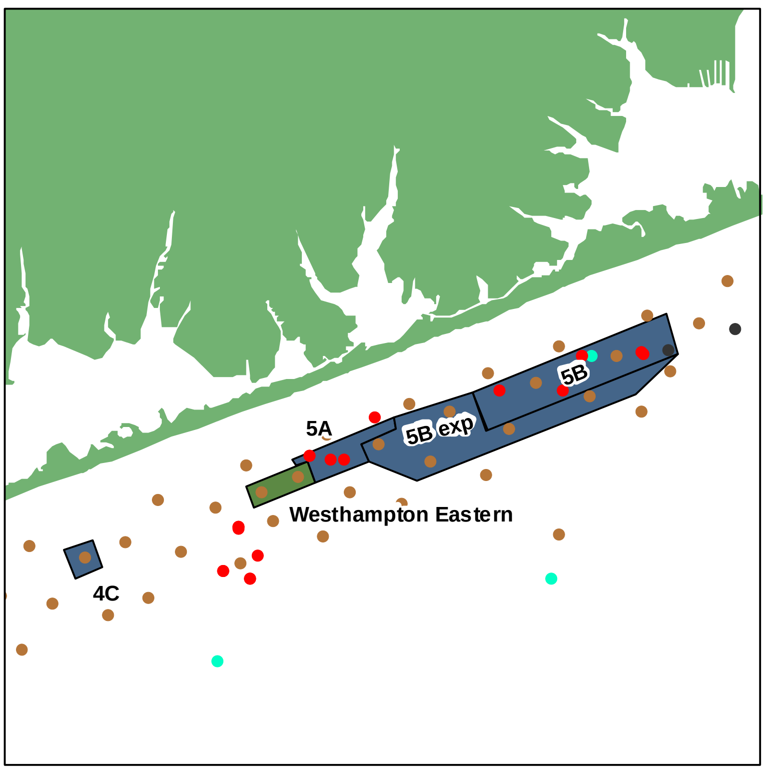
The Long Island Coastal Planning Project

Inventories of Sediment Budgets and Borrow Areas, and Borrow Area Management Plans



Final Report

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1. INTRODUCTION

Natural sediment transport processes, significant weather events, and human interference have resulted in sediment-related problems for the shorelines and coastal watersheds of the Atlantic Coast of Long Island. The purpose of the Long Island Coastal Planning Project is to undertake studies to institutionalize Regional Sediment Management (RSM), make more effective use of sediment from inlets and other sources, enhance environmental habitat, improve the collection and dissemination of data about the movement of sediment, facilitate cooperation among federal and non-federal interests, and assure the most effective use of taxpayer funds. The project will lead over the study lifetime to a regional water resource strategy for Long Island, developed by communities and state agencies in cooperation with the US Army Corps of Engineers – New York District (USACE-NAN).

The study area includes the Atlantic Coast of Long Island, New York, encompassing the 120 miles of shoreline from Coney Island in the west to Montauk Point in the east. The study was conducted along a portion of the Atlantic Coast of New York, adjacent to Nassau and Suffolk Counties.

The objectives of this effort were to create an inventory of existing sediment budgets, compile existing data for sand borrow areas into a GIS database, and develop a regional plan to monitor borrow areas along the Atlantic Coast of Long Island.

Figure 1-1: Study Area extends from Coney Island to Montauk Point

2. INVENTORY OF PREVIOUS SEDIMENT BUDGETS

An inventory of existing sediment budgets for the Atlantic shore of Long Island from Coney Island to Montauk Point was prepared. The goal of this task is to develop a summary of these sediment budgets that will clearly identify data sources, assumptions, methodology, budget period, results, and uncertainty estimates, if available. Existing inlet sediment budgets are also included in the inventory. Where available, uncertainty estimates are presented.

Sediment budgets are presented in chronological order based on their publication date and from oldest to most recent. Note that a summary of some of these budgets was prepared by Gravens et al. (1999) and it is reproduced below for the most part literally in the following sections.

2.1 Taney (1961a,b), South Shore of Long Island

Taney discusses littoral transport processes for the south shore of Long Island, providing geomorphic support for the general east-to-west direction of (net) longshore sediment transport based on migration of inlets prior to stabilization, and impoundment at jetties east of the inlets after stabilization. However, he mentions two locations in which there appears to be a reversal in (net) longshore sediment transport, one of which is within the Fire Island to Montauk Point (FIMP) region. Immediately west of Fire Island Inlet, a reversal in (net) longshore sediment transport occurs due to tidal currents and wave refraction of the shoal at the mouth of the inlet. He emphasizes that the littoral drift rate varies with distance alongshore.

Taney (1961a) estimates a littoral transport rate for three locations along Long Island, two of which are within the FIMP study reach, based on two methods: (a) Method 1 estimates the littoral transport rate from the accretion rate updrift of a littoral barrier, up until impoundment capacity, using periodic profiles; and (b) Method 2 estimates the littoral transport rate from the product of the average annual growth of the updrift shore of an inlet and the average inlet depth. Method 1 is considered more accurate, due to the fact that Method 2 cannot account for the quantity of sediment that bypasses the inlet or is lost to the flood or ebb shoals. Of course, it must be recognized that the equilibrium state of the shoreline updrift of the location of interest affects the estimate. For example, Taney discusses the lack of advancement at Democrat Point from 1930-34 and the possible correlation of this with the opening of Moriches Inlet, which occurred in 1931. Taney (1961b) also estimates a rate of 76,500 m^3/yr from the wave-cut moraine bluffs at Montauk Point.

At Moriches Inlet, Taney estimated approximately 230,000 m^3/yr for the (assumed to be net) littoral transport rate. Note that this estimate reflects conditions prior to the construction of the Westhampton Groin Field. The net longshore sand transport rates for Fire Island Inlet range from 122,000 to 460,000 m^3/yr with, 344,000 m^3/yr considered the "most acceptable estimate." Taney does not present his calculations, although data for growth of the updrift spit prior to (and after) stabilization are provided in figures and tables, and profile data are provided in two appendices (see "Analyses – Impoundment at Democrat Point for a net littoral transport estimate calculated using Taney's data" in Gravens et al., 1999).

Taney concludes that "the present rate of littoral drift is much greater than can be derived from this source" (the headland bluffs). "Streams do not contribute sediments to the system," and "the shoreward movement of the nearshore bottom sediments is questionable." "Therefore, the great difference between the estimates of the amount of sediments moving and that supplied by the bluff unit of the headlands section would indicate that a source of beach material in addition to the bluffs is required. It appears that the only remaining sources of supply of littoral materials are the existing beaches, and possibly a small portion of the nearshore bottom."

2.2 Panuzio (1968), South Shore of Long Island

In a general paper about the South Shore of Long Island, Panuzio discusses longshore sand transport rates (assumed to be net) for various locations along the study shoreline: Shinnecock Inlet 230,000 m^3/yr, Moriches Inlet 267,000 m^3/yr, and Fire Island Inlet 460,000 m^3/yr. Presumably, these rates were derived from impoundment of littoral material at jetties, migration of pre-stabilized inlet spits, and wave refraction calculations. Panuzio also gives an evaluation of the Westhampton Groins 1 through 11, 18 months after construction. East of Groin 4, the beach accreted, and west of Groins 4 through 11 eroded (Groins 12 through 15 had not yet been constructed). West of the Groin 11, a reversal in the direction of net longshore sand transport was believed to occur due to the trapping and filling of the updrift groins.

2.3 Research Planning Institute (1983), Fire Island to Montauk Point

The Research Planning Institute (1983) prepared a sediment budget in support of USACE-NAN to aid in the design of storm damage reduction, and inlet navigation projects for the Fire Island Inlet to Montauk Point project reach. In formulating the sediment budget, several criteria were employed to select data used in the budget: historical data were given preference over theoretical calculations; data representing stabilized inlets were favored over pre-stabilization data; and extreme ("rare") events such as the 1980 Moriches Breach were considered perturbations to the normal long-term trends of the sediment budget, and therefore were considered inappropriate in making future beach maintenance decisions. In reviewing the available data, controlled profile data measured in June 1955 and December 1979 were determined to best meet the data selection criteria, although profile data from June 1933, January 1940, and June 1967 were also applied to develop intermediate sediment budgets.

Analysis of the profile data set indicated an "inflection point" (shift from onshore losses to offshore gains) at approximately –25 ft Mean Sea Level (MSL). Based on this, and to meet USACE-NAN requirements for offshore cells separated at 6 ft depth intervals, -24 ft MSL was taken as the seaward boundary of the littoral transport cells. Thus, in the on-offshore direction, volumetric changes for three lenses were represented in the sediment budget: between the profile baseline to Mean High Water (MHW), representing the dune and visible portion of the beach; MHW to Mean Low Water (MLW), representing the intertidal beach type; and MLW to –24 ft MSL, which included the offshore bar. As requested by USACE-NAN, volumetric changes were also reported for regions defined by: profile baseline to MHW; MHW to Mean Sea Level (MSL); MSL to MLW; MLW to –6 ft contour; and four other segments at 6-ft intervals out to the –30 ft MSL contour. The authors found a good correlation between the MSL contour movement and unit width volume change V, with MSL movement (ft/year) = 7.5*V, where the volume is given in cubic yards. In the alongshore direction, 25 fixed compartments/sub-compartments were established based on the availability of profile data and existing morphological features (e.g., inlets). Annualized volumetric changes calculated using the profile data formed the primary basis for formulation of the sediment budget, and were calculated for each alongshore compartment and on-offshore lens. Other quantities applied in the budget are discussed below:

- Originally, longshore sediment transport rates as calculated from wave energy flux were planned for use with the sediment budget. However, the net direction of longshore sediment transport as estimated using wave energy flux did not agree with geomorphic evidence. Thus, these data were only used as a guide for the magnitude of longshore sediment transport rates. Instead, longshore sediment transport rates as inferred from 1940 to 1955 impoundment rates updrift of Fire Island Inlet (306,000 m^3/yr) formed the basis for calculation of longshore sediment transport rates at each alongshore compartment.
- Dredge and fill records were applied in solving the budget, despite incomplete fill/disposal records. Assumptions about disposal/fill quantities and locations, which averaged approximately 2.5 m3/m/year between 1955 and 1979, were made to complete the budget.

- A theoretical quantity for the offshore loss of sediment due to profile adjustment because of sea level rise was applied based on an equation from Hands (1981), assuming a sea level rise rate of 3 cm/year based on New York Harbor data. The rate of offshore sediment loss due to sea level rise ranged from 0.59 to 0.76 m^3/yr.
- Losses to the littoral budget due to washovers and breaches were estimated from historical data or narratives. These estimates were determined by estimating a plan view area for the washover deposit, and assuming an average thickness ranging from 0.3 to 0.45 m based on published studies. For breach channels, a typical depth was estimated to be 0.9 to 1.5 m which would have removed a sand wedge from 2.4 to 3.7 m thick. The authors discuss the severity of the 1938 hurricane, which is the storm of record for the project area. Making several assumptions, the authors estimate that this storm removed 468,000 m^3 from Westhampton Beach.

Sediment budgets are presented for ten time periods, based on pairing each profile survey date with a subsequent profile data set. A sediment budget for the 1955 to 1979 time period is recommended as representing the most "typical" long-term conditions for the project area. Major conclusions for this 24.5-year period are summarized:

- For the project area, the beach above MHW gained 100,000 m^3/yr, which is less than the estimated fill quantity (320,000 m^3/yr).
- Approximately 25,600 m^3/yr were lost from the control volume due to overwashes and breaches. If the Moriches 1980 breach were included, this quantity would double.
- Approximately 229,000 m^3/yr was lost between the baseline and the -7.3 m (-24 ft) MSL contour.
- From Montauk to Southampton, 7.5 m^3/m/yr was lost, with approximately 50 percent of this average derived from the offshore lens
- Shinnecock, Westhampton, and Moriches Inlet compartments gained 6.9 m^3/m/yr, with beach fill projects contributing 4.5 m^3/m/yr.
- On average, central Fire Island was stable (less than 0.08 m^3/m/yr), although individual compartments experienced gains and losses.
- Western Fire Island experienced large net losses (14.8 m^3/m/yr), with 85 percent of this from the offshore lens.
- On Fire Island, western compartments from Sunken Forest to Robert Moses State Park lost over 23,000 m^3/yr above MHW.
- Democrat Point gained sediment at 20.5 m^3/m/year.

The report concludes by discussing sensitivity of the sediment budget to various input quantities:

- There is a small differential between the average net loss to the project area (1.9 m^3/yr) and the apparent input averaging 0.76 m^3/yr. If these values are in error by 20 to 25 percent, it could significantly affect longshore sediment transport calculations.
- The average estimate for offshore losses due to sea level rise is comparable to the average net loss for the entire project reach. Reducing the average rate by half would have a cumulative increase of 134,000 m^3/yr for the entire project reach.
- Estimates for overwash and breach quantities represent only 5 10 percent of the annualized volume changes, and therefore assumptions made in these calculations result in relatively little effect on the sediment budget.
- Dredge and fill volumes are probably accurate within ±25 percent, which would produce up to ±0.63 m^3/m/yr error in the budget.

2.4 USACE-NAN (1987), Shinnecock Inlet

In a sediment budget formulated for Shinnecock Inlet, USACE-NAN estimated a net longshore sand transport rate 1 km east of the inlet equal to 230,000 m^3/yr, and a net longshore sand transport 1.8 km west of the inlet equal to 189,000 m^3/yr.

2.5 Nersesian and Bocamazo (1992), Shinnecock Inlet

In another sediment budget for Shinnecock Inlet, Nersesian and Bocamazo estimated the net transport east of Shinnecock equal to 281,000 m^3/yr.

2.6 Williams and Morgan (1993), Fire Island

These authors used sedimentological evidence from four offshore and 11 onshore samples along Fire Island to quantitatively link two of the offshore samples, representing buried glacial to fluvioglacial lobes of the Huntington-Centreport Pleistocene channel, to the immediately-onshore or slightly downdrift onshore samples. Although representing only two offshore sample data points, these results provide some evidence that offshore sediment may be a contributor to the sediment budget of Fire Island. Taney (1961) had cited westward littoral drift as the dominant mechanism introducing sand-sized material from wave-cut moraine bluffs at Montauk Point (76,500 m^3/yr). However, to satisfy the sediment budget, an additional 152,000 m^3/yr at Moriches Inlet and 45,500 m^3/yr (Taney 1961) to 408,500 m^3/yr (Panuzio 1968) at Fire Island Inlet would be required to balance the sediment budget. RPI (1983) indicated a 300,000 m^3/yr deficit from west-central Fire Island to Fire Island Inlet. Based on these results, the authors speculate that there may also be an eastern Fire Island on-offshore sedimentological link (specifically, the Smithtown-Brookhaven Pleistocene channel).

2.7 USACE-NAN (1988), East Rockaway Inlet to Rockaway Inlet

As part of an evaluation of the effectiveness of a beach restoration project along East Rockaway an Existing (c.1986) and historical sediment budget were developed for the time period of 1976-1986 by USACE-NAN in conjunction with the Monitoring Completed Coastal Projects (MCCP) Program. Dredging records at both Rockaway Inlet and East Rockaway Inlet as well as beach fill quantities at 3 separate sections of East Rockaway were recorded during this time period and included in the sediment budget. In addition the location of three potential borrow areas was identified by USACE-NAN.

The East Rockaway shoreline was split into 4 sections for the sediment budget: (1) Area B, extending from Crest Rd. to Beach 49th St.; (2) Area A, extending from Beach 49th St. to Beach 114th St.; (3) Area C, extending from Beach 114th St. to 149th St.; and (4) Area BP, extending from 149th St. to the jetty at Rockaway Inlet. An assumption made by USACE-NAN in developing the sediment budget was that only the transport of sediment onshore and offshore was responsible for the volumetric erosion or accretion within each section. The cross-shore sediment transport rates were adjusted to include the amount of beach fill placed within each segment in order to represent the total amount of sediment lost or gained. The results for the Existing (c. 1986) sediment budget are shown in Figure 2-1, where LST stands for longshore sediment transport and CST stands for cross-shore sediment transport. A summary of the results for the Existing (c.1986) sediment budget is given below:

- The annual dredged material at Rockaway Inlet and East Rockaway Inlet is 65,000 cy/yr (50,000 m^3/yr) and 55,500 cy/yr (42,500 m^3/yr) respectively.
- The three identified borrow area locations are the East Bank Shoal, located offshore of Rockaway Inlet; Rockaway Offshore, located offshore of Rockaway Park; and Far Rockaway Offshore, located offshore of Rockaway Inlet.

- The total amount of beach fill from 1975-1986 is 6,148,000 cy (4,703,000 m³) at Area A, 3,983,000 cy (3,047,000 m³) at Area B from 1976-1986, and 1,146,000 cy (877,000 m³) at Area C from 1977-1986.
- The adjusted cross-shore sediment transport rates were -266,000 cy/yr (-203,500 m³/yr) at Area A, -202,00 cy/yr (-154,000 m³/yr) at Area B, 81,000 cy/yr (62,000 m³/yr) at Area C, and 183,000 cy/yr (140,000 m³/yr) at Area BP.
- An additional 138,000 cy/yr (106,000 m³/yr) of beach fill is included from Far Rockaway borrow area and 6,500 cy/yr (5,000 m³/yr) of beach fill is included from the East Bank Shoal.

2.8 USACE-NAN (1989), Jones Inlet to East Rockaway Inlet

An Existing (c. 1988) conditions sediment budget was developed by Frederic R. Harris, Inc for the Long Beach Island area based on data from the time period of 1963-1988. The sediment budget was computed for 5 segments of the Long Beach Island shoreline: (1) Pt. Lookout, extending from Inwood Ave to and including the Town of Hempstead Park; (2) Lido Beach, extending from the Town of Hempstead Park to Maple Blvd.; (3) Long Beach, extending from Maple Blvd. to Nevada Ave.; (4) Eastern Atlantic Beach, extending from Nevada Ave., to Flamingo St.; (5) Western Atlantic Beach, extending from Flamingo St. to the jetty at East Rockaway Inlet. Average shoreline erosion and accretion rates for each segment were calculated from 1963 and 1988 beach profile survey results and aerial photos during this time span. Volumetric change rates were estimated by assuming 1ft/ft of shoreline change equals 1 cy/ft of sediment erosion or accretion.

Dredging records from 1963-1985 and 1960-1979 were provided by USACE-NAN for East Rockaway Inlet and Jones Inlet respectively. Both sets of dredging records show that the annual amount of sediment dredged increased over time. Harris explains the increased shoaling at both inlets by stating, “It is evident that the annual dredging rate increased as the east sand fillet was filling to capacity”. The existing conditions shoaling rates at both inlets were estimated assuming the east sand fillets were nearing capacity and dredging rates would increase to annual rates of 200,000 cy/yr (153,00 m³/yr) at Jones Inlet and 100,000 cy/yr (76,500 m³/yr) at East Rockaway Inlet. Aerial photographs were used to measure the impoundment rates at both inlets. The existing conditions impoundment rates were estimated to be 150,000 cy/yr (115,000 m³/yr) and 50,000 cy/yr (38,000 m³/yr) at Jones Inlet and East Rockaway Inlet respectively by assuming the east sand fillets were nearing capacity.

Net longshore transport rates of 550,000 cy/yr (421,000 m³/yr) west and 400,000 cy/yr (306,000 m³/yr) west at the eastern end of Jones Inlet and East Rockaway Inlet respectively, were obtained from a 1965 report by USACE-NAN titled, “Beach Erosion Control and Interim Hurricane Study, Atlantic Coast of Long Island, New York, Jones Inlet to East Rockaway Inlet”. The total amount of bypassed sediment at each inlet was assumed to be equal to the longshore sediment transport rate minus the shoaling and impoundment rates.

An additional assumption made in computing the Existing (c. 1988) sediment budget was that in any erosive segment, 10% of the total eroded material was transported offshore due to nearshore wave energy and sea level rise. The sediment budget was computed along the Long Beach Island area by starting at Pt. Lookout and stepping westward through each segment after computing the net longshore transport rate at the western edge of the segment. The results for the Existing (c. 1988) sediment budget are shown in Figure 2-1 and given below:

- Sediment bypassing rates of 200,000 cy/yr (153,000 m³/yr) west at both Jones Inlet and East Rockaway Inlet.

- Volumetric change rates of -25,000 cy/yr (-19,000 m³/yr) at Pt. Lookout, -60,000 cy/yr (-46,000 m³/yr) at Lido Beach, -75,000 cy/yr (57,000 m³/yr) at Long Beach, -40,000 cy/yr (-31,000 m³/yr) at Eastern Atlantic Beach, and +50,000 cy/yr (+38,000 m³/yr) at Western Atlantic Beach.
- Offshore sediment transport rates of -3,000 cy/yr (-2,300 m³/yr) at Pt. Lookout, -6,000 cy/yr (-4,600 m³/yr) at Lido Beach, -7,000 cy/yr (-5,400 m³/yr) at Long Beach, -4,000 cy/yr (-3,000 m³/yr) at Eastern Atlantic Beach, and 0 cy/yr at Western Atlantic Beach.
- Net longshore sediment transport rates of 222,000 cy/yr (170,000 m³/yr) west at the Town of Hempstead Park, 276,000 cy/yr (211,000 m³/yr) west at Maple Blvd, 344,000 cy/yr (263,000 m³/yr) west at Nevada Ave, 380,000 cy/yr (291,000 m³/yr) west at Flamingo St.

2.9 Gravens et al. (1991), Coney Island

The authors evaluated the performance of various shore protection alternatives along the Coney Island area for the time period of 1966-1988 using the numerical GENEralized Model for SImulating Shoreline Change (GENESIS). GENESIS, developed by USACE, calculates the longshore sediment transport rate and resulting plan shape of the modeled coast based on wave conditions. An existing conditions sediment budget was developed from Corbin Place to Beach 44th St. to aid in the interpretation of the numerical results. Digitized topographic maps of the MHW shoreline from 1962 and 1970 were used in the calibration of GENESIS, and digitized topographic maps of the MLW shoreline from 1966 and 1988 were used in the verification of GENESIS model results and the development of the sediment budget.

In the development of the sediment budget the Coney Island area was segmented into 5 cells: (1) Block 1, extending from Corbin Place to Sea Breeze Ave; (2) Block 2, extending from Sea Breeze Ave to West 12 St.; (3) Block 3, extending from West 12th St. to West 27th St.; (4) Block 4, extending from West 27th St. to West 37th St.; and (5) Sea Gate, extending from West 37th St. to Beach 44th St. Surveyed and modeled shoreline change rates within each cell were computed from the shoreline change between the 1966 surveyed shoreline and the 1988 surveyed and modeled shoreline. An average berm height of 3 m and a cut-off depth of 6 m were assumed in converting both surveyed and modeled shoreline change rates to volumetric change rates. The resulting average volumetric change rate for the entire project area was an erosion of 27,000 m^3/yr for the surveyed shoreline change, and an erosion of 17,000 m^3/yr for the modeled shoreline change.

Longshore sediment transport rates were initially calculated from the GENESIS model. However, in order to account for the shoreline change model’s under-estimation of erosion an additional longshore transport rate of 2,500 m^3/yr exiting both ends of the project was included, as well as an offshore sediment transport rate of 5,000 m^3/yr at the terminal groin located at West 37th St. Justification for these modifications was provided by the authors based on the influence of tidal currents along the Coney Island shoreline, which at the ends of the project reach can be significant enough to at least influence breaking wave conditions and may also produce some alongshore movement of sand. Because the GENESIS model did not account for cross-shore sand transport, half of the under-estimated volumetric erosion was assumed to be lost into the 8 m-deep Coney Island Channel (due to the proximity of the channel and the terminal groin at West 37th Street).

The final sediment budget results are shown in Figure 2-1 and given below:

- Volumetric change rates of -11,500 m³/yr in Block 1, -3,200 m³/yr in Block 2, -8,000 m³/yr in Block 3, -1,200 m³/yr in Block 4, and -3,100 m³/yr in Sea Gate.
- Net longshore sediment transport rates of 11,700 m³/yr east at Corbin Place, 200 m³/yr east at Sea Breeze Ave, 3,000 m³/yr west at West 12th St., 11,000 m³/yr west at West 27th St., 7,200 m³/yr west at West 37th St., and 10,300 m³/yr west at Sea Gate.
- Offshore sediment transport rate of 5,000 m³/yr at West 37th St.

2.10 USACE-NAN (1992), Coney Island

USACE-NAN developed a Historical sediment budget along the Coney Island area for the 1961 to 1988 time period. The sediment budget was calculated for two cells comprising the public beach shoreline: (1) Brighton Beach, extending from Corbin Place to West 10th St.; and (2) Coney Island, extending from West 10th St. to West 37th St. Shoreline change rates from 1961-1988 were obtained from a Coastal Engineering Research Center (CERC) geomorphic study, which included the following surveys: Norman Porter Associates, Consulting Engineers shorefront topographic survey from July-August 1966, New York State construction survey from 1961, and a topographic survey from aerial photography taken on November 3rd, 1988. The CERC geomorphic study found that the shoreline along Coney Island was accreting at an average rate of +0.2 ft/year and the shoreline along Brighton Beach was eroding at average rate of -3.1 ft/yr. Volumetric change rates of 2,500 cy/yr (1,900 m^3/yr) and -27,500 cy/yr (21,000 m^3/yr) were estimated at Coney Island and Brighton Beach respectively from the shoreline change rates.

Initial longshore sediment transport rates were calculated from wave climate data and equations 4-38 and 4-50b in the Shore Protection Manual (SPM), which relate the longshore sediment transport rate to energy flux due to wave action. The initial longshore sediment transport rates were further refined by considering the effect of tidal currents. USACE-NAN assumed the terminal groin at West 37th St. prevented any sediment from entering Coney Island from the west, no sediment entered Brighton Beach from the East, and that little or no sediment was transported from offshore into each cell. The following paragraph describes how USACE-NAN calculated the Historical sediment budget.

The final Historical sediment budget was obtained after adjusting the calculated longshore transport rates downward until little or no sand was needed from offshore to balance the governing equations. This constraint was chosen because it was believed that little or no sand bypasses to Coney Island from across Rockaway Inlet, and little movement of sand occurs onto the beaches from the interior of Jamaica Bay or the East Bank Shoal. Also, it was acknowledged that the sediment transport calculations using the energy flux method are subject to a large amount of uncertainty and are commonly adjusted when the method is applied.

The final Historical sediment budget results are shown in Figure 2-1 and given below:

- Accretion of sediment in Coney Island (+2,500 cy/yr or +1,900 m^3/yr) and erosion of sediment in Brighton Beach (-27,500 cy/yr or -21,000 m^3/yr).
- Net longshore sediment transport rates of 16,200 cy/yr (12,400 m^3/yr) east at Corbin Place, 11,900 cy/yr (9,100 m^3/yr) west at West 10th St., and 11,400 cy/yr (8,700 m^3/yr) west at West 37th St.
- In order to close the sediment budget an onshore sediment transport rate of 600 cy/yr (450 m^3/yr) at Brighton Beach and 2,000 cy/yr (1,500 m^3/yr) at Coney Island was assumed.

2.11 USACE-NAN (1995), Jones Inlet to East Rockaway Inlet

A Historical as well as a Projected sediment budget was developed for the Long Beach Island area by USACE-NAN. The historical sediment budget was calculated for 1963-1988 based on comparison of the beach profiles and the records of beach fills during that time period. The general conclusions from the historical sediment budget are described in the following paragraph.

The pattern observed alongshore is one of alternating erosive and accretive zones. Transport is net westerly, with an overall erosive trend, losing an estimated 80,000 cy/year (61,000 m^3/yr) over the entire Atlantic shoreline. As seen from the historic shoreline comparison, the location of accretive and erosive zones shifts alongshore over time, so that any given location will experience cycles of both deposition and loss.

The historical sediment budget was computed for 4 segments of the Long Beach Island shoreline: (1) Point Lookout, extending from Inwood Ave to Sharen Dr.; (2) Long Beach, extending from Sharen Dr. to Laurelton Blvd.; (3) East Atlantic Beach, extending from Laurelton Blvd. to Scott Dr.; (4) West Atlantic Beach, extending from Scott Dr. to the eastern jetty at East Rockaway Inlet. The results of the Historical sediment budget are given below:

- Sediment bypassing rates of 200,000 cy/yr (153,000 m^3/yr) west at Jones Inlet.
- 642,000 cy (491,000 m^3) of beach fill placed on the mid-portion of the island from 1963-1988.
- Volumetric change rates of -105,000 cy/yr (-80,000 m^3/yr) in the Pt. Lookout segment, +21,000 cy/yr (+16,000 m^3/yr) in the Long Beach segment, -61,000 cy/yr (-47,000 m^3/yr) in the East Atlantic Beach segment, +66,000 cy/yr (+50,000 m^3/yr) in the West Atlantic Beach segment.
- Net longshore sediment transport rates of 305,000 cy/yr (233,000 m^3/yr) at Sharen Dr., 284,000 cy/yr (217,000 m^3/yr) at Laurelton Blvd., 345,000 cy/yr (264,000 m^3/yr) at Scott Dr., 279,000 cy/yr (213,000 m^3/yr) at the eastern jetty at East Rockaway Inlet.

Modifications to the historical sediment budget were made by USACE-NAN in order to create a 50 year Projected sediment budget. The modifications are listed below:

- Measured erosion rates were averaged over relatively long reaches to capture the effects of migrating erosive and accretive zones.
- Measured erosion rates from 1963-1988 were increased to account for sea level rise by applying the Bruun Rule.
- Deterioration of groins alongshore will result in increased sediment movement.
- It was assumed that the east end fillet at Rockaway Inlet will reach capacity early in the 50 year period, stopping the impoundment in Western Atlantic Beach.
- Losses of sediment were increased because the time period of 1963-1988 contained relatively few severe storms and thus most likely underestimates losses.

The predicted sediment budget was computed for 4 segments of the Long Beach Island shoreline: (1) Lido Beach, extending from Inwood Ave to Maple Blvd.; (2) Long Beach, extending from Maple Blvd. to Putnam Blvd.; (3) Atlantic Beach, extending from Putnam Blvd. to Flamingo St.; (4) West Atlantic Beach, extending from Flamingo St. to the eastern jetty at East Rockaway Inlet. The results of the 50 year Projected sediment budget are shown in Figure 2-2 and given below:

- Sediment bypassing rates of 200,000 cy/yr (153,000 m^3/yr) west at Jones Inlet.
- Volumetric change rates of -83,000 cy/yr (-63,000 m^3/yr) at Lido Beach, -104,000 cy/yr (-80,000 m^3/yr) at Long Beach, -8,000 cy/yr (-6,000 m^3/yr) at Atlantic Beach, 0 cy/yr at West Atlantic Beach.
- Longshore sediment transport rates of 283,000 cy/yr (216,000 m^3/yr) at Maple Blvd., 387,000 cy/yr (296,000 m^3/yr) at Putnam Blvd., 395,000 cy/yr (302,000 m^3/yr) at Flamingo St., 395,000 cy/yr (302,000 m^3/yr) at Eastern jetty at East Rockaway Inlet.

2.12 Moffatt & Nichol (1998), Jones Inlet

An Existing (c. 1997) sediment budget was developed by Moffatt & Nichol for Jones Inlet and the adjacent updrift and downdrift beaches. The sediment budget was developed based on:

- Previously developed sediment budgets over the past 40-year period (1959-1996);
- Analyses of recently acquired data including dredging records (1990, 1994, 1996);

- Aerial photographs from 1995, 1996, 1997;
- Pre- and post-dredging sounding surveys for the navigation channel from 1990 to 1996;
- Adjacent beach profiles from 1995.

Analysis of the aerial photography from 1995, 1996, and 1997 showed:

- Updrift (Jones Beach) shoreline stabilization in recent years.
- Westward longshore transport likely flowing around the jetty into the ebb shoal regime.

Comparison of the bathymetric contours from 1964 and 1996 show:

- Sediment accretion at updrift beach and offshore area: 8.6 million cy (6.6 million m^3).
- Sediment accretion at downdrift beach: 370,000 cy (283,000 m^3).
- Sediment deficit at outer navigation channel: 6.0 million cy (4.6 million m^3).
- Sediment accretion at offshore downdrift beach: 6.5 million cy (5.0 million m^3).

The Existing (c. 1997) sediment budget for Jones Inlet is shown in Figure 2-2. The following summarizes conclusions of the existing conditions sediment budget at Jones Inlet:

- The net shoreline change updrift of Jones Inlet is minimal.
- Shoaling in the inlet channel from the east is approximately 120,000 cy/yr (92,000 m^3/yr).
- Shoaling into the inlet from the west remains constant at approximately 80,000 cy/yr (61,000 m^3/yr).
- Average annual dredging rate is approximately 200,000 cy/yr (153,000 m^3/yr).
- Natural bypassing and/or ebb shoal accumulation rate is approximately 480,000 cy/yr (367,000 m^3/yr).
- The shoreline in front of Town of Hempstead and Nassau Beaches will continue to erode and accrete relative to maintenance operations.
- The required annual sand placement rate is estimated between 150,000 to 200,000 cy/yr (115,000 to 153,000 m^3/yr) depending on the compatibility of the beach fill material, location of fill, and the wave climate after the fill.
- The study also concluded that "maintenance activities can have a positive impact on the shoreline fronting Point Lookout. Continued maintenance is, however, required to mitigate persistent shore erosion."

2.13 Kana (1995), Fire Island to Montauk Point

Kana updated RPI's (1983) sediment budget from Fire Island Inlet to Montauk Point by including volumetric changes as calculated using profile data seaward of the -7.3 m (24.0 ft) MSL contour out to depth of closure (determined to vary between -9.1 m (29.9 ft) MSL along Fire Island and Westhampton Beach to -12.2 m (40.0 ft) MSL in the vicinity of Montauk Point). (Note that RPI (1983) had calculated a line sink at -24 ft MSL due to equilibrium profile adjustment; this rate of profile adjustment ranged from 1.9 to 2.5 m^3/m/yr. Kana's (1995) formulation extended to the depth of closure, meaning that there was no profile adjustment included.)

The sediment budget was based on comparative profile data from June 1955 to December 1979, and was calculated using 25 alongshore cells, with a width of 7.6 km (excluding inlets). Each cell was represented by 3 to 5 long profiles. This time period represents "present-day conditions" (at that time) after inlet stabilization and construction of groin fields, and was sufficiently removed from the storms of 1960 and 1962 to represent typical conditions.

Montauk Point was estimated to provide 110,000 m^3/yr. The east fillet at Shinnecock Inlet was determined to grow at 220,000 m^3/yr, which agrees with Panuzio (1968). To solve the budget, a reversal in net longshore sediment transport was determined to occur west of the Westhampton Groin Field, resulting in 85,000 m³/yr net longshore sediment transport to the east. Net longshore sediment transport rates at Fire Island Inlet were determined to be 360,000 m³/yr (agrees with USACE, 1958; Panuzio, 1969; RPI, 1985). A map showing the cells and sediment budget are shown in Figure 2-3, where all values are presented as the annualized an in 1,000 m³yr. The values located within a cell in Figure 2-3 are the average annual volume change (+accretion; -erosion), Qdf are the beach fill volumes, Qlout are the computed longshore transport rates at western end of compartment (+westerly; - easterly), and the number below each cell is the cell number. Major conclusions of the study were:

- The magnitude of net longshore sediment transport does not increase uniformly in magnitude from the source at Montauk Point.
- The groin field at Westhampton interrupts all net (eastbound) longshore sediment transport, resulting in a reversal in this region.
- Net longshore sediment transport rates at Moriches Inlet are lower than previously reported.
- The middle portion of Fire Island (20 km east of Fire Island Inlet) had a lower net longshore sediment transport rate (110,000 m³/yr) than expected.
- Severe erosion of eastern Fire Island is feeding the central portion; of this erosion, 87 percent is between MLW and -9.1 m MSL. Abandoned Fire Island Inlet shoals appear to have been a significant source of sediment through the early 1900s. However, because of the erosion of west Fire Island beaches, this source appears to be largely gone.

2.14 Gravens et al. (1999), Fire Island to Montauk Point

As part of the Fire Island to Montauk Point (FIMP) Reformulation Study, Gravens et al. (1999) developed a historical sediment budget representative of coastal sediment transport pathways and magnitudes during the 1979 to 1995 period. In addition, the authors developed an existing sediment budget reflecting littoral transport processes along the barrier island and inlets as of the time of their study (c. 1999). Both budgets were based on an analysis of the mainland and barrier island shorelines within the FIMP project area conducted by the Coastal Hydraulics Laboratory (CHL), and an analysis of the three inlets contained in the FIMP project area conducted by Moffatt and Nichol (M&N) (see USACE-NAN, 1998). The authors applied shoreline position data available in 1979, 1983 and 1995 to derive estimates of volume change for each sediment budget cell by assuming the shoreline translated parallel to itself over the active profile depth. The latter is measured as the difference in elevation between the top of the seaward-most active berm and the depth of closure. Gravens et al. used profile data in 1979 and 1995 to compute an active profile depth of 10.5 m (34.4 feet) as representative of the beach profiles within FIMP. The two budgets are referred to herein as the Historical (1979-95) and Existing (c. 1999) sediment budgets.

Gravens et al. divided the 133-km project shoreline extending from Fire Island Inlet to Montauk Point into three major morphological reaches: (1) Montauk Reach extending from Montauk Point in the east to Shinnecock Inlet in the west (58.1 km), (2) Westhampton Reach extending from Shinnecock Inlet to Moriches Inlet (24.8 km), (3) Fire Island Reach extending from Moriches Inlet to Fire Island Inlet (49.5 km).

The Historical and Existing (c. 1999) sediment budget developed by Gravens et al. is shown in Figure 2-4. Conclusions from their study are reproduced in the following paragraphs. For a more detailed discussion see Gravens et al. (1999).

> *The Historical [1979-1995] and Existing [c. 1999] condition sediment budgets provide estimates of net longshore sand transport rates, include engineering activities (beach fill placement and dredging), and sources and sinks representative of the Fire Island to Montauk Point study area. These sediment budgets indicate net LST that fall within accepted ranges as derived by previous researchers and as calculated through independent analyses herein. As compared to earlier*

sediment budget formulations, differences (such as west of the Westhampton Groin Field) appear reasonable given knowledge of the engineering activities and coastal processes occurring during the time periods representative of the Historical (1979 to 1995) and Existing (~1999) conditions. East- and west-directed components of the net longshore sand transport rate can be derived from the potential longshore sand transport rate calculations, as discussed in Chapter 6 of this report.

Beach fill placement (and/or transfer of littoral material to adjacent beaches) is a significant process and constitutes an important mechanism in maintaining the study area beaches. The majority of the beach fill placement most likely occurs through dredging of the inlets and bays, and placement on the adjacent beaches, in effect, a mechanical bypassing (or backpassing) mechanism. From 1933 to 1979 and 1979 to 1995, the cumulative rate of beach fill placed from Montauk Point to Fire Island was 295,000 and 309,000 m^3/yr , respectively. Estimating that only 25 percent of fills placed to close breaches reflects an alongshore movement of littoral material reduced the 1979 to 1995 value to 208,000 m^3/yr . Similar values for the 1979 to 1997 time period are 468,000 (total fill) and 357,000 m^3/yr (adjusted for breach fill). These rates of beach fill placement are of the same order as estimates of the net longshore sand transport rate at Fire Island Inlet (Taney (1961a,b): 344,000 m^3/yr ; RPI (1985): 240,000 m^3/yr ; Kana (1995): 360,000 m^3/yr ; growth rate of Democrat Point prior to stabilization (this study): 159,000 to 238,000 m^3/yr ; impoundment rate at Fire Island East jetty (this study): 385,000 m^3/yr (high; may include ebb shoal welding)). Thus, on a regional scale, future projects must maintain this nourishment rate to preserve present-day beach conditions.

Shoals and the inner shelf offshore of central Fire Island have been postulated by other researchers as a required source for solving the regional sediment budget. The sediment budgets formulated herein do not require an offshore source to formulate net longshore sand transport rates within an accepted range. However, incorporation of a lower-bound estimate (75,000 m^3/yr) for the offshore source also agrees with the accepted range for net longshore transport at Fire Island Inlet. However, integration of the upper-bound estimate results in net longshore sand transport rates at Fire Island Inlet which exceed accepted values. It is concluded that a source of sediment offshore of central Fire Island may exist, but its contribution to the littoral zone is of the order 75,000 m^3/yr .

2.15 Schwab et al (1999)

The authors present results of geologic mapping of the inner continental shelf offshore of Fire Island based on high-resolution sidescan-sonar imaging and subbottom profiling. Their results indicate that the inner continental shelf offshore of Watch Hill, the oldest (1,200 years) and most stable part of the barrier system from Shinnecock Inlet to Fire Island Inlet, most likely behaved as a headland during times of lower sea level. Erosion of this headland during the past 10,000 years furnished sediment to the inner continental shelf downdrift and was reworked into a series of shoreface-attached sand ridges. These ridges are 5-m thick immediately west of the outcrop, and less than 1 m thick or absent in other regions.
Previous sediment budgets have indicated that (net) longshore sediment transport rates along the Fire Island barrier are roughly 200,000 m^3/yr, whereas approximately 360,000 m^3/yr is believed to be passing into Fire Island Inlet. The authors suggest that the deficit in previous sediment budgets can be accounted for by an onshore sediment flux from the shoreface-attached sand ridges. Schwab speculated that the magnitude of the onshore sediment flux ranges from 75,000 to 390,000 m^3/yr, and feeds into the littoral system for a region extending from just west of Watch Hill through Point of Woods, Fire Island.

2.16 Batten (2003), Jones Inlet to Montauk Point

Batten (2003) used long profiles taken as part of the Atlantic Coast of New York Monitoring Program (ACNYMP) from 1995-2001 to estimate the total volumetric accretion or erosion from Jones Inlet to

Montauk Point. In his analysis, the shoreline from Jones Inlet to Montauk Point was split into 4 reaches: (1) Montauk, extending from Montauk Point to Moriches Inlet, (2) Westhampton, extending from Moriches Inlet to Shinnecock Inlet, (3) Fire Island, extending from Shinnecock Inlet to Fire Island Inlet, (4) Jones, extending from Fire Island Inlet to Jones Inlet. However, Batten does not report longshore sediment transport estimates along the shoreline or any analysis of the inlets.

Long profiles were taken on a biannual to annual basis by ACNYMP and the average spacing between long profiles was 1.5 km. Typically profiles are evenly distributed along the coast, becoming denser in the vicinity of inlets. Profile coverage for Coney Island, Rockaway and Long Beach reaches was inadequate; therefore Batten excluded these reaches from the volume change calculations.

The amount of sediment gained or lost at an individual profile transect was calculated from the profile monument to a depth of 24 ft using the software package USACE Beach Morphology Analysis Package (BMAP). The total volumetric change for a reach was determined by interpolating between transects. The results are shown in Figure 2-3 and summarized below:

- Total volumetric accumulation (+) or erosion (-) between 1995 and 2001 of 4,437,000 m^3 in Montauk, 2,935,000 m^3 in Westhampton, -239,000 m^3 in Fire Island Reach East, 4,413,000 m^3 in Fire Island Reach West, -257,000 m^3 in Jones Island.
- Total beach fill placements between 1995 and 2001 of 4,400 m^3 in Montauk, 4,610,000 m^3 in Westhampton, 1,848,000 m^3 in Fire Island (majority of fill placed in Robert Moses State Park), 2,307,000 m^3 in Jones Island (entirety of fill places at Gilgo Beach).
- Batten computed a net gain of 3,662,000 m^3, or 585,944 m^3/yr for the 6.25 yr analysis period. More over, the author concludes that "Though the uncertainty in the calculations is large, the data supports an onshore flux of sediment with a minimum value of 585,944 m^3/yr for the study period."
- Moreover, Batten concludes that the spatial distribution of sediment accretion and erosion during this time period corresponds well with the distribution of offshore sediment sources. Shorefaces fronting denser distributions of offshore Holocene sediments were observed to correlate to onshore accretion, while areas with sparser distributions of Holocene sediments were observed to erode.

2.17 Moffatt & Nichol (2007), Fire Island to Montauk Point

A new sediment budget was developed for FIMP in 2007 by Moffatt & Nichol incorporating recent morphological changes, beach/inlet management practice, medium- to long-term (10-30 years) historic trends, ongoing management practices, and engineering activities. Two sediment budgets were developed, a Recent (1995-2001) and Existing (c.2001) sediment budget. The reach designations used for the Recent (1995-2001) and Existing (c. 2001) sediment budget developed by M&N (2007) for FIMP are shown in Figure 2-5. Conclusions from their study are reproduced in the following paragraphs and shown in Figure 2-6 and Figure 2-7. For a more detailed discussion see M&N (2007).

<u>Summary of Results for the Recent (1995-2001) Regional Sediment Budget</u>

> *Qualitatively, this budget is similar to previous studies in that it shows increasing transport from east to west and it also shows that erosion along the beaches from Montauk Point to Southampton is the main source for a relatively large net westerly directed longshore sediment transport rate at updrift of Shinnecock Inlet (68,000 to 304,000 m^3/yr shown in previous studies). The budget also shows erosion along the two barrier island reaches downdrift of Shinnecock and Moriches Inlet: W4 (Tiana Beach) and FI3 (Smith Point County Park and the eastern end of the Wilderness Area), respectively. In fact, erosion rates in reach W4 are very similar to those*

shown in Kana (1995) and in Gravens et al. (1999), which were approximately 50,000 to 60,000 m³/yr. On the other hand, erosion rates in the FI3 cell during the 1995-2001 period were roughly half of those shown in those two studies (100,000 to 120,000 m³/yr). As explained above, this new result seems reasonable considering that Moriches Inlet appears to have been bypassing sand fairly efficiently in recent years.

In fact, perhaps the most significant difference between the Recent (1995-2001) budget and previous studies (particular Gravens et al., 1999 and USACE-NAN, 1999) is that Shinnecock and Moriches Inlet, and to smaller extent the Westhampton groin field, do not appear to be intercepting as much of the westerly sand flow as they had in the past. This seems reasonable considering that these two inlets have now been open for more than 70 years and stabilized with rock jetties for over 50 years. And although recent inlet modifications at Moriches Inlet (1986) and Shinnecock Inlet (1990) caused profound changes to the configuration of the channel and the ebb shoal, they do not appear to have caused a significant net increase in ebb shoal volume. However, this finding should be viewed somewhat skeptically until additional surveys are collected and analyzed over the next decade or so to confirm or refute it. Additional discussion regarding expected medium- to long-term trends at the inlets is presented in the following section.

As in the previous studies, particularly in Kana (1995), central Fire Island shoreline (cell F2) appears to be fairly stable or even slightly accreting. The Recent (1995-2001) budget also shows net accretion in western Fire Island (75,000 m³/yr in cell FI1), whereas Gravens et al. suggested very little net accumulation (8,000 m³/yr) and Kana showed significant erosion (more than 150,000 m³/yr) despite some fill (roughly 25,000 m³/yr) being placed in this area during the analysis period for that budget (1955-1979). Kana also shows high erosion rates within Robert Moses State Park between 1955 and 1979 (42,000 m³/yr) despite fill at rate of 14,000 m³/yr.

Computed net westerly transport entering Fire Island Inlet between 1995 and 2001 (394,000 m³/yr) compares favorably with the range of estimates (including Panuzio, 1969; RPI, 1985; Kana, 1995) prior to Gravens et al. (1999), which shows a significantly lower estimate of 194,000 m³/yr. Increased sediment supply from updrift as a result of more efficient bypassing around Shinnecock and Moriches Inlet and, more importantly, the Westhampton groin field, combined with a large amount of fill placed at Westhampton may be at least partially responsible for increased westerly transport along Fire Island and at Fire Island Inlet between 1995 and 2001. In previous studies these large westerly transport estimates were arrived at on the basis of historic spit growth analysis at Fire Island and updrift fillet accumulation after construction of the Democrat Point breakwater, however updrift volume changes from Fire Island to Montauk Point did not support that much transport at Fire Island and thus required other sources of sediment such as an offshore supply. Kana (1995) speculated that up until the early 1900s the source of this sediment was an abandoned delta off western Fire Island whereas between 1979 and 1995 this relict source had largely disappeared and the foreshore in western Fire Island was being "cannibalized" instead. Note that the more recent spit growth and impoundment analysis performed by Gravens et al. (1999) suggest slightly lower longshore sediment transport rates than Taney (1961a,b): 159,000 to 300,000 m³/yr based on spit growth and 385,000 m³/yr based on impoundment at Democrat Point. The authors considered the latter estimate to be most likely "high" because it probably included "some contribution due to onshore welding of the eastern portion of the Fire Island ebb shoal" after construction of the east jetty.

Note that the fact the Recent (1979-1995) sediment budget does not necessarily require an offshore sediment source to yield an estimate of net westerly transport arriving at Fire Island Inlet that matches estimates based on spit growth prior to stabilization or impoundment at

Democrat Point. However, this does not necessarily mean that there is no offshore source. In fact, accumulation within the inlet and dredging rates still yield a somewhat low westerly transport rate on Gilgo Beach downdrift of Fire Island Inlet (145,000 m³/yr), which would be increased by an offshore source of sediment.

Summary of Results for the Existing (c. 2001) Regional Sediment Budget

An Existing (c. 2001) conditions sediment budget presenting estimates of volume changes and longshore sediment transport rates for 18 beach cells and 3 inlets within the FIMP study area was developed using available survey data. The budget incorporates relevant long-term trends identified in previous studies as well as recent changes, including relatively new inlet and shoreline management practices such as the deposition basin at Shinnecock Inlet and the Westhampton Interim Project.

Most estimates of volume change rates for the beach cells were computed as a prorated average of the Recent (1995-2001) and Historic (1979-1995) changes, which effectively results in an estimate of the long-term (1979 to 2001) changes in that cell. 1995-2001 estimates alone where used in cells where the recent trends are considered more representative of existing and future conditions (e.g., FI3). At the inlets, an attempt was made to account for recent management and morphological evolution changes without discounting previously identified long term trends and established theories regarding the impacts that inlets have on longshore sediment transport and a barrier island processes.

Overall, this budget shows longshore sediment transport rates that fall within the range of previously published estimates (e.g., 151,000 m³/yr, 238,000 m³/yr, and 404,000 m³/yr entering Shinnecock, Moriches, and Fire Island Inlets, respectively). Transport appears to increase from east to west and the initial source of sediment feeding the net longshore sediment transport from east to west appears to be erosion along the beaches from Montauk Point to Southampton, specifically in cells M5, M2, and M1.

The budget suggests that the effects of the Westhampton groin field have been largely offset by the construction of the Westhampton Interim Project. Specifically, the estimate of sediment entering Moriches Inlet (238,000 m³/yr) is higher than values presented in other recent studies (e.g., Kana, 1995) and very similar to the estimate by Taney (1961a,b) of 230,000 m³/yr under conditions prior to the construction of the Westhampton groin field.

Also similarly to previous studies, the Existing (c. 2001) condition budget suggest erosion along the two barrier island reaches downdrift of Shinnecock and Moriches Inlet: W4 (Tiana Beach) and FI3 (Smith Point County Park and the eastern end of the Wilderness Area), respectively, albeit at somewhat smaller rates, particularly at cell FI3. This reduction may be a result of increased bypassing at Shinnecock and Moriches Inlet in recent years.

Nonetheless, the three inlets in the FIMP study area, particularly Fire Island Inlet, continue to be a sediment sink. Specifically, available surveys and assumptions regarding the effects of sea level rise on inlet morphology suggest that Shinnecock, Moriches, and Fire Island Inlet accumulate 32,000, 25,000, and 108,000 m³/yr, respectively. Therefore, the total loss to the system is 165,000 m³/yr, which represents a significant percentage of the average longshore sediment transport along the FIMP shoreline.

On the other hand, approximately 431,000 m³/yr of beach fill dredged from offshore sources are placed along the shoreline between Montauk Point to Fire Island Inlet, mostly as part of the Westhampton Interim Project (250,000 m³/yr).

The Existing (c. 2001) condition regional budget does not explicitly include an offshore sediment source because it was not required to balance the budget at Fire Island Inlet or to yield reasonable estimates of longshore transport entering and exiting the inlet. Although its possible existence and contribution to the nearshore sediment transport system is recognized. Specifically, differences between potential net transport computed with GENESIS and transport computed based on volume changes in central Fire Island suggest an onshore sediment flux of approximately 200,000 m³/yr to explain the well documented relative shoreline stability in this area. This value matches the estimate suggested by Schwab et al. (2000) based on the sediment budget by Kana (1995). However, Gravens et al. (1999) suggested a lower value, 75,000 m³/yr, based on results from their sediment budget and Fire Island spit growth estimates.

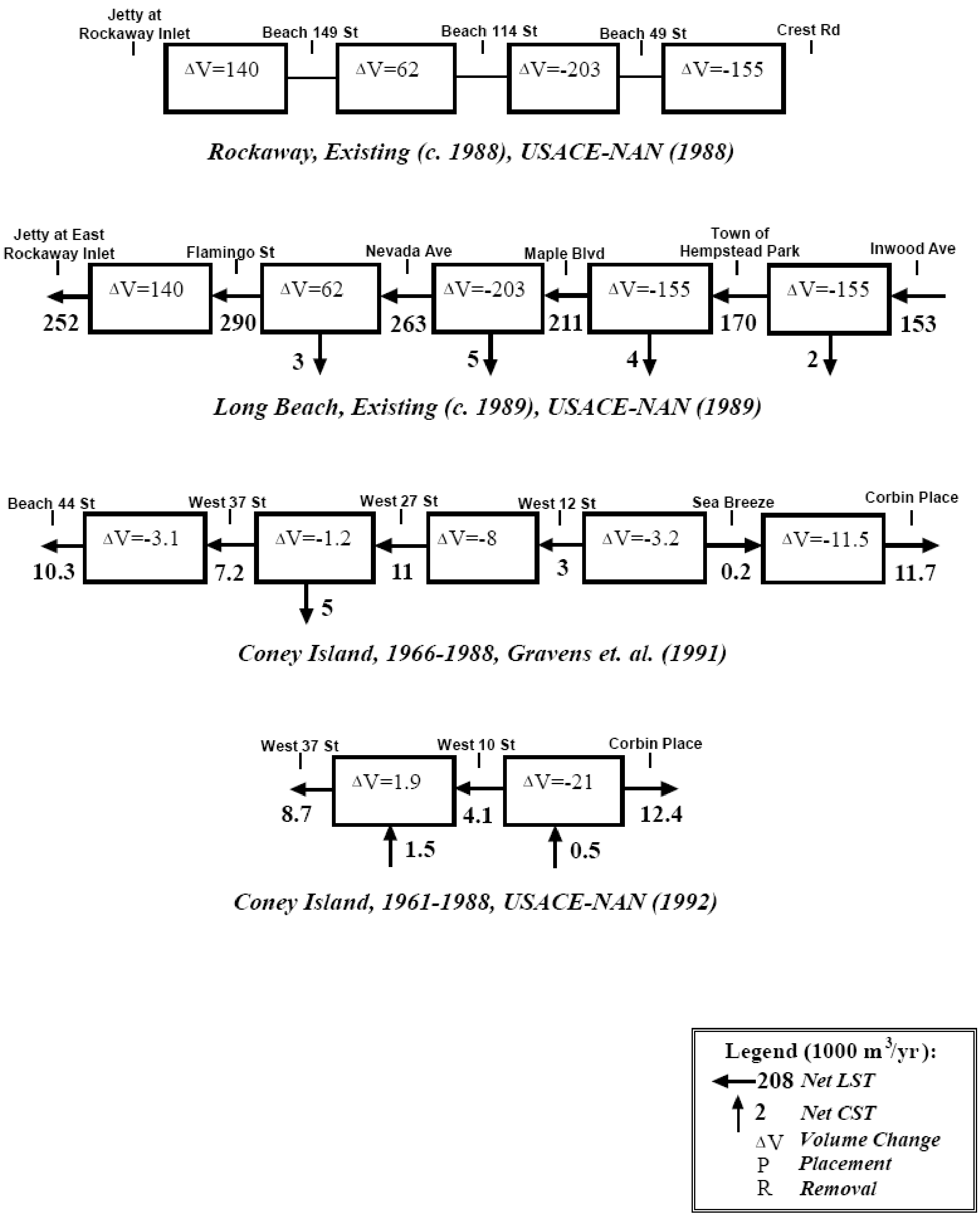


Figure 2-1: Previous Sediment Budgets

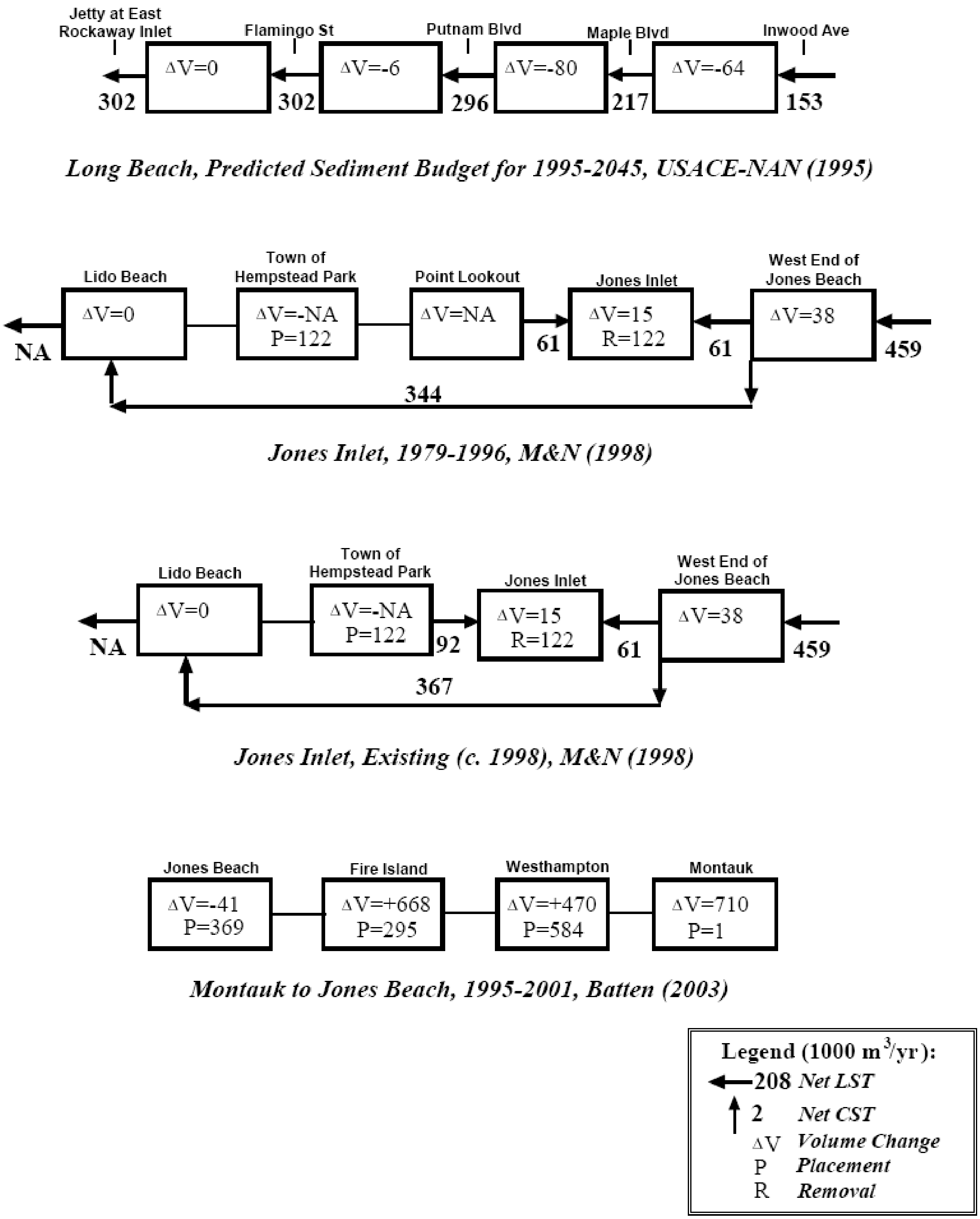


Figure 2-2: Previous Sediment Budgets

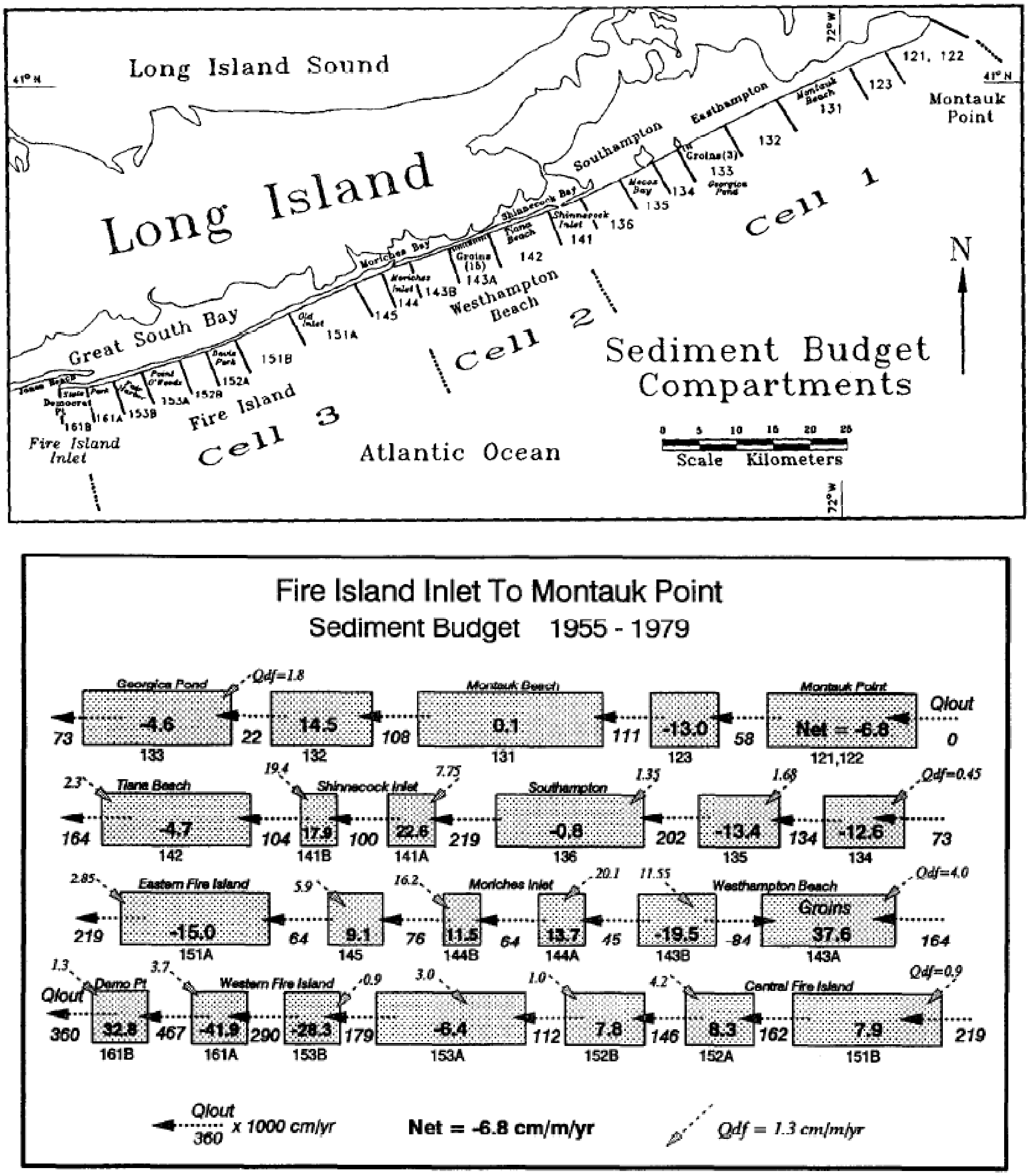
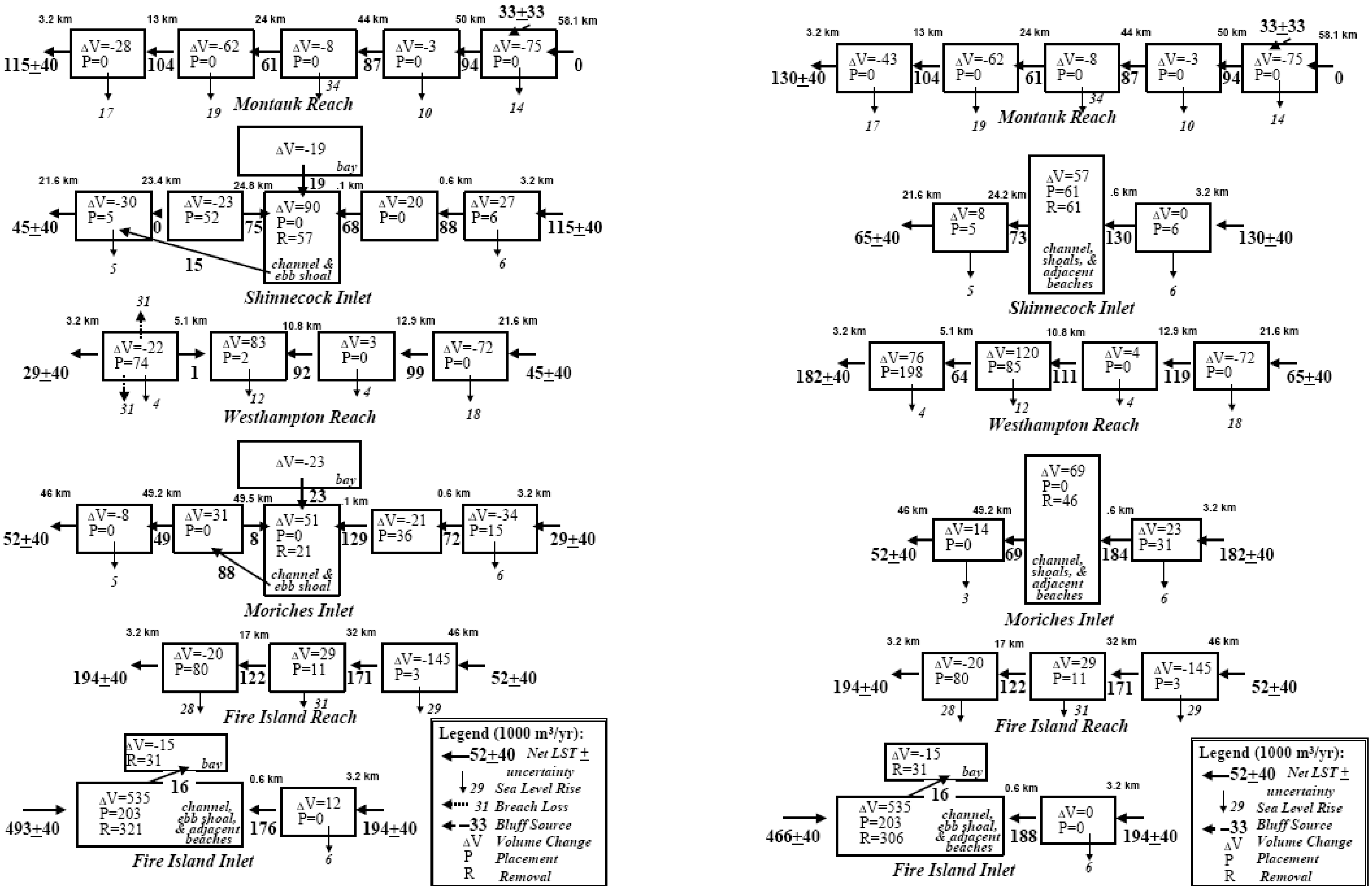


Figure 2-3: Sediment Budget developed by Kana (1995) for Fire Island to Montauk Point



Historical sediment budget **Existing** condition sediment budget

Figure 2-4: FIMP Historical (1979-1995) and Existing (c. 1999) Sediment Budget, Gravens et. al. (1999)

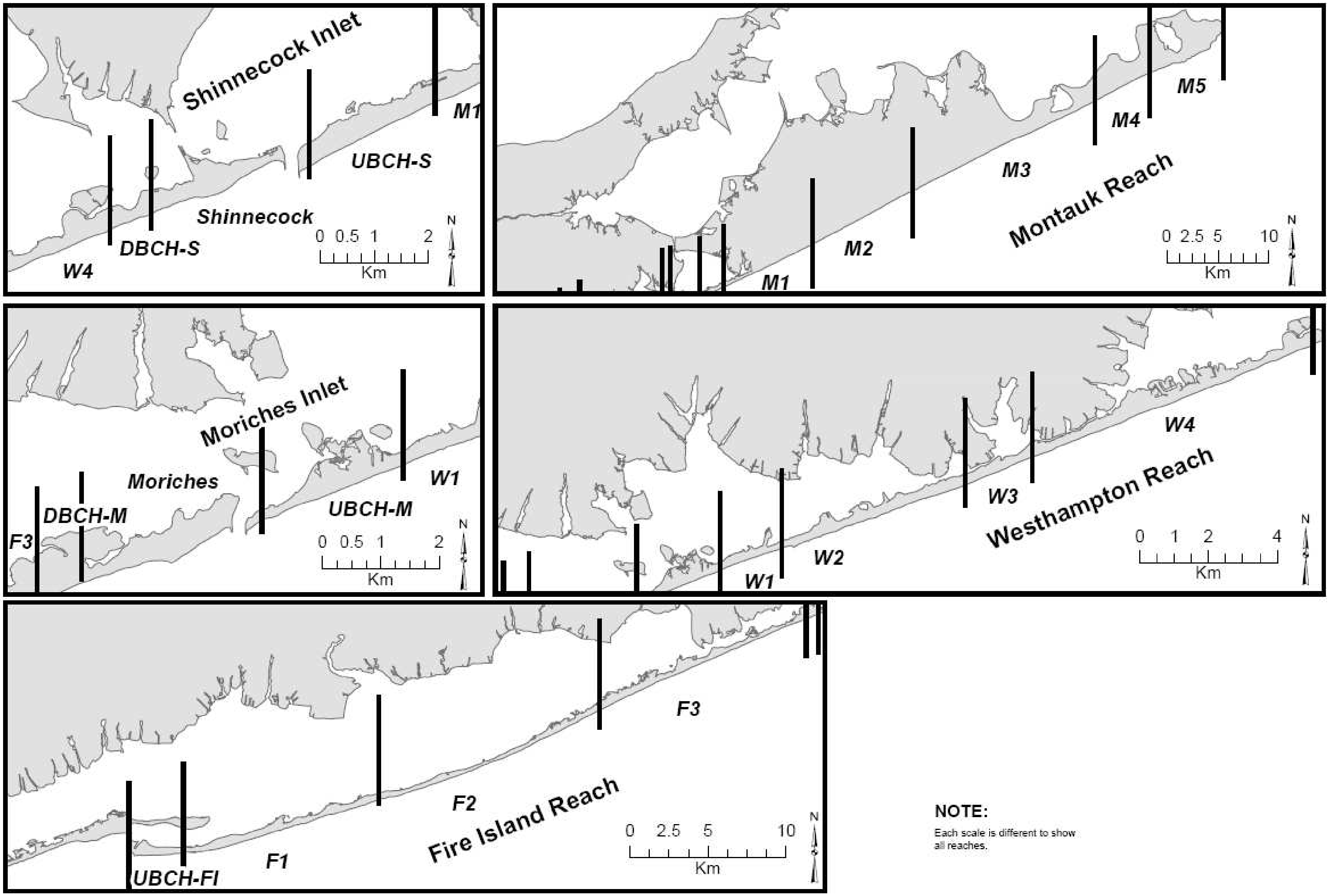


Figure 2-5: M&N 2007 FIMP Sediment Budget Reaches

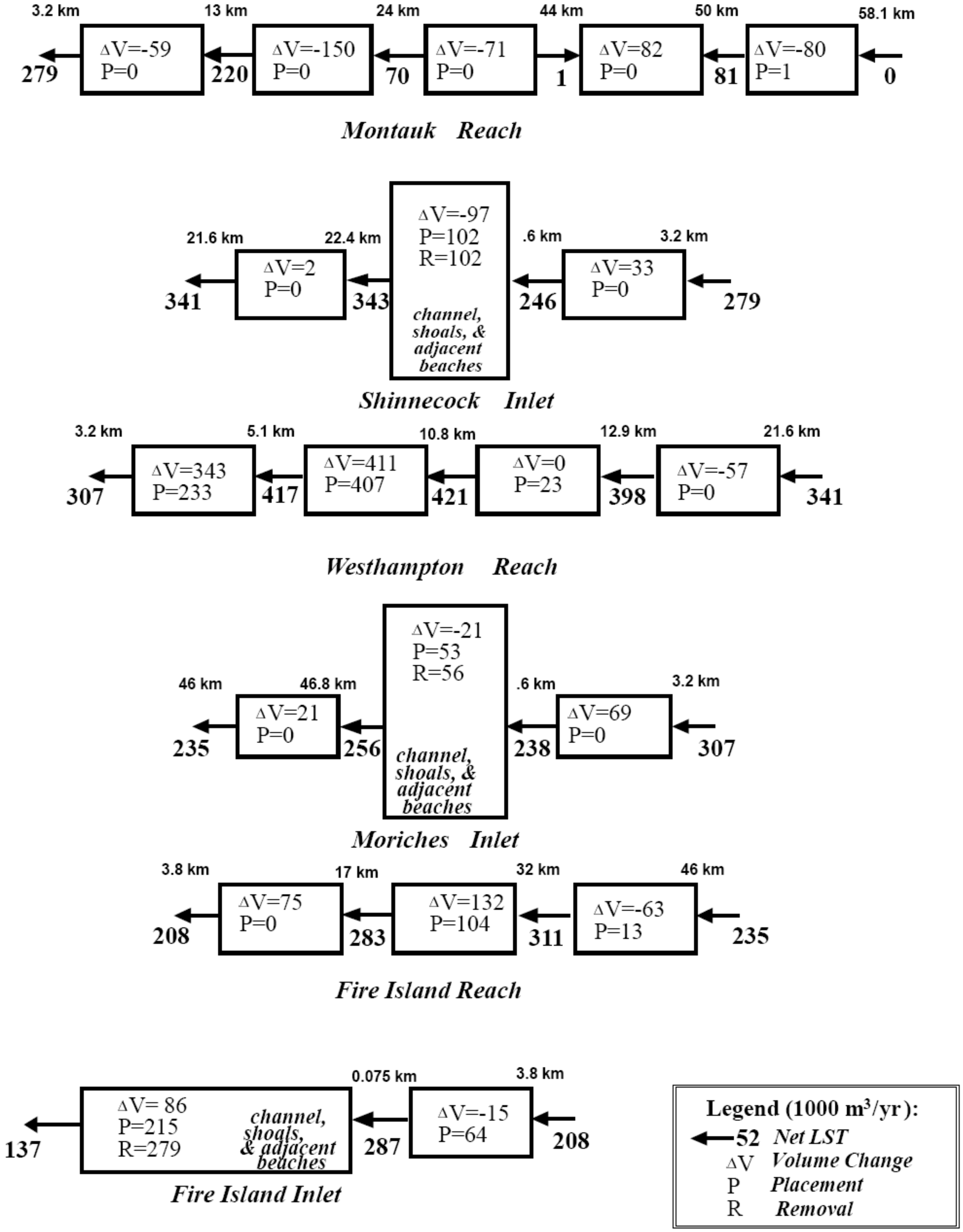


Figure 2-6: FIMP Recent (1995-2001) Sediment Budget, M&N (2007)

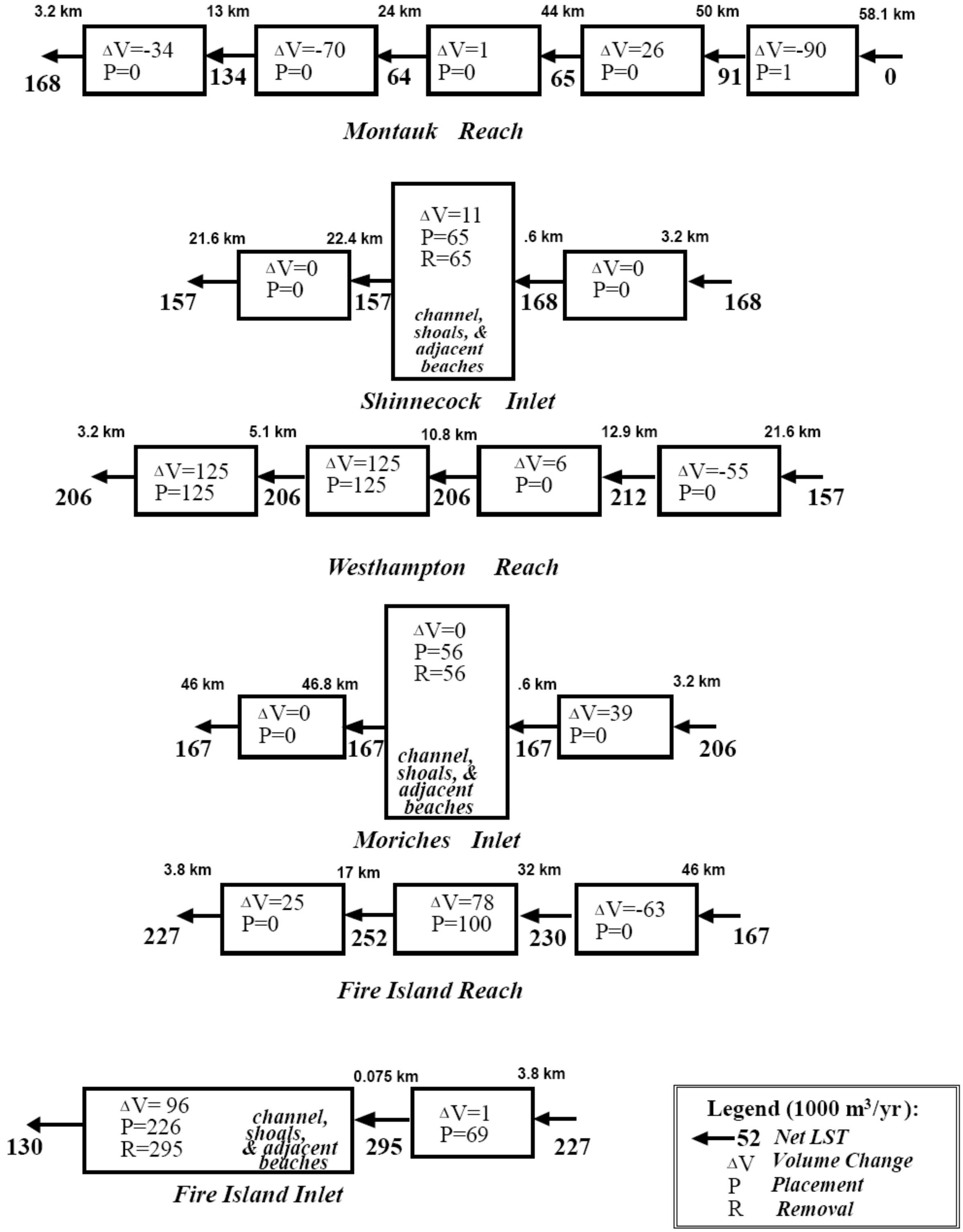


Figure 2-7: FIMP Sediment Budget, Existing (c. 2001) Conditions, M&N (2007)

3. CONCEPTUAL SEDIMENT BUDGET UNCERTAINTY

Volume changes and sediment transport quantities required for the formulation of a coastal sediment budget cannot be measured directly and therefore values of such quantities have to be obtained through indirect and/or incomplete measurements (e.g., shorelines or beach profiles), with predictive formulas, or through estimates based on experience and judgment. The reliability of a coastal sediment budget can be quantified by specifying the uncertainty associated with estimates of volume changes and sediment transport quantities. Uncertainty consists of error and true uncertainty (Kraus and Rosati, 1998). A general source of error is limitation in measurement process or instrument. Typically the estimates of the potential error associated with various instruments (e.g. total stations, GPS, lasers, echosounders, etc.) and measurement processes (land surveys, boat surveys, sled profile surveys, Scanning Hydrographic Operational Airborne Lidar Survey (SHOALS), aerial mapping, orthorectifying, digitizing, etc.) can be quantified. However, true uncertainty in estimates of coastal engineering quantities is more difficult to determine and unfortunately, generally much more significant than error because it includes natural temporal (daily, seasonal, annual) variability and spatial variability (alongshore and across shore) as well as many unknowns (e.g. grain size, past and future wave climate) and variability imposed by choices regarding various definitions which are necessary to compute these estimates (e.g., average shoreline orientation, berm location, depth of closure, etc.).

Kraus and Rosati (1998) showed that the uncertainty in various representative sediment budgets may be greater than the estimates themselves. Given the myriad of data sources, and incomplete documentation of how each sediment budget along Long Island was derived, formal uncertainty estimates from statistical analysis were not calculated. Instead conceptual uncertainty estimates based on differences between all the available sediment budgets for a shoreline reach were made. It is important to note that the sediment budgets reviewed for Long Island were calculated for different time periods and varying data sources. During the time span for which the sediment budgets were derived yearly variability in the wave conditions and a variety of engineering projects (e.g. construction of jetties and groin fields, beach nourishment, dredging, etc.) have influenced the sediment budgets along the south shore of Long Island. Consequently, consideration of conceptual uncertainty estimates by comparing sediment budgets for different time periods should be preceded with caution.

An additional complication in comparing longshore sediment transport (LST) rates from different studies is that in some studies the LST rate the end of a reach is determined from the impoundment rate at a jetty, and in other instances the LST may be estimated by the net balance of sedimentation and bypassing at an inlet. Therefore, there is typically more uncertainty at an inlet because it is difficult to determine if all of the littoral drift is being impounded at a jetty, and it is rare that there is sufficient bathymetric coverage at the inlet to determine the amount of sedimentation or bypassing with certainty.

Conceptual uncertainty estimates have been made for 7 shoreline reaches along the south shore of Long Island (Figure 1-1). Each reach is separated by an inlet and all but the Coney Island and Montauk reach are barrier islands. Note that the “Montauk” reach includes the entire shoreline from Montauk Point to Shinnecock Inlet; the label “Montauk” is used for simplicity.

There have been numerous sediment budgets (up to 8) developed for sections from Fire Island to Montauk Point and very few sediment budgets developed for areas between Jones Beach and Coney Island. In the following sections the conceptual uncertainty at each reach along the south shore of Long Island is analyzed by displaying the ranges in published LST rates at each end of a reach (**Error! Reference source not found.**). Additionally, the minimum, maximum, and mean (LST) rate at each end of a reach is given in Table 1.

3.1 Montauk Reach

Estimates of the amount sediment entering the eastern end of the Montauk reach from the wave-cut bluffs at Montauk Point ranged from 0 to 110,000 m³/year, with a mean value of 42,000 m³/year. At the western end of the Montauk reach (Shinnecock Inlet) LST estimates varied between 115,000 and 281,000 m³/year, with a mean value of 205,000 m³/year. Given the large number of estimates at the western (8) and eastern end (6) of the Montauk reach and the relatively small variation in the LST estimates the conceptual uncertainty for the Montauk reach is smaller.

3.2 Westhampton Reach

At the eastern end of the Westhampton reach estimates of the LST range from 45,000 to 251,000 m³/year, with a mean value of 119,000 m³/year. All 4 estimates at the eastern end of the Westhampton reach are similar. Therefore, the conceptual uncertainty is moderate. At the western end the LST estimates range from 29,000 to 437,000 m³/year, with a mean of 235,000 m³/year. The large discrepancy in LST estimates at the western end indicates there is large uncertainty in the sediment budget for this reach. It is also an indicator that over time large changes in the sediment dynamics may have resulted from the construction of groins and beach nourishment in the Westhampton reach.

3.3 Fire Island Reach

At the eastern end of the Fire Island reach estimates of the LST range from 52,000 to 345,000 m³/year, with a mean of 165,000 m³/year. The large variations in the LST might once again be due to the corresponding fluctuations in LST at the western end of the Westhampton reach, which affect the sediment bypassing rate at Moriches Inlet, and also due to different assumptions regarding bypassing at Moriches Inlet. At the western end of the Fire Island reach the LST estimates range from 194,000 to 460,000 m³/year, with a mean of 317,000 m³/year. The uncertainty in the sediment budgets for this reach should be considered large given the large variations in the LST values at the both ends of the reach. Adding to the uncertainty for this reach is the debate on whether or not there is an offshore source of sand contributing to the sediment budget for Fire Island. The possibility of such a source has been suggested by a number of previous studies (e.g., Williams, 1976, Williams and Meisburger, 1987, Williams and Morgan, 1993, Schwab et al. 1999, Schwab et al. 2000).

3.4 Jones Beach Reach

At the eastern end of the Jones Beach Reach, just downdrift of the Fire Island Inlet, the LST estimates range from -79,000 to -493,000 m³/year, with a mean of -294,000 m³/year. The negative sign indicates that the LST is directed to the east, toward Fire Island Inlet. The large discrepancy between the LST rates is a result of differences in the measured amounts of shoaling in Fire Island Inlet. At the western end of the Jones Beach reach the LST estimates range from 420,500 to 459,000 m³/year, with a mean of 449,000 m³/year. Since these estimates are more variable at the eastern end, the conceptual uncertainty is higher there than at the western end. It should be noted that none of the sediment budgets reviewed included the entirety of the Jones Beach reach in their budgets, instead only one end of the Jones Beach reach was included in any individual sediment budget.

3.5 Long Beach Reach

At the eastern end of the Long Beach reach the estimates of the LST range from 7,600 to 283,000 m³/year, with a mean of 147,000. The discrepancy in the LST at the east end of the Long Beach reach could be attributable to the filling up of the fillet at the eastern end of Jones Inlet and the subsequent increase of sediment bypassing. Estimates of the LST at the western end of the Long Beach reach range from 213,000 to 306,000 m³/year, with a mean of 274,000 m³/year. Based on the variations in the LST rates at both ends of the reach it is apparent that the conceptual uncertainty is higher at the eastern end than at the western end.

3.6 Rockaway Reach

There is only one estimate of the LST rate at both ends of the Rockaway Beach reach: 153,000 m³/year at the eastern end and 139,000 m³/year at the western end. Because only one estimate is available, it is not possible to estimate the level of uncertainty associated with this reach.

3.7 Coney Island Reach

Two sediment budgets have been developed for the Coney Island Reach. Both studies estimate significantly smaller LST rates than for other reaches of Long Island. At the eastern end the LST estimates are -12,400 and -8,900 m³/year (negative sign indicates eastward transport) and 8,700 and 5,500 m³/year at the western end. At each end of the reach the LST values are similar indicative of a smaller uncertainty.

3.8 Sumary of Atlantic Coast of Long Island, New York

The large number of sediment budgets formulated for the Montauk, Westhampton and Fire Island reaches re-iterate the uncertainty in sediment budgets because estimates of the longshore sediment transport rate differ by as much as 300,000 m³/year. Despite the variability and uncertainty in sediment budgets it is judged that they can still provide a realistic, albeit only semi-quantitative, description of the sediment transport processes than can be used to assist in the planning, design, and formulation of shore protection and storm damage reduction measures for Long Island.

Table 1: Range of longshore sediment transport rates (m³/yr) at the end of each reach

Location	Max	Min	Mean	# of Estimates
East end Montauk Reach	110,000	0	42,083	6
West end Montauk Reach	281,000	115,000	205,250	8
East end of Westhampton Reach	251,000	45,000	119,500	4
West end of Westhampton Reach	437,000	29,000	235,333	6
East end of Fire Island Reach	345,000	52,000	165,000	4
West end of Fire Island Reach	460,000	194,000	316,714	7
East end of Jones Beach Reach	-79,000	-493,000	-294,500	4
West end of Jones Beach Reach	459,000	420,500	449,375	4
East end of Long Beach Reach	153,000	153,000	146,600	6
West end of Long Beach Reach	306,000	7,600	273,767	3
East end of Rockaway Reach	153,000	153,000	153,000	1
West end of Rockaway Reach	139,000	139,000	139,000	1
East end of Coney Island Reach	-8,900	-12,400	-10,650	2
West end of Coney Island Reach	8,700	5,500	7,100	2

Positive values correspond to westward transport and negative values correspond to eastward transport.

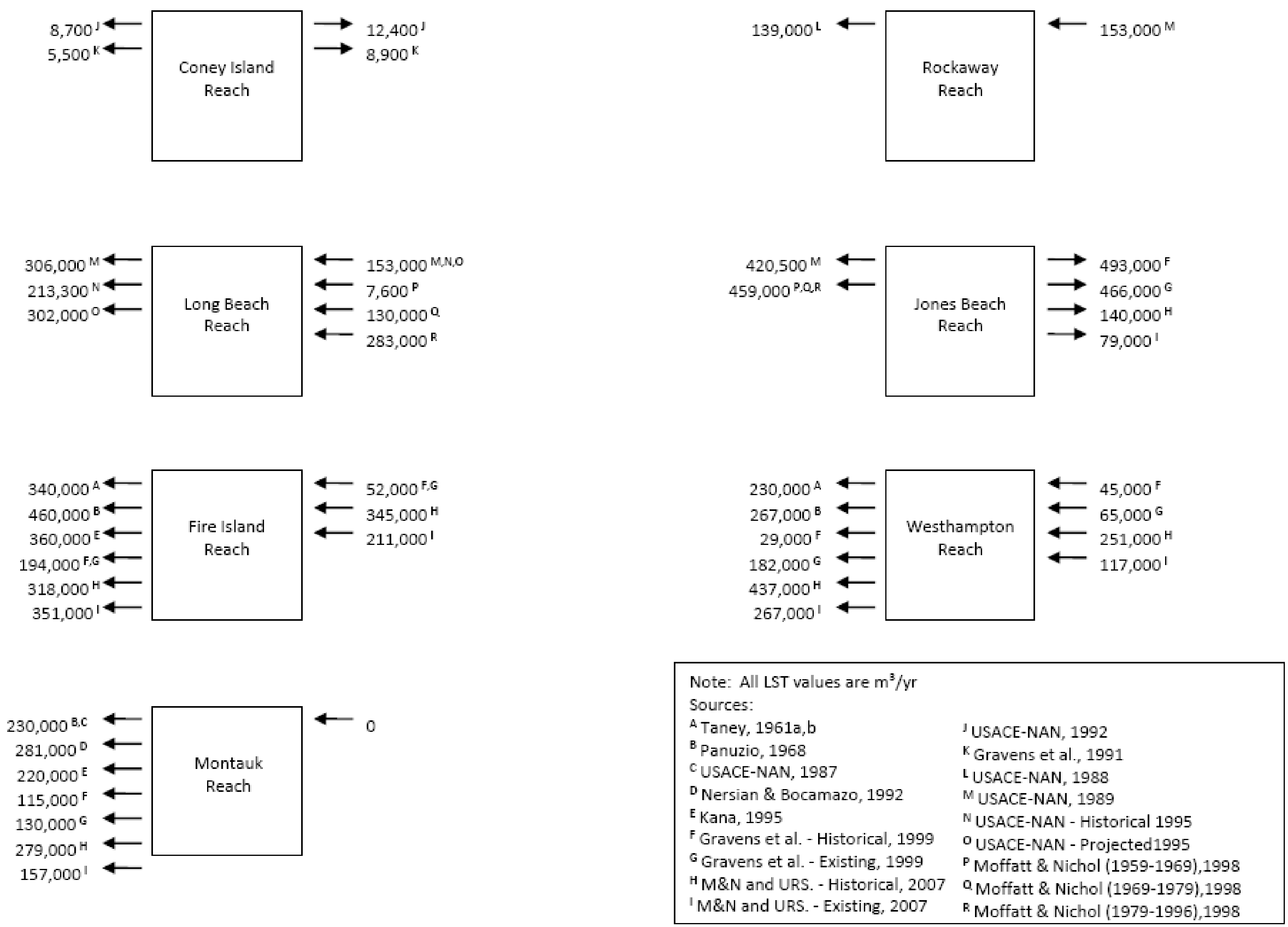


Figure 3-1: Range of Published LST values for South Shore of Long Island

4. SEDIMENT BUDGET IMPROVEMENT OPPORTUNITIES

Numerous sediment budgets have been developed for the FIMP region of Long Island, including a recent and comprehensive sediment budget developed by USACE-NAN for FIMP (USACE-NAN, 2007). However, significantly fewer sediment budgets have been developed for the region west of Fire Island. Nor has a sediment budget been developed for Jones Beach, which stretches from Fire Island Inlet in the east to Jones Inlet in the west. The section of shoreline from Fire Island Inlet to Coney Island has not had any recent sediment budgets developed (the most recent was in 1998 for Jones Inlet). Therefore, the sediment budget work done for the FIMP area should be regularly updated as new data is collected and ultimately extended all the way to Coney Island.

Presently a beach profile monitoring system for the entire South Shore of Long Island is in place through ACNYMP. ACNYMP provides semi-annual to annual profile measurements at 348 monuments located approximately 600 m apart from Coney Island to Montauk Point. In addition, ACNYMP captures semi-annual aerial photographs to provide a qualitative measure of shoreline erosion/accretion between survey monuments. The profile measurements and shoreline position data inferred from aerial photos has been used to estimate the volumetric change rates along the shoreline (e.g., USACE-NAN, 2007). However, volumetric changes along a beach based on different synoptic sources (e.g. aerial photographs, short profiles, long profiles, etc.) can be very different. These differences, which are of the same order of magnitude as the estimates of long shore sediment transport or even larger (USACE-NAN, 2007), are the principal source of uncertainty in the existing sediment budgets. Therefore, it is suggested that a study be undertaken to quantify the uncertainty and errors in estimates of volumetric changes using different data sources along a representative stretch of shoreline. The results of this study could be used to better quantify and ultimately reduce the uncertainty in existing and future sediment budgets.

In 2007 a comprehensive study and modeling effort was completed for Shinnecock, Morriches, and Fire Island Inlets (USACE-NAN, 2007). As part of the study, sediment transport paths, sand bypassing rates, inlet stability, longshore transport rates, and erosion rates at updrift and downdrift beaches were evaluated. Similar studies should be undertaken for Jones, East Rockaway, and Rockaway Inlets as very little is currently known about sediment transport at these inlets. In addition the “working” numerical models and sediment budgets already developed for Shinnecock, Moriches, and Fire Island Inlets should be maintained and updated with new inlet surveys and wave data to improve understanding of sediment transport at these inlets. Annual surveys should be taken at all inlets with either Global Positioning System – Real Time Kinematic (GPS-RTK) multibeam or SHOALS systems using a consistent vertical datum and tidal benchmark from ocean to bay. GPS with RTK corrections eliminates one of the most common problems in accurately measuring the sea bottom elevations in and around a tidal inlet, i.e., the calculation of the tidal elevation corrections. In a typical bathymetric survey using standard GPS techniques, a tide gauge is installed at one location and used to measure tides for the entire survey area which will then be used to “correct” the measured water depths. However, tidal elevations are very different in the ocean and bay sides of the inlet and even along the inlet’s mouth (e.g., Fire Island Inlet). GPS-RTK, which has already been used by USACE contractors for several recent inlet condition surveys, eliminates the need for a tidal gauge by tying directly to an existing benchmark with horizontal and vertical control.

Additionally, water level and wave measurements just outside the inlets and inside the bays should be collected long-term. Note that ad-hoc, short-term, data collection efforts are much less useful because very often they do not include large storm events or do not provide data for the full period between two consecutive beach and/or inlet surveys.

Finally the possibility of conducting sediment tracer studies, particularly at the inlets, should also be strongly considered as means to improve/calibrate the numerical models and sediment budgets. Sediment tracer studies could significantly reduce the uncertainty in the current long shore sediment and inlet bypassing estimates. The deployed sediment tracer would "behave" the same (in terms of sediment transport) as the littoral sediment. The tracer could be deployed concurrent with dredging projects at the inlets, beach renourishment efforts, or independent of these actions.

5. INVENTORY OF BORROW AREAS

An inventory of existing and previously dredged sediment borrow areas has been developed for the Atlantic Coast of Long Island. The inventory is based on information provided by USACE-NAN and includes borrow areas identified as part of completed or ongoing federal projects and studies. Each borrow area has been spatially referenced in a GIS database and any relevant information pertaining to the borrow area (i.e. mean grain size, volume available, etc.) has been included in the database. In addition the location and characteristics of core samples taken in previous studies to identify suitable borrow areas has been included in the database. The database provides a comprehensive inventory of existing borrow areas and core samples along Long Island in GIS format (shapefiles) for easy distribution and transfer. A complete description of the database is provided in Appendix A. Appendix B contains figures of the current borrow areas that have been designated for Federal Shore Protection Projects on the Atlantic coast of Long Island.

6. BORROW AREAS MANAGEMENT AND MONITORING PLAN

Four separate storm damage reduction projects are currently in place or under consideration for Coney Island, Rockaway Beach, Long Beach, and the FIMP area. Additionally, interim projects at Westhampton and West of Shinnecock Inlet have been created to provide interim protection and prevent storm damages until FIMP is implemented. An inventory of estimated sediment volume needs by project and borrow area was developed to help facilitate regional sediment management.

The sediment volume needs for each project are based on maintaining a specific design profile over the lifetime of a project. All the estimated sediment volume needs include overfill and tolerance. Table 2 shows the estimated sediment needs for each shore protection project as well as the remaining sediment needs for active projects based on information provided by CENAN.

For each of the storm damage reduction projects, offshore borrow areas have been designated to meet the volume needs of the project. The volume available in borrow areas is estimated by determining the depth of suitable material from cores and seismic profiles. Additionally, any areas that might contain archaeological significant artifacts are excluded from the usable borrow area. In cases where archaeological investigations have not been performed, it is generally assumed that 25% of the borrow area will be unsuitable. Extensive analysis of the distribution of grain sizes within the borrow area is performed to determine the compatibility of the borrow area and the native sediment on the beach. In most cases a certain fraction of the borrow material is expected to be lost immediately following placement. This factor is called the overfill factor (Ra) and has already been included in each project's estimated volume needs. Table 3 lists the borrow areas that have been designated for the fill projects. Included in the table is the volume available, volume anticipated to be dredged during the lifetime of the fill project, and expected volume remaining at the end of the project.

Both Coney Island and Long Beach are expected to have sufficient sediment in the identified borrow areas for the lifetime of the project. However, East Rockaway, FIMP and Westhampton Interim currently have insufficient sediment volumes designated for the life of the project. The borrow areas in the vicinity of Reaches GSB-D2 and GSB-D3 in Fire Island are expected to run out of available sediment during project year 36 (USACE-NAN, 2008). Therefore, either new borrow sites will need to be identified in the vicinity of reaches GSB-D2 and GSB-D3 or the borrow areas located further away will need to be dredged at a higher cost. Borrow area 5B has sufficient sediment available to meet the demands of both the FIMP and Westhampton Interim Projects. 13-18 million cubic yards have been identified for East Rockaway. New borrow areas will need to be developed to meet the remaining 12-17 million cubic yards of the preliminary estimated fill needs for the East Rockaway Reformulation Study.

Table 2: Estimated Sediment Volume Needs by Storm Damage Reduction Project

Fill Project	Project Timeline	Estimated Initial Fill (cy)	Estimated Renourishment Fill Per Cycle (cy)	Renourishment Interval (yr)	Estimated Total Fill Quantity (cy)	Actual Initial Fill Quantity (cy)	Number of Renourishments to Date	Remaining Fill Quantity Needed (cy)[1]
Coney Island	1995-2045	2,280,000	990,000	10	6,240,000	2,317,513	0	3,960,000
East Rockaway	50 Year Project	-	-	-	30,000,000[2]	-	-	40,000,000
Long Beach	50 Year Project	6,600,00	1,726,000	5	22,134,000	-	-	22,134,000
Fire Island Inlet to Shores Westerly	1973-Indefinitely	2,470,000	1,200,000	2	-	954,080	17	-
FIMP	50 Year Project	12,430,000[4]	3,823,400[4]	4	61,000,000	-	-	61,000,000
Westhampton Interim	1997-2027	4,486,600	1,117,900[3]	3	10,413,000	3,529,530	2	7,825,300
West of Shinnecock Interim	2005-2011	600,000	400,000	3	1,400,000	764,831	0	800,000

All volume estimates include overfill. Tolerance and advanced nourishment are included where applicable.

[1] Remaining fill quantities are based on estimated initial and renourishment fill volumes.

[2] 10 million cy are needed for the extension of the Section 934 Project. The remaining 30 million cy are preliminary estimates for reformulation study.

[3] The first renourishment only requires 981,000 cy.

[4] Initial and renourishment fill estimates are adjusted to include overfill. An average overfill number of 1.13 was determined from estimated total fill volume needs for FIMP with (61,000,000 cy) and without (54,000,000) overfill included.

Table 3: Available Borrow Area Volumes

Borrow Area	Project	Subreach	Average Dredging cut Depth (ft)	Area (acres)	Percent Unusable[2]	Average Ra	Volume Available (cy)	Expected Volume to be Dredged (cy)	Est. Volume Remaining at End of Project (cy)
East Bank Shoal	Coney Island	-	-[1]	385	28	-	12,045,000[1]	6,240,000	5,805,000
A-West	East Rockaway	-	18	441	25	1.08	9,000,000	9,000,000	0
A-East	East Rockaway	-	17	459	25	1.15	8,000,000	8,000,000	0
B-West	East Rockaway	-	17.8	33	25	1.06	1,000,000	1,000,000	0
LB	Long Beach	-	18.4	1194	0	-	35,800,000	22,134,000	13,666,000
1A	FIMP	GSB-D2	10.5	90	25	1.02	1,140,000	845,000	295,000
2C	FIMP	GSB-D2	12.7	522	25	1.03	8,010,000	7,858,000	152,000
2B	FIMP	GSB-D3	5	500	25	1.05	3,020,000	3,020,000	0
2F	FIMP	GSB-D3	9.5	90	25	1.04	1,030,000	593,000	437,000
2G	FIMP	GSB-D3	4.3	90	25	1.04	470,000	338,000	132,000
2A	FIMP	GSB-D3	15	165	25	1.25	2,990,000	4,845,000	-1,855,000[4]
2D	FIMP	GSB-D3	10.1	200	25	1.28	2,440,000	2,439,000	1,000
2H	FIMP	GSB-D3	17.2	90	25	1.19	1,870,000	1,328,000	542,000
3A	FIMP	GSB-D4	7	609	25	1.06	5,150,000	5,049,000	101,000
3B	FIMP	GSB-D4	4.6	90	25	1.21	500,000	0	500,000
4A	FIMP	MB-D2	13	74	25	1.26	1,160,000	720,000	440,000
4B	FIMP	MB-D2	20	140	25	1.1	3,380,000	2,880,000	500,000
4C	FIMP	MB-D2	20	90	25	1.22	2,180,000	1,791,000	389,000
5A	FIMP	SB-D1	14.5	132	25	1.16	2,310,000	2,160,000	150,000
5B exp	FIMP	SB-D1	18	300	25	1.21	6,530,000	0	6,530,000
5B	FIMP	SB-D1	13	610	25	1.2	9,580,000	5,738,000	3,842,000
5C	FIMP	SB-D1	15	43	25	1.17	780,000	0	780,000
6B	FIMP	SB-D2	17.8	23	25	1.19	490,000	0	490,000
6C	FIMP	SB-D3	9.9	110	25	1.18	1,320,000	0	1,320,000
6A	FIMP	P-D1	15	74	25	1.22	1,340,000	0	1,340,000

Borrow Area	Project	Subreach	Average Dredging cut Depth (ft)	Area (acres)	Percent Unusable[2]	Average Ra	Volume Available (cy)	Expected Volume to be Dredged (cy)	Est. Volume Remaining at End of Project (cy)
6E	FIMP	P-D1	10	90	25	1.05	1,090,000	0	1,090,000
6F	FIMP	P-D1	9	90	25	1.16	980,000	0	980,000
6G	FIMP	P-D1	10	90	25	1.25	1,090,000	806,000	284,000
6H	FIMP	P-D1	10	90	25	1.1	1,090,000	806,000	284,000
6I	FIMP	P-D1	15	90	25	1.17	1,630,000	1,383,000	247,000
7A	FIMP	P-D1	8	90	25	1.16	870,000	1,209,000	-339,000[4]
7B	FIMP	P-D1	12	90	25	1.09	1,310,000	1,209,000	101,000
7C		P-D1	11	90	25	1.23	1,200,000	403,000	797,000
7D	FIMP	P-D1	5	90	25	1.19	540,000	0	540,000
7E	FIMP	P-D1	15	90	25	1.1	1,630,000	0	1,630,000
8A	FIMP	M-D1	15	184	25	1.23	3,340,000	3,180,000	160,000
8B	FIMP	M-D1	11	90	25	1.06	1,200,000	0	1,200,000
8C	FIMP	M-D1	8	90	25	1.09	870,000	636,000	234,000
8D	FIMP	M-D1	13.3	90	25	1.13	1,450,000	1,291,000	159,000
Westhampton Western	Westhampton Interim	-	-	160	-[3]	1.07	4,200,000[3]	4,200,000	0
Westhampton Eastern	Westhampton Interim	-	-	100	-[3]	1.05	3,400,000[3]	3,400,000	0
Shinnecock	West of Shinnecock Interim	-	-	62	-	-	-	-	-

[1] *Volume available estimates were completed using -35 ft MLW as the limiting dredging depth*

[2] *For FIMP and East Rockaway it was assumed that 25% of the borrow area material will be unusable based on past experience*

[3] *The available volume avoids all cultural anomalies identified by remote sensing*

[4] *A Negative quantity remaining in a borrow area volumes indicate that the current borrow are usage plan for FIMP is dredging more sediment than has been estimated to be available.*

6.1 Plan to Monitor & Manage Offshore Borrow Areas

One objective of the Long Island Coastal Planning Project (RSM) is to develop a borrow area monitoring plan that facilitates efficient management of Long Island's offshore sediment sources while identifying the effect that mining these resources has on coastal processes. USACE typically conducts a detailed evaluation of potential shoreline and littoral transport impacts of borrow area excavation as part of their borrow area evaluations during the feasibility assessment phase of a project. The evaluation usually includes detailed numerical modeling efforts using a nearshore wave transformation model (e.g., STWAVE) and the shoreline change modeling (e.g., GENESIS). Potential biological and cultural resource impacts are also evaluated and accounted for in the selection and delineation of borrow areas.

During the construction phase of the project, USACE also implements a detailed monitoring plan which typically includes the following components:

- Sediment removal and infilling rates are documented by pre- and post- dredge hydrographic surveys of the borrow area. A nearby, similar area outside the designated borrow area is included in the survey to serve as a control (i.e. to document naturally occurring bottom changes).
- Survey computations are done to verify the quantity and the location of material removed during each nourishment or re-nourishment operations.
- Midway through the life of any nourishment project, a hydrographic survey is repeated to determine the pattern and depth of material accumulation.
- Vibracores are taken and subbottom seismic profiling is performed to obtain sediment layering and grain size distribution curves in the infilled areas. Vibracore data analysis includes a representative number of material samples taken from each core, determined by an experienced geologist, that are used to characterize each core and subarea within the borrow region. All lab analyses and operations are standardized to obtain consistent descriptions of sediment type and grain size distribution.
- All surveys are mapped to indicate spatial changes in the borrow area both horizontally and vertically.
- Suitability of sediment as beach fill material is determined from the cores. Areas previously dredged are typically examined for possible reuse in the future based on material suitability and quantities available.

The aforesaid studies are all recommended as part of any future projects that include offshore dredging. In addition, the USGS has recently proposed the following potential additions to the impact assessment and subsequent monitoring activities for borrow sites offshore Fire Island. These studies focus primarily on the effects that dredging has on onshore sediment transport from offshore (i.e., from beyond depth of closure) sediment sources:

- **Numerical Modeling.** Development of a three-dimensional coupled wave-oceanographic-sediment numerical model. The model could be used to predict wind driven waves, regional ocean circulation patterns, nearshore surf-zone wave driven currents, and the resulting sediment transport due to bedload and suspended load processes. Modeling scenarios would focus on two aspects: 1) understanding the existing wind and wave driven circulation and sediment transport of the region and 2) addressing the impact of dredge removal of offshore sedimentary deposits on the circulation and sediment transport at the dredge site and in the nearshore and surfzone.

- **Offshore High-Resolution Bathymetric Surveys.** Measurements of offshore bathymetry are required to accurately determine the change in seafloor elevation due to the dredging activities. These surveys will be conducted using interferometric sonar, capable of providing wide swaths of high-resolution bathymetric measurements of the dredge site locations and adjacent seafloor up to a distance of 1 km from the edge of the dredge site. Both pre- and post- dredging surveys are necessary in order to estimate the volume of material removed. The surveys would also provide baseline data for numerical modeling, which could be used to assess the impacts of bathymetric change on circulation, wave transformation, and sediment transport. Subsequent surveys of the area as part of a periodic monitoring program would provide additional information, which could be used to assess the rate of dredge area re-filling.

- **Nearshore Bathymetry and Side-scan Sonar Surveys.** This data collection will provide first-of-its kind data on the nearshore bathymetry (0 – 10m water depth). Repeat surveys in the nearshore will provide the necessary data to begin to address the issues of onshore/offshore transport of sand. The data collection effort will complement ongoing studies of mapping changes within the subaerial beach system (see following bullet point). The data derived from these analyses can be combined to provide a seamless topographic/bathymetric surface. These data, in turn, can be combined with bathymetric data collected farther offshore to provide the necessary foundation for modeling the hydrodynamics of storm waves. This will help to provide information on how the removal of material from proposed borrow sites may affect wave patterns, and ultimately impact the evolution of the subaerial beach system. The nearshore surveys will utilize both a single-beam fathometer to capture high resolution in the very nearshore (bar and inner bar); multibeam and side-scan sonar will be used to map the nearshore region from the nearshore bar to approximately 1 km offshore (approximately 10-12 m water depth).

- **Field Measurements.** Field measurements of waves, currents, and sediment transport processes provide practical quantification of the local conditions and insight into the mechanisms controlling local processes. These observational data are also necessary to validate numerical models of the local and regional environment. Field measurements will focus on collection of wave, current, bottom stress, bed form, and suspended-sediment concentration observations in the nearshore and surf zone regions, with some additional collection of offshore forcing data (e.g. wave heights, water levels, and wind). Each targeted data collection effort would consist of frame-mounted equipment deployed for several months in the offshore region and several weeks in the nearshore.

The studies proposed by USGS would contribute to the existing state of knowledge regarding inner shelf sediment transport processes and the potential impacts associated with borrow site excavation. Some of them overlap and extend studies typically conducted by USACE and listed previously (e.g., offshore bathymetric surveys and borrow site sediment measurements). Others, especially the modeling and nearshore bathymetry collection, significantly expand the typical scope of a USACE study. The modeling in particular is very ambitious in scope, relatively costly, mostly unprecedented, and potentially useful only in the vicinity of Fire Island. The proposed field measurements, most of which would only be required in support of the modeling, would also be costly. Therefore, it is recommended that the real value as engineering and impact assessment tools of these studies be first tested in a limited scope application to a specific site offshore Fire Island before incorporating them into a larger Management and Monitoring Plan for the Atlantic Coast of Long Island.

7. SUMMARY

An initial step towards implementing RSM was taken in this study by creating an inventory of existing sediment budgets and borrow areas for the south shore of Long Island. The inventory is based on work already completed as part of the Fire Island to Montauk Point (FIMP) study and published reports from Federal, New York State, county, and various local township projects. Summaries of existing sediment budgets were developed identifying the data sources used (e.g. aerial photography, beach profiles, etc.), assumptions made, methodologies used, time period of budget, uncertainties, and results. Longshore sediment transport rates at distinct locations along the coastline were extracted from the inventory and compared, providing a qualitative estimate of the uncertainty in the sediment budgets. In addition opportunities to improve the existing sediment budgets by utilizing advances in technology/numerical modeling were identified.

Existing and previously dredged borrow areas were catalogued in a geospatial database along with all relevant information pertaining to the borrow area (e.g. mean grain size, volume available, etc.). In addition, the location and characteristics of all core samples taken in past projects were included in the geospatial database. The database was used to develop a borrow area management plan which identifies the estimated sediment needs and sediment availability for each borrow area as well as each proposed project. Additionally, important aspects of a borrow area monitoring plan were outlined.

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APPENDIX A

BORROW AREA INVENTORY

A.1. INTRODUCTION

An inventory of existing and previously dredged sediment borrow areas has been developed for the Atlantic Coast of Long Island. The inventory is based on information provided by USACE-NAN and includes borrow areas identified as part of completed or ongoing federal projects and studies. Each borrow area has been spatially referenced in a GIS database and any relevant information pertaining to the borrow area (i.e. mean grain size, volume available, etc.) has been included in the database. In addition the location and characteristics of core samples taken in previous studies to identify suitable borrow areas has been included in the database. The database provides a comprehensive inventory of existing borrow areas and core samples along Long Island in GIS format (shapefiles) for easy distribution and transfer.

Delineations for the borrow areas were obtained from previous work done by URS in 2000, from historic reports provided by USACE-NAN, and by direct correspondence with USACE-NAN. Currently the GIS database contains borrow areas that may have been dredged multiple times and may no longer contain usable sediment as well as active borrow areas that have been designated for future beach fill projects. In addition the database contains 353 cores obtained through a combination of digital files and historic reports provided by USACE-NAN. Important characteristic pertaining to the cores (i.e. mean grain size, date of core sampling, etc.), core logs, and grain size distributions were obtained and scanned from old reports so that they could be included in the database. Grain size distribution curves and core logs have been electronically linked to the GIS database and can be quickly viewed while in the ARCGIS environment.

Each borrow area and core sample has been referenced to the report from which borrow area or core characteristics were obtained. While the geographic location of most of the core samples was provided from records kept by the contractor(s), the geographic location for one set of the core samples and borrow areas, from Alpine Geophysical Associates, Inc., 1974, was obtained by ortho-rectifying a map showing the location of the core samples and borrow areas. The geographic accuracy of these core samples and borrow areas is limited by the ortho-rectifying procedure which can result in errors on the order of tens of meters. The characteristics of core samples were obtained by manually copying values from reports. The values in the new database of have been spot checked for accuracy.

A.2. CONTENTS OF DATABASE

The structure of the GIS database is based on two shapefiles, Vcores.shp and BorrowAreas.shp, which contain the geographic location and delineation of each core and borrow area. These two shapefiles are linked to project websites (e.g. http://www.nan.usace.army.mil/fimp/index.htm), PDF files of grain size distributions and core logs, and an excel file containing dredging history for each borrow area. The two shapefiles, Vcores.shp and BorrowAreas.shp, are setup as a table. Definitions of the parameters contained in the shapefiles for borrow areas and core samples are shown in Table 1 and Table 2.

Grain size distribution curves and core logs are linked to their respective core samples, where such information was available. An example of a linked grain size distribution curve and core log is shown in Figure 2-1 and Figure 2-2. In addition the framework for relating dredging events to borrow areas has been setup. Currently the dredging history file is just a template because historical dredging information has not been provided. The historical dredging template is shown in Table 3.

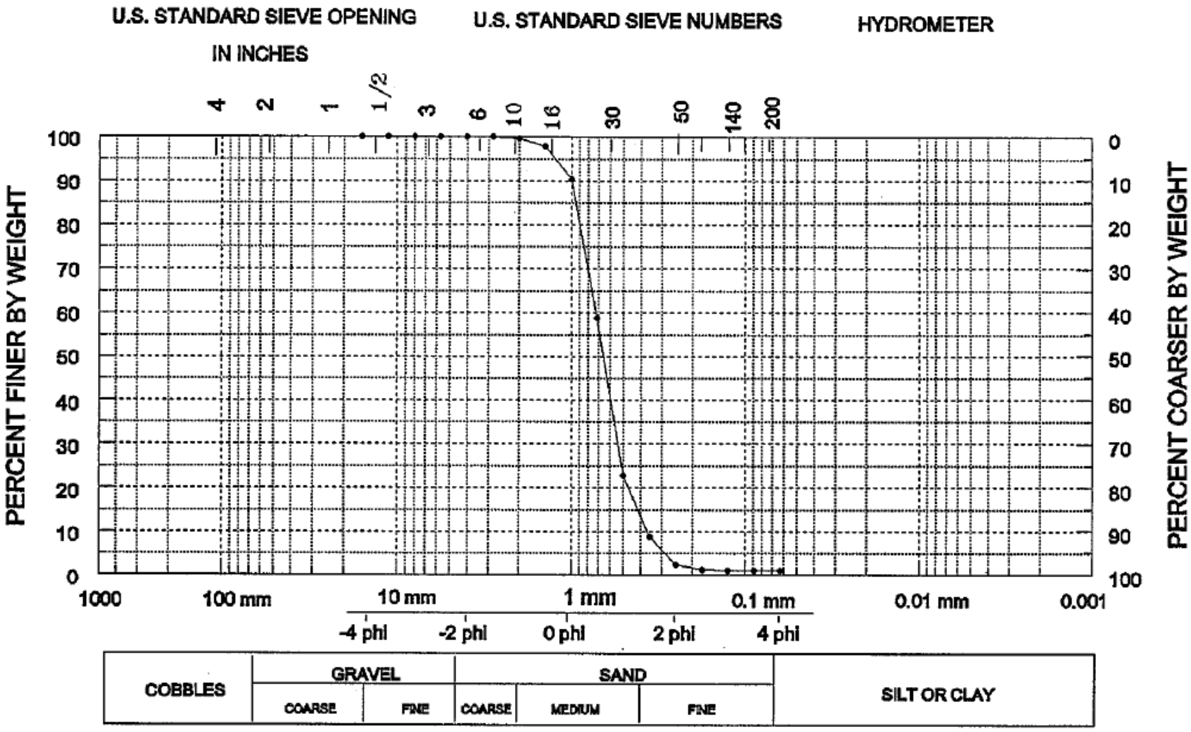
Table 1: Borrow Area Characteristics in BorrowAreas.shp

Characteristic	Definition
BA_Name	Name of borrow area as given in referenced report.
Ra	Overfill factor, Ra. This factor predicts the amount of over dredge required due to dredging processes and natural sorting.
Volume	Estimated volume of suitable sediment in the borrow area (CY).
Dredging	Average dredging depth below grade (ft).
Env_Stat	Environmental suitability of the borrow site (yes, no, or NA)
Project	Name of project with which Borrow Area delineations were defined.
Place_Area	Placement area of the borrow area material.
Area	Approximate area of borrow area (acres).
Status	Classification of the borrow site based on whether it is believed to be the most recent borrow area defined for its vicinity (Current or Old).
Link	Web link to project website
LabelC	Text Label placed on map.
Ref	Referenced to document in which borrow area characteristics were obtained. (May contain more than one reference).

Table 2: Core Sample Characteristics in Vcores.shp

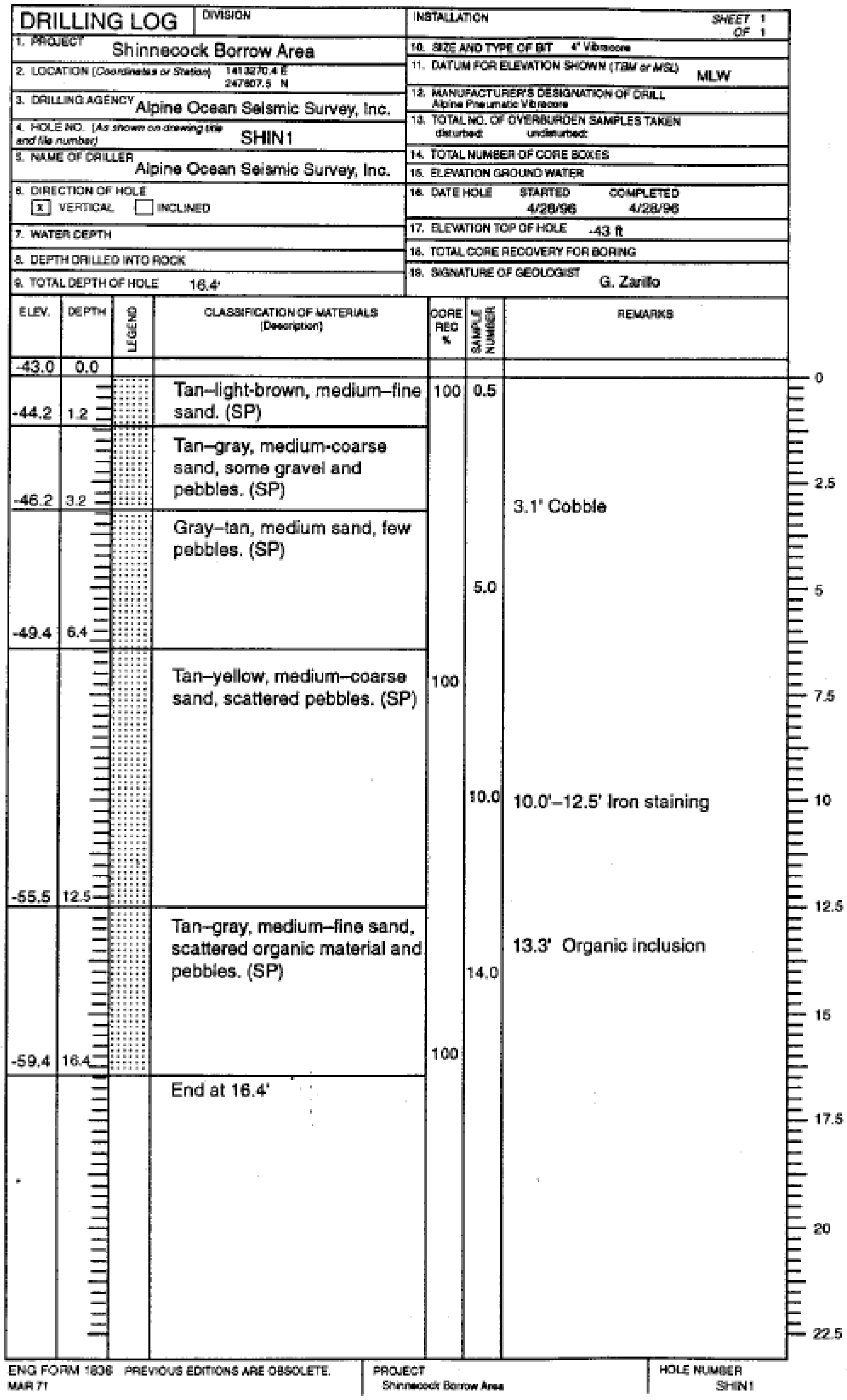
Characteristic	Definition
Core_ID	Name of core sample as given in reference report.
Easting	Easting values in NAD 1983 StatePlane New York Long Island FIPS 3104 Feet.
Northing	Northing values in NAD 1983 StatePlane New York Long Island FIPS 3104 Feet.
M_mm	Mean grain size (mm).
med_mm	Median grain size (mm).
Length	Length of core sample (ft).
phi_16	16 percent coarser (phi units).
phi_84	84 percent coarser (phi units).
phi_50	50 percent coarser (phi units), same as median.
Mphi	Mean grain size (phi units).

SDphi	Standard deviation of sand sizes (phi units).
BM_Loc	Beach placement location.
BM_Mphi	Mean grain size (phi units) of beach placement location.
BM_SDphi	Standard deviation (phi units) of sand at beach placement location.
Ra	Overfill factor, Ra. This factor predicts the amount of over dredge required due to dredging processes and natural sorting.
Rj	Renourishment ratio, Rj. This factor measures the stability of placed sediment relative to the native sand at the beach placement location.
Project	Name of project with which core characteristics were defined.
YR_Core	Year core sample was taken. This date is often provided in Core Logs.
Core_Log	PDF file name of core log. This provides the electronic linkage between the PDF file and the shape file.
GSD_Curve	PDF file name of grain size distribution curve. This provides the electronic linkage between the PDF file and the shape file.
BA_1	Name of enclosed borrow area (BA_Name). If the core sample is enclose within multiple borrow areas then BA_2 and BA_3 are used.
BA_2	Name of enclosed borrow area (BA_Name).
BA_3	Name of enclosed borrow area (BA_Name).
Ref	Document reference in which borrow area characteristics were obtained. (May contain more than one reference).



SAMPLE NO.	ELEV.	CLASSIFICATION	PROJECT Storm Damage Protection
SHIN16-5.0		medium sand (SP)	AREA Shinnecock, NY
			BORING NO. SHIN 16
			DATE June 15, 1996

Figure 2-1: Sample Grain Size Distribution Curve (Alpine Ocean Seismic Survey, Inc., 1996).



DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1
1. PROJECT	Shinnecock Borrow Area	10. SIZE AND TYPE OF BIT	4" Vibracore
2. LOCATION (Coordinates or Station)	1413270.4 E 247807.5 N	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MLW
3. DRILLING AGENCY	Alpine Ocean Seismic Survey, Inc.	12. MANUFACTURER'S DESIGNATION OF DRILL	Alpine Pneumatic Vibracore
4. HOLE NO. (As shown on drawing title and file number)	SHIN1	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	disturbed: undisturbed:
5. NAME OF DRILLER	Alpine Ocean Seismic Survey, Inc.	14. TOTAL NUMBER OF CORE BOXES	
6. DIRECTION OF HOLE	[x] VERTICAL [ ] INCLINED	15. ELEVATION GROUND WATER	
7. WATER DEPTH		16. DATE HOLE	STARTED 4/28/96 COMPLETED 4/28/96
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE	-43 ft
9. TOTAL DEPTH OF HOLE	16.4'	18. TOTAL CORE RECOVERY FOR BORING	
		19. SIGNATURE OF GEOLOGIST	G. Zarillo

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS
-43.0	0.0					
-44.2	1.2		Tan–light-brown, medium–fine sand. (SP)	100	0.5	
-46.2	3.2		Tan–gray, medium-coarse sand, some gravel and pebbles. (SP)			3.1' Cobble
-49.4	6.4		Gray–tan, medium sand, few pebbles. (SP)		5.0	
-55.5	12.5		Tan–yellow, medium–coarse sand, scattered pebbles. (SP)	100	10.0	10.0'–12.5' Iron staining
-59.4	16.4		Tan–gray, medium–fine sand, scattered organic material and pebbles. (SP)	100	14.0	13.3' Organic inclusion
			End at 16.4'			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT Shinnecock Borrow Area | HOLE NUMBER SHIN1

Figure 2-2: Sample core log (Alpine Ocean Seismic Survey, Inc., 1996).

Table 3: Historical Dredging Template

Characteristic	Definition
BA_Name	Name of borrow area as defined in BorrowAreas.shp
Who_Drg	Contracted company responsible for dredging
Year	Year dredging was completed
Cut_V	Actual volume dredged from borrow area (CY)
Fill_V	Desired fill volume at beach placement sites (CY)
Area	Area dredged (CY)
M_mm	Mean grain size (mm) of dredged material
Mob_Dem	Mobilization and de-mobilization cost ($)
$/cy	Cost per CY of cut volume ($)
Total_$	Total cost of dredging ($)

A.3. VIEWING BORROW AREA AND CORE CHARACTERISTICS

The project websites, PDF files, and dredging information, can all be easily viewed from within ArcMap. This section provides some simple steps required to view all of the linked files and documents.

Core logs and grain size distributions can be viewed within ArcMap by following the steps provided below:

1. Click the “Properties” option on the drop down menu for the shape file (Figure 3-1a.
2. Click “Display” tab and check the box next to “Support Hyperlinks using field” and scroll down to either Core_Log or GSD_Curve (Figure 3-1b).
3. Once the hyperlinks have been turned on, select the lightening icon on the toolbar which allows the user to click on a core to view its core log (Figure 3-2b). Any core that has been linked to electronic PDF will turn blue (Figure 3-2a) as soon as the lightning bolt icon is selected.

Historical dredging files, project websites, as well as the core logs and GSD curves can be viewed in ArcView using the identifier tool. The following steps provide an example of how to use the identifier tool:

1. Click on the blue and white identifier icon (white i embedded in blue circle as pointed to with arrow in Figure 3-3a). This activates the identifier tool.
2. After the identifier tool has been activated click on any core location to bring up the core characteristics (Figure 3-3b). At this point the GSD curve and core log can be viewed by clicking on the PDF file name (next to the yellow lightning bolt).
3. If a borrow area is selected with the identifier than the borrow area characteristics are shown (Figure 3-3c). Inside the table is the project link which allows the project website to be opened. If a historical dredging record exists for the borrow area it will show up on the tree chart on the left

panel of the identifier window. If the dredging history tab is selected the historical dredging information will be shown in the right panel of the identifier window (Figure 3-3Figure 3-1d).

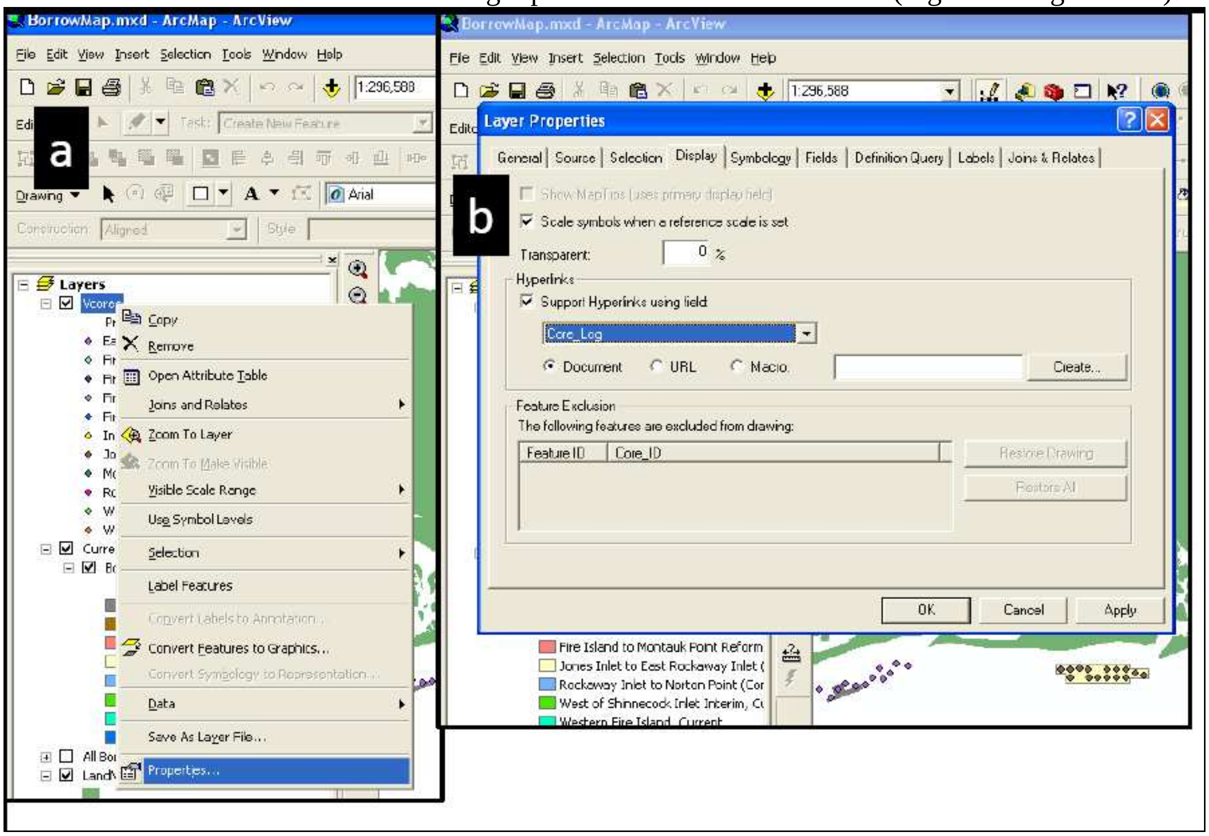


Figure 3-1 Demo - Viewing core logs and grain size distribution curves in ArcMap

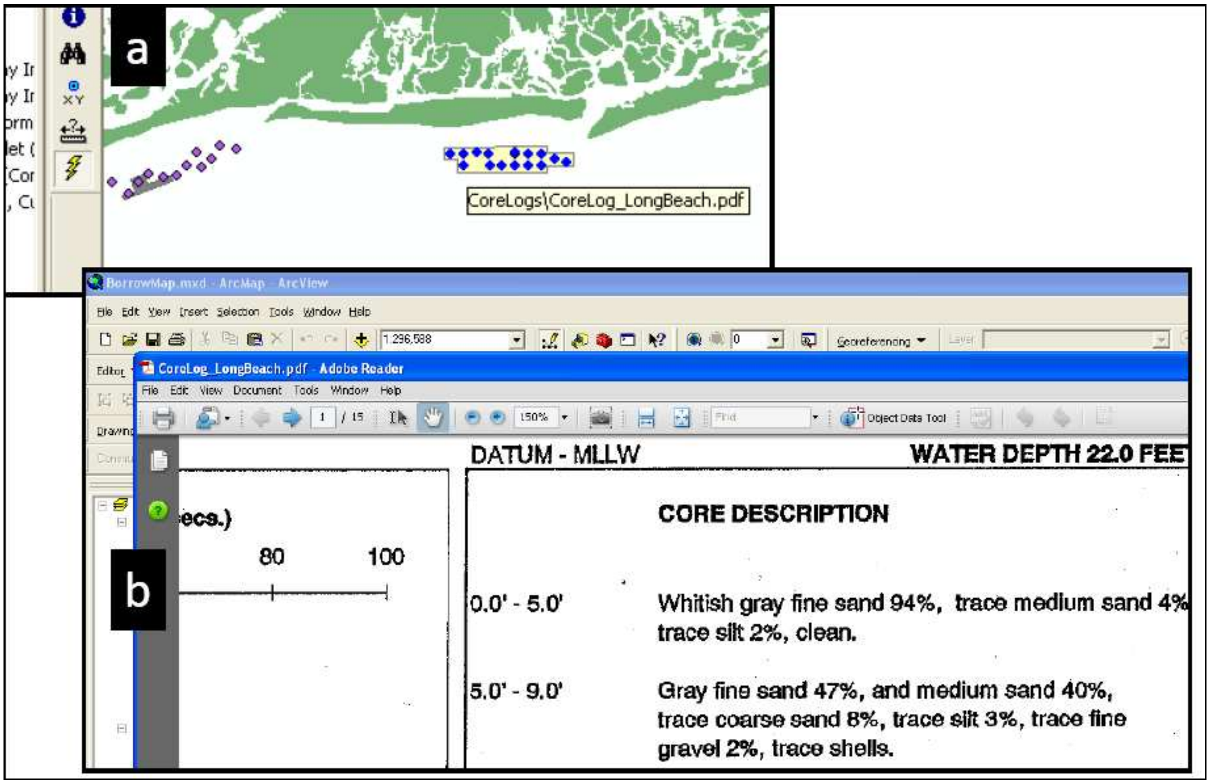


Figure 3-2 Demo - Viewing core logs and grain size distribution curves in ArcMap

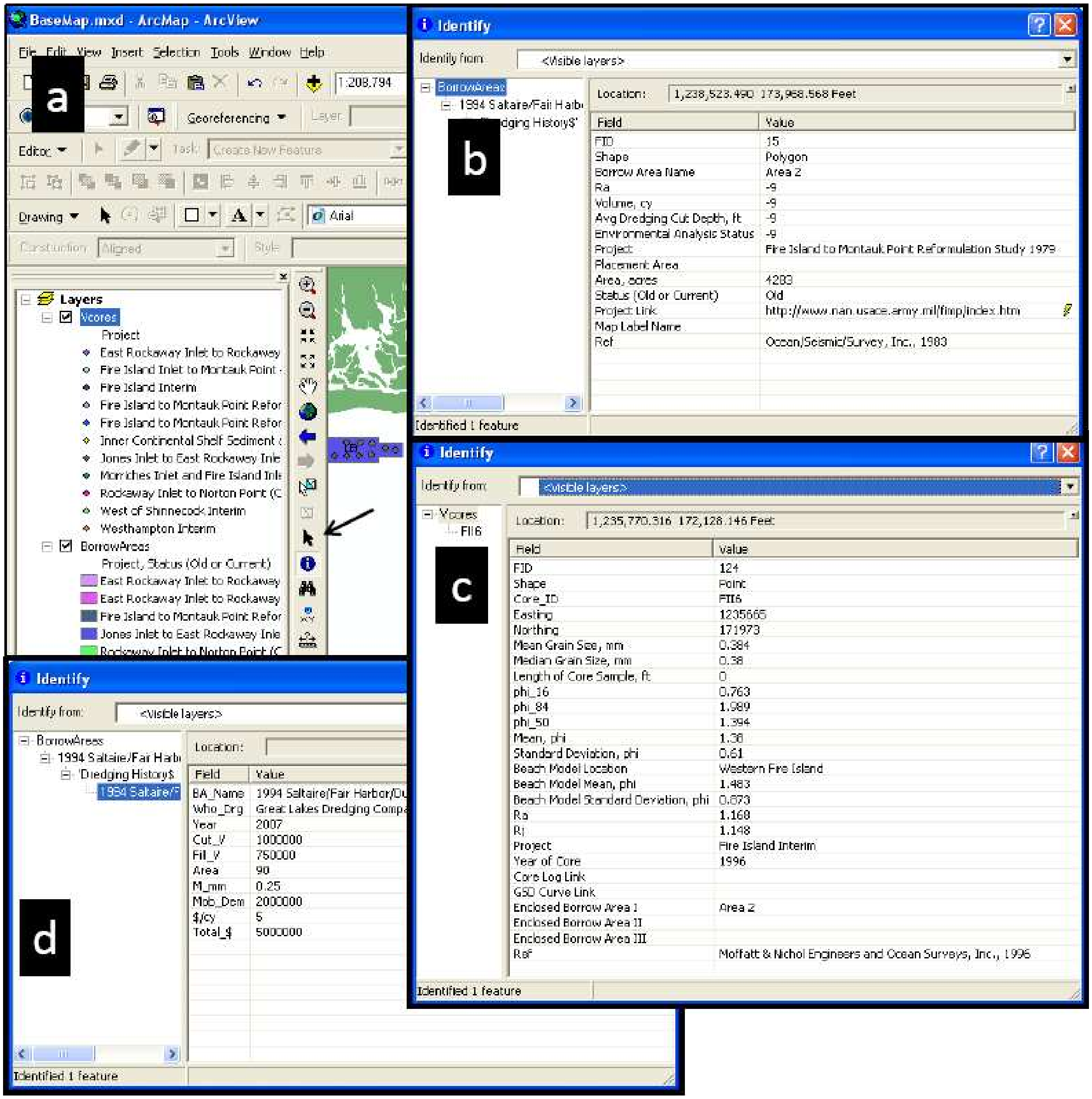


Figure 3-3: Demo - Viewing historical dredging files, project websites, as well as the core logs and GSD curves using Identifier in ArcView

A.4. FUTURE IMPROVEMENT OPPORTUNITIES AND UPDATES

The GIS database completes a critical first step in inventorying borrow areas, core samples, and dredging history along Long Island. The database will be an essential tool in regional sediment management and allows efficient distribution of borrow area information. The GIS database will need to be continually updated with new borrow area delineations and core samples to remain a helpful tool for coastal planners. The database is flexible enough and can be expanded to include environmental records for the borrow areas. It is recommended that a complete set of GSD curves and core samples be added and linked to the database. In addition, the database would benefit greatly from inclusion of historical dredging records at borrow sites. However, that was beyond the scope of this initial inventory effort.

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APPENDIX B

BORROW AREA PLATES

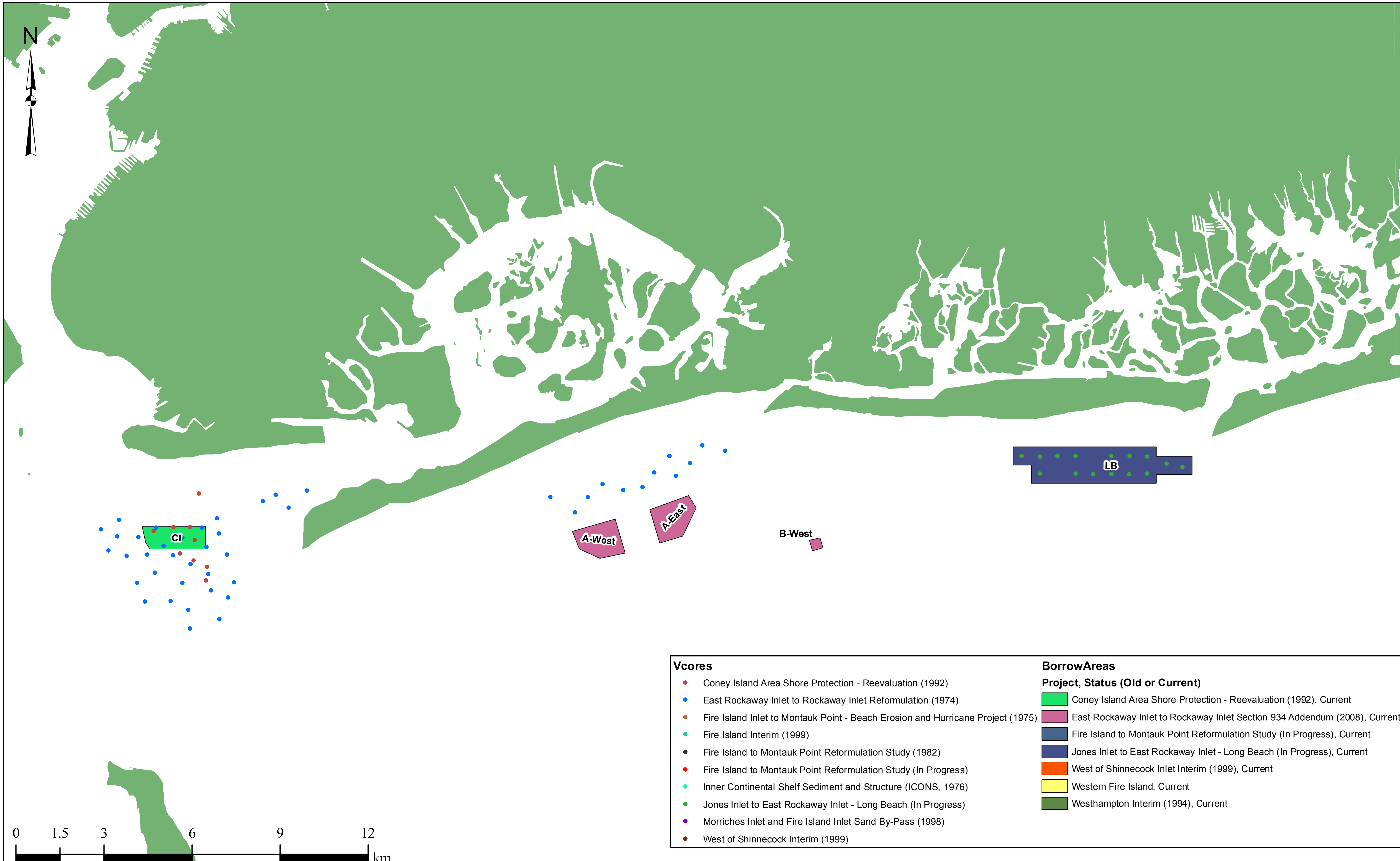

Figure B-1: Active Borrow Sites for Coney Island, Rockaway, and Long Beach

Figure B-2: Active Borrow Sites for Jones Beach

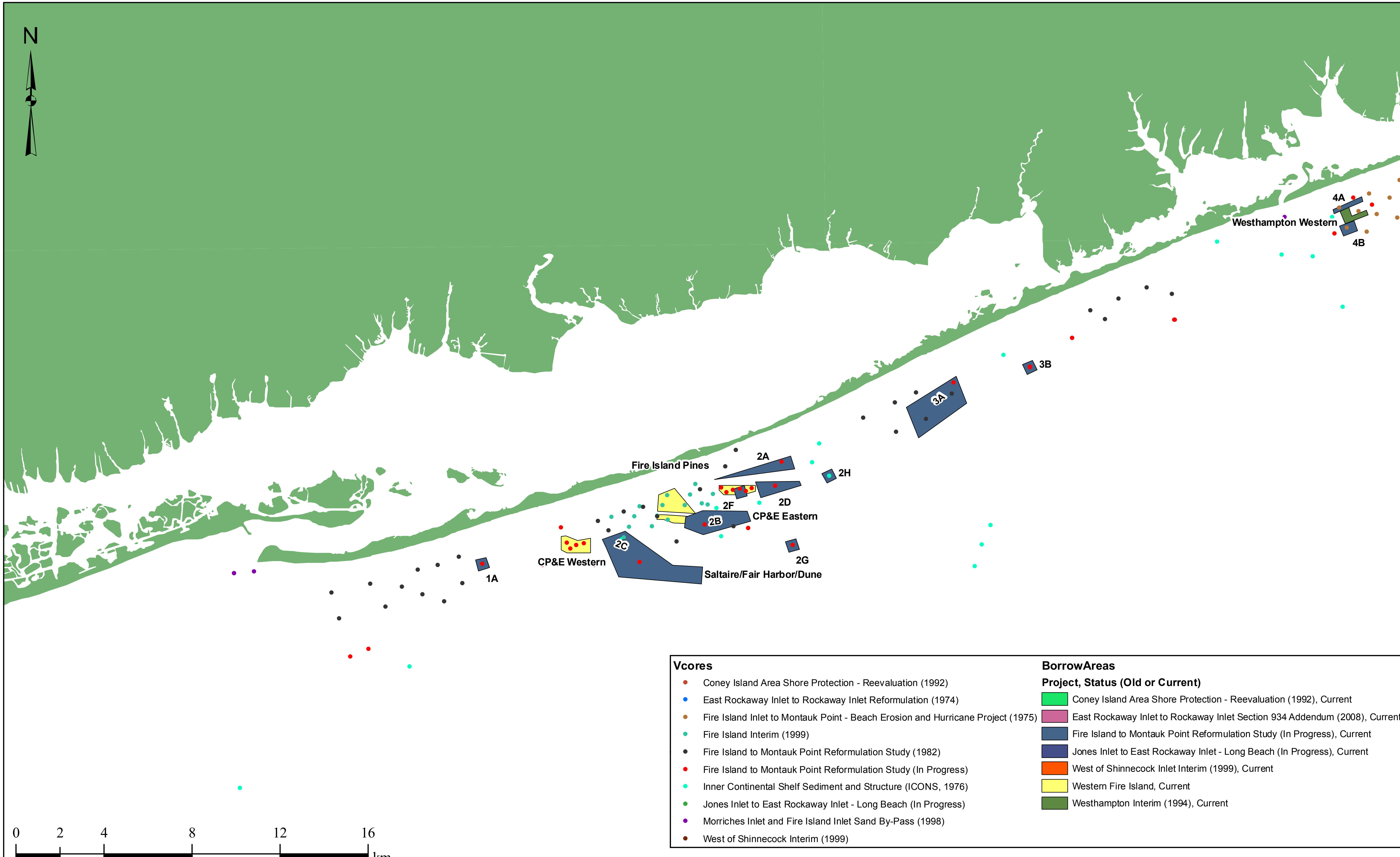

Figure B-3: Active Borrow Sites for Fire Island

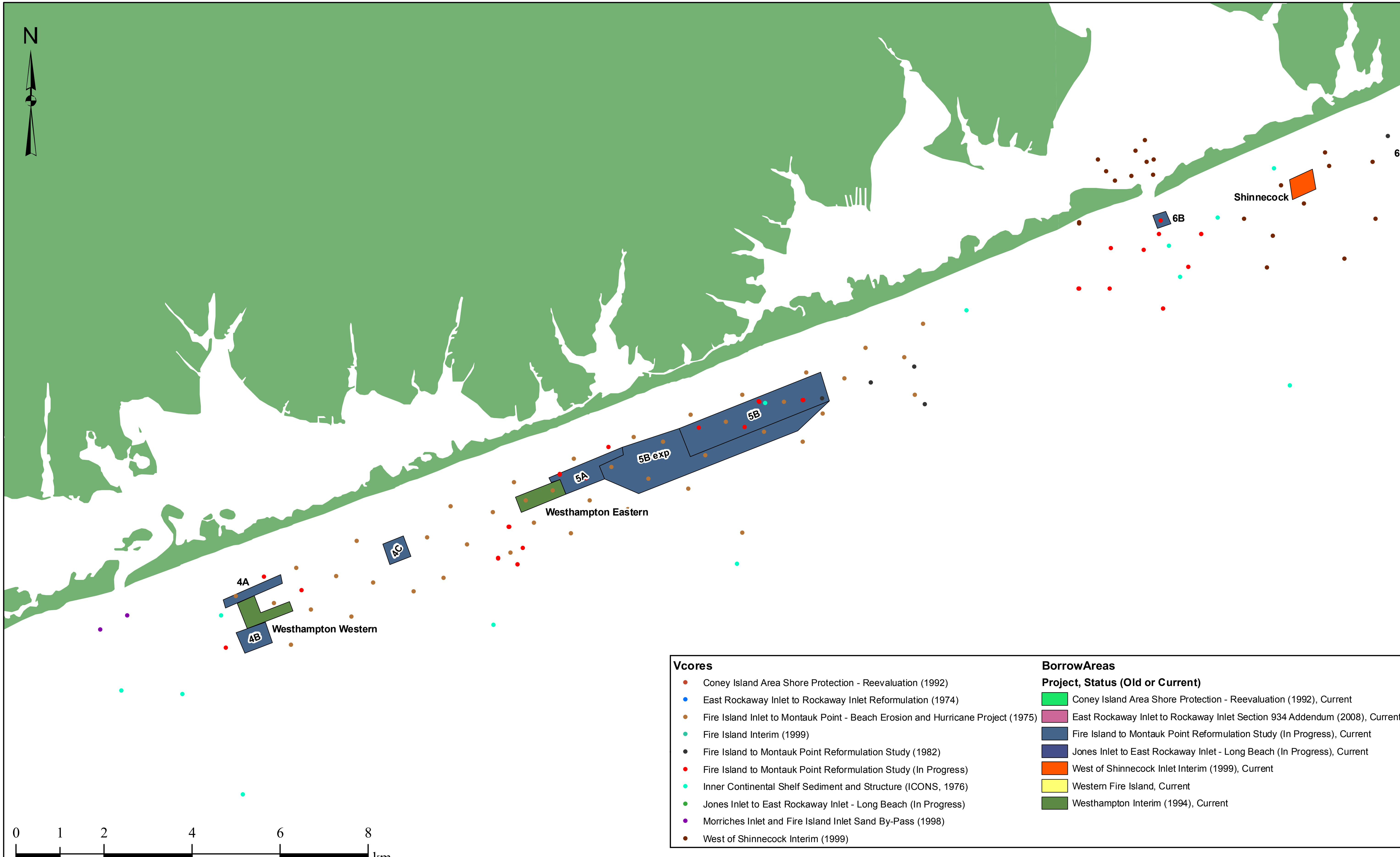

Figure B-4: Active Borrow Sites for Westhampton

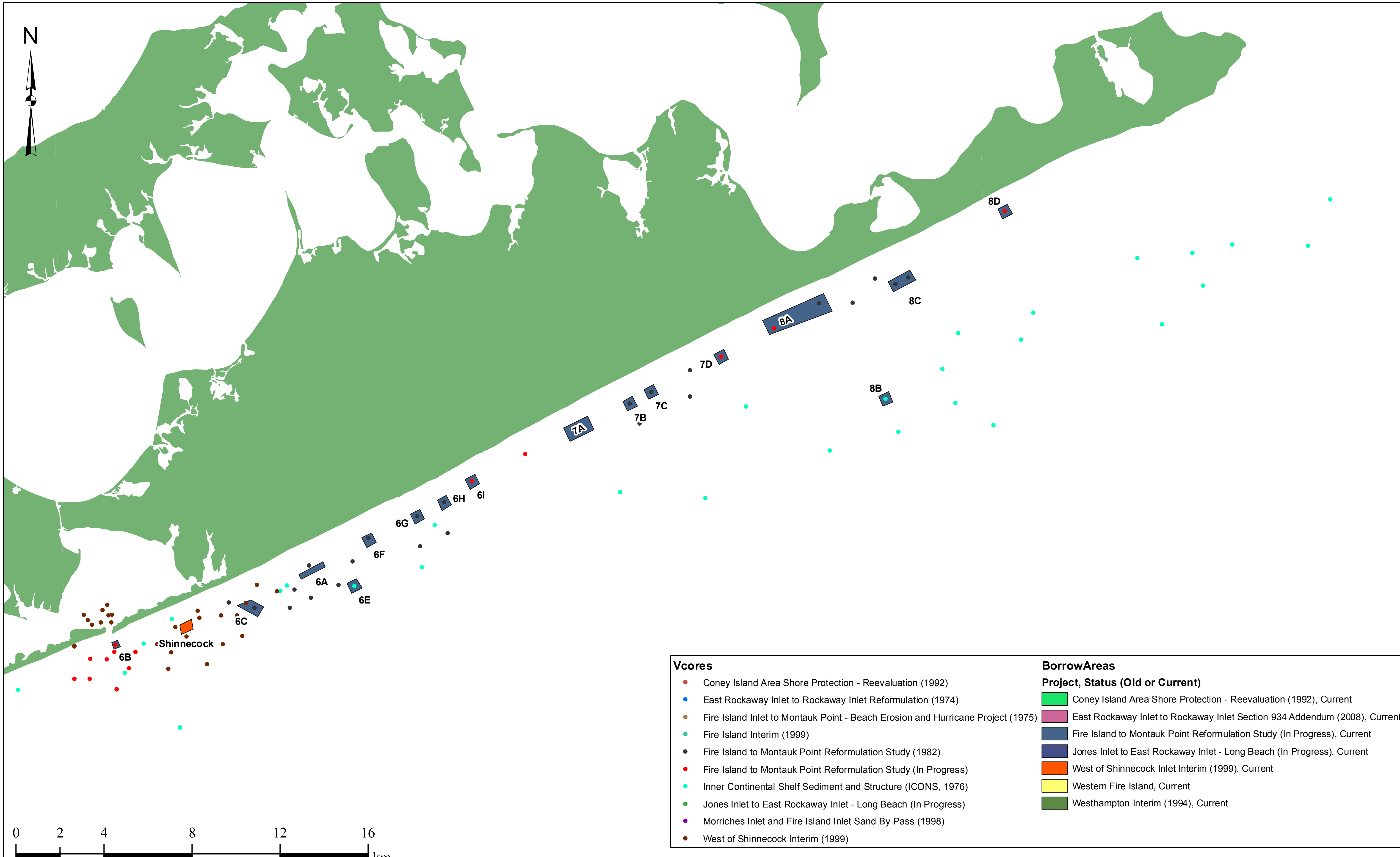

Figure B-5: Active Borrow Sites for Montauk