-term, Commonwealth-wide basis. The issue is substantially broader than the question of coping with the disposal of materials from Hampton Roads. Options for beneficial use of dredged material from navigation projects should be considered in the context of a long-term dredged material management plan. Long-term planning is required because the analysis of alternatives is time consuming, and should a candidate beneficial use option emerge, the administrative processing time for consideration under Federal programs is substantial.

While the Corps of Engineers routinely operates with extended planning and analysis for project development and maintenance, the Commonwealth resource management and advisory agencies do not operate along comparable time-lines. Rather, these agencies work with the Corps on a consultative basis in the later stages of planning, generally after a subset of disposal alternatives have been determined. In order for the Commonwealth to take better advantage of the potential of beneficial uses of dredged material, the appropriate state agencies need to engage in long-range planning.

RECOMMENDATION: The appropriate resource management, advisory, and economic development agencies of Virginia should join together to draft a long-term dredged material management plan, which includes consideration of beneficial uses, for subsequent review by the Executive and the Legislative branches. Elements considered in the draft plan should include:

a. Establishment of goals, objectives, and mechanisms for long-term dredged material planning for Federal navigation projects in the Commonwealth.

b. Identification of resource management goals and objectives which can be supported by appropriate beneficial use and general impact mitigation strategies.

c. Determination of strategies for effective interagency cooperation between state, federal and local governments in program implementation.

d. Initiation of a generic evaluation framework to guide review of specific projects with respect to management objectives and resource trade-offs associated with beneficial uses of dredged material.

e. Examination of potential funding mechanisms to meet non-Federal cost sharing requirements for beneficial uses.

f. Examination of potential state policy issues.

g. Determination of additional agency resources required to execute a long-term dredged material management program.

B. Limitations of Beneficial Uses for Inner Harbor Dredged Materials. Beneficial uses of dredged material for habitat creation or modification should not be viewed as a strategy to replace ocean disposal or to significantly relieve the pressure for a confined disposal site. However, limited habitat creation could serve to augment these means of disposal. This view of limited application is held because:

1. Within the Inner Harbor approximately 250 million cubic yards of dredged material will be generated over a 50 year term. Of the beneficial use options reviewed, creation of islands for varied wetland and/or waterfowl utilizes the largest volume of dredged material per unit area. A 1,000 acre island would utilize about 16 to 20 million cubic yards. There are a limited number of suitable sites, a number insufficient to accommodate the volume of material generated.

2. Creation of an island for varied wetland and waterfowl habitat necessitates construction of dikes with sandy material in order to contain the fine-grained silts and clays pumped to fill the site. The channels and anchorages to be dredged in the inner harbor contain a very limited supply of suitable dike material. This further constrains the number and scale of such habitat creation. While additional sand material could be obtained from borrow sites external of the channels, additional costs and resource tradeoffs at the borrow site would come into play.

3. The cost of habitat development which requires multiple or special handling is significantly greater than ocean disposal, even if the site is within a distance equivalent to the ocean disposal site. Preliminary cost analysis by the Corps of Engineers for island habitat creation indicates a negative cost factor of about 1.5 to 2 compared to disposal at the Dam Neck Ocean Disposal Site. Comparisons with disposal at the somewhat more distant Norfolk Disposal Site, yet to be designated, would presumably be somewhat more favorable. Those estimates exclude costs associated with pre-construction planning or post-disposal shaping of the habitat, planting, and monitoring. Costs would also likely increase if seasonal disposal restrictions were imposed.

RECOMMENDATION: In spite of the limitations noted, it is recommended that evaluations continue on the most promising options for habitat creation or modification. Viewed over the long-term such applications could be an important testing ground to demonstrate the utility of such beneficial uses. Of the beneficial use options reviewed, three emerge as candidates for further evaluation:

- Development of islands in the lower James -Hampton Roads for accrued wetland and/or waterfowl habitat.

- Development of oyster reef habitat in the lower James River, and

- Application of dredged material, in a thin layer, for benthic habitat enhancement for target finfish species in the lowermost portion of the Chesapeake Bay.

1. **Island Creation for Wetland/Waterfowl Habitat**

   a. Adjacent to Ragged Island Wildlife Management Area. This site has received initial screening by the Beneficial Uses Workgroup. Construction at this site would expand the scale of existing habitat, and with suitable design could reduce ongoing shoreline erosion. Substantial further evaluation will be required, including:

      - Evaluation of resource tradeoffs. This requires field studies of the existing benthic community, and design of the intended habitat.

      - Three-dimensional hydrodynamic modeling analysis of the potential influence of various configurations on the flow patterns in the lower James River.

      - Determination of site management.

      - Engineering analysis and refined cost estimation.

      - Planning and design of monitoring studies to evaluate functional response.

   b. **Adjacent to West Side of Craney Island**. While the site may have potential for habitat development, the first step necessary is a determination whether such development would violate the intent of House Bill No. 1478. Pending that outcome, the same elements noted above pertain to the evaluation required.

2. **Oyster Reef Habitat in the Lower James River**. The oyster beds of the lower James River have been critically important to the Virginia oyster industry. Restoration of the oyster stocks is a critical need. Evaluation of a pilot-scale oyster reef restoration project is warranted. Site evaluation should be undertaken in the vicinity of Wreck Shoal-Point of Shoals. Relief created with sandy dredged material should be covered with shell cultch for oyster settlement. While the site should be held as a no-harvest sanctuary, the larvae generated from the site will support the oyster bottoms open to harvest. Elements in further evaluation include:

   - Strategies to minimize impacts on active oyster grounds.

   - Studies of potential influence on larval transport patterns.

   - Assessment of benthic resource tradeoffs.

- Detailed engineering analysis and cost estimation.

- Planning and design of monitoring studies to assess functional objectives.

3. **Benthic Habitat Enhancement Using Dredged Material.** This recommendation should not be interpreted as conventional open water disposal. Rather, what is intended is a pilot-scale test as to the potential benefit of limited, "thin layer", application for benthic resource enhancement. Such application is not recommended within the areas of the Inner Harbor or lower James River. However, sites within the southernmost sector of the Chesapeake Bay should be evaluated as to whether dredged materials from the Thimble Shoals Channel or the Inner Harbor channels would be suitable to achieve enhancement of the benthic habitat with respect to targeted finfish species.

REFERENCES

[1] U. S. Army Corps of Engineers. 1986. "Beneficial Uses of Dredged Material." Engineer Manual 1110-2-5026. Washington, DC.

[2] Hampton Roads Maritime Association. 1992. The Port of Greater Hampton Roads Annual. 1992. Norfolk, Virginia. 242 pp.

[3] Yockum, Gilbert R., and Vinod B. Agarwal. 1988. "The Economic Impact and Rate of Return of Virginia's Ports on the Commonwealth." College of Business and Public Administration, Old Dominion University, Norfolk, Virginia. 132 p.

[4] National Research Council. 1985. "Dredging Coastal Ports, An Assessment of the Issues." National Academy Press. Washington, DC. 212 p.

[5] U. S. Army Corps of Engineers. 1990. "Norfolk Harbor and Channels, Virginia; Long-Term Disposal (Inner Harbor)." 1990. U. S. Army Engineer Norfolk District.

[6] U. S. Army Corps of Engineers. 1986. General Design Memorandum 1, Norfolk Harbor and Channels, Virginia, June. U. S. Army Engineer Norfolk District.

[7] U. S. Fish and Wildlife Service. 1989. "Planning Aid Report on the Norfolk Harbor and Channels, Virginia, Long-Term Disposal Study," October.

[8] Personal Communication, Samuel E. McGee, Norfolk District, Corps of Engineers.

[9] National Research Council. 1989. "Contaminated Marine Sediments, Assessment and Remediation." National Academy Press, Washington, DC. 493 p.

[10] U. S. Army Corps of Engineers. 1977. "Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Water." U. S. Army Engineer Waterways Experiment Station. Vicksburg, Mississippi.

[11] U. S. Environmental Agency. 1991. "Evaluation of Dredged Material Proposed for Ocean Disposal." EPA-503/8-91/001. U. S. Environmental Protection Agency. February.

[12] Personal Communication, Samuel E. McGee, Norfolk District, Corps of Engineers.

[13] Nichols, Maynard M. and M. M. Howard-Strobel. 1991. "Evolution of an Urban Estuarine Harbor: Norfolk, Virginia." Journal of Coastal Research. Vol. 7, No. 3. pp.745-757

[14] Boyd, M. B. *et al.* 1972. "Disposal of Dredge Spoil, Problem Identification and Assessment and Research Program Development." Technical Report H-

72-8, U. S. Army Engineer Waterways Experiment Station. Vicksburg, Mississippi. 121 p.

[15] National Oceanic and Atmospheric Administration and U. S. Army Corps of Engineers. 1990. "Pilot Study to Determine the Feasibility of Establishing a Nationwide Program of Fisheries Habitat Restoration and Creation." 58 p.

[16] Maryland Department of Transportation. 1991. "Recommendations of Governor William Donald Schaefer's Task Force on Dredged Material Management." 13 p.

[17] U. S. Army Corps of Engineers. 1991. "Chester River, Queen Anne County, Maryland," Section 1135 Feasibility Report and Draft Environmental Assessment. U.S. Army Engineer Baltimore District.

[18] Vann, Ronald G. and Elizabeth G. Waring. "Beneficial Uses of Dredged Material, Concepts and Experiences." U. S. Army Engineer Norfolk District, unpublished manuscript. 9 p.

[19] Lunz, John D., *et al.* 1978. "Habitat Development Field Investigations: Windmill Point Marsh Development Site, James River, Virginia." Technical Report D-77-23, U. S. Army Engineer Waterways Experiment Station. 116 p.

[20] U. S. Army Corps of Engineers. 1991. Interagency Work Group Meeting on Lower Bay Dredged Material Beneficial Uses, 13 February, 1991. U. S. Army Engineer Norfolk District. 14 p.

[21] U. S. Army Corps of Engineers. 1991. "Candidate Beneficial Use Projects." Working Paper for Interagency Work Group Meeting, 10 April, 1991. U. S. Army Engineer Norfolk District. 14 p.

[22] U. S. Army Corps of Engineers. 1992. "Alternatives,Environmental and Economic Evaluations," Lower Bay Dredged Material Beneficial Uses Study, June, 1992. U. S. Army Engineer Norfolk District. 66 p.

[23] Bedenbaugh, Robin L. 1991. "Beneficial Uses of Dredged Material." Applied Marine Research Laboratory, Old Dominion University, Norfolk, Virginia. 6 p.

[24] De Alteris, Joseph T. 1986. "The Sedimentary Processes and Geomorphic History of Wreck Shoal, An Oyster Reef of the James River, Virginia." Unpublished Ph.D. dissertation, School of Marine Science, College of William and Mary. 205 p.

[25] Wilber, Pace. 1992. "Thin-Layer Disposal: Concepts and Terminology." Information Exchange Bulletin, Vol. D-92-1. U. S. Army Engineer, Waterways Experiment Station, Vicksburg, Mississippi.

[26] Lunz, John D., R. J. Diaz, and R. A. Cole. 1978. "Upland and Wetland Habitat Development with Dredged Material: Ecological Considerations." Technical Report DS-78-15. U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. 50 p.

[27] McGee, Samuel E. 1988. "Beach Nourishment and Shoreline Stabilization: The Use of Dredged Material From the Hampton Roads Deepening Project." in Landin, M. C., Editor. 1988. "Beneficial Uses of Dredged Material", Proceedings of the North Atlantic Regional Conference, 12-14 May, 1987, Baltimore, Maryland. U. S. Army Engineer Waterways Experiment Station. 231 p.

[28] Ulanowicz, R. E. and J. H. Tuttle. 1992. "The Trophic Consequences of Oyster Stock Rehabitation in Chesapeake Bay." Estuaries. Vol. 15, No. 3. p. 298-306.

[29] Clarke, D. and R. Diaz. 1990. "Benthic Recovery at a Massive Dredged Material Disposal Mound," 20th Annual Marine Benthic Ecology Meeting, 26-29 March. Newport, Rhode Island [abs].

[30] Personal Communication, James Colvocoresses, Virginia Institute of Marine Science.

[31] Personal Communication, Craig Seltzer, U. S. Army Corps of Engineers, Norfolk District.

APPENDIX 1

CHAPTER 686

An Act to amend the Code of Virginia by adding a section numbered 62.1-132.20. relating to the Craney Island Disposal Area.

[H 1478]

Approved April 3, 1991

Be it enacted by the General Assembly of Virginia:

1. That the Code of Virginia is amended by adding a section numbered 62.1-132.20 as follows:

§ *62.1-132.20. Craney Island Disposal Area.–*

A. No agency of the Commonwealth, including the Virginia Port Authority, shall have the authority to expand the Craney Island Disposal Area northward or westward or beyond its present capacity or to cause activities which will result in such expansion of the Craney Island Disposal Area. In addition, no state funds shall be expended for any activities which will result in the expansion of Craney Island northward or westward or beyond its present capacity as a disposal area for material dredged from any site, including the Hampton Roads Harbor.

B. The Virginia Port Authority is hereby directed, in coordination with other state and federal agencies, including the United States Army Corps of Engineers, to locate, establish, and use ocean disposal areas for ocean-suitable dredge materials from Hampton Roads Harbor, or some other suitable site, and to use the existing Craney Island Disposal Area for dredge material suitable or unsuitable for alternate disposal, including ocean disposal, with priority given to materials dredged from the Southern Branch of the Elizabeth River.

C. Prior to the disposal of any dredged material either at an ocean area or on the Craney Island Disposal Area, after the Craney Island Disposal Area has attained its capacity limit, the appropriate state agencies shall investigate and consider the cost and availability of beneficial uses of the dredged material. The appropriate state agencies shall consult with state and federal agencies to ensure the environmental acceptability of any beneficial use. When such environmentally acceptable beneficial use is available and economically feasible, the appropriate state agencies shall pursue such use.

For purpose of this section, "Craney Island Disposal Area" means that parcel of land lying and being in the body of water known as Hampton Roads Harbor, within the City of Portsmouth and adjacent to the City of Suffolk.

APPENDIX 2

WATER RESOURCES DEVELOPMENT ACT OF 1986

§1115. PROJECT MODIFICATIONS FOR IMPROVEMENT OF ENVIRONMENT.

(a) The Secretary is authorized to review the operation of water resources projects constructed by the Secretary before the date of enactment of this Act to determine the need for modifications in the structures and operations of such projects for the purpose of improving the quality of the environment in the public interest.

(b) The Secretary is authorized to carry out a demonstration program in the two-year period beginning on the date of enactment of this Act for the purpose of making such modifications in the structures and operations of water resources projects constructed by the Secretary before the date of enactment of this Act which the Secretary determines (1) are feasible and consistent with the authorized project purposes, and (2) will improve the quality of the environment in the public interest. The non-Federal share of the cost of any modifications carried out under this section shall be 25 percent.

(c) The Secretary shall coordinate any actions taken pursuant to this section with appropriate Federal, State, and local agencies.

(d) Not later than two years after the date of enactment of this Act, the Secretary shall transmit to Congress a report on the results of the review conducted under subsection (a) and on the demonstration program conducted under subsection (b). Such report shall contain any recommendations of the Secretary concerning modification and extension of such program.

(e) There is authorized to be appropriated not to exceed $25,000,000 to carry out this section.

and

WATER RESOURCES DEVELOPMENT ACT OF 1990

Title III - Generally Applicable Provision

Section 304. The time period for the Section 1135 program for project modifications for the improvement of the environment is deleted, and $15 million is authorized to be appropriated annually to carry the program out.

APPENDIX 3

COOPERATIVE AGREEMENT

BETWEEN THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

AND

DEPARTMENT OF THE ARMY

FOR A PROGRAM TO RESTORE AND CREATE FISH HABITAT

Background: Within the National Oceanic and Atmospheric Administration (NOAA), the National Marine Fisheries Service (NMFS) is assigned the primary Federal responsibility for the conservation, management, and development of the Nation's living marine resources. The NMFS Habitat Conservation Policy recognizes that mankind will inevitably alter marine, estuarine, and anadromous fish and shellfish habitats which are essential to maintaining the Nation's fisheries. The ability of these habitats to support fish production is diminishing while pressures for conversion for other uses are continuing. In accordance with the Policy, NMFS is proceeding to: (1) promote, support, and originate habitat restoration and creation by Federal, state, and local resource, construction, and regulatory agencies and the private sector and (2) work directly with these agencies in developing policies, guidelines, and rule making to promote the conservation of coastal and anadromous fish habitats.

Within the Department of the Army, the U. S. Army Corps of Engineers (Corps) has general authority and broad experience, expertise, and capability to conduct water resources development activities. These include protection and restoration of fish and wildlife habitats. In addition, the Corps has conducted extensive basic and applied research in the beneficial uses of dredged materials. This research has shown that under the proper conditions, the restoration and creation of wetlands, seagrass beds, and other aquatic habitats necessary for fish production is both possible and feasible. It is Corps policy to restore and create fish habitat at existing projects when it can be accomplished in an acceptable manner without added cost. If added costs are involved, the Corps will consider those opportunities using funds and authorities which may be available to them and with appropriate cost sharing by non-federal interests.

This Agreement has resulted from a 1986-88 NMFS-Corps Pilot Study, which was conducted to:

> "... determine the practicability of establishing, within existing authorities, resources and funding, a NMFS-Corps nationwide habitat restoration and creation program. Such a program would contribute towards balancing fish habitat conservation with orderly development and management of the Nation's water resources."

11. Marine Research, Protection and Sanctuaries Act of 1972, as amended, Title II, 33 U.S.C. § 1441 et seq.

12. Federal Water Pollution Control Act, as amended, 33 U.S.C. § 1251 et seq.

13. River and Harbor and Flood Control Act of 1965, Section 219, 10 U.S.C. § 3036d.

14. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. § 1451 et seq.

General Scope: This continuing Program will consist of: (1) systematically identifying fish habitat restoration and creation opportunities within the Civil Works Program; (2) formulating, coordinating, evaluating, and selecting habitat features[2]; (3) implementing selected features; and (4) carrying out required research/monitoring activities. It will involve field offices, laboratory, and headquarters offices of both agencies.

Because it is not intended that selected features be limited to wetland construction using dredged material, the broadest range of restoration needs and opportunities should be examined and included (e.g., restoration of salmon runs through removal of stream obstructions, increased shrimp production through water structure regulation to improve access, establishment of oysters through bed construction and seeding, and construction of artificial reefs).

The support and cooperation of other agencies, both Federal and state, is essential for Program success. Because individual sites will be found primarily in state waters, support of state agencies is critical. The U.S. Fish and Wildlife Service, the Environmental Protection Agency, and other resource agencies will also be invited to participate.

Under the Program, restoration and creation work will be carried out by the five NMFS regions and those participating Corps major subordinate commands (MSC) and district commands (DC), in cooperation with the above-cited other parties. The Program will be implemented primarily at the field level and will combine NMFS technical expertise with the Corps' broad water resources planning, engineering, design and construction expertise and capability.

Habitat features will be identified at projects of the overall Civil Works Program. Restoration an creation features may include marine, estuarine, and anadromous fish habitats. Features will be designed to result in a net increase of fish productivity when compared with current conditions. Thus, work under this Program should not be carried out with the purpose of mitigating anticipated damages from Corps projects.

Fish habitat restoration and creation features are highly individual in nature, requiring tailored and, sometimes, innovative design applications to fit unique site and resource conditions. Results are not always readily predictable and benefits are sometimes difficult to quantify. Because of these conditions, the Program may include two general types of habitat features: (1) readily implementable features, which will not involve long term monitoring requirements; and (2) experimental feature, which will require substantial monitoring and research activities. Readily implementable features will be constructed with the objective of increasing fish productivity, thus improving overall project efficiencies. Experimental features will have the primary objective of improving the technologies of fish habitat restoration and creation and/or environmental engineering, while expanding the understanding of the effectiveness and value of existing techniques.

Responsibilities: Within NMFS, Program implementation is delegated to its regional directors. Corps MSCs are authorized to pursue directly implementable features which do not involve added Corps project costs. Directly implementable and experimental features involving added project costs will require approval of the Assistant Secretary of the Army (Civil Works) (ASA(CW)) before implementation. Corps Headquarters, in coordination with ASA (CW), and NMFS headquarters will provide direction to their respective field offices on matters of national policy and program guidance. The Program should be designed and managed as an interagency team effort.

[2]. As used herein, the term "habitat feature" refers to the construction or other work required for habitat restoration and creation purposes within a Civil Works project (e.g., the artificial reef feature constructed under the NMFS-Corps Pilot Study at Mission Bay, CA).

Annually, each MSC will inform its respective NMFS region and other involved agencies of ongoing and future Civil Works projects. From the identified projects, NMFS regions and other involved agencies will identify potential areas and sites for habitat restoration and creation and assess potential fish benefits. Approved features will be planned, placed into the project schedule, and implemented cooperatively within the unique missions, authorities, capabilities, and expertise of the agencies.

Approved sites will be included in the Corps' O&M or project schedules. Each feature's planning, construction, and maintenance will be integrated routinely into scheduled project work.

The research offices of the Corps and NMFS may jointly oversee and monitor experimental features. Responsibilities for performing and funding these activities shall be addressed in the approval process for these features. Provisions will be made for publication and distribution of resulting scientific and technical information.

Funding: Each agency will be responsible for funding necessary for its participation both at the national and field levels.

Reports and Documentation: On an annual basis, participating NMFS regional directors and MSC commanders will submit joint progress reports to designated Washington headquarters offices. These reports will be evaluated and consolidated into a single annual progress report for Washington-level review. At the conclusion of two years, a joint NMFS-Corps assessment report will be submitted to the Under Secretary for Oceans and Atmosphere, U.S. Department of Commerce, and the Assistant Secretary of the Army (Civil Works). This report will include conclusions and recommendations with regard to continuation of the Program.

Effective Date and Duration: This Agreement will become effective upon signature by both parties and will remain in effect as long as both parties agree to participate. Differences should be resolved at the field level, if possible, and in headquarters, if not. Either party may terminate the agreement 30 days after written notice to the other party, with provision for an orderly closing out of ongoing operations.

U. S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	DEPARTMENT OF THE ARMY
Under Secretary for Oceans and Atmosphere	Acting Assistant Secretary of the Army (Civil Works)
Date	Date

Signed on 31 January 1991

APPENDIX 4

WATER RESOURCES DEVELOPMENT ACT OF 1992

TITLE II

§ 204. BENEFICIAL USES OF DREDGED MATERIAL

(a) IN GENERAL. The Secretary is authorized to carry out projects for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance by the Secretary of an authorized navigation project.

(b) SECRETARIAL FINDINGS. Subject to subsection (c) of this section, projects for the protection, restoration, or creation of aquatic and ecologically related habitats may be undertaken in any case where the Secretary finds that—

(1) the environmental, economic, and social benefits of the project, both monetary and nonmonetary, justify the cost thereof; and

(2) the project would not result in environmental degradation.

(c) COOPERATIVE AGREEMENT. Any project undertaken pursuant to this section shall be initiated only after non-Federal interests have entered into a cooperative agreement in accordance with the requirements of section 221 of the Flood Control Act of 1970 in which the non-Federal interests agree to—

(1) provide 25 percent of the cost associated with construction of the project for the protection, restoration, and creation of aquatic and ecologically related habitats, including provision of all lands, easements, rights-of-way, and necessary relocations;

and

(2) pay 100 percent of the operation, maintenance, replacement, and rehabilitation costs associated with the project for the protection, restoration, and creation of aquatic and ecologically related habitats.

(d) DETERMINATION OF CONSTRUCTION COSTS. Costs associated with construction of a project for the protection, restoration, and creation of aquatic and ecologically related habitats shall be limited solely to construction costs which are in excess of those costs necessary to carry out the dredging for construction, operation, or maintenance of the authorized navigation project in the most cost effective way, consistent with economic, engineering, and environmental criteria.

(e) AUTHORIZATION OF APPROPRIATIONS. There is authorized to be appropriated not to exceed $15,000,000 annually to carry out this section. Such sums shall remain available until expended.

APPENDIX F

BENEFICIAL USE CONCEPTS

Methods and Assumptions

Used to Estimate

Preliminary Costs

APPENDIX F

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INTRODUCTION

Each of the options included here is somewhat unique in that they use different amounts and types of dredged material, and have different locations and objectives with respect to habitat development. In order to have a common yardstick for comparing this group of beneficial use options, unit costs (per cubic yard of material dredged) were developed with a similar degree of precision and detail for each of the estimating inputs. Cost estimating worksheets for constructing the berm for the James River 200 acre island are found at the beginning of this appendix and illustrate the methodology for computing total cost for each component of an option. Similar estimates were made for each of the beneficial use options and are on file with Norfolk District. Some of the most important determinants of cost are the type of work (new or maintenance), because it affects the percent of solid material removed with each bite of the bucket dredge, the size of the scow, number of tugs, and transport distance to placement site. The quality of the estimates is limited by the accuracy of the assumptions, which do not have the benefit of detailed engineering and design. Physical conditions at the dredging site and the beneficial use location have significant potential to change the relative unit costs which this study describes. However, the detailed engineering studies that would be needed to design and construct an option are not appropiate where there are many potential candidates. Because of the expense of these studies, relative unit cost becomes one of the screening tools for deciding which options are appropriate for further investigation.

In order to construct unit costs for a project from the information in this appendix, the cost of all the components of the project must be included. A baseline or comparative cost is developed using a similar source and quantity of material dredged by bucket and transported by scow to the Dam Neck Ocean Disposal Site. This is the site that would be in use first when Craney Island no longer accepts material that can be disposed of in the ocean. Taking the 200 acre island adjacent to Ragged Island east of the James River Bridge

as an example, the costs of the following construction activities were added and divided by the total amount of dredged material (cubic yards) which the option can use:

- Bucket dredging of 4.3 mcy of material from Norfolk Harbor Channel
- Berm built from 1.75 mcy of new work material (fine compacted sand) from Norfolk Harbor Channel
- Interior fill from 2.55 mcy of new work material from Norfolk Harbor Channel
- Riprap bedding and armor stone on the North, East and West sides of the dikes to elevation +4 MLW, and the cost of dredging an acccess channel for equipment to place the stone

The resulting costs are added on the summary page for this option and are shown as a unit cost in Table 1.

To create the baseline unit cost for disposal at Dam Neck Ocean Disposal Site the following components must be included:

- Dredging 4,300,000 cubic yards of new work material from Norfolk Harbor Channel, transporting it an average distance of 36 miles to Dam Neck Ocean Disposal site and emptying the material from the bottom of the scow

For both ocean disposal and beneficial use, no costs are included for monitoring, environmental studies, or planting and shaping a site specifically for the creation of wildlife habitat.

The increment of difference between the baseline cost and the beneficial use option is converted to a ratio in the last column of Table 1. A 200 Acre Island is 1.60 times more expensive than taking material to the Dam Neck Ocean Disposal Site.

Table I. COST COMPARISONS BETWEEN BENEFICIAL USE OPTIONS AND PLACEMENT AT DAM NECK OCEAN SITE

OPTION	LOCATION	MATERIAL VOLUME (MCY)	OPTION COST ($000)*	OPTION COST PER CY	DNODS COST PER CY	PER CY COST RATIO**
1025 Acre Island	Ragged Island	16.3	242,704	$14.89	$7.51	2.00
200 Acre Island	Ragged Island	5.7	69,375	$12.28	$7.50	1.60
50 Acre Island	Ragged Island	1.9	24,811	$13.23	$7.50	1.80
250 Acre Island	Hampton Flats	5.0	33,130	$6.63	$7.50	0.90
46 Acre Wetland	Mulbery Island	0.34	5,356	$16.55	$7.60	2.00
8 Acre Oyster Reef	Point of Shoals	0.031	344	$23.05	$16.61	1.40
Thin Layer (3443 acres)	Thimble Shoals	5.5	45,375	$8.25	$7.29	1.10
Fish Habitat (0.8 acre)	Lower Bay	0.009	125	$14.50	$7.82	1.80
Deep Trough Placement	E of H.R. Br/Tunnel	5.1	34,784	$6.82	$7.75	0.90

* Island cost includes riprap, does not include shaping, planting, and monitoring

** COST RATIO = Alternate Disposal Option/Disposal Cost @ DNODS

DNODS = Dam Neck Ocean Disposal Site

TITLE: ISLAND PLACEMENT BERM, NORFOLK HARBOR CHANNEL
200 AC, 2 SCOWS
FILE: IPNHCB
CLAMSHELL ESTIMATE
J. E. RICH 14 FEB 92
18 C.Y. CLAMSHELL

PG 1 of 5

UNIT COST.. $7.18 PER C.Y.

DREDGE TIME 7.90 MONTHS
HAUL TIME.. 7.58 MONTHS

BID ITEM # 1 MOBILIZATION

BID ITEM # 2 EXCAVATION

ESTIMATED DREDGING QUANTITY:

PG 2 of 5

DREDGING AREA: 10,270,000 SQ. FT.

REQUIRED		1,750,000 C.Y.		
PAY O.D.	+	0 C.Y.		
BID QUANT.	=	1,750,000 C.Y.		
NOT DUG	-	0 C.Y.	AVE. BANK HEIGHT:	
NET PAY	=	1,750,000 C.Y.	@	4.6 FT PAY
NON-PAY	+	380,400 C.Y.	@	1.0 FT OVERDIG.
GROSS	=	2,130,400 C.Y.		5.6 FT TOTAL

DREDGE PRODUCTION WORKSHEET

PG 3 of 5

	Override	Database	Used
Dredge Efficiency Factor	0.75	0.75	0.75
Operating Time Factor	0.75	0.8	0.75
Buckets per min. Reduction Factor	0	0.9	0.9
Fill Factor	0.85	0.7	0.85

Bucket Capacity Adjustment Factor.....> 25.81875
Bucket Size.....> 18 C.Y.
Bucket Cycle Time.....> 72 Seconds or 0.8 Buckets per min.

Ave. Bucket Production.....> 6.45 c.y. per minute
(25.82 x 18 / 72)

DISPOSAL PRODUCTION WORKSHEET

PG 4 of 5

Scow Size	3000 c.y.
Useable Volume	95 Percent
Percent Solids	90 Percent
Prepare for Scow Tow	15 Minutes
Haul Distance	13 Miles
Haul Speed	
to Disposal Area	3 Miles per hour
from Disposal Area	3.5 Miles per hour
Dumping or Pumpout	290 Minutes
Disengage Scow Tow	15 Minutes
Towing Efficiency	100 Percent
Number of Towing Vessels	2 Tug(s)

PG 5 of 5

CLEANUP DREDGING 5 PERCENT ADDITIONAL TIME

SPECIAL EXCAVATION COSTS	$0 PER MONTH
ADDITIONAL EXCAV. COSTS	$0 LUMP SUM
CONTRACTOR'S OVERHEAD	12 PERCENT OF CONTRACT
CONTRACTOR'S PROFIT	10 PERCENT OF CONTRACT
CONTRACTOR'S BOND	1 PERCENT OF CONTRACT

A CLAMSHELL DREDGE ESTIMATE BID ITEM # 2

1 PROJECT	ISLAND PLACEMENT BERM 200 AC, NORFOLK HARBOUR, 2 SCOWS				
2 LOCATION	Dredge Material Placement Concepts			INVIT. NO.	PRELIMINARY
3 BID ITEM NO.	Concept	ESTIMATOR	Rich & Associates	CHKED BY	
4 DESCRIPTION OF WORK	Channel to Norfolk Harbour to Island Placement. Bucket pump out to Berm. 2-3000 cy scows.				
	Costs for rip rap and fill in are shown in separate estimates.				
	No costs are included for environmental studies.				

5 EXCAVATION			REMARKS
A. REQUIRED		1,750,000 C.Y.	10,270,000 Square Feet
B. PAY OVERDEPTH	+	0 C.Y.	
C. MAX. PAY YARDAGE	=	1,750,000 C.Y.	(Yardage used on Bid Form)
D. O.D. NOT DREDGED	-	0 C.Y.	
E. NET PAY YARDAGE	=	1,750,000 C.Y.	(Yardage used to figure Unit Price per c.y.)
F. NON-PAY YARDAGE	+	380,400 C.Y.	1 Feet Average Overdigging
G. GROSS YARDAGE	=	2,130,400 C.Y.	(Yardage used to figure Production Time & Cost)

PRODUCTION WORK SHEET

B — DREDGE PRODUCTION — BID ITEM # 2

1 SIZE OF DREDGE		18 C.Y. CLAMSHELL	
2 SIZE OF BUCKET		18 C.Y.	
A. BUCKET FILL FACTOR	x	85% SOLIDS	Bank, Material, Compaction, & Swell
B. WORKING CAPACITY.....>		15.3 C.Y./BUCKET	
3 AVERAGE OPERATING CYCLE		72 SECONDS	
A. CYCLES PER MINUTE		0.83	(60 Secs per min / 72 Secs per cycle)
B. CYCLE ADJUSTMENT FACTOR	x	0.9	Water Resistance & Bucket Washout
C. BUCKETS PER MINUTE		0.75 BUCKETS/MIN	
D. WORKING CAPACITY	x	15.3 C.Y./BUCKET	
E. PRODUCTION		11.5 C.Y./MINUTE	
4 DREDGE EFFICIENCY FACTOR	x	0.75	50 Min work hour, Management, Advance delays, Refueling, Scow positioning, & Crew efficiency
5 OPERATING TIME FACTOR	x	0.75	Unexpected Down Time, Weather, & Repair
6 NET PRODUCTION RATE		6.47 C.Y./MINUTE	
OR		283,386 C.Y./MONTH	(6.47 c.y. per min x 60 Min per hr x 730 hrs per mo)
7 GROSS CUBIC YARDS		2,130,400 CY (GROSS)	
8 CUBIC YARDS PER MONTH	/	283,386 CY/MO	
9 DREDGE TIME	=	7.52 MONTHS	
10 CLEAN UP 5.0%	+	0.38 MONTHS	
11 TOTAL DREDGE TIME	=	7.90 MONTHS	

C

PRODUCTION WORK SHEET

TOWING CYCLE TIME

BID ITEM # 2

1 SIZE OF TUG: 3000 HP DIESEL--TWIN SCREW

2 TIME PER AVERAGE LOAD CYCLE:

			REMARKS
A. PREPARE FOR SCOW TOW		15 MIN	[Prepare towing lines and maneuver away from dredge safely]
B. TO DISPOSAL AREA	+	260 MIN	13 miles / 3 miles per hr x 60 min
C. DUMPING OR PUMPOUT	+	290 MIN	
D. FROM DISPOSAL AREA	+	223 MIN	13 miles / 3.5 miles per hr x 60 min
E. DISENGAGE TOW RIGGING AND TIE UP SCOW	+	15 MIN	[Prepare towing lines and maneuver away from dredge safely]
3 TOTAL DISPOSAL CYCLE TIME	=	803 MIN/LOAD	

PRODUCTION WORK SHEET

D — DISPOSAL TIME — BID ITEM # 2

				REMARKS
1 SIZE OF SCOW		3,000	C.Y.	
A. USEABLE VOLUME	x	95%	CAPACITY	
SUBTOTAL.....>		2,850	C.Y.	
B. PER CENT MATERIAL	x	90%	SOLIDS	
2 AVERAGE LOAD		2,565	C.Y.	
3 LOAD RATE	/	6.47	C.Y./MINUTE	
4 AVE. LOADING TIME PER SCOW	=	396	MINUTES/LOAD	
5 CALENDAR MINUTES PER DAY		1440	MIN/DAY	(60 MIN/HR x 24 HRS/DAY)
6 PERCENT EFFECTIVE TIME	x	100%		Towing Operation
7 DAILY EFFECTIVE TIME	=	1440	MIN/DAY	
8 TOWING CYCLE TIME	/	803	MIN/LOAD	
9 NUMBER OF LOADS PER DAY PER TOWING VESSEL	=	1.8		
10 NUMBER OF TOWING VESSELS	x	2		
11 NUMBER OF LOADS PER DAY	=	3.6		
12 CUBIC YARDS PER LOAD	x	2,565		
13 OPERATING DAYS PER MONTH	x	30.42		(365 DAYS/YR DIVIDED BY 12 MO/YR = 30.42 DAYS PER MONTH)
14 MONTHLY RATE	=	280,898	CY/MO	
15 GROSS CUBIC YARDS		2,130,400	CY (GROSS)	
16 CUBIC YARDS PER MONTH	/	280,898	CY/MO	
17 DISPOSAL TIME	=	7.58	MONTHS	

E — EXCAVATION COSTS — BID ITEM # 2

		REMARKS
1 DREDGE TIME	7.90 MONTHS	
2 DISPOSAL TIME	7.58 MONTHS	

F MONTHLY PLANT OWNERSHIP & LABOR COST SUMMARY BID ITEM # 2

1 EQUIPMENT 18 C.Y. CLAMSHELL & ATTENDANT PLANT

2 PLANT OWNERSHIP & OPERATING EXPENSE		REMARKS
A. CLAMSHELL DREDGE.....>	$192,500 /MO	
B. TOWING VESSEL.....> +	$236,500 /MO	3000 HP DIESEL--TWIN SCREW including Crew
.....> +	$236,500 /MO	Plus 1 Additional Towing Vessel
C. SURVEY VESSEL.....> +	$55,000 /MO	Full-time
D. WORK TUG.....> +	$21,100 /MO	
E. SCOW BARGES.....> +	$41,500 /MO	1st-3000 c.y. Scow Barge
.....> +	$41,500 /MO	Plus 1 Additional 3000 c.y. Scow Barges
F. OTHER EQUIPMENT.....> +	$332,500 /MO	Discharge Equipment
3 SPECIAL EXCAVATION COSTS.....> +	/MO	
4 LABOR EXPENSE.....> +	$122,800 /MO	
5 TOTAL MONTHLY COST =	$1,279,900 /MO	

3 EXCAVATION TIME.....>			7.90	MONTHS	[Greater of disposal time or dredge time]
4 TOTAL MONTHLY COST		x	$1,279,900	/MO	
SUBTOTAL.....=			$10,106,090		
5 SPECIAL COSTS (EXPLAIN)		+	$0		
SUBTOTAL.....=			$10,106,090		
6 OVERHEAD	12.0%	+	$1,212,731		$11,318,821 <--Subtotal
7 PROFIT	10.0%	+	$1,131,882		$12,450,703 <--Subtotal
8 BOND COST	1.0%	+	$113,188		
9 TOTAL PRODUCTION COSTS		=	$12,563,891		
10 NET PAY YARDAGE		/	1,750,000	CY	
11 UNIT COST		=	$7.18	/CY	[FOR BID SCHEDULE]
12 MAX PAY YARDAGE		x	1,750,000	CY	[FROM BID SCHEDULE]
13 EXCAVATION, UNCLASSIFIED		=	$12,565,000		

G MOB & DEMOB BID ITEM # 1

1 TOTAL MONTHLY COST		$1,279,900 /MO	REMARKS	
	/	30.42 DAYS/MO		
2 DAILY MOB & DEMOB RATE	=	$42,074 /DAY		
3 PREPARATION FOR TRANSFER OF PLANT		2 DAYS	MOBILIZATION	
4 TRANSFER TO SITE OF WORK	+	4.2 DAYS	1,000 MILES @	10 MPH / 24 HRS/DAY
5 PREPARING PLANT FOR WORK	+	1 DAYS		
6 DEMOB PREPARATION	+	1 DAYS		
7 DEMOBILIZATION	+	4.2 DAYS	1,000 MILES @	10 MPH / 24 HRS/DAY
8 TOTAL DAYS	=	12.4 DAYS		
	x	$42,074 /DAY	DAILY MOB & DEMOB RATE	
9 TOTAL FIELD COST	=	$521,718		
10 SPECIAL FEES	+	$10,000	TOWING INSURANCE	
SUBTOTAL.....	=	$531,718		
11 OVERHEAD 12.0%	+	$63,806	$595,524 <--Subtotal	
12 PROFIT 10.0%	+	$59,552	$655,076 <--Subtotal	
13 BOND COST 1.0%	+	$5,955		
14 TOTAL MOB & DEMOB COSTS	=	$661,031		

804 - 547-3467

Rich & Associates

COST ENGINEERS

1825 Cedar Road • Chesapeake, Virginia 23323

February 19, 1992

Rollins and Associates
4663 Haygood Road, Suite 207
Virginia Beach, Virginia 23455

Attention: Albert E. Rollins, P.E.

RE: Dredged Materials Placement Concepts
Lower Bay Study

Dear Al,

Attached are estimates for placing dredged materials as required for the original contract scope, plus those added on both changes. Part one contains 23 dredging estimates for placing materials in various locations. Part two contains nine dredging estimates and three riprap estimates for three different island placement schemes. Since the original and new estimates are so related the complete package is submitted. Also submitted are 2 summary sheets describing the project, showing equipment used, and unit costs.

All dredging estimates have been run on the Corps of Engineers Lotus spreadsheet. Production assumptions and adjustments to stored pricing are shown in the front of each part. Discussions with Norfolk Dredging and Great Lakes are reflected in assumptions. Work not priced is listed on the description of work with each estimate. Pricing is for dredging only, no studies or shore work, other than riprap for Island Placement is included.

Where estimates were run on a different equipment selection the same quantity of dredging, same source, and placement area a comparison of cost is shown in "Placement Area" of the write up. Due to the way the program is set up changes in haul distance may not change the unit price. Under production the mileage at which cost changes is shown.

Also changing volume does not change dredging unit cost, some slight difference may be reflected in mob/demob costs.

On the summary sheet an allowance of: 20% for contingencies, 5% for SIOH, and 4% for Engineering and Design has been added. Engineering and Design of 8% was added to the riprap estiamtes. There are some changes to estimates in the original report, costs

shown here should be used for all concepts.

If any further information is needed, please feel free to call at anytime.

Sincerely,

J. E. Rich, P.E., C.C.E.
RICH AND ASSOCIATES

JER/dsk

INDEX	DREDGE METHOD
THIN LAYER	HYD
UNDERWATER FISH HABITAT	HOPPER
OYSTER REEF 18 CY	BUCKET
OYSTER REEF 12 CY	BUCKET
DEEP TROUGH NHC (1)	BUCKET
DEEP TROUGH NHC (2)	BUCKET
DEEP TROUGH ANCHORAGE	HYD
WETLANDS - NEW	BUCKET
WETLANDS - MAINTENANCE	BUCKET
THIMBLE SHOALS/DAM NECK	
1 EA 3000 CY	BUCKET
2 EA 3000 CY	BUCKET
1 EA 6000 CY	BUCKET
2 EA 6000 CY	BUCKET
NEWPORT NEWS/DAM NECK	
2 EA 6000 CY	BUCKET
3 EA 6000 CY	BUCKET
2 EA 6000 CY	BUCKET
3 EA 6000 CY	BUCKET
2 EA 3000 CY	BUCKET
3 EA 3000 CY	BUCKET
NORFOLK HARBOR CHANNEL/DAM NECK	
2 EA 6000 CY	BUCKET
2 EA 6000 CY	BUCKET
ANCHORAGE DAM NECK	
2 EA 3000 CY	BUCKET
3 EA 3000 CY	BUCKET
ISLANDS	
1025 ACRE ISLAND	
1025 NHC BERM	BUCKET
1025 NHC FILL IN (3)	BUCKET
1025 NNC FILL IN (2)	BUCKET
1025 NHC FILL IN (2)	BUCKET
RIPRAP	
200 ACRE ISLAND	
200 NHC BERM (3)	BUCKET
200 NHC FILL IN (3)	BUCKET
200 NHC FILL IN (2)	BUCKET
RIPRAP	
50 ACRE ISLAND	
50 NHC BERM (3)	BUCKET
50 NHC FILL IN (3)	BUCKET
RIPRAP	

DREDGED MATERIAL PLACEMENT CONCEPT - O P E R A T I N G C O S T

27" DREDGE	STORED	USED
OWNERSHIP	65,500	72,000
OPERATING:		
LABOR	224,500	230,000
OPERATING	346,000	380,000
	570,500	610,000
BOOSTER	156,000	172,000
PIPELINE 27" SAND		
FLOATING	7.40	7.80
SUBMERGED	5.00	5.25
LAND	3.00	3.15

DREDGED MATERIALS PLACEMENT CONCEPTS - H Y D R A U L I C

	THIN LAYERING	DEEP TROUGH
NATURE	NEW	NEW
QUANTITY	5,500,000	800,000
AREA	32,300,000	4,700,000
DREDGE SIZE	27"	27"
PIPELINE LENGTH	7,000	18,500
EFFECTIVE PUMPING LENGTH	7,800	19,300
BOOSTERS	1	1
BOOSTER FACTOR	1.0	0.9
MATERIAL FACTOR	1.2	1.2
BANK FACTOR	0.852	0.852
OTHER FACTOR	0.50	1.00
NET PRODUCTION CY/HR	690	866
OPERATING HOURS/DAY	18	18
OPERATING DAYS/MONTH	22	22
FUEL	0.90	0.90
MOB/DEMOB MILES	1,500	1,500

DRDGED MATERIAL PLACEMENT - PRODUCTION ASSUMPTIONS FOR SCOW PUMP OUT

		OYSTER REEF	OYSTER REEF	WETLAND	ISLAND BERM ALL	ISLAND FILL IN 1025 & 200 ACRE	ISLAND FILL IN 50 ACRE
DREDGE	CY	18	12	18	18	18	18
PUMPOUT SIZE	INCHES	22	22	27	27	27	27
CHART LG	FT	4000	4000	5500	5500	5500	5500
STANDARD PROD.	CY/HR	800	800	1500	1500	1500	1500
BOOSTER		NO	NO	YES	NO	YES	NO
EFF. DISTANCE	LF	4400	4400	4950	8300	5800	8300
PRODUCTION AT EFF. DISTANCE	CY/HR	750	750	1500	1200	1450	1200
REDUCTION		40%	40%	50%	40%	20%	5%
	CY/HR	480	480	750	720	1160	1140
SCOW SIZE	CY	3000	3000	3000	3000	3000	3000
PUMPOUT	HR	6.25	4.2	4	4.2	2.6	2.6
	MIN	375	255	240	255	160	160
ALLOW CONNECT / DISCONNECT	MIN	30	30	30	35	30	30
TOTAL PUMPOUT	MIN	405	285	270	290	190	190

DREDGED MATERIAL PLACEMENT CONCEPTS - B U C K E T D R E D G I N G

E Q U I P M E N T C O S T

BUCKET SIZE	18 CY		12 CY	
	STORED	USED	STORED	USED
CLAM SHELL DREDGE (+10%)	175,000	195,200		150,000
TOWING VESSEL +5% (FUEL CONSTANT)	225,893	236,500	225,893	236,500
SURVEY VESSEL PART TIME	15,000	16,000		16,000
FULL TIME		55,000		55,000
WORK TUG	19,162	21,100		21,100
SCOW 2,000 CY				30,000
SCOW 3,000 CY	37,758	41,500		41,500
SCOW 6,000 CY		75,000		
LABOR (+10%) BUCKET	111,572	122,800	111,572	122,800
LABOR DISCHARGE		72,000		72,000
FUEL	0.65	0.90	0.65	0.90
BOOSTER 27"	156,000	172,000		
27" LINE				
FLOATING	7.40	7.80		
SUBMERGED	5.00	5.25		
LAND	3.00	3.15		
BOOSTER 22"			100,000	110,000
22" LINE			5.80	6.40
FLOATING			3.70	4.10
SUBMERGED			2.50	2.75
LAND				

DREDGED MATERIAL PLACEMENT CONCEPTS

SUPPORTING EQUIPMENT FOR PUMPOUT FROM SCOW

OPERATION	OYSTER REEF	WETLAND	ISLAND BERM AND FILL IN 50 ACRES	ISLAND FILL IN 1025 ACRE 200 ACRE	TO DAM NECK
BUCKET SIZE (CY)	12 / 18	18	18	18	18
PIPELINE SIZE (IN)	22	27	27	27	BOTTOM DUMP NO PUMPOUT
SUBMERGED LINE (LF)					
UNIT COST		5.25	5.25	5.25	
TOTAL					
FLOATING LINE (LF)	4,000	7,000	7,500	7,500	
UNIT COST	6.40	7.80	7.80	7.80	
TOTAL	25,600	54,600	58,500	58,500	
LAND LINE (LF)		2,000		3,000	
UNIT COST		3.15	3.15	3.15	
TOTAL		6,300		9,450	
PUMPOUT DREDGE	110,000	172,000	172,000	172,000	
DISCHARGE BARGE	30,000	30,000	30,000		
DISCHARGE CREW	72,000	72,000	72,000	72,000	
TOTAL	237,600	506,900	332,500	483,950	

S U P P O R T I N G E Q U I P M E N T - H Y D R A U L I C

OPERATION	THIN LAYER
DREDGE SIZE	HYD 27"
PIPELINE SIZE (IN)	27
SUBMERGE LINE (LF)	4,000
UNIT COST	5.25
TOTAL	
FLOATING LINE (LF)	3,000
UNIT COST	7.80
TOTAL	IN PROGRAM
LAND LINE (LF)	
UNIT COST	
TOTAL	
PUMPOUT DREDGE	
DISCHARGE BARGE	50,000
DISCHARGE CREW	100,000
TOTAL	150,000

*NOTE: THIN LAYER USES A HYDRAULIC DREDGE. EQUIPMENT COSTS SHOWN ARE ADDITIONAL EQUIPMENT NEEDED TO PROVIDE A ONE FOOT THICK PLACEMENT.

DREDGED MATERIAL PLACEMENT CONCEPT - C R E W S

DISCHARGE CREW PROTECTED

TUGMASTER	1 EA	11.69	11.69	
TUG MATE	1 EA	11.17	11.17	
EQUIP OPE	1 EA	12.30	12.30	
DECKHANDS	1 EA	9.15	9.15	
FOREMAN	1 EA	12.00	12.00	
	$/HR		83.76	/HR
	OVERTIME 1.143		95.73	/HR
	TAXES, INS, FRINGE		163.70	/HR

163.70 X 20 HRS/DAY X 22 DAYS = 72,028 MONTH
USED 72,000 MONTH

DISCHARGE CREW THIN LAYERING

TUGMASTER	1 EA	11.69	11.69	
TUG MATE	1 EA	11.17	11.17	
EQUIP OPE	2 EA	12.30	24.60	
DECKHANDS	5 EA	9.15	45.75	
FOREMAN	1 EA	12.00	12.00	
	$/HR		105.71	/HR
	OVERTIME 1.143		120.81	/HR
	TAXES, INS, FRINGE		206.59	/HR

206.59 X 20 HRS/DAY X 22 DAYS = 99,989 MONTH
USED 100,000 MONTH

DREDGE MATERIAL PLACEMENT CONCEPT - ANCHORAGE TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 800,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 33 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 3,000 cy scows. An estimate was prepared using three tugs and three scows. Prices obtained were lower than this equipment selection (+1.12/cy) (budget). The 33 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 37 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by hauling time; decreasing the haul distance to 21 miles would reduce the cost; increasing the haul distance would increase the cost. Under 21 miles haul production controls pricing, no cost reduction would occur. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	8.00
MOBILIZATION/DEMOB	0.59
TOTAL CONTRACT	8.59
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	11.24
MOB/DEMOB (CONTRACT)	472,800

DREDGE MATERIAL PLACEMENT CONCEPT - ANCHORAGE TO DAM NECK 3 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 800,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 33 miles.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 3,000 cy scows. An estimate was prepared using two tugs and two scows. Prices obtained were higher than this equipment selection (+1.12/cy) (budget). The 33 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 37 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by hauling time; decreasing the haul distance to 21 miles would reduce the cost; increasing the haul distance would increase the cost. Under 21 miles haul production controls pricing, no cost reduction would occur. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	6.97
MOBILIZATION/DEMOB	0.77
TOTAL CONTRACT	7.74
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	10.12
MOB/DEMOB (CONTRACT)	613,700

DREDGED MATERIAL PLACEMENT CONCEPT - NN CHANNEL TO DAM NECK 3 SCOWS

MATERIAL SOURCE: Newport News Channel, Maintenance, 500,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 37 miles.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 3,000 cy scows. An estimate was prepared using two tugs and two scows. Prices obtained were lower than this equipment selection (+1.89/cy) (budget). The 37 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .65; operating time factor .70; buckets per minute reduction factor .9; fill factor .75; cycle time 72 seconds, resulting in a net production rate of 4.6 cy/min Hauling was assumed at 37 miles each way using three tugs and three scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by hauling; reducing the haul distance to 34 miles would decrease cost; increasing the haul distance would increase the cost. At a haul distance of under 34 miles production controls pricing, no costs reduction would occur. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	11.47
MOBILIZATION/DEMOB	1.23
TOTAL CONTRACT	12.70
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	16.61
MOB/DEMOB (CONTRACT)	613,700

DREDGED MATERIAL PLACEMENT CONCEPT - NN CHANNEL TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, Maintenance, 500,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 37 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 3,000 cy scows. An estimate was prepared using three tugs and three scows. Prices obtained were lower than this equipment selection (+1.89/cy) (budget). The 37 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .65; operating time factor .70; buckets per minute reduction factor .9; fill factor .75; cycle time 72 seconds, resulting in a net production rate of 4.6 cy/min Hauling was assumed at 37 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by hauling; reducing the haul distance to 22 miles would decrease cost; increasing the haul distance would increase the cost. At a haul distance of under 22 miles production controls pricing, no costs reduction would occur. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	13.19
MOBILIZATION/DEMOB	0.95
TOTAL CONTRACT	14.14
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	18.50
MOB/DEMOB (CONTRACT)	472,800

DREDGE MATERIAL PLACEMENT CONCEPT - NN CHANNEL TO DAM NECK 3 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 1,750,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 37 miles.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 6,000 cy scows. An estimate was prepared using two tugs and two scows. Prices obtained were lower than this equipment selection (+2.41/cy) (budget). The 37 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 37 miles each way using three tugs and three scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by production; reducing the haul distance would not decrease the cost; increasing the haul distance to 64 miles would not increase the costs. At a haul distance of over 64 miles costs would increase. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	7.22
MOBILIZATION/DEMOB	0.38
TOTAL CONTRACT	7.60
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	9.94
MOB/DEMOB (CONTRACT)	664,600

DREDGED MATERIAL PLACEMENT CONCEPT - NN CHANNEL TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 1,750,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 37 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 6,000 cy scows. An estimate was prepared using three tugs and three scows. Prices obtained were higher than this equipment selection (+2.41/cy) (budget). The 37 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 37 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by production; reducing the haul distance would not decrease the cost. At a haul distance of over 42 miles costs would increase. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT		5.47
MOBILIZATION/DEMOB		0.29
TOTAL CONTRACT		5.76
TOTAL INCL CONTG (20%, E&D, SIOH (9%)		7.53
MOB/DEMOB	(CONTRACT)	506,700

DREDGE MATERIAL PLACEMENT CONCEPT - NN CHANNEL TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 4,500,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 37 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 6,000 cy scows. An estimate was prepared using three tugs and three scows. Prices obtained were higher than this equipment selection (+2.34/cy) (budget). The 37 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 37 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller, less efficient equipment would be used. The indicated price is controlled by production; reducing the haul distance would not decrease the cost; increasing the haul distance to 42 miles would not increase the cost. At a haul distance of over 42 miles costs would increase. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	5.47
MOBILIZATION/DEMOB	0.11
TOTAL CONTRACT	5.58
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	7.30
MOB/DEMOB (CONTRACT)	506,700

DREDGED MATERIAL PLACEMENT CONCEPT - NH CHANNEL TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 4,300,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 36 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 6,000 cy scows. No alternate equipment selection was used since this selection was the lowest price option from the Newport News Channel. The 36 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 36 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by production; reducing the haul distance would not decrease cost; increasing the haul distance to 42 miles would not increase the cost. At a haul distance of over 42 miles costs would increase. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	5.47
MOBILIZATION/DEMOB	0.12
TOTAL CONTRACT	5.59
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	7.31
MOB/DEMOB (CONTRACT)	506,700

DREDGED MATERIAL PLACEMENT CONCEPT - NH CHANNEL TO DAM NECK 2 SCOWS

MATERIAL SOURCE: Newport News Channel, New Work, 1,750,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 36 miles.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 6,000 cy scows. No alternate equipment selection was used since this selection was the lowest price option from the Newport News Channel. The 36 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 36 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by production; reducing the haul distance would not decrease cost; increasing the haul distance to 42 miles would not increase the cost. At a haul distance of over 42 miles costs would increase. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	5.47
MOBILIZATION/DEMOB	0.29
TOTAL CONTRACT	5.76
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	7.53
MOB/DEMOB (CONTRACT)	506,700

DREDGE MATERIAL PLACEMENT CONCEPT - THIMBLE SHOALS TO DAM NECK 1 SCOW

MATERIAL SOURCE: Thimble Shoals Channel, New Work, 5,000,000 pay cubic yards.

PLACEMENT AREA: Ocean dumping in the Dam Neck Disposal site. Material will be bottom dumped. Average bottom depth is 35 ft. Average haul distance is 23 miles.

EQUIPMENT USED: 18 cy bucket dredge with one tug and one 6,000 cy scows. This combination of equipment produced a lower unit cost (by $2.15 c.y.) than using two tugs and two scows. The 23 mile haul distance is too great for efficient hydraulic production. Either a hopper dredge or bucket and scow methods could be used. The use of a bucket dredge was considered to be the most cost effective. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min Hauling was assumed at 23 miles each way using one tug and one scow at 3 MPH loaded, 3.5 MPH empty. At the discharge site a dump time of 15 minutes plus 15 minutes lost time was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. The indicated price is controlled by hauling time; decreasing the haul distance to 20 miles would reduce the cost; increasing the haul distance would increase the price. Under 20 miles haul production controls pricing, no cost reduction would occur. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COST - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	7.15
MOBILIZATION/DEMOB	0.07
TOTAL CONTRACT	7.22
TOTAL INCL CONTG (20%, E&D, SIOH (9%)	9.44
MOB/DEMOB (CONTRACT)	348,900

ISLAND PLACEMENT - TOTAL PROJECT, 1025 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel and Newport News Channel. Berm requires 3,500,000 cy all from the Norfolk Harbor Channel. Fill in requires 12,800,000 cy; Norfolk Harbor Channel new work 800,000 cy, Newport News Channel 4,500,000 cy, Norfolk Harbor Channel maintenance work, five consecutive annual contracts of 1,500,000 cy each for 7,500,000 total maintenance dredging. Riprap material will come from local quarries.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Project constructs a riprap protected berm to 6' above MLW on the north, east, and west sides and to 4' above ML water on the south side. No riprap is to be placed on the southside berm. Fill in material would be placed so as to drain to the south. Average bottom depth for berm was assumed at -9' MLW and -6' MLW for fill in. An allowance was made for 1' of bottom settlement. Haul distances are 13 miles from Norfolk Harbor Channel and 6.5 miles from Newport News Channel. Pump out distances are 7,500' for berms and 10,500' for fill in. Front dike is 19,050 ft in length with a 50' top width; back dike is 18,550 ft in length with a 40' top width. Bottom dike area is 235 acres, bottom fill in is 1,025 acres.

EQUIPMENT USED: 18 cy bucket dredge with two or three tugs and scows. A rehandler pump is used at the placement area. Dike requires a barge discharge, fill in requires an additional booster. Discharge will start at water level and be raised as fill progresses. The haul distance is too great for efficient hydraulic production. A hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to the shallow water depths at the placement area. Mobilization for dredge equipment was assumed at 1,000 miles. For riprap placement a 100 ton floating rig with 100' boom and attendant plant was assumed. Dredging of an access channel will be required. Material will be barge delivered.

MATERIALS CHARACTERISTICS: New material is assumed to be a fine compacted sand. Maintenance material is assumed to be a loose muddy silt. Bank height for new work is 4.6' plus 1' of non pay over depth; for maintenance work is 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75 (maint. .65); operating time factor .75 (maint .70); buckets per minute reduction factor .9; fill factor .85(maint .75); cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. (maint. 4.61). Hauling was assumed at 6.5 or 13 miles each way using two (or three) tugs and two (or three) scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 or 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

ISLAND PLACEMENT - TOTAL PROJECT, 1025 ACRE ISLAND

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, or construction of wildlife habitat.

PRICE RANGE: Costs shown were developed assuming work would be new work or maintenance dredging projects. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller, less efficient equipment would be used. Total mobilization costs will remain constant and unit costs will vary inversely with the quantity placed in the project. If funding allows multiple pieces of this project to be built at the same time, mobilization/demob costs can be reduced.

TOTAL PROJECT COSTS - PRICING LEVEL 1 JANUARY 1992

	Qty (cy)	Dredge ($)	Mob/demob ($)	Total ($)	Total w/ Contig SIOH, E&D
Berm	3,500,000	25,130,000	661,000	25,791,000	33,735,000
Fill in NHC	800,000	6,424,000	737,000	7,161,800	9,368,000
Fill in NNC	4,500,000	36,135,000	738,000	36,873,000	48,230,000
Fill in NHC * Maint.	7,500,000	98,550,000	3,689,000	102,239,000	133,721,000
RipRap (tn)	267,000	12,920,000	100,000	13,020,000	17,650,000
Total Cost		179,159,000	5,926,000	185,084,000	242,704,000

Dredge cy 16,300,000

Riprap (TN) 267,000

Cost for project per cubic yard of dredged material $14.89

*A total of 5 ea yearly contracts will be required. Costs shown are not escalated. Mob/demob for 5 contracts is included.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS 1025 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work 3,500,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed so as to form a dike to retain material from future dredging projects. Dike enclosing North, East, and West side will be to a top height of +6' MLW, 50' berm top width with 8-1 side slopes. South dike will be to a top height of +4' MLW, 40' berm top width with 8-1 side slopes, an allowance for 1' settlement of existing bottom material was made. This source provides 100% of the total dike material required. Average bottom depth was assumed at -9' MLW. Average haul distance is 13 miles each way, average pump out distance is 7,500'. Front dike is 19,050 ft in total length, back dike is 18,550' in total length, bottom area is 10,200 sq ft or 235 acres. This estimate provides 50% of this dike.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 3,000 cy scows. At the disposal area a rehandler pump and 7,500' of discharge line with a barge discharge will be used. Discharge will start at water level and be progressively raised to dike height. The 13 mile distance from the source is too long for efficient hydraulic production, a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 13 miles each way using three tugs and three scows @ 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Pump out production was factored at 60% to reflect control of material to place in berm. Clean up dredging of 5% additional time was allowed.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies. Shaping of berm for riprap placement is included with riprap.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy., then smaller, less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the berm.

DREDGED MATERIAL PLACEMENT CONCEPT-ISLAND PLACEMENT RIPRAP ON BERM
1025 ACRE ISLAND

MATERIAL SOURCE: Riprap bedding and armor stone will come from local quarries in the central Virginia area. Delivery will be by rail with the material reloaded on a barge for transport to the construction site. Pricing is based upon barge delivery at the site by the supplier, total haul distance is assumed to be between 75 and 100 miles.

PLACEMENT AREA: Material is to be placed on the North, East, and West sides of the Island Placement Dikes to elevation +4 MLW. Material removed for an equipment access channel will be side cast onto the new berm or on the adjacent bottom.

EQUIPMENT USED: Equipment selected is a floating crane of approximately 100 ton capacity with 100' boom. A work barge and access work boat will also be required. Material prices reflect equipment to deliver stone. Mobilization was allowed at 250 miles.

MATERIAL CHARACTERISTICS: Material for riprap will be a durable stone meeting C of E specification requirements. A 6" thick bedding layer and an 18" thick 1,000-1,500 lb. armor stone layer was assumed.

PRODUCTION: Assumptions made were: dredge access channel 100 cy/hr; place riprap and bedding including allowance for shaping slopes 80 tons/hr. Lost time allowance used was 200 hours. Mobilization and demobilization of 10 days or 100 hours was used. Overtime on labor was included as a 10% allowance.

WORK EXCLUDED: Cost shown include furnishing and placing riprap, bedding, and armor stone on previously placed dike. Dredging an access channel for equipment access is also included. No costs are included for environmental studies or for monitoring.

PRICE RANGE: Costs shown reflect placing 67,000 tons of bedding material and 200,000 tons of armor stone. Unit costs will vary inversely with quantity placed. Increases will cause very small decreases in unit prices; decreases will cause slight increases in unit costs. See 200 acre and 50 acre island estimates for comparative prices on reduced scope.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NN CHANNEL 2 SCOWS 1025 ACRE ISLAND

MATERIAL SOURCE: Newport News Channel, New Work, 4,500,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 2,000' x 18,550'; 445,200,000 sq ft or 1,025 acres. This source provides 35% of the material required to fill in behind the berm. Average haul distance is 6.5 miles each way; average pump out distance is 10,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two scows. At the disposal area a rehandler pump with booster and 10,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 6.5 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 6.5 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller, less efficient equipment would be used. Total mobilization costs will remain constant, and unit costs will vary inversely with the quantity placed.

DREDGE MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NORFOLK HARBOR CHANNEL 3 SCOWS 1025 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work, 800,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 2,000' x 18,550'; 445,200,000 sq ft or 1,025 acres. This source provides 6% of the material required to fill in behind the berm. Average haul distance is 23.5 miles each way; average pump out distance is 10,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three scows. At the disposal area a rehandler pump with booster and 10,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 23.5 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 23.5 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NORFOLK HARBOR CHANNEL 3 SCOWS 1025 ACRE ISLAND MAINTENANCE

MATERIAL SOURCE: Norfolk Harbor Channel, Maintenance, 1,500,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 2,000' x 18,550'; 445,200,000 sq ft or 1,025 acres. This source provides 59% of the material required to fill in behind the berm. To provide the total required quantity, a series of 5 yearly maintenance contracts will be required to provide a total of 7,500,000 cy. Average haul distance is 13 miles each way; average pump out distance is 10,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three scows. At the disposal area a rehandler pump with booster and 10,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 13 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be loose muddy silt. Bank height is assumed at 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .65; operating time factor .70; buckets per minute reduction factor .9; fill factor .75; cycle time 72 seconds, resulting in a net production rate of 4.61 cy/min. Hauling was assumed at 13 miles each way using three tugs and three scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller, less efficient equipment would be used. Total mobilization costs will remain constant, and unit costs will vary inversely with the quantity placed.

ISLAND PLACEMENT - TOTAL PROJECT, 200 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel and Newport News Channel. Berm requires 1,750,000 cy, fill in requires 3,900,000 cy. Berm material is from Norfolk Harbor Channel. Fill in material sources are : Norfolk Harbor Channel 2,550,000 cy; Newport News Channel 1,350,000 cy. Riprap material will come from local quarries.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Project constructs a riprap protected berm to 6' above MLW on the north, east, and west sides and to 4' above ML water on the south side. Fill in material would be placed so as to drain to the south. Average bottom depth for berm was assumed at -9 MLW and -6' MLW for fill in. An allowance was made for 1' of bottom settlement. Haul distances are 13 miles from Norfolk Harbor Channel and 6.5 miles from Newport News Channel. Pump out distances are 7,500' for berms and 10,500' for fill in. Front dike is 9,500 ft in length with a 50' top width; back dike is 9000 ft in length with a 40' top width. Bottom dike area is 115 acres, bottom fill in is 200 acres.

EQUIPMENT USED: 18 cy bucket dredge with two or three tugs and scows. A rehandler pump is used at the placement area. Dike requires a barge discharge, fill in requires an additional booster. Discharge will start at water level and be raised as fill progresses. The haul distance is too great for efficient hydraulic production. A hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to the shallow water depths at the placement area. Mobilization for dredge equipment was assumed at 1,000 miles.

For riprap placement a 100 ton floating rig with 100' boom and attendant plant was assumed. Dredging of an access channel will be required. Material will be barge delivered.

MATERIALS CHARACTERISTICS: New material is assumed to be a fine compacted sand. Maintenance material is assumed to be a loose muddy silt. Bank height for new work is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85: cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 6.5 or 13 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 or 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

ISLAND PLACEMENT - TOTAL PROJECT, 200 ACRE ISLAND

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring,environmental studies,or construction of wildlife habitat.

PRICE RANGE: Costs shown were developed assuming work would be a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the project. Combining projects would reduce mobilization/demob cost, project size may become to large to be practical from a funding viewpoint.

TOTAL PROJECT COSTS: PRICING LEVEL 1 JANUARY 1992

	Qty (cy)	Dredge ($)	Mob/demob ($)	Total ($)	Total w/ Contig SIOH, E&D
Berm	1,750,000	12,565,000	661,000	13,226,000	17,300,000
Fill in NHC	2,550,000	20,451,000	738,000	21,189,000	27,715,000
Fill in NNC	1,350,000	10,840,000	738,000	11,578,000	15,145,000
RipRap (TN)	134,000	6,700,000	100,000	6,800,000	9,215,000
Total Cost		50,556,000	2,237,000	52,793,000	69,375,000
Dredge cy	5,650,000				
Riprap TN	134,000				

Cost for project per cubic yard of dredged material $12.28

Note: To determine the true cost of constructing this or any other beneficial use option, deduct from the cost of dredging and constructing the island or other structure the cost for dredging and disposal of the same quantity of material (from the same channel) by whatever lower cost option is available and likely to be used. This analysis uses ocean disposal at the Dam Neck site as the "without beneficial use condition". The increment of cost above disposal at Dam Neck is the relevant cost of constructing the beneficial use alternative. This cost increment can also be converted into a cost per acre. For this island, 50 acres is the

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS 200 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work 1,750,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed so as to form a dike to retain material from future dredging projects. Dike enclosing North, East, and West side will be to a top height of +6' MLW, 50' berm top width with 8-1 side slopes. South dike will be to a top height of +4' MLW, 40' berm top width with 8-1 side slopes, an allowance for 1' settlement of existing bottom material was made. This source provides 50% of the total dike material required. Average bottom depth was assumed at -9' MLW. Average haul distance is 13 miles each way, average pump out distance is 7,500'. Front dike is 9,500 ft in total length, back dike is 9,000' in total length, bottom area is 4,987,00 sq ft or 115 acres.

MATERIAL CHARACTERISTICS: Material assumed to be fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 3,000 cy scows. At the disposal area a rehandler pump and 7,500' of discharge line with a barge discharge will be used. Discharge will start at water level and be progressively raised to dike height. The 13 mile distance from the source is too long for efficient hydraulic production. A hopper dredge could be used with additional rehandling costs. A bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 13 miles each way using three tugs and three scows @ 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Pump out production was factored at 60% to reflect control of material to place in berm. Clean up dredging of 5% additional time was allowed.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS 200 ACRE ISLAND

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies. Shaping of berm for riprap placement is included with riprap.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy., then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the berm.

DREDGED MATERIAL PLACEMENT CONCEPT-ISLAND PLACEMENT RIPRAP ON BERM 200 ACRE ISLAND

MATERIAL SOURCE: Riprap bedding and armor stone will come from local quarries in the central Virginia area. Delivery will be by rail with the material reloaded on a barge for transport to the construction site. Pricing is based upon barge delivery at the site by the supplier, total haul distance is assumed to be between 75 and 100 miles.

PLACEMENT AREA: Material is to be placed on the North, East, and West sides of the Island Placement Dikes to elevation +4 MLW. Material removed for an equipment access channel will be side cast onto the new berm or on the adjacent bottom.

EQUIPMENT USED: Equipment selected is a floating crane of approximately 100 ton capacity with 100' boom. A work barge and access work boat will also be required. Equipment for delivery of stone is reflected in the material prices. Mobilization was allowed at 250 miles.

MATERIAL CHARACTERISTICS: Material for riprap will be a durable stone meeting C of E specification requirements. A 6" thick bedding layer and 18" thick 1,000-1,500 lb. armor stone layer was assumed.

PRODUCTION: Assumptions made were: dredge access channel 100 cy/hr; place riprap and bedding including allowance for shaping slopes 80 tons/hr. Lost time allowance used was 110 hours. Mobilization and demobilization of 10 days or 100 hours was used. Overtime on labor was included as a 10% allowance.

WORK EXCLUDED: Cost shown include furnishing and placing riprap, bedding, and armor stone on previously placed dike. Dredging an access channel for equipment access is also included. No costs are included for environmental studies or for monitoring.

PRICE RANGE: Costs shown reflect placing 34,000 tons of bedding material and 100,000 tons of armor stone. Unit costs will vary inversely with quantity placed. Increases will cause small decreases in unit prices; decreases will cause increases in unit costs. See 1025 acre and 50 acre island for comparative pricing on varying quantities.

DREDGE MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NORFOLK HARBOR CHANNEL 3 SCOWS 200 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work, 2,550,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 1,000' x 8,700'; 87,000,000 sq ft or 200 acres. This source provides 65% of the material required to fill in behind the berm. Average haul distance is 13 miles each way; average pump out distance is 10,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three scows. At the disposal area a rehandler pump with booster and 10,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 13 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 13 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NN CHANNEL 2 SCOWS 200 ACRE ISLAND

MATERIAL SOURCE: Newport News Channel, New Work, 1,350,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 1,000' x 8,700'; 87,000,000 sq ft or 200 acres. This source provides 35% of the material required to fill in behind the berm. Average haul distance is 6.5 miles each way; average pump out distance is 10,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two scows. At the disposal area a rehandler pump with booster and 10,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 6.5 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency.75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 6.5 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

ISLAND PLACEMENT - TOTAL PROJECT, 50 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel. Berm requires 900,000 cy, fill in requires 975,000 cy. Riprap material will come from local quarries.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Project constructs a riprap protected berm to 6' above MLW on the north, east, and west sides and to 4' above ML water on the south side. Fill in material would be placed so as to drain to the south. Average bottom depth for berm was assumed at -9 MLW and -6' MLW for fill in. An allowance was made for 1' of bottom settlement. Haul distance is 13 miles from Norfolk Harbor Channel. Pump out distances are 7,500' for berms and 7,500' for fill in. Front dike is 4,900 ft in length with a 50' top width; back dike is 4500 ft in length with a 40' top width. Bottom dike area is 58 acres, bottom fill in is 50 acres.

EQUIPMENT USED: 18 cy bucket dredge with two or three tugs and scows. A rehandler pump is used at the placement area. Dike and fill in requires a barge discharge. Discharge will start at water level and be raised as fill progresses. The haul distance is too great for efficient hydraulic production. A hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to the shallow water depths at the placement area. Mobilization for dredge equipment was assumed at 1,000 miles.

For riprap placement a 100 ton floating rig with 100' boom and attendant plant was assumed. Dredging of an access channel will be required. Material will be barge delivered.

MATERIALS CHARACTERISTICS: New material is assumed to be a fine compacted sand. Maintenance material is assumed to be a loose muddy silt. Bank height for new work is 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85: cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling distance of 13 miles each way was assumed using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 or 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, or construction of wildlife habitat.

ISLAND PLACEMENT - TOTAL PROJECT, 50 ACRE ISLAND

PRICE RANGE: Costs shown were developed assuming work would be new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller, less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the project. Combining projects would reduce mobilization/demob cost, project size may become to large to be practical from a funding viewpoint.

TOTAL PROJECT COSTS: PRICING LEVEL 1 JANUARY 1992

	Qty (cy)	Dredge ($)	Mob/demob ($)	Total ($)	Tot w/Contig SIOH & E&D
Berm	900,000	6,462,000	661,000	7,123,000	9,317,000
Fill in NHC	975,000	7,000,500	661,000	7,661,500	10,021,000
RipRap (TN)	70,000	3,935,000	100,000	4,035,000	5,473,000
Total Cost		17,397,500	1,422,000	18,819,500	24,811,000

Dredge cy	1,875,000
Riprap (TN)	70,000

Cost for project per cubic yard of dredged material $13.23

Note: To determine the true cost of constructing this or any other beneficial use option, deduct from the cost of dredging and constructing the island or other structure the cost for dredging and disposal of the same quantity of material (from the same channel) by whatever lower cost option is available and likely to be used. This analysis uses ocean disposal at the Dam Neck site as the "without beneficial use condition". The increment of cost above disposal at Dam Neck is the relevant cost of constructing the beneficial use alternative. This cost increment can also be converted into a cost per acre. For this island, 50 acres is the measurement of the footprint underwater. Because of sloped banks, the surface above water will be less.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS 50 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work 900,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed so as to form a dike to retain material from future dredging projects. Dike enclosing North, East, and West side will be to a top height of +6' MLW, 50' berm top width with 8-1 side slopes. South dike will be to a top height of +4' MLW, 40' berm top width with 8-1 side slopes, an allowance for 1' settlement of existing bottom material was made. This source provides 100% of the total dike material required. Average bottom depth was assumed at -9' MLW. Average haul distance is 13 miles each way, average pump out distance is 7,500'. Front dike is 4,900 ft in total length, back dike is 4,500' in total length, bottom area is 2,537,000 sq ft or 58 acres.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three 3,000 cy scows. At the disposal area a rehandler pump and 7,500' of discharge line with a barge discharge will be used. Discharge will start at water level and be progressively raised to dike height. The 13 mile distance from the source is too long for efficient hydraulic production, a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency.75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 13 miles each way using three tugs and three scows @ 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 290 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Pump out production was factored at 60% to reflect control of material to place in berm. Clean up dredging of 5% additional time was allowed.

DREDGED MATERIAL PLACEMENT CONCEPT - ISLAND BERM NH CHANNEL 3 SCOWS 50 ACRE ISLAND

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies. Shaping of berm for riprap placement is included with riprap.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy., then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the berm.

DREDGED MATERIAL PLACEMENT CONCEPT-ISLAND PLACEMENT RIPRAP ON BERM 50 ACRE ISLAND

MATERIAL SOURCE: Riprap bedding and armor stone will come from local quarries in the central Virginia area. Delivery will be by rail with the material reloaded on a barge for transport to the construction site. Pricing is based upon barge delivery at the site by the supplier, total haul distance is assumed to be between 75 and 100 miles.

PLACEMENT AREA: Material is to be placed on the North, East, and West sides of the Island Placement Dikes to elevation +4 MLW. Material removed for an equipment access channel will be side cast onto the new berm or on the adjacent bottom.

EQUIPMENT USED: Equipment selected is a floating crane of approximately 100 ton capacity with 100' boom. A work barge and access work boat will also be required. Equipment for delivery of stone is reflected in the material prices. Mobilization was allowed at 250 miles.

MATERIAL CHARACTERISTICS: Material for riprap will be a durable stone meeting C of E specification requirements. A 6"thick bedding layer and an 18" thick 1,000-1,500 lb. armor stone layer was assumed.

PRODUCTION: Assumptions made were: dredge access channel 100 cy/hr; place riprap and bedding including allowance for shaping slopes 80 tons/hr. Lost time allowance used was 70 hours. Mobilization and demobilization of 10 days or 100 hours was used. Overtime on labor was included as a 10% allowance.

WORK EXCLUDED: Costs shown include furnishing and placing riprap, bedding, and armor stone on previously placed dike. Dredging an channel for equipment access is also included. No costs are included for environmental studies or for monitoring.

PRICE RANGE: Costs shown reflect placing 18,000 tons of bedding material and 52,000 tons of armor stone. Unit costs will vary inversely with quantity placed. Increases will cause small decreases in unit prices; decreases will cause increases in unit costs.

DREDGE MATERIAL PLACEMENT CONCEPT - ISLAND FILL IN NORFOLK HARBOR CHANNEL 3 SCOWS 50 ACRE ISLAND

MATERIAL SOURCE: Norfolk Harbor Channel, New Work, 975,000 pay cubic yards.

PLACEMENT AREA: Lower James River adjacent to Ragged Island east of the James River Bridge. Material is to be placed within the berm constructed under other estimates. Average bottom elevation is -6' MLW. Material will be placed so as to slope from a north elevation of +6' MLW to a south elevation of +4' MLW. An allowance of 1' for settlement of existing bottom was made. Total bottom area is 500' x 4,360'; 2,180,000 sq ft or 50 acres. This source provides 100% of the material required to fill in behind the berm. Average haul distance is 13 miles each way; average pump out distance is 7,500 ft.

EQUIPMENT USED: 18 cy bucket dredge with three tugs and three scows. At the disposal area a rehandler pump and 7,500 ft of discharge line will be used. Discharge will be at water level or surface of previously placed material. The 13 mile haul is too long for efficient hydraulic production; a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumptions made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 13 miles each way using two tugs and two scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 190 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, creation of wildlife habitats, or planting.

PRICE RANGE: Costs shown were developed assuming a new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

LOWER CHESAPEAKE BAY STUDY
DREDGED MATERIAL ISLAND
CONCEPT DESIGNS

1. GENERAL: The following concept design information for dredged material islands in the vicinity of Newport News is based on the Virginia Institute of Marine Science Port Island Study, the Norfolk Harbor and Channels (Deepening) General Design Memorandum, and current estimates of maintenance dredging requirements for the Newport News Channel. Concept designs for a large dredged material island capable of providing adequate capacity for the new work dredging of the Channel to Newport News and the 55-Foot Anchorage and for a small dredged material island based on the placement of dredged material from the maintenance of the Newport News Channel.

2. ISLAND SITE SELECTION: The proposed location for the dredged material island is identified in the VIMS report as "Area C" and the approximate location is shown on the attached map. The site is located in proximity to the Channel to Newport News, the 55-Foot Anchorage, the Sewells Point 45-Foot Anchorages and the Norfolk Harbor Channel Entrance Reach. Any of these Federal Navigation projects could provide dredged material for island construction, however for the scope of this investigation only the dredged material from the Channel to Newport News and the 55-Foot Anchorage will be used. The site is characterized as being relatively flat and shallow with the average depth assumed to be 10 feet below mean low water. The site is exposed and can experience fairly large wave conditions and tidal fluctuations during storm events. It is expected that the east side of the island will require some type of hard shore protection, rip-rap, concrete dolos, concrete rubble, etc., the west side of the island is much less exposed and may be protected by some type of soft protection such as geotextile bags or suitable vegetation.

3. LARGE ISLAND CONCEPT:

a. General: This concept is for a large dredged material island capable of providing adequate capacity for the new work dredging (deepening) of the Newport News 55-foot Channel and the 55-foot anchorage.

b. Island Configuration: It is assumed that the island will be designed to conform to the prevailing current patterns at the site and shaped to result in the least impact to the existing currents. For this concept design it is assumed that the island will have a length to width ratio of about 3 to 1, the axis of the island aligned with the prevailing current direction, and the ends of the island will be curved to be hydrodynamically compatible with current flow.

c. Design Criteria: The following island design criteria are assumed:

Average Water Depth 10 feet below mean low water
Island Elevation 5 feet above mean low water
Side Slopes: 1 vertical on 30 horizontal below water line and 1 vertical on 3 horizontal above water line
Length 3 times the width
Construction Quantity
Newport News Channel 4,500,000 cubic yards
55-Foot Anchorage 500,000 cubic yards
Total Quantity 5,000,000 cubic yards
Construction Method Hydraulic Pipeline Dredge, not to exceed one booster pump.

d. The CADD system was used to estimate the following island dimensions:

Island Elevation: 5 feet above mean low water

Length 4,800 feet
Width 1,600 feet
Area 250 acres

4. SMALL ISLAND CONCEPT:

a. General: This concept is for a small dredged material island that could be a demonstration project, a maintenance dredging beneficial use, or as a small island to used in conjunction with a large dredged material island. The size of the island is derived from the estimated quantity of material to maintain the Channel to Newport News 50-foot project.

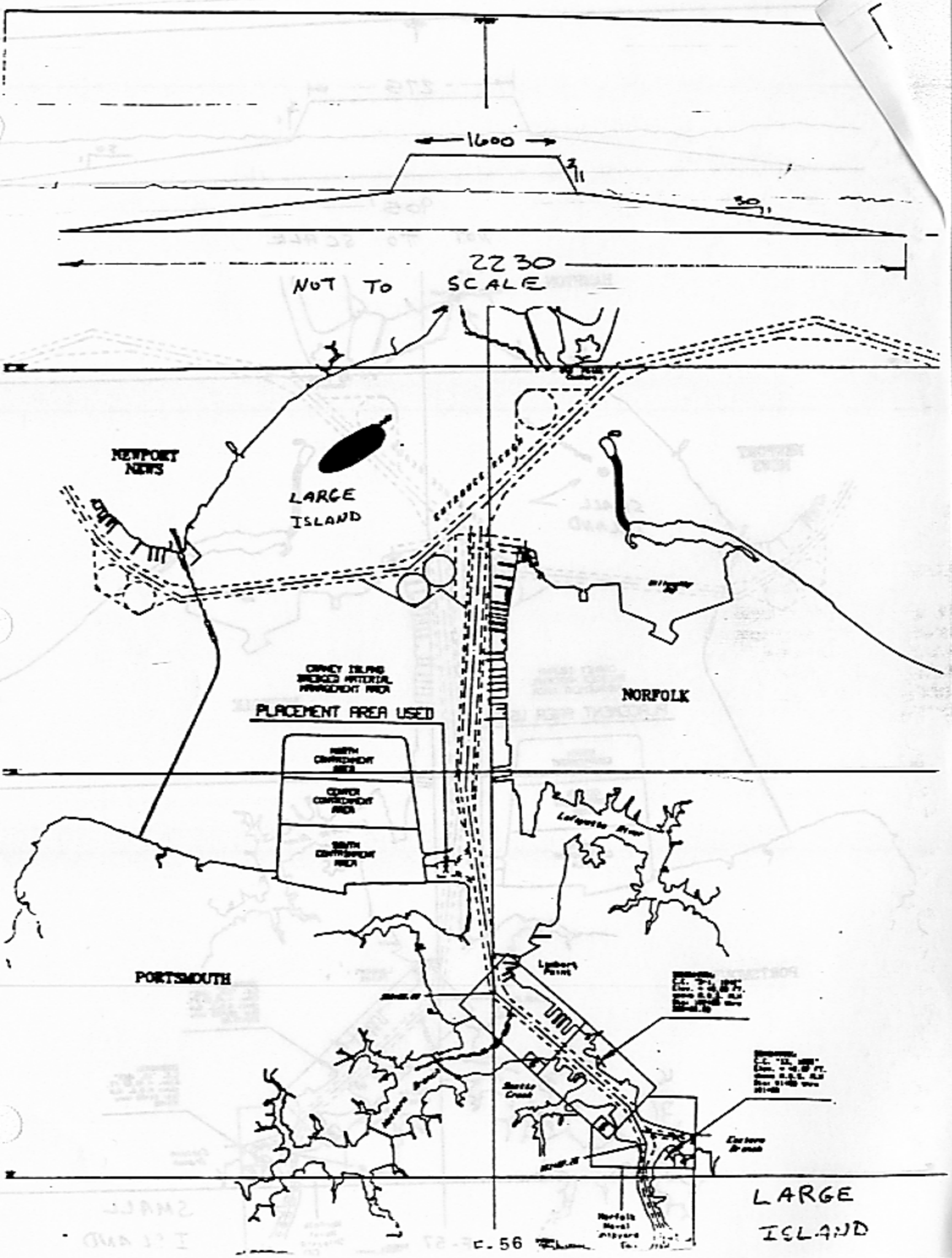
b. Island Configuration: It is assumed that a small island will have a relatively small impact on the currents and the shape will not be a significant design concern. In order to keep this concept simple, the shape is assumed to be round.

c. Design Criteria: The following small island design criteria are assumed:

Average Water Depth 10 feet below mean low water
Island Elevation 5 feet above mean low water
Side Slopes: 1 vertical on 30 horizontal below water line and 1 vertical on 3 horizohtal above water line.
Island shape circular
Construction Quantity 265,000 cubic yards
Construction Method Hydraulic Pipeline Dredge, not to exceed one booster pump.

d. The CADD system was used to determine the following small island dimensions:

Island Radius 275 feet
Island Area 15 acres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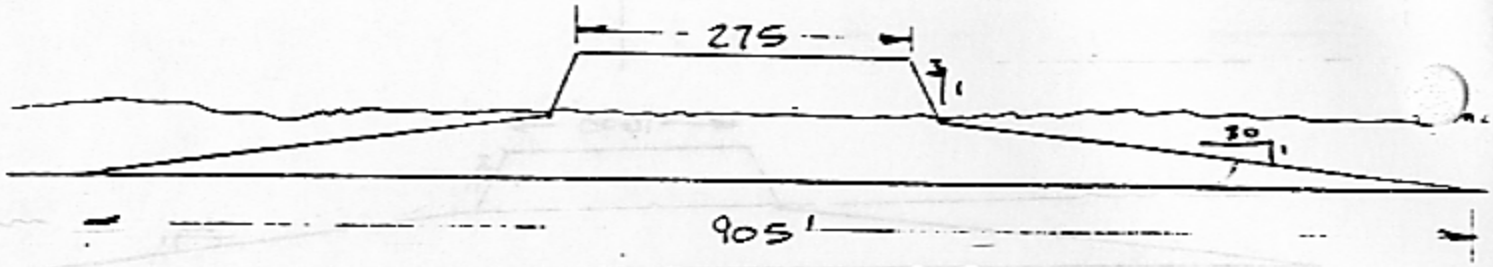
NOT TO SCALE
NEWPORT NEWS
LARGE ISLAND
NORFOLK
PLACEMENT AREA USED
PORTSMOUTH
LARGE ISLAND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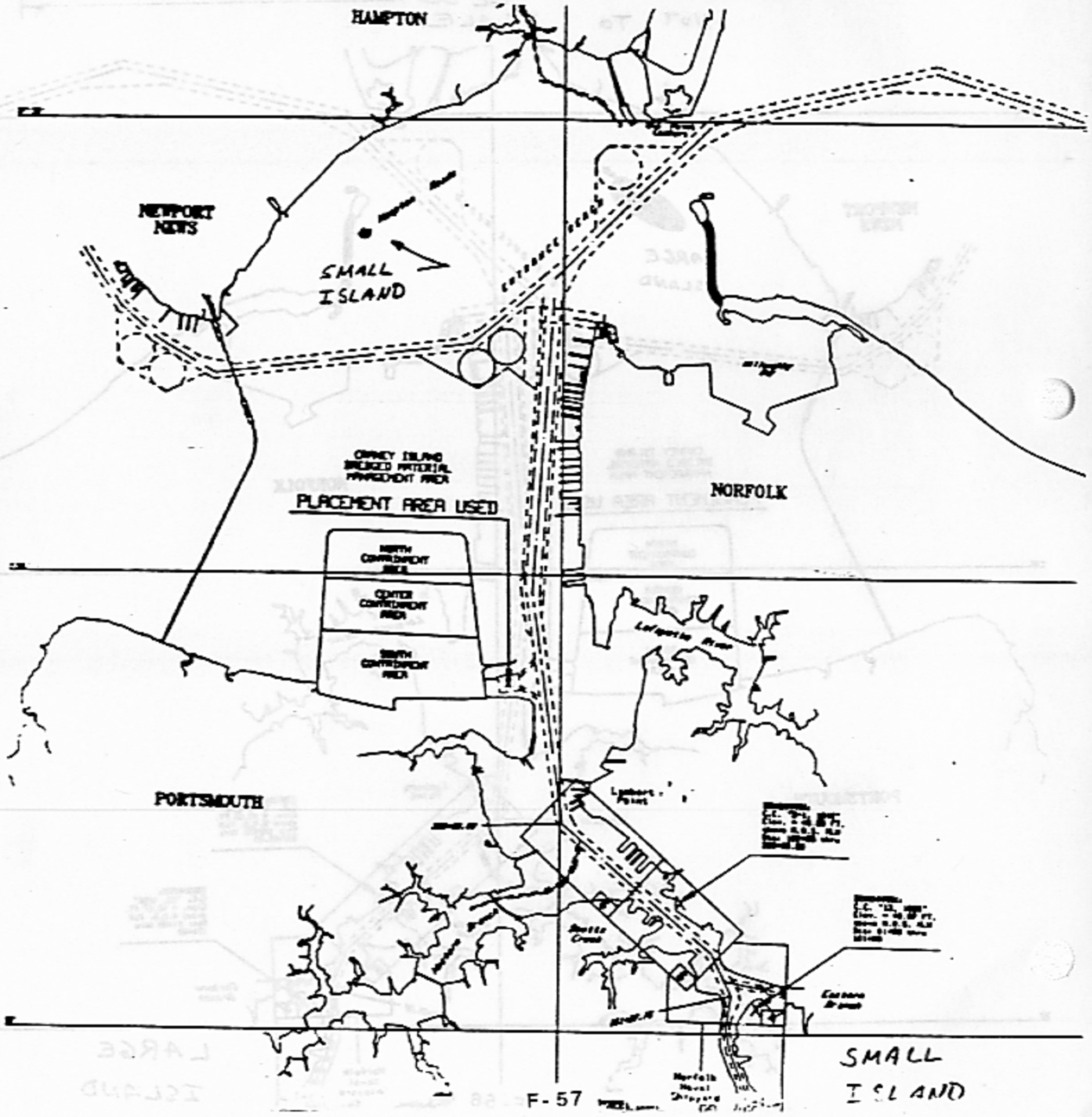

HAMPTON
NEWPORT NEWS
SMALL ISLAND
ENTRANCE CANAL
CRANEY ISLAND DREDGED MATERIAL MANAGEMENT AREA
PLACEMENT AREA USED
NORTH CONFINEMENT AREA
CENTER CONFINEMENT AREA
SOUTH CONFINEMENT AREA
NORFOLK
PORTSMOUTH
SMALL ISLAND

MATERIAL PLACEMENT CONCEPTS ISLAND - NEWPORT NEWS

	LARGE ISLAND DREDGE (BOTH REQUIRED)			SMALL ISLAND DREDGE (ONE REQUIRED)	
	NEWPORT NEWS CHANNEL	55 FT ANCHORAGE	RIP RAP	NEWPORT NEWS CHANNEL	NEWPORT NEWS CHANNEL
MAT'L TYPE	NEW	NEW		MAINT.	MAINT.
DREDGE METHOD	HYD	HYD		HYD	HYD
QTY CY	4,500,000	500,000		265,000	265,000
BANK HEIGHT	5.6	5.6		3.4	3.4
DREDGE SIZE	27 INCH	27 INCH		24 INCH	18 INCH
CHART	1,141	1,236		881	356
EFFECTIVE	758	739		575	277
BOOSTER	NO	YES		NO	NO
MAT'L FACTOR	1.2	1.2		1.7	1.7
BANK FACTOR	0.85	0.85		0.64	0.76
OTHER FACTOR	0.65	0.65		0.60	0.60
PIPELINE LENGTH	8,500	15,500		8,000	8,000
CY PER MONTH	300,200	292,737		227,695	109,860
MONTHLY COST	805,950	999,100		616,884	400,528
MOB/DEMOB	1,112,000	1,185,000		949,000	350,500
DREDGE $/CY	4.27	5.43		5.01	6.75
MOB/DEMOB $/CY	0.25	2.37		3.58	1.32
GROSS CY	5,478,300	608,700		375,400	375,400
CONTR COST W/MOB DEMOB	4.52	7.80		8.59	8.07
UNIT COST INCL CONTIG,SIOH,E&D	5.91	10.20		11.23	10.55

*NOTE: SEE NARRATIVE SHEETS FOR RIP RAP COST TO BE ADDED TO EACH ISLAND AND FOR SUMMARY OF COSTS.

DREDGED MATERIAL ISLAND CONCEPT DESIGN
NEWPORT NEWS AREA

MISCELLANEOUS EQUIPMENT

SHAPING PLACEMENT AREA

D-4 DOZER (LGP)	2	EA @	25.00	50.00	
FOREMAN	1	EA @	15.00	15.00	
OPERATOR	2	EA @	13.00	26.00	
LABORER	4	EA @	10.00	40.00	
ALLOW OT	15 %			11.00	
TAXES INS FRINGES ON LABOR 70.8%				65.00	
				207.00	PER HOUR
			USE	210.00	PER HOUR DIRECT COST

MOBILIZATION / DEMOBILIZATION

8 HRS EACH	1,600	
TUG / BARGE / UNLOAD ALLOW	3,400	
	5,000	EACH WAY

LARGE ISLAND (STORM ALLOWANCE) ALLOW 7 TRIPS = 8 TOTAL

SMALL ISLAND (STORM ALLOWANCE) ALLOW 2 TRIPS = 3 TOTAL

	MOB	DEMOB
LARGE	40,000	40,000
SMALL	15,000	15,000

(DIRECT COST)

(SHOWN UNDER LINE 8 SECTION D MOB & DEMOB)

DREDGD MATERIAL ISLAND CONCEPT DESIGNS

TOTAL PROJECT LARGE ISLAND

MATERIAL SOURCE: Newport News Area, Newport News Channel and 55' Anchorage. Island requires 5,000,000 cy. Fill material sources are: Newport News Channel, 4,500,000 cy; 55' Anchorage 500,000 cy. Riprap will come from local quarries.

PLACEMENT AREA: North of Newport News Channel in Hampton Flats area. Project constructs a 250 acre island (at existing bottom); above water area is 160 acres. Riprap protection will be placed on the east side and portions of the south and north sides. Fill for the entire island will be placed prior to construction of the riprap berm. Average bottom depth is ten feet. Pumping distance is 8,500 lf for Newport News Channel and 15,500 lf for 55' Anchorage. Island above MLW is an approximate ellipse with a north-south dimension of 1,600' and east-west dimension of 4,800'. Berm slopes will be shaped at 3 on 1 prior to riprap placement; underwater slope will be 30 on 1.

EQUIPMENT USED: 27" hydraulic dredge with required pipeline. Newport News Channel requires 8,500 lf of pipeline; 55' Anchorage requires 15,500 lf of pipeline with one booster. Two low ground pressure D-4 dozers are used in both sources to spread material and shape at berm areas. Hopper or bucket dredges would require rehandling of material; a hydraulic dredge was used as being the most cost effective. Mobilization for the hydraulic dredge was assumed at 1,500 miles. Placement of riprap was assumed to be from shore using off road trucks for haul and a 50 ton crane at both the unloading area and placement area. A D-4 LGP dozer is used to shape and maintain haul roads. Dredging of an access channel will be by a barge mounted crane. Material will be barge delivered, unloaded to trucks, and hauled to the placement area.

MATERIAL CHARACTERISTICS: Material is assumed to be new work consisting of a fine compacted sand. Bank height is 4'6" plus 1' for non pay overdepth.

PRODUCTION: Dredging assumptions made were: Newport News Channel, Chart production at 9,300 lf effective pumping is 1125 cy/hr, booster factor 1, material factor 1.2 sand, bank factor .852 (5.6'), placing efficiency .65, giving a net production of 758 cy/hr; 55' Anchorage: chart production at 17,000 lf effective pumping with one booster 1,236 cy/hr, booster factor .9, material factor 1.2 sand, bank factor .852 (5-6'), placing efficiency .65, giving a net production of 739 cy/hr. Clean up dredging of 5% additional time was allowed. Placing efficiency reflects lost time moving discharge lines to place selected material in dikes and to provide an island height of 5'.

Riprap: access channel dredging production was assumed at 100 cy/hr; placing riprap was assumed at 70 tons/hr for both bedding and riprap, truck hauling was assumed at 10 tons/truck with a 14 minute round trip. An allowance of 1 hour/50' of berm for shaping was also included.

WORK EXCLUDED: Costs are for dredging and placement of dredged materials and riprap. No costs are included for monitoring, environmental studies, or construction of wildlife habitat.

PRICE RANGE: Costs shown were developed assuming work would be new work dredging projects. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 300,000 cy, then smaller less efficient equipment would be used. Total mobilization cost will remain constant, unit costs will vary inversely with the quantity placed in the project. Combining the dredging projects would reduce mobilization/demobilization costs.

TOTAL PROJECT COSTS: Pricing level: 1 January 1992.

	QTY (CY)	DREDGE ($)	MOB/DEMOB ($)	TOTAL ($)	TOTAL W/ CONTIG/ SIOH,E&D
NNC	4,500,000	19,215,000	1,112,000	20,327,000	26,590,000
55 FT ANCHORAGE	500,000	2,715,000	1,185,000	3,900,000	5,100,000
RIPRAP (TN)	16,500	890,000	170,000	1,060,000	1,440,000
TOTAL COST		22,820,000	2,467,000	25,287,000	33,130,000

DREDGE CY 5,000,000

RIP RAP (TN) 16,000

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

NEWPORT NEWS AREA - LARGE ISLAND - NEWPORT NEWS CHANNEL

MATERIAL SOURCE: Newport News Channel, new work 4,500,000 pay cubic yards. This source provides 90% of the required material.

PLACEMENT AREA: North of Newport News Channel in Hampton Flats area. This placement area constructs an approximate elliptical shaped island with a north-south dimension of 1,600' and an east-west dimension of 4,800'. Bottom area at existing bottom is 250 acres. Berm slopes will be shaped at 3 on 1 prior to riprap placement: underwater slope will be 30 on 1. Average bottom depth is ten feet. Pumping distance is 8,500 lf.

EQUIPMENT USED: 27" pipeline dredge with 8,500 lf of disposal line. Fuel was used at $0.90/gallon. Two D-4 low ground pressure dozers are used to shape discharged material. A hydraulic method is the only way to place material in shallow water to a height of 5' above MLW. Hopper or bucket dredges would require rehandling of material and were not considered in estimate preparation. Mobilization for the hydraulic dredge was assumed at 1,500 miles.

MATERIAL CHARACTERISTICS: Material is assumed to be new work consisting of a fine compacted sand. Bank height is 4'6" plus 1' for non-pay overdepth.

PRODUCTION: Chart production for 9,300 lf effective pumping distance is 1,125 cy/hr. Factors used were: booster 1.0; material 1.2 sand; bank .852 (5.6'); placing efficiency .65; giving a net production of 748 cy/hr. Operating hours/day are 18; days/month are 22. The .65 placing efficiency reflects lost time moving discharge lines to place selected material in dikes and to provide an island height of 5'.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, or providing wildlife habitat.

PRICE RANGE: Costs shown were developed assuming a new work quantity of 4,500,000 pay cy. Unit costs for moving material will vary inversely with changes in quantity. These changes would be minor unless the quantity becomes less than 300,000 cy (1 months dredging time). Total mobilization/demobilization costs will remain constant, unit costs will vary inversely with total quantity.

UNIT COSTS: Pricing level: 1 January 1992

Dredge Contract:	$4.27
Mobilization Demob:	.25
Total Contract:	4.52
Total Incl Contg (20%),	5.42
E&D, SIOH (9%):	$5.91
Mob/Demob Contract:	$1,112,000

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

NEWPORT NEWS AREA - LARGE ISLAND - 55 FT ANCHORAGE

MATERIAL SOURCE: 55 Ft Anchorage, new work 500,000 pay cubic yards. This source provides 10% of the required material.

PLACEMENT AREA: North of Newport News Channel in Hampton Flats area. This placement area constructs an approximate elliptical shaped island with a north-south dimension of 1,600' and an east-west dimension of 4,800'. Bottom area at existing bottom is 250 acres. Berm slopes will be shaped at 3 on 1 prior to riprap placement: underwater slope will be 30 on 1. Average bottom depth is ten feet. Pumping distance is 15,500 lf.

EQUIPMENT USED: 27" pipeline dredge with one booster and 15,500 lf of disposal line. Fuel was used at $0.90/gallon. Two D-4 low ground pressure dozers are used to shape discharged material. A hydraulic method is the only way to place material in shallow water to a height of 5' above MLW. Hopper or bucket dredges would require rehandling of material and were not considered in estimate preparation. Mobilization for the hydraulic dredge was assumed at 1,500 miles.

MATERIAL CHARACTERISTICS: Material is assumed to be new work consisting of a fine compacted sand. Bank height is 4'6" plus 1' for non-pay overdepth.

PRODUCTION: Chart production for effective pumping distance is 1,236 cy/hr. Factors used were: booster 0.9; material 1.2 sand; bank .852 (5'6"); placing efficiency .65; giving a net production of 739 cy/hr. Operating hours/day are 18; days/month are 22. The .65 placing efficiency reflects lost time moving discharge lines to place selected material in dikes and to provide an island height of 5'.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, or providing wildlife habitat.

PRICE RANGE: Costs shown were developed assuming a new work quantity of 500,000 pay cy. Unit costs for moving material will vary inversely with changes in quantity. These changes would be minor unless the quantity becomes less than 300,000 cy (1 months dredging time). Total mobilization/demobilization costs will remain constant, unit costs will vary inversely with total quantity.

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

NEWPORT NEWS AREA - RIP RAP ON BERM - LARGE ISLAND

MATERIAL SOURCE: Rip rap bedding and armor stone will come from local quarries in the central Virginia area. Delivery will be by rail with the material reloaded on a barge for transport to the construction site. Pricing is based upon barge delivery at the site by the supplier, total haul distance is assumed to be between 75 and 100 miles. Rehandling into trucks at the placement area is included in installation costs.

PLACEMENT AREA: Material is to be placed on the east side and portions of the north and south sides, slope will be 3 on 1. Protection will be provided from 1' below MLW to a height of 5' above MLW. Material removed for an equipment access channel will be side cast on the adjacent bottom.

EQUIPMENT USED: Access channel and turning area will be excavated using a 100 ton floating crane with a 100' boom. Equipment for delivery of stone is reflected in material prices. Material will be unloaded from delivery barges using a 50' land crane, loaded into off road trucks for haul to the placement area. Placement will be by a 50 ton land crane. A D-6 LGP dozer will be used to maintain the haul roads. Mobilization was allowed at 250 miles.

MATERIAL CHARACTERISTICS: Material for riprap will be a durable stone meeting C of E specification requirements. A 6" thick bedding layer and an 18" thick 1,000-1,500 lb. armor stone layer was assumed.

PRODUCTION: Assumptions made were: dredge access channel 100 cy/hr; place riprap and bedding at slopes 70 tons/hr. Truck hauling at 14 minute/trip for a 10 ton load was used. Shaping slopes prior to bedding placement was assumed at 50 lin. ft per hour. Mobilization/demobilization of 2 days for land equipment and 10 days for marine equipment was used. An additional allowance of 2 days for land equipment was included to allow for removal due to weather.

WORK EXCLUDED: Costs shown include furnishing and placing riprap, bedding, and armor stone on previously placed dike. Dredging an access channel an a temporary bulkhead for equipment access is also included. No costs are included for environmental studies, monitoring, or providing wildlife habitat.

PRICE RANGE: Costs shown reflect placing 3,500 tons of bedding material and 12,500 tons of armor stone. Unit costs will vary inversely with quantity placed. Increases will cause small decreases in unit prices; decreases will cause increases in unit cost. Mobilization/demobilization costs are included at $170,000 contract costs and would be expected to remain constant.

DREDGED MATERIAL ISLAND PLACEMENT DESIGNS
NEWPORT NEWS AREA

PLACE RIP RAP - EQUIPMENT/LABOR SUMMARY, LARGE ISLAND

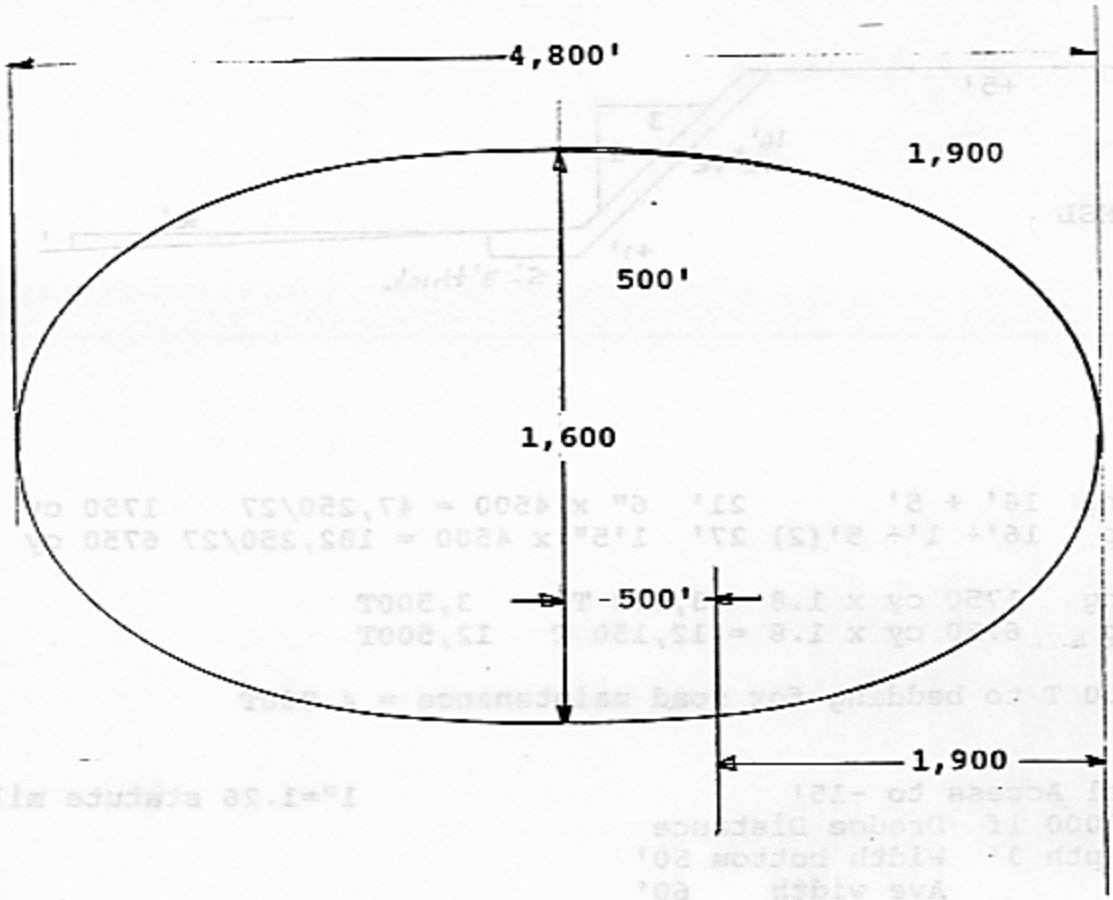
		Dredge Access	Mob/ Demob		RipRap	Mob/ Demob*	Total
Floating Rig		300	80		-		380
50' crane		-	-		640	64	672
10 T Truck		-	-		960	96	1008
D-4 LGP Dozer		-	-		320	32	352
Foreman		300	80		320	80	780
Crane Operator		300	80		640	80	1100
Rigger	(2)	600	160	(3)	960	96	1816
Laborers	(2)	600	160	(3)	960	96	1816
Truck Driver		-	-	(3)	960	96	1056
Dozer Operator		-	-		320	32	352

* Allows for one removal / return due to weather

DREDGED MATERIAL ISLAND PLACEMENT CONCEPTS

NEWPORT NEWS AREA

RIP RAP LENGTH - LARGE ISLAND

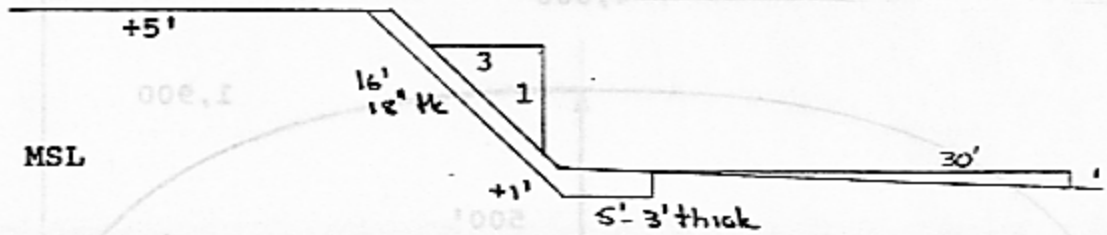


1,900
1,900
1,600
5,400 X .8 = 4,320 lf
USE 4,500 lf

DREDGED MATERIAL ISLAND PLACEMENT DESIGNS

NEWPORT NEWS AREA

PLACE RIPRAP - QUANTITIES - LARGE ISLAND



Bedding	16' + 5'	21'	6" x 4500 = 47,250/27	1750 cy
Riprap	16'+ 1'+ 5'(2)	27'	1'5" x 4500 = 182,250/27	6750 cy

Bedding	1750 cy x 1.8 = 3,150 T	3,500T
Riprap	6750 cy x 1.8 = 12,150 T	12,500T

Add 500 T to bedding for road maintenance = 4,000T

Channel Access to -15' 1"=1.26 statute miles
Use 3000 lf Dredge Distance
Ave Depth 3' Width bottom 50'
Ave width 60'

Channel Vol = 3000' x 3' x 60' = 540,000
Work turn around at Island 150' x 150' x 12' = 270,000
810,000 = 30,000 cy

@ 100 cy/hr = 300 hrs

Floating Crane w/operator
Riggers 2 ea
Laborers 2 ea

DREDGED MATERIAL ISLAND PLACEMENT DESIGNS

NEWPORT NEWS AREA

Place Riprap - Production - Large Island

Construct Rehandling area
Bulkhead allow 20' x 100' = 2000 sf

Place Riprap
Use:
3 ea Trucks off road
1 ea 50 T crane on mats at unloading area
1 ea 50 T crane on mats at placement area
1 ea D-4 LGP dozer maintaining roads
Allow stone for problem areas in roads 500 T
1 ea Foreman
3 ea Riggers
3 ea Laborers

Place bedding at 70 T/hr	3500 T =	50 hrs
Place riprap at 70 T/hr	12500 T =	180 hrs
		230 hrs

Trucks

Load	3 min
Haul 10 MPH/ 1/2 Mile	3 min
Unload/turnaround	5 min
Return	3 min
	14 min

55 min hr / 14 min + 3.9 trips/hr
At 10 tons = 40 tons / truck / hr
allow 3 trucks

Shape side allow 1 hr / 50 ft = 90 hrs

Total time for crew 230 hrs + 90 hrs = 320 hrs

Allow Mob/Demob 2 days 16 hrs

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

TOTAL PROJECT SMALL ISLAND

MATERIAL SOURCE: Newport News Area, Newport News Channel. Island requires 265,000 cy. Riprap will come from local quarries.

PLACEMENT AREA: North of Newport News Channel in Hampton Flats area. Project constructs a 15 acre island at existing bottom; above water area is 1.4 acres. Riprap protection will be placed on the entire perimeter. Fill for the entire island will be placed prior to construction of the riprap berm. Average bottom depth is ten feet. Pumping distance is 8,000 lf for Newport News Channel. Island is an circular diameter of 275'. Berm slopes will be shaped at 3 on 1 prior to riprap placement; underwater slope will be 30 on 1.

EQUIPMENT USED: 18" hydraulic dredge with required pipeline. Newport News Channel requires 8,000 lf of pipeline. Two low ground pressure D-4 dozers are used to spread material and shape at berm areas. Hopper or bucket dredges would require rehandling of material; a hydraulic dredge was used as being the most cost effective. Mobilization for the hydraulic dredge was assumed at 1,500 miles. Placement of riprap was assumed to be from shore using off road trucks for haul and a 50 ton crane at both the unloading area and placement area. A D-4 LGP dozer is used to shape and maintain haul roads. Dredging of an access channel will be by a barge mounted crane. Material will be barge delivered, unloaded to trucks, and hauled to the placement area.

MATERIAL CHARACTERISTICS: Material is assumed to be maintenance work consisting of a loose muddy silt. Bank height is 2'4" plus 1' for non pay overdepth.

PRODUCTION: Dredging assumptions made were: Newport News Channel, Chart production at 8,800 lf effective pumping is 356 cy/hr, booster factor 1, material factor 1.7 mud, bank factor .764 (3.4'), placing efficiency .60, giving a net production of 277 cy/hr. Clean up dredging of 5% additional time was allowed. Placing efficiency reflects lost time moving discharge lines to place selected material in dikes and to provide an island height of 5'.

Riprap: access channel dredging production was assumed at 100 cy/hr; placing riprap was assumed at 70 tons/hr for both bedding and riprap, truck hauling was assumed at 10 tons/truck with a 14 minute round trip. An allowance of 1 hour/50' of berm for shaping was also included.

WORK EXCLUDED: Costs are for dredging and placement of dredged materials and riprap. No costs are included for monitoring, environmental studies, or construction of wildlife habitat.

PRICE RANGE: Costs shown were developed assuming work would be new work dredging projects. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization cost will remain constant, unit costs will vary inversely with the quantity placed in the project. Combining the dredging projects would reduce mobilization/demobilization costs.

TOTAL PROJECT COSTS: Pricing level: 1 January 1992.

	QTY (CY)	DREDGE ($)	MOB/DEMOB ($)	TOTAL ($)	TOTAL W/ CONTIG SIOH,E&D
NNC	265,000	1,790,000	350,000	2,140,000	2,800,000
RIPRAP (TN)		405,000	85,000	490,000	665,000
TOTAL COST		2,195,000	435,000	2,630,000	3,465,000
DREDGE (CY)	265,000				
RIPRAP (TN)	3,250				

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

NEWPORT NEWS AREA - SMALL ISLAND - NEWPORT NEWS CHANNEL

MATERIAL SOURCE: Newport News Channel, maintenance work 265,000 pay cubic yards. This source provides 100% of the required material.

PLACEMENT AREA: North of Newport News Channel in Hampton Flats area. This placement area constructs a circular shaped island with a radius of 275 ft. Bottom area at existing bottom is 15 acres. Berm slopes will be shaped at 3 on 1 prior to riprap placement: underwater slope will be 30 on 1. Average bottom depth is ten feet. Pumping distance is 8,000 lf.

EQUIPMENT USED: 18" pipeline dredge with 8,000 lf of disposal line. Fuel was used at $0.90/gallon. Two D-4 low ground pressure dozers are used to shape discharged material. A hydraulic method is the only way to place material in shallow water to a height of 5' above MLW. Hopper or bucket dredges would require rehandling of material and were not considered in estimate preparation. Mobilization for the hydraulic dredge was assumed at 1,500 miles.

MATERIAL CHARACTERISTICS: Material is assumed to be new work consisting of a fine compacted sand. Bank height is 2'4" plus 1' for non-pay overdepth.

PRODUCTION: Chart production for 8,800 lf effective pumping distance is 356 cy/hr. Factors used were: booster 1.0; material 1.7 mud; bank .764 (3.4'); placing efficiency .60; giving a net production of 277 cy/hr. Operating hours/day are 18; days/month are 22. The .60 placing efficiency reflects lost time moving discharge lines to place selected material in dikes and to provide an island height of 5'.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring, environmental studies, or providing wildlife habitat.

PRICE RANGE: Costs shown were developed assuming a new work quantity of 265,000 pay cy. Unit costs for moving material will vary inversely with changes in quantity. These changes would be minor unless the quantity becomes less than 100,000 cy (1 months dredging time). Total mobilization/demobilization costs will remain constant, unit costs will vary inversely with total quantity.

UNIT COSTS: Pricing level: 1 January 1992

Dredge Contract:	$6.75
Mobilization Demob:	1.32
Total Contract:	8.07
Total Incl Contg (20%),	9.68
E&D, SIOH (9%):	$10.55
Mob/Demob Contract:	350,000

DREDGED MATERIAL ISLAND CONCEPT DESIGNS

NEWPORT NEWS AREA - RIP RAP ON BERM - SMALL ISLAND

MATERIAL SOURCE: Rip rap bedding and armor stone will come from local quarries in the central Virginia area. Delivery will be by rail with the material reloaded on a barge for transport to the construction site. Pricing is based upon barge delivery at the site by the supplier, total haul distance is assumed to be between 75 and 100 miles. Rehandling into trucks at the placement area is included in installation costs.

PLACEMENT AREA: Material is to be placed on the entire perimeter, slope will be 3 on 1. Protection will be provided from 1' below MLW to a height of 5' above MLW. Material removed for an equipment access channel will be side cast on the adjacent bottom.

EQUIPMENT USED: Access channel and turning area will be excavated using a 100 ton floating crane with a 100' boom. Equipment for delivery of stone is reflected in material prices. Material will be unloaded from delivery barges using a 50' land crane, loaded into off road trucks for haul to the placement area. Placement will be by a 50 ton land crane. A D-6 LGP dozer will be used to maintain the haul roads. Mobilization was allowed at 250 miles.

MATERIAL CHARACTERISTICS: Material for riprap will be a durable stone meeting C of E specification requirements. A 6" thick bedding layer and an 18" thick 1,000-1,500 lb. armor stone layer was assumed.

PRODUCTION: Assumptions made were: dredge access channel 100 cy/hr; place riprap and bedding at slopes 70 tons/hr. Truck hauling at 14 minute/trip for a 10 ton load was used. Shaping slopes prior to bedding placement was assumed at 50 lin. ft per hour. Mobilization/demobilization of 2 days for land equipment and 10 days for marine equipment was used. An additional allowance of 2 days for land equipment was included to allow for removal due to weather.

WORK EXCLUDED: Costs shown include furnishing and placing riprap, bedding, and armor stone on previously placed dike. Dredging an access channel an a temporary bulkhead for equipment access is also included. No costs are included for environmental studies, monitoring, or providing wildlife habitat.

PRICE RANGE: Costs shown reflect placing 750 tons of bedding material and 2,500 tons of armor stone. Unit costs will vary inversely with quantity placed. Increases will cause small decreases in unit prices; decreases will cause increases in unit cost. Mobilization/demobilization costs are included at $85,000 contract costs and would be expected to remain constant.

DREDGE MATERIAL PLACEMENT CONCEPT - WETLAND ENHANCEMENT NEW

MATERIAL SOURCE: Channel to Newport News, New Work, 344,000 pay cubic yards. Estimate also given for maintenance work.

PLACEMENT AREA: Lower James River Mulberry Island. Average water depth at point of placement is -1 MLW; material is to be an elevation of +1 MLW, average placement width is 200'. Material is to be placed along 23,200' (4.4 miles) of shoreline covering 106 acres. Placement areas will not be continuous since natural drainage must be kept open. Average haul distance is 21 miles each way, pump out distance is 4,950 lf.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 3,000 cy scows. At the disposal area a rehandler pump and 4,950 lf of discharge line will be used to place the material due to shallow water depths at the placement area. A bucket dredge was considered to be the most cost effective equipment. The 21 mile distance from the source is too long for efficient hydraulic production and a use of a hopper dredge would result in additional rehandling costs. Mobilization at 1,000 miles was assumed. Mob/demob costs are for all equipment used in dredging and wetland creation.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' plus 1' of non pay over depth.

PRODUCTION: Assumption made were: dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds, resulting in a net production rate of 6.45 cy/min. Hauling was assumed at 21 miles each way using two tugs and two 3000 cy scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 270 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Pump out production was reduced by 50% to reflect placing material in a 2' layer and lack of water depth for floating pipeline. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal of 344,000 c.y.and include all mobilization/demob for dredging and additional pump out equipment for wetlands placement. No costs are included for monitoring or environmental studies, shore protection, marsh creation (planting), keeping open existing drainage or lease of oyster grounds for access to site.

DREDGE MATERIAL PLACEMENT CONCEPT - WETLAND ENHANCEMENT NEW

PRICE RANGE: Costs shown were developed assuming a 344,000 cy new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COSTS - PRICING 1 JANUARY 1992

DREDGING - CONTRACT	$10.53
MOBILIZATION/DEMOB	$02.12
TOTAL CONTRACT	$12.65
TOTAL INCL CONTG (20%), E&D, SIOH (9%)	$16.55
MOB/DEMOB (CONTRACT)	$729,000

DREDGE MATERIAL PLACEMENT CONCEPT - WETLAND ENHANCEMENT MAINTENANCE

MATERIAL SOURCE: Channel to Newport News, New Work, 344,000 pay cubic yards.

PLACEMENT AREA: Lower James River Mulberry Island. Average water depth at point of placement is -1 MLW; material is to be an elevation of +1 MLW, average placement width is 200'. Material is to be placed along 23,200' (4.4 miles) of shoreline covering 106 acres. Placement areas will not be continuous since natural drainage must be kept open. Average haul distance is 21 miles each way, pump out distance is 4,950 lf.

EQUIPMENT USED: 18 cy bucket dredge with two tugs and two 3,000 cy scows. At the disposal area a rehandler pump and 4,950 lf of discharge line will be used to place the material due to shallow water depths at the placement area. A bucket dredge was considered to be the most cost effective equipment. The 21 mile distance from the source is too long for efficient hydraulic production and a use of a hopper dredge would result in additional rehandling costs. Mobilization at 1,000 miles was assumed. Mob/demob costs are for all equipment used in dredging and wetland creation.

MATERIAL CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is assumed at 2.4' plus 1' of non pay over depth.

PRODUCTION: Assumption made were: dredge efficiency .65; operating time factor .70; buckets per minute reduction factor .9; fill factor .75; cycle time 72 seconds, resulting in a net production rate of 4.6 cy/min. Hauling was assumed at 21 miles each way using two tugs and two 3000 cy scows at 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 270 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Pump out production was reduced by 50% to reflect placing material in a 2' layer and lack of water depth for floating pipeline. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal of 344,000 c.y.and include all mobilization/demob for dredging and additional pump out equipment for wetlands placement. No costs are included for monitoring or environmental studies, shore protection, marsh creation (planting), keeping open existing drainage or lease of oyster grounds for access to site.

DREDGE MATERIAL PLACEMENT CONCEPT - WETLAND ENHANCEMENT MAINTENANCE

PRICE RANGE: Costs shown were developed assuming a 344,000 cy new work dredging project. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000 cy, then smaller less efficient equipment would be used. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed.

UNIT COSTS WITH MAINTENANCE MATERIAL

DREDGING - CONTRACT	$15.79
MOBILIZATION/DEMOB	$02.12
TOTAL CONTRACT	$17.91
TOTAL INCL CONTG (20%), E&D, SIOH (9%)	$23.43
MOB/DEMOB (CONTRACT)	$729,000

DREDGED MATERIAL PLACEMENT CONCEPTS - OYSTER REEF 18 CY

MATERIAL SOURCE: Channel to Newport News, Maintenance Dredging, 500,000 pay cubic yards total project was calculated. Volume to be placed in Oyster Reef is 31,200 pay cubic yards.

PLACEMENT AREA: Lower James River, Tylers Beach, Point of Shoals. Average water depth at placement area is 4': material is to be placed to a top elevation of 0 MLW. Berm: top width 100': bottom width 260'; top length 1,050'; bottom length 1,250'. Bottom area 325,000 sf or 7.5 acres. Average haul distance is 22 miles each way, pump out distance is 4,000'.

EQUIPMENT USED: 18 CY bucket dredge with 2 tugs and two 3,000 cy scows. An estimate was prepared using a 12 cy bucket and two ea 2000 cy scows. Costs were $5.97/cy higher (budget). At the disposal area a rehandler pump, 4,000' of discharge line, and a discharge barge discharging at the water surface will be used. The 22 mile distance from source to discharge is too great for efficient hydraulic production, a hopper dredge could be used with additional rehandling costs. The use of a bucket dredge was considered to be the most cost effective. Rehandling of the material at the disposal area is required due to shallow water depths at the placement area. Mobilization at 1,000 miles was assumed.

MATERIALS CHARACTERISTICS: Material is assumed to be a loose muddy silt. Bank height is assumed at 2.4' plus 1' of non pay overdepth.

PRODUCTION: Assumptions made were: dredge efficiency .65; operating time factor .7; buckets per minute reduction factor .9; fill factor .75; cycle time 72 seconds, resulting in a net production rate of 4.6 cy/min. Hauling was assumed at 22 miles each way using two tugs and two scows @ 3 MPH loaded, 3.5 MPH empty. At the discharge site a pump out time of 405 minutes plus 15 minutes to disengage scows was used. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Because of the small quantity of material involved, costs shown were developed assuming this work would be part of a larger maintenance dredging project. Mobilization/demobilization allowances included are only for the extra equipment required for pump out and discharge. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total project quantity becomes less than 100,000, then smaller less efficient equipment would be used. Also, if more than one Oyster Reef was constructed additional costs would be incurred moving pump out and discharge equipment to the second location. Total mobilization costs will remain constant, unit costs will vary inversely with the quantity placed in the reef.

DREDGED MATERIAL PLACEMENT CONCEPTS - OYSTER REEF

UNIT COSTS - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	$14.17
MOBILIZATION/DEMOB	$ 3.45 (31,200 CY)
TOTAL CONTRACT	$17.62
TOTAL INCL CONTG (20%), E&D, SIOH (9%)	$23.05
MOB/DEMOB (CONTRACT)	$107,600 (contract)

DREDGED MATERIAL PLACEMENT CONCEPTS - THIN LAYER PLACEMENT

MATERIAL SOURCE: Thimble Shoal Channel, New Work 5,500,000 pay cubic yards.

PLACEMENT AREA: Chesapeake Bay North of Thimble Shoal Channel. Material to be placed to an average depth of 1'. The disposal area has a width of 6,000', a length of 25,000', and covers 3,443 acres. Average water depth at placement site is 24', average pumping distance is 7,000'.

EQUIPMENT USED: 27" Pipeline dredge with 7,000' of disposal line, one booster, and discharge equipment to provide for 1' average disposal depth. Fuel price = $0.90/gal. Discharge equipment includes abarge with bottom diffuser for placement of material near the bottom. A pipeline dredge was selected as being the most likely method that could produce a discharge layer of 1' average depth. Due to the exposed location of work a large dredge will be required, the 27" dredge used satisfies this requirement as well as the quantity of work required. Mob/demob at 1,500 miles.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine sand (material factor 1.2). Bank height is assumed at 5.6' including 1' of non pay overdepth.

PRODUCTION: Chart production for 7,000' of pipeline is 1,500 cy/hr. Factors used were: Booster -.9; Material-1.2; bank-.852; disposal-.5, giving a net production of 690 cy/hr. Operating hours/day are 18; day/month are 22. The .5 disposal factor is for lost time moving discharge equipment to produce a 1' depth. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming a quantity of 5,500,000 pay cy. Unit costs for moving material would be expected to vary inversely with changes in quantity. These price changes would be minor unless the quantity became less than 500,000 cy (2 months dredging time). At this scope the learning curve for placing material in a 1' layer could be expected to cause larger price increases. Total mob/demob costs will remain constant, unit cost will vary inversely with total quantity.

UNIT COSTS - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT (5,500,000 CY)	$6.11
MOBILIZATION/DEMOB	$0.20
TOTAL CONTRACT	$6.31
TOTAL INCL CONTG (20%), E&D, SIOH (9%)	$8.25
MOB/DEMOB (CONTRACT)	$1,125,000

DREDGED MATERIAL PLACEMENT CONCEPTS - UNDERWATER FISH HABITAT BERM

MATERIAL SOURCE: Thimble Shoal Channel, New Work 1,000,000 pay cubic yards total project was calculated. Volume in each reef is 4,320 cy (2 Hopper Dredge trips per berm).

PLACEMENT AREA: Lower Chesapeake Bay North Northwest of Entrance to Cherrystone Inlet. Average water depth is 28', material is to be placed 7' deep to a top elevation of -21' MLW. Volume placed is 4,320 cy per berm (total of 2 berms). Top dimensions of each are 30'x130'; bottom dimensions 100'x160' for a bottom area of 16,000 sq ft or .4 acres per berm (.8 acres total). Haul distance is 28 miles each way.

EQUIPMENT USED: 3,600 cy hopper dredge with an effective capacity of 2,160 cy. Material will be bottom dumped. The 28 mile distance from source to discharge is too great for efficient hydraulic production, the exposed location would make bucket work difficult. The hopper dredge was selected as being the most cost effective. Mobilization at 1,000 miles was used.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine sand. Dredging height of 3' plus 1' non pay overdepth was assumed.

PRODUCTION: Assumptions made were: dredging at 525 cy/hr (247 min.); two turns at 10 min. ea (20 min.); to disposal area 28 miles at 10 MPH (168 min.); dumping time 15 min.; return 28 miles at 12 MPH (140 min.) or 590 min./load. Effective time was assumed at 83%, operating work days per month 22. Clean up dredging at 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming that this work would be part of a larger channel deepening project. Developed unit costs assume that two full loads will be placed in each berm (4,320 cy). For the price to be valid, increments of 2,160 cy per location must be assumed. Unit costs for moving material will vary inversely with changes in quantity. These changes would be small. Dredging time is approximately 50% of the total cycle time; increasing or decreasing travel lengths would cause proportional changes in 50% of the total unit costs. Total mobilization/demobilization costs are fixed, unit costs will vary inversely with the total quantity of the basic contract.

UNIT COSTS - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	$10.87
MOBILIZATION/DEMOB (1,000,000 cy)	$ 0.21
TOTAL CONTRACT	$11.08
TOTAL INCL CONTG (20%), E&D AND SIOH (9%)	$14.50
MOB/DEMOB (CONTRACT)	$206,400

DREDGED MATERIAL PLACEMENT CONCEPTS - DEEP TROUGH - ANCHORAGE

MATERIAL SOURCE: Anchorage, New Work 800,000 pay cubic yards,

PLACEMENT AREA: Chesapeake Bay North of Thimble Shoal Channel and northeast of the Hampton Roads Tunnel. Material to be placed to 82' below MLW. The average water depth at placement site is 90', average pumping distance is 18,500'. Placement area is 1000' wide, 15,000' long covering 345 acres.

EQUIPMENT USED: 27" Pipeline dredge with 18,500' of disposal line and one booster. Fuel was used at $0.90/gal.

A pipeline dredge was selected as being the most economical method. Due to the exposed location of work a large dredge will be required, the 27" dredge used satisfies this requirement as well as the quantity of work required. Mob/demob at 1,500 miles.

MATERIALS CHARACTERISTICS: Material is assumed to be a fine sand (material factor 1.2). Bank height is assumed at 5.6' including 1' of non pay overdepth.

PRODUCTION: Chart production for 18,500' of pipeline is 1,084 cy/hr. Factors used were: Booster -.9; Material-1.2; bank-.852; disposal 1.0, giving a net production of 997 cy/hr. Operating hours/day are 18; day/month are 22. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown were developed assuming a quantity of 800,000 pay cy. Unit costs for moving material would be expected to vary inversely with changes in quantity. These price changes would be minor unless the quantity became less than 400,000 cy (1 months dredging time). Total mob/demob costs will remain constant, unit cost will vary inversely with total quantity.

UNIT COSTS - PRICING LEVEL 1 JANUARY 1992

DREDGING - CONTRACT	$3.85	
MOBILIZATION/DEMOB	$1.45	(800,000 CY)
TOTAL CONTRACT	$5.30	
TOTAL INCL CONTG (20%), E&D, SIOH (9%)	$6.93	
MOB/DEMOB (CONTRACT)	$1,158,900	

MATERIAL PLACEMENT CONCEPTS - DEEP TROUGH (2 SCOWS)

MATERIAL SOURCE: Norfolk Harbor Channel, New work, 4,300,000 pay cubic yards.

PLACEMENT AREA: Lower Chesapeake Bay entrance—to Hampton Roads North East of the Hampton Roads Tunnel. Water depth -90' MLW, material to be placed to 82' below MLW. Placement area is 1,000' wide, 15,000' long covering 345 acres.

EQUIPMENT USED: 18 cy bucket dredge with one tug and two 3000 cy scows. An estimate was run using 1 ea 3000 cy scow. Costs were $2.17/cy higher (budget). The haul distance of 9.2 miles is too great for efficient hydraulic production. Either a hopper or bucket dredge could be used. A bucket dredge was selected as being the most cost efficient. Material will be bottom dumped. Mobilization at 1,000 miles was assumed.

MATERIAL CHARACTERISTICS: Material is assumed to be a fine compacted sand. Bank height is assumed at 4.6' with 1' non pay over depth.

PRODUCTION: Assumptions made were: Dredge efficiency .75; operating time factor .75; buckets per minute reduction factor .9; fill factor .85; cycle time 72 seconds; resulting in a production of 6.45 cy per minute. Hauling was assumed at 9.2 miles each way using one tug and one scow at 3 MPH loaded, 3.5 MPH empty. Towing efficiency of 100% was assumed. Clean up dredging of 5% additional time was allowed.

WORK EXCLUDED: Costs are for dredging and disposal only. No costs are included for monitoring or environmental studies.

PRICE RANGE: Costs shown are developed using a pay quantity of 4,300,000 cy. Unit costs for moving material would be expected to vary inversely with changes in quantity. These changes would be minor unless the total quantity became less than 100,000 cy, then smaller less efficient equipment would be used. Varying the haul length may also change pricing. The indicated price is controlled by dredge time. Reducing haul distance would not decrease the price; increasing the haul distance beyond 21 miles would increase pricing. Mobilization/demobilization total costs are fixed, unit costs will vary inversely with the total dredged quantity.

UNIT COSTS - PRICING LEVEL 1 JANUARY 1992

DREDGING CONTRACT	$5.09	
MOBILIZATION/DEMOBILIZATION	$0.11	(4,300,000 CY)
TOTAL CONTRACT	$5.20	
TOTAL INCL CONTG (20%), E&D & SIOH (9%)	$6.80	
MOBILIZATION/DEMOB (CONTRACT)	$473,000	