SYNOPSIS

RECOMMENDATIONS

EXECUTIVE SUMMARY

ASSESSMENT OF THE VULNERABILITY OF THE GREAT SOUTH BAY SHORELINE TO TIDAL FLOODING

Prepared for:

New York Coastal Partnership
Babylon New York

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Prepared for:

New York Coastal Partnership
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[CSE'93-94 (726) R]
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PREFACE

Severe damage was done to the Long Island coastline by the northeasters of 1992 and the major storm of March 1993. These storms caused local short-term damage and disruption; however, more importantly, they raised the specter of significant economic injury to communities already experiencing the rigors of a recession. Given the downturn in defense, construction, and general economic activity, Long Island cannot afford a serious setback to its image as a great place to live and work. The response to this damage included a series of local initiatives, the formation of activists groups, and the call for all kinds of studies and hearings. The State of New York then organized the Coastal Erosion Task Force. There has, however, been very little physical work performed.

To many of us involved in the economic life of Long Island, there appeared to be one significant issue not being addressed — a rational analysis of the alternatives available and the cost of those alternatives. We need to understand the economic impact to the entire island's economy if these alternatives are not acted upon. Accordingly, the New York Coastal Partnership was formed with one mission:

. . . to develop a true cost/benefit analysis of coastal erosion impacts . . .

To achieve this end, we developed a methodology and focussed on a significant segment of the coastline, Fire Island. This methodology included overall scientific reviews and planning, combined with site-specific projections. The partnership commissioned two studies. The first, presented herein, is an engineering analysis of causes and mitigants of coastal erosion, including the prospect for breaching of the barrier beach.

The second study, already commenced, will provide an economic analysis of the impact of such erosion and breaches on both the mainland and the barrier islands. This study, hopefully, will also provide the cost-benefit analysis required for activation of a U.S. Army Corps of Engineers beach stabilization project and the impetus to apply the same methodology to the remainder of the Long Island coastline.

Dan Keane, Maurice Barbash, Irving Like
Babylon, New York July 1994

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SYNOPSIS OF FINDINGS AND RECOMMENDATIONS

- The mainland shoreline around Great South Bay is vulnerable to storm tides and will sustain even greater damages if Fire Island and Oak Beach are breached.

- While most of Fire Island is wide, high, and not eroding fast, several sites are narrow, low, and eroding. These short, unhealthy stretches of the barrier island provide the initial conditions for breaches during a severe storm.

- History, particularly at Westhampton Beach, has proved that **initial** breaches during a storm are small and do not significantly change mainland flood levels. Existing inlets control that.

- Once formed, one or two breaches will persist and enlarge under normal tides. They become the "existing inlets" for the next storm.

- The next storm, regardless of size, will increase bay tides and mainland flooding by way of the breach inlet(s).

- The maximum potential increase in bay storm tides is about 3 feet (ft) but a more likely scenario is 1-2 ft because multiple huge breach inlets are unlikely to persist; one or two middle-sized inlets will persist. If the peak 100-year storm-tide elevation is now 6 ft at a locality, large breach inlets will potentially raise it to 8 ft.

- A 2-ft rise in Great South Bay storm-tide elevations expands the flood inundation area by roughly 25-33 percent (~4,500 acres or ~7 square miles).

- Regardless of storm intensity, the mainland flood area will increase if a breach(es) is left open and expands. This means either flooding at higher elevations for a given storm, or more frequent flooding over time for a given flood plain location.

- The impact of additional flooding on the mainland, as described in this report, is an incremental (~25 percent) increase when considered broadly over a large area. Yet for specific facilities situated at the present peak flood elevation, higher tides may force shutdowns and exponentially increase damages.

- The **additional** average annual damages due to breaches are conservatively estimated at $15 million per year (versus ~$60 million per year for expected damages under existing conditions).

- These additional mainland damages can be avoided by restoring and maintaining a "healthy" barrier island cross-section. The report provides specific criteria and cost estimates (Table S-1) for barrier island preservation through nourishment and related activities.

- An analysis of beach erosion shows eastern Fire Island now looks like Westhampton Beach in the 1950's because of high erosion rates, lack of nourishment, low dunes, and a narrow width. This condition is likely to shift west over the next 30 years if nothing is done.

- Central Fire Island remains stable although several localized erosion hot spots, notably Old Inlet and Water Island, need repairs to reduce the threat of a breach. Many other sections could benefit from dune enhancement after the storms of December 1992 and March 1993, but the overall condition of the central barrier is healthy.

- Western Fire Island, particularly the area from Ocean Beach to Robert Moses State Park, will erode at a faster rate in the future because of offshore changes since the 1950's.

- Western Fire Island erosion accounts for most of the sand entering Fire Island Inlet. Reducing erosion rates in this area by way of groins (one of several alternatives recommended in the report) would offer secondary benefits including reduced shoaling rates in Fire Island Inlet.

- **Recommended Plan**

  — Initial nourishment — 6,000,000 cubic yards (cy) in Year 1 with 50 percent placed in each of two five-mile reaches (Moriches Inlet to Smith Point County Park and Fire Island Pines to Ocean Beach). Each of these beach fills will gradually feed areas to the west.

  — Periodic renourishment at a rate averaging 500,000 cy per year beginning in Year 6 with the major portion added at the east end of Fire Island.

  — Construction of sand-retaining structures (e.g., groins) along a six-mile reach from Ocean Beach to Robert Moses State Park.

  — Dune enhancement, restoration at washovers, and breach closure on an episodic basis (Table S-1) where dune volumes above flood levels are lacking (criteria of Section 4.0).

  — Regular shoreline monitoring to document conditions, track performance of improvements, and refine future designs.

  — Periodic maintenance of Oak Beach shore-protection structures.

The report is multidisciplinary, covering the specialized fields of coastal erosion, storm-tide prediction, and shoreline flooding. Chapters cover a regional sediment budget, summaries of predicted flood elevations, estimates of damage, and alternatives for mitigation and prevention of breaches. An expanded executive summary provides an overview of study methods, findings, and implications. The main report includes detailed tables, figures, and discussions of the results.

TABLE S-1. Preliminary cost estimate (in current dollars) for the recommended plan over 10-, 20-, and 50-year periods, assuming all items are completed during the period of interest.

Item	Net Cost (thousands)	Frequency	Average Annual Cost (thousands)		
			10-Year	20-Year	50-Year
Dune Rebuilding at Washovers	250	Once in 10 years	25	25	25
Dune Enhancement to Storm Tide Levels	750	Once in 25 years	75	37.5	30
Breach Closure After Major Storms	1,000	Once in 25 years	100	50	40
Beach Disposal from Navigation Projects	5,000	Over 10 years	500	500	500
Annual ***Maintenance Nourishment***	1,800	Each year after Year 6	900	1,350	1,620
Sand-Trapping Structures Western Fire Island	10,000	Once in 50 years	1,000	500	200
Initial Nourishment	40,000	Once in 50 years	4,000	2,000	800
Contingency/Maintenance/ Monitoring	500	Every year	500	500	500
Average Annual Cost (divided by 1,000 and rounded)			**$7,000**	**$5,000**	**$3,700**
Total Cost (actual — rounded)			**$70,000,000**	**$100,000,000**	**$185,000,000**
Average Annual Cost (actual — rounded) per ft of Shoreline			**$40/ft/yr**	**$30/ft/yr**	**$20/ft/yr**

ADDENDUM — NOVEMBER 1994

Following completion of the present report, Coastal Science & Engineering, Inc. (CSE) was asked to prepare rough cost estimates for specific barrier-island protection schemes. These are provided below as "first-cut" approximations for discussion purposes and comparison with the expected benefits from maintaining the integrity of Fire Island.

CSE bases the cost estimates primarily on results of the updated sediment budget (Section 3.0) and profile volume analysis (Section 4.0) as well as recent history of nourishment costs in New York. However, results from analogous projects in other states are also drawn upon to insure the approaches are feasible and the unit cost estimates are realistic. Because an up-to-date shoreline survey is not available yet, the quantity estimates are based on older data. Experience has shown that even out-of-date profile surveys which confirm regional decadal trends (e.g., groin field accretion, jetty fillets, inlet trapping, etc.) will yield reasonable predictions of future changes. The profile volume approach to nourishment (Kana, 1993) also yields quantity estimates (for underwater, beach, and dune volumes) where comparative surveys are lacking.

An important variable is the unit cost of sand. For obvious reasons, accessibility and transportation distance tend to control unit costs. To simplify the cost estimates, CSE assumes nourishment from **external** (nonlittoral) sources will cost at least $5 per cubic yard. This is similar to unit costs of sand delivery within 30,000 ft for the 1993 Gilgo/Robert Moses nourishment using sand from Fire Island Inlet and for the 1993-1994 breach closure at Westhampton Beach using an offshore borrow site (USACE—New York District, unpubl. data). Small-scale projects such as dune reshaping by bulldozers using in-situ sand or lagoon dredging with harbor dredges can be performed at much lower cost, sometimes well under $2 per cubic yard.

For medium-to-large-scale projects, we draw on more than 20 beach restoration projects CSE has completed since the early 1980's using a variety of borrow sources and placement techniques. Performance reports from many of these projects, particularly those at Hunting Island, Myrtle Beach, and Seabrook Island (South Carolina), offer insight regarding loss rates as a function of project length and unit volumes.

An overriding assumption in CSE's estimates for Fire Island is that cross-shore changes will dwarf average annual changes. These cross-shore changes constitute the "beach cycle," whereby storms erode the upper beach but poststorm periods nearly restore the profile to average or "equilibrium" conditions. Long-term maintenance of eroding beaches and dunes, therefore, depends on sustained nourishment which replaces the **net** losses of sand over time, generally using **external** sources of sand. Emergency repairs, in contrast, are sometimes needed to accelerate the recovery of the beach and dunes soon after storms. Most emergency repairs can be performed cost effectively using **internal** sources of sand, such as beach and dune scraping by bulldozers.

South Carolina's experience after Hurricane *Hugo* (Kana et al., 1990) illustrates these two fundamentally different approaches to beach restoration. In South Carolina, 65 miles of emergency dunes were scraped into place less than one month after *Hugo*. This $1.5 million project cost only $4.50 per linear foot (1989) because it simply entailed reshaping of the profile by bulldozers. Expenditures for beach nourishment in comparison were many times greater at approximately $65 per linear foot over a length of 20 miles. Most of the post-*Hugo* nourishment projects involved placement of sand from **external** sources in an attempt to replace the net losses attributed to *Hugo*. The scale of those projects was, in turn, much smaller that a ten-year requirement for nourishment at the individual sites. Emergency dunes formed the nucleus of today's foredune along much of the impacted coast. In some reaches, however, the scraped dune quickly eroded because of a persistent sand deficit in the profile. Similar variations will occur along Fire Island depending on whether an individual reach has a sand surplus or deficit **before** a storm.

For purposes of developing a more specific plan and cost estimate for maintaining the viability of Fire Island, CSE recommends two hierarchies of need. The first is based on costs and attempts to prioritize actions that, if taken early, provide the greatest returns on investment (largely through reduced costs compared with later implementation). The second hierarchy is based on the impact of an action on the regional, decadal sediment budget. Clearly, the first hierarchy emphasizes low-cost alternatives whereas the second ranks large-volume projects highest.

HIERARCHY OF NEEDS — BASED ON COSTS (Low to High)

1) Episodic dune rebuilding (in place) at washovers via in-situ sand scraping where the nearshore profile volumes are "healthy" (e.g., Old Inlet 1994). *Cost range*: <$10/ft; applies to ~25,000 ft of shoreline following the 1992-1993 storms. CSE assumes such activities will be required once per decade following major storms. *Net budget impact:* <$250,000 / 10 years

2) Dune enhancement via scraping/sand fencing (etc.) using in-situ sand where dune volumes are lower than desirable and the *nearshore profile volumes are "healthy."* Goal should be to provide 10-30 cy/ft above the 25-100 year (stillwater) flood elevation over the length of the barrier island (applicable and cost effective along certain central Fire Island reaches) (see Section 4.0). *Cost range*: <$15/ft; assume applies to ~50,000 ft of shoreline. CSE assumes this activity will be required only once per 20 years. *Net budget impact:* $750,000 / 20 years

3) Breach closure immediately after storms using land-based equipment/nearby sand sources. Incipient flood-tidal deltas from breaches should be considered a primary borrow source. In-situ sand from the adjacent beach should be used to expedite closure. If monitoring confirms the littoral volume "borrowed" has a measurable adverse impact on adjacent areas, later nourishment from an external source can mitigate for the sand removed under emergency conditions. *Cost range*: < $200/ft (limited reaches) would apply to a relatively small length of shoreline on the order of 5,000 ft. This is assumed only once per 25 years after major storms. *Net budget impact:* $1 million / 25 years

4) Beach disposal of sand from navigation projects. Beach nourishment should be the designated disposal option for most navigation projects. Poor-quality sediments (muddy or contaminated) should **not** be disposed on the beach. Acceptable mud content for beach disposal is < 15 percent in most cases. Disposal should be as far as possible from inlets to reduce the tendency for sediments to recycle back to an inlet. **Additional cost** (beyond budget for the navigation project) of booster pumps (etc.) is estimated at $2.50/cy. CSE estimates this can provide at least 33 percent of the annual maintenance nourishment requirement for Fire Island (i.e., 1 cy/ft/yr), particularly if the placement is concentrated along eastern Fire Island in connection with Moriches Inlet projects. Estimated applicable sand volume — 200,000 cy/yr. *Net budget impact:* < $5 million / 10 years

5) Annual maintenance nourishment for Fire Island. CSE's estimated needs **average** 3 cy/ft/yr (500,000 cy/yr) of which a portion can be derived from routine navigation dredging (Item 4). The remainder (~ 2 cy/ft/yr) will have to come from other sources such as offshore deposits similar to the borrow areas used for the Westhampton breach closure and recent nourishment at Fire Island Pines, Fair Harbor, and Saltaire. Unit nourishment costs will vary principally with transportation distances. In general, maintenance nourishment should focus on hot spots and be placed as far updrift as feasible to improve longevity. CSE assumes unit construction costs will average $5.50/cy which, when apportioned over the 165,000-ft length of Fire Island, yields total annual costs of ~ $1.8 million. CSE further assumes this level of maintenance will not be required until Year 6 if initial nourishment (Item 7) is completed in Year 1.

6) Selectively install sand-trapping structures along western Fire Island where there is a measurable depletion of offshore deposits and accelerated dune erosion. Groins or segmented breakwaters (the typical class of structures) should be as short as possible to allow efficient sand bypassing once the cells between structures are filled. The logical terminus of a groin field is Democrat Point; however, a detailed study of alternative groin configurations (spacing, length, crest height, and profile slope) should be conducted with the idea of minimizing the number of sand-retaining structures. Impounded sand and a trend of accretion along compartment 161B (Democrat Point) means a field of groins could be tapered and ended well updrift of Fire Island Inlet.

Analogs for this recommendation are groins placed along bulges in the shorelines of Garden City and Debidue Island (South Carolina). In these two cases, previous inlet positions produced the initial bulge because of extra sand trapped by ebb-tidal deltas. Inlet migration and depletion of the abandoned delta shoals caused accelerated erosion several decades later. To hold the shoreline at the bulge, several groins were built at each locality. Once each cell filled to capacity, excess sand bypassed the structures (Fig. A-1).

The purpose of groins in any setting should be to reduce the rate of erosion without increasing downdrift erosion. Therefore, care is required before implementing this solution. Nevertheless, CSE believes it is a viable alternative for western Fire Island because of the clear trend of accelerating erosion from compartments 153A (Point O'Woods) to 161A (Robert Moses State Park) followed by rapid accretion in compartment 161B (Democrat Point). A strategically placed groin field along the "bulge" would provide a secondary benefit of reduced shoaling in Fire Island Inlet.

The scale of the Garden City (South Carolina) "bulge" is much smaller than the Fire Island Inlet bulge (in the vicinity of Kismet) due to differences in the scale of the inlets. Therefore, it is expected more sand-retaining structures would be required to stabilize western Fire Island. Using Westhampton Beach's groin field (where the structures were longer than necessary) as a guide, somewhat shorter structures on the order of 300 ft long, spaced about 1,500 ft apart, provide a first-cut estimate of costs. CSE assumes a field of 20 such groins would be required to stabilize an ~6-mile reach between Ocean Beach and the state park. With the installation of a field of groins, volumetric erosion rates in the protected area will decrease to a fraction of present rates. Well-constructed, rubblemound groins in this setting will cost from $1,000 to $2,500 per linear foot. Therefore, a field of 20 such structures would cost $6-15 million, say $10 million for initial planning purposes. This is assumed to be a one-time cost over 50 years.

7) Initial nourishment for Fire Island. CSE estimates 6 million cubic yards are presently required to restore a healthy dune/beach/underwater profile along 60,000 ft (~33 percent) of Fire Island. This nourishment is based on an estimated profile volume requirement below mean sea level (foredune to -20 ft NGVD) of about 500 cy/ft. This should be placed principally in the areas between Moriches Inlet and Smith Point County Park, and between Fire Island Pines and Ocean Beach. These two areas will feed downdrift reaches and improve longevity of the project. Upon receipt of updated profiles, the existing unit volumes can be compared to identify reaches with the greatest sand deficit and refine the nourishment plan. The preferred sand sources are offshore deposits, testing at least as coarse as the intertidal beach sediments. Construction costs will average around $5.50/cy based on recent experience, but CSE assumes additional soft costs (engineering, environmental impact analyses, permitting, and contingencies) will raise the price to $6.75/cy (or $675/ft) in the nourished areas. The net, one-time cost of initial nourishment would be ~$40 million.

HIERARCHY OF NEEDS BASED ON SEDIMENT BUDGET (High to Low)

There is often much debate over the impact of various shore-protection activities, but viewed from the perspective of sediment budget preservation, the following is clear: nourishment from an external source and maintenance of littoral transport are the primary ways of favorably impacting the sediment budget along the coast. Installation of sand fences, Christmas trees, or other low-cost alternatives yield a negligible impact on the sediment budget. The following hierarchy is based on the Fire Island Inlet to Montauk sediment budget as well as CSE's experience in similar settings.

1) *Restore annual beach nourishment and dredging disposal* on beaches to 1960's levels, particularly from Pikes Beach (Westhampton) to Smith Point County Park. This is considered more important than initial nourishment (#2) because it represents a long-term commitment.
2) Perform *initial nourishment* to achieve minimum healthy dune/beach/underwater profiles along entire Fire Island.
3) *Slow erosion rates along the "bulge"* of western Fire Island by means of sand-retaining structures.*
4) *Close breaches and return flood tidal delta deposits* to the ocean side of breaches.
5) *Restore dunes in washovers.*
6) *Enhance dunes* mechanically to preserve the littoral budget seaward of the foredune during storms (i.e., minimize washovers).

*NOTE: Retarding longshore transport in this case will produce secondary benefits through reduced shoaling in Fire Island Inlet. The effect downdrift will be a reduction in the rate of accretion at the jetty fillet of Democrat Point. The effect of short groins along western Fire Island on erosion at Gilgo Beach, if it could be quantified accurately, would be dwarfed by the regional effects of sand trapping at Fire Island Inlet, one of the largest inlets along the mid Atlantic coast.

7) *Plant dune grass.*

8) *Install sand fences, Christmas trees, etc.*

SUMMARY OF COSTS

The above-listed barrier restoration estimates have been totaled and annualized in Table A-1 for 10-year, 20-year, and 50-year periods (in current dollars) for purposes of comparing with expected benefits. The total costs vary slightly from those given in Section 8.0 of the report because of additional items such as sand-trapping structures. Beach disposal from navigation projects reduces the annual maintenance nourishment requirement from other sources. A contingency line item provides for soft costs such as engineering, environmental protection and mitigation, repairs along Oak Island, and periodic monitoring.

TABLE A-1. Preliminary cost estimate (in current dollars) for the recommended plan over 10-, 20-, and 50-year periods, assuming all items are completed during the period of interest.

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Initial Nourishment	40,000	Once in 50 years	4,000	2,000	800
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Average Annual Cost (divided by 1,000 and rounded)			**$7,000**	**$5,000**	**$3,700**
Total Cost (actual — rounded)			**$70,000,000**	**$100,000,000**	**$185,000,000**
Average Annual Cost (actual — rounded) per ft of Shoreline			**$40/ft/yr**	**$30/ft/yr**	**$20/ft/yr**

Relationship of CSE Recommendations to New York Governor's Coastal Erosion Task Force Recommendations*

Issue	New York State	CSE
Inlet Sand Bypassing	Recommended for Moriches and Fire Island Inlets (among others)	Bypassing technically means excavation of an updrift beach (e.g., jetty fillet) before sand enters an inlet, and discharge along the downdrift beach. CSE supports this implicitly but believes it is often more practical to apply this by means of channel dredging (i.e., after sediments enter the inlet) and disposal along downdrift beaches. CSE also makes a case for updrift disposal (i.e., back passing) at Fire Island Inlet using inexpensive means such as trucking for small-scale projects. An updated regional sediment budget will help establish appropriate rates and schedules for bypassing and back passing.
Maintain Barrier Integrity by Filling Washovers and Breaches	**Recommended** general approach without specific criteria	**Recommended** — CSE offers specific criteria regarding unit volumes for dunes and barrier cross-sections (Section 4.0) and recommends use of nearby deposits (details in this memo).
Reserve of Funds for Emergency Response	Recommended	CSE supports, but does not specifically mention this in the report.
Erosion Monitoring	Recommended	Recommended.
Expedite Reformulation Study	Recommended	Recommend focus on an updated sediment budget and more detailed development of criteria for dune/beach restoration based on profile volumes and volumetric erosion rates.
Cost Sharing	Outlines alternatives	Not discussed.

[continued . . .]

Issue	New York State	CSE
Priority Actions		
a) Augment downdrift placement of sand from navigation projects	Recommended	Recommended.
b) Fill washovers	Recommended	Recommended with some specific criteria. Note: The state cost estimate appears high considering this can often be accomplished using in-situ sand.
c) Reserve fund for rapid response	Recommended	CSE supports but does not specifically recommend a fund.
Long-Term Strategy (Selected Items)		
a) Channel dredging; disposal on adjacent beaches	Recommended	Recommended (back passing also recommended for western Fire Island).
b) Hold shoreline position	Recommended for Coney Island, Rockaway, etc., but does not mention western Fire Island communities	Recommended for Fire Island communities and Oak Beach based on rough benefit/cost analysis with respect to potential of breach impacts along the mainland.
c) Shoreline monitoring	Recommended	Recommended.
d) Restore beach/ dunes (first costs)	Budget estimate at $60 million	Budget estimate at $40 million (average annual, 20-year cost estimate with renourishment is $4.5 million per year).
e) Sand-retaining structures	Not mentioned for Fire Island	Recommended for a limited reach along western Fire Island to reduce the rate of erosion and shoaling in Fire Island Inlet.

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