APPENDIX B

BORROW SOURCE INVESTIGATIONS

East Rockaway Inlet to Rockaway Inlet, NY, Reformulation Study

1. Objective. The East Rockaway Inlet to Rockaway Inlet and Jamaica Bay, NY, Reformulation Study is being performed to re-evaluate hurricane and storm damage reduction works along the Atlantic Coast of New York City between East Rockaway Inlet and Rockaway Inlet. The objective of the borrow investigations described herein was to identify suitable borrow sediment in sufficient volume for any beach fill alternatives identified in the study, and to collect data for this purpose. Preliminary life time fill volume estimates for reformulation beach fill alternatives is approximately 30,000,000 cy over a 50-year project life. More immediate needs have arisen for three more renourishments of the Section 934 Project, subtotaling approximately 10,000,000 cy, thereby the total of material to be identified by this investigation is 40,000,000 cy.

2. Location. The study area is located on the Rockaway Peninsula, along the Atlantic Coast of New York City, between east Rockaway Inlet and Rockaway Inlet, and includes the Atlantic Ocean shoreline as well as lands within and surrounding Jamaica Bay (see Figure B-1). The sand source investigation included all upland sources as well as bay, channel, and offshore sources within economically feasible access of the project.

3. Geologic Setting. The study area includes several bodies of water, consisting of the Hudson River, New York Harbor, Lower New York Harbor, Raritan Bay, the Raritan River, Hempstead Bay inside of Jones Inlet, and the area offshore of the Lower New York Harbor, between Sandy Hook, NJ and western Long Island, NY. The generalized geologic histories of these areas are similar, and are described summarily below.

4. Bedrock and Coastal Plain Sediments. Bedrock is present on the land surface of Staten Island and Brooklyn, with outcrops being present at both ends of the Verrazano Narrows Bridge. The bedrock surface slopes rapidly to the south and east from this area, including a deeply incised valley between Staten Island and Brooklyn. Depth to bedrock under Sandy Hook is estimated to be approximately 1,200 feet, while the depth to bedrock under Rockaway on the western Long Island coast is estimated to be 1,100 feet. The sediments directly above bedrock over the study area comprise the Coastal plain units, varying in age from Cretaceous (130 to 65 million years Before Present (BP) at the base of the sequence, up through Pleistocene (2 million years to 10,000 years BP). The Coastal Plain sediments are primarily silts and clays with inter-bedded sandier units.

5. Pleistocene Sediments. During the latest low stand of the sea level, occurring during the Pleistocene Period and ending approximately 10,000 tears BO, the sea level offshore of the work areas was lowered to approximately 300 feet below the present level. During that time, the glaciers advanced to a line across the center of Staten Island extending along the north side of Long Island. Deposits of dense glacial till are present on land in these areas. The melt waters of the glaciers carried a wide variety of very poorly sorted sands and gravels to the south and east, down the exposed Hudson River channel. During the period between 10,000 and 3,000 years BP, the glaciers melted back to the north and the large volumes of melt waters generated by this melt back carved an erosional canyon down the Hudson River and offshore. A similar effect occurred on the

Raritan River, eroding a channel within the general area of the Raritan River Estuary Basin, including Raritan Bay, joining the Hudson River valley just offshore of Sandy Hook. The Raritan Channel, which eroded approximately 170 feet below sea level into the Raritan Formation, has been since filled with sand, gravel, and silt (Williams and Duane, 1974).

6. Holocene and Recent Sediments. Above the Pleistocene sediments are the Holocene and recent sediments, which include both organic silts and fine to coarse sands. The inshore sediments within the study area are generally finer grained, while the offshore sediments are primarily sands and gravels. As the sea level rose to approximately the present level, normal coastal processes influenced the distribution of sediments across the continental shelf, up to and including New York Harbor. The river valleys were initially filled with sand from the glaciers. Then the deposition of organic silts and clays in a lagoonal environment took over, filling in the remainder of the valleys with thick sequences of soft sediments. Along the western shore of Long Island, the rise in sea level has caused the gradual retreat of the barrier island sequence. The sediments likely to be present in the marshes and channels of Hempstead and Jamaica Bays are similar in distribution to those which were present offshore of these areas during the lower stand of sea level. The channels were eroded slightly into the underlying Pleistocene outwash sediments, while the thick sequences of organic silts and clays typical of the areas between the channels are built up above the former outwash land surface. As the sea level rose, the barrier island beach face migrated to the north, with the erosion of the sediments above the former land surface, and the burial and subsequent preservation offshore of the former bay channels.

7. Methodology. The objective of the borrow area investigation was to identify and delineate sources of sand borrow material for use as design fill and nourishment material for this project. Beachfill sediments were sought which were of suitable grain size and distribution, and present in sufficient volume, within a reasonable distance from the project shoreline. Grain size distributions and available volumes of the potential borrow sources were obtained from samples collected at the upland stockpile and offshore vibracore samples collected for this study. The grain sizes were compared with typical native beach sand size distribution taken from the project site to determine the compatibility of the borrow material. Those suitable borrow sources were checked to determine if volume at the borrow site would be sufficient for the beachfill project.

8. Previous Offshore Work and Reports Related to the Study Area. The region of the New York Bight and the southern part of Lower New York Harbor and the inlets and channels surrounding the Rockaway Peninsula constitute the study area (see Figure B-1). The locations of previous sediment sampling and geophysical work are described below.

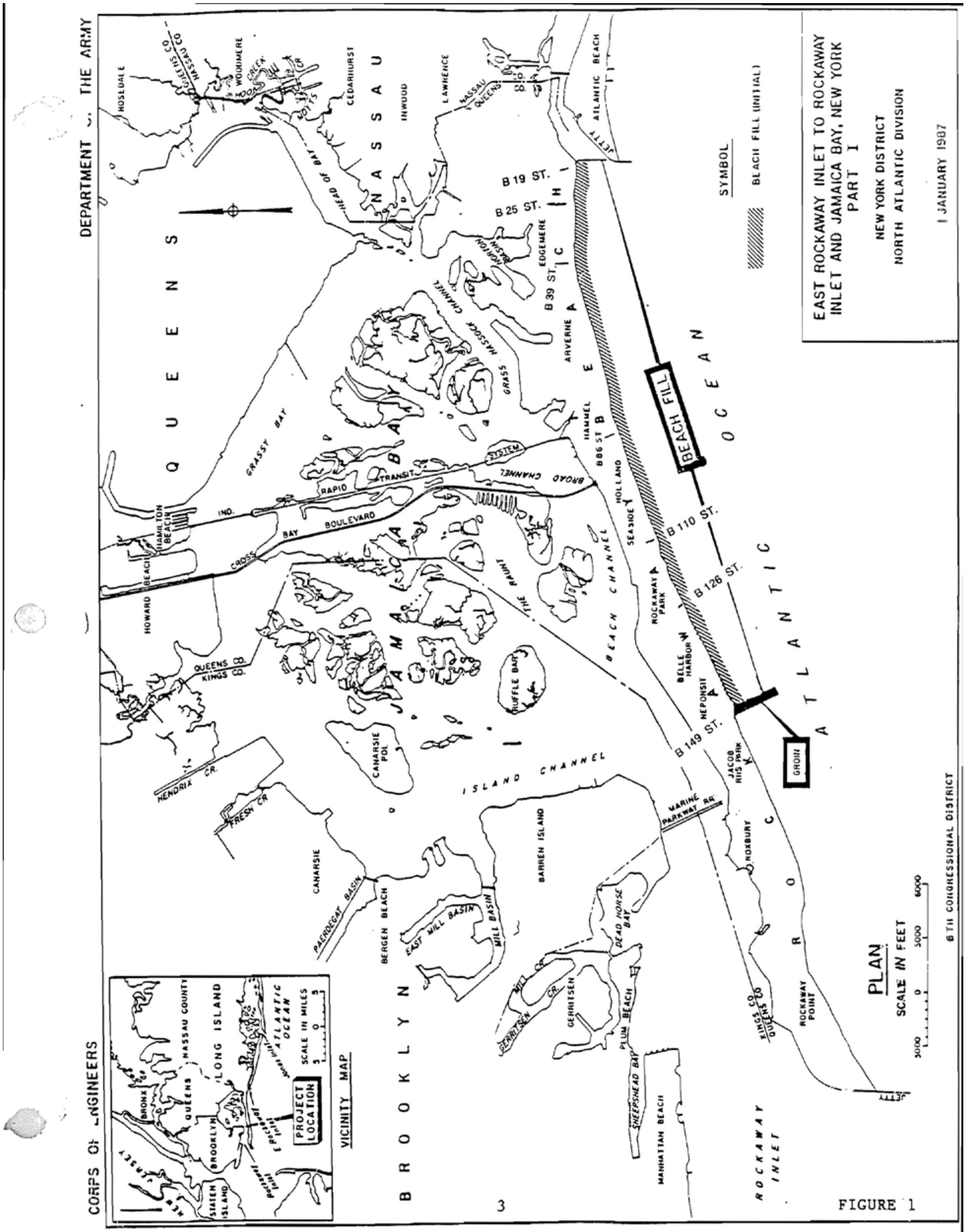

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
EAST ROCKAWAY INLET TO ROCKAWAY INLET AND JAMAICA BAY, NEW YORK
PART I
NEW YORK DISTRICT
NORTH ATLANTIC DIVISION
1 JANUARY 1987
SYMBOL
BEACH FILL (INITIAL)
BEACH FILL
GROIN
ATLANTIC OCEAN
QUEENS
NASSAU
BROOKLYN
JAMAICA BAY
ROCKAWAY INLET
VICINITY MAP
PROJECT LOCATION
PLAN
SCALE IN FEET
8TH CONGRESSIONAL DISTRICT
3
FIGURE 1

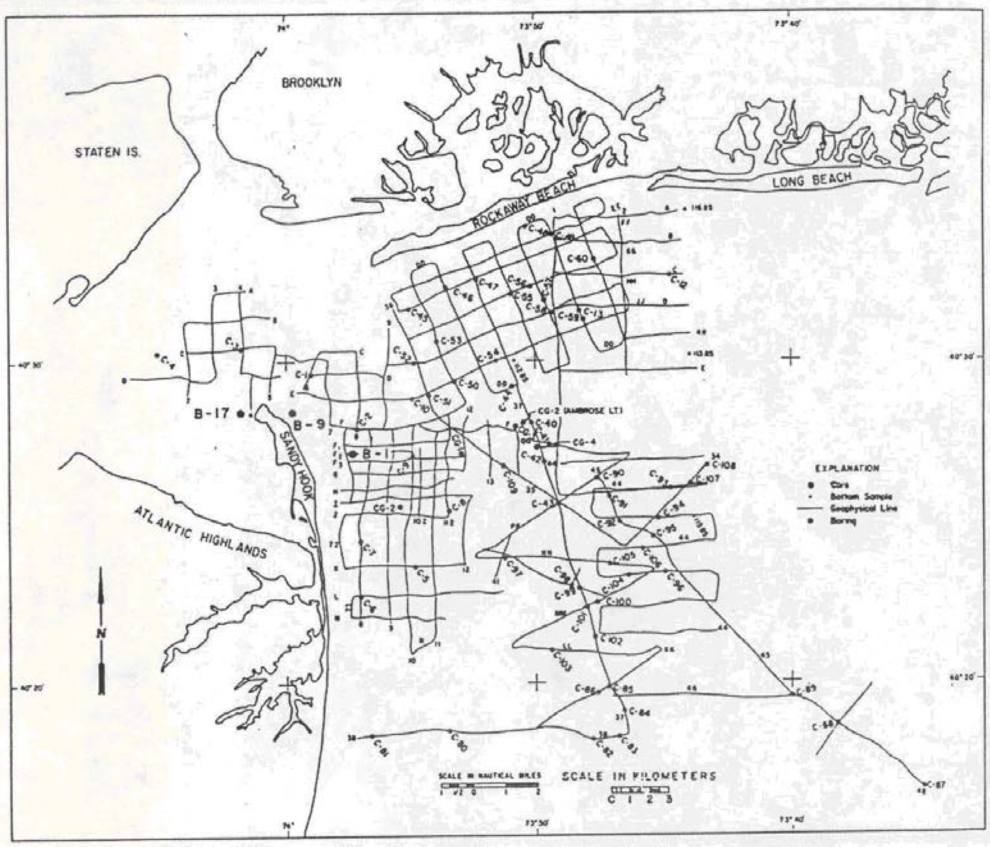
Figure B-1

a. ICONS Study.

i. Starting in the late 1960's, Alpine conducted extensive geophysical surveying in the area just offshore of Lower New York Harbor, The results of these surveys were presented in "Geomorphology and Sediments of the Inner New York Bight Continental Shelf" Technical Memorandum No. 45, by Williams and Duane, 1974. The purpose of the survey was to map the distribution of sand and gravel on the Inner Continental Shelf. The methods used included dual frequency sparker sound source geophysical profiling, using 20 and 200 joule sources, along with vibracore sampling to 20 feet below ocean bottom. Figure B-2 shows the seismic line and core locations. The survey concluded that there were extensive potential sources of usable sand and gravel present in the New York Bight. The report described a linear area of steeply cross-bedded sediments located offshore of Sandy Hook, and extending in a north-south direction. Based on the data available, the source of these sediments was attributed to a former river channel deposit from late Pleistocene early Holocene time. The sediments outside the channel were also found to consist mostly of sands and gravels, until the upper end of the deeper Hudson Canyon was encountered. In the area of the head of the Hudson Canyon, water depths are more than 100 feet, and the sediments on the sea floor are mostly finer silts.

ii. In the early 1980's, New York District and the New York/New Jersey Port Authority initiated a review of the possibility of constructing a coal loading facility in the New York Harbor. At the time, the majority of coal loaded out of the east coast of the United States came out of Chesapeake Bay, where the maximum draft is limited to approximately 55 feet due to the presence of the Chesapeake Bay Bridge-Tunnel structure limits. New York has relatively deep water in the Hudson River Canyon offshore of the Lower Harbor. A project to dredge a channel to 80 feet below mean low water from the inner harbor to the 80-foot contour near the head of the canyon was proposed. The project was halted due to budgetary constraints. Alpine Ocean Seismic conducted a series of 40-foot vibracore samples from the area of the Kill Van Kull near Staten Island to the 80-foot contour offshore of New York Lower Harbor. As part of the study, Alpine also conducted a series of seismic lines along the proposed route. The study found evidence of a former relatively deep channel across the mouth of the harbor, interpreted by Alpine as a former inlet.

Figure B-2



ICONS Data Coverage –1974. (Reproduced from Figure 2, Technical Memorandum No. 45, Page 10.)

b. Marine Sciences Research Center, State University of New York (SUNY), Stony Brook, NY

   i. Special Report 15: "Environmental Effects of Sand Mining in the Lower New York Harbor", by Kastens, Fray, and Schubel, 1978. This report includes the results of current meter studied, geophysical surveying and surficial grab sampling analyses in the Lower Harbor and Raritan Bay (locations shown in Figure B-3). Also addressed are the special distribution of macro fauna in the sediments and the distribution of tidal and non-tidal currents across the channels in the study area. An additional purpose of the study was to determine whether geophysical profiling, together with a limited amount of subsurface coring, could be used to map sediment types across the study area. The conclusion was that a number of closely spaced lines, together with a pattern of cores could be used to describe an area.

   ii. Special Report No. 21: "Textural Properties of Surficial Sediments of Lower Bay New York Harbor", by Jones, Fray, and Schubel, 1979. This study included a summary of the 254 samples collected (mostly grab samples, but some conventional cores and vibracores) in the Lower New

York Harbor area. The appendix included descriptive core logs (but no grain size data) of the 34 cores collected.

c. Liberty Pipeline Survey, 1991. Alpine conducted a geophysical and vibracore survey along the route of a proposed natural gas pipeline. The route was to run from southwest Raritan Bay, across the bay, passing north of Sandy hook and continuing across the Lower Harbor to a landing point on Long Beach Island, NY. The pipeline was to be located within a mapped pipeline corridor, which already contained a 24-inch natural gas pipeline. The proposed pipeline was never constructed. A total of 35 cores were collected along the proposed pipeline route, and based on the resulting grain size analysis, several of the cores were found to be potentially suitable for the Rockaway project. (Of course the borrow area can not be located directly in the pipeline corridor limits, however, similar sediments have a chance of being found in adjacent areas.) Results of side scan and magnetometer surveys showed a significant amount of relatively small targets along the pipeline corridor. No shipwrecks or other potentially significant targets; however submarine telephonic cables were found (again, within the pipeline corridor limits).

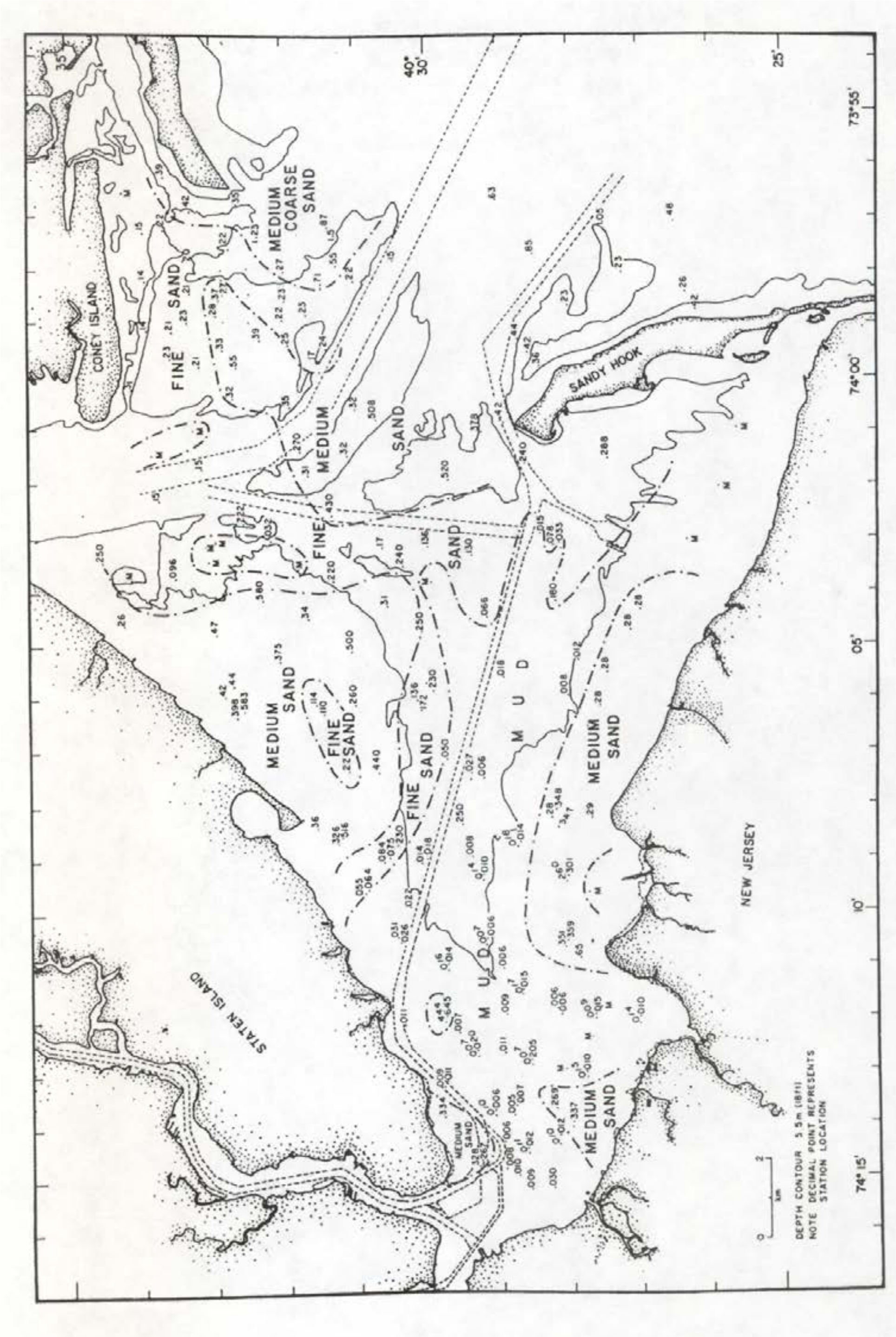
d. Atlantic Coast of Long Island, Jones Inlet to East Rockaway Inlet, Long Beach Island, NY, Feasibility Report, USACE, NYD, 1995. In support of the feasibility study, Alpine conducted a geophysical and vibracore survey along the south shore of Long Beach Island, in order to identify potential borrow sources. The area of survey ended at Jones Inlet on the east end and extended to the west along the coast. The results of the survey showed that the sediments above a depth of 19 feet below the sea floor were all sandy. A clay layer below this was found to cover a significant portion of the surveyed area.

e. Atlantic Coast of Long Island, East Rockaway Inlet to Rockaway Inlet, NY, General Design Memorandum, USACE, NYD, 1974. Three borrow areas surrounding 6 suitable cores (out of the 45 collected) were identified and utilized in the beach fill operations from the 1975 through 2004; one in Rockaway Inlet (unnamed), one on the East bank Shoal (Borrow Area 1), and one offshore of Rockaway Beach (Borrow Area 2). These areas (as shown in Figure B-4) are now depleted.

f. Atlantic Coast of Long Island, East Rockaway Inlet to Rockaway Inlet, NY, Supplement to General Design Memorandum, USACE, NYD, 1976. One suitable core out of five collected lead to the identification of Borrow Area 3 offshore of east Rockaway Inlet, which was utilized from 1976 through 1986. This area is now depleted.

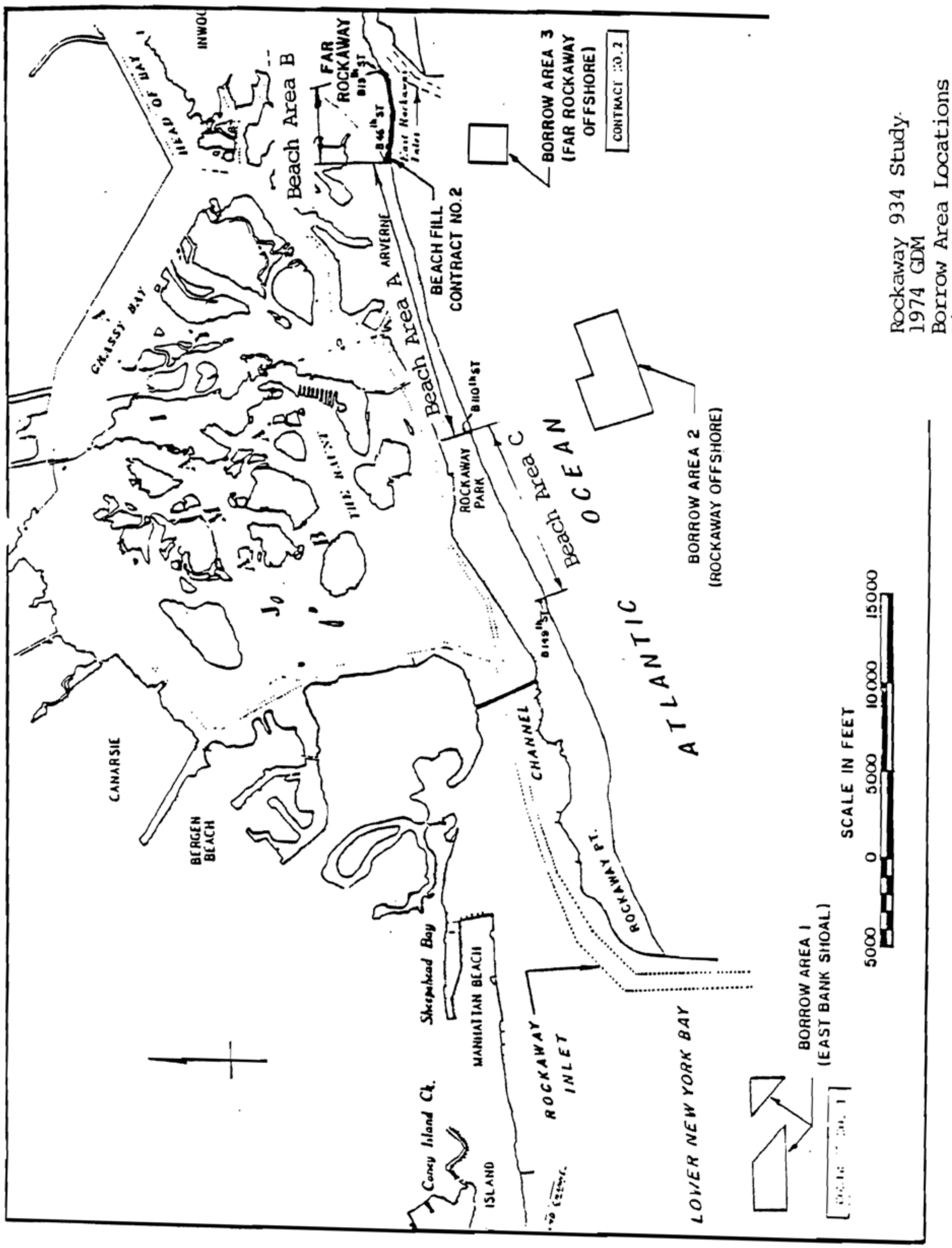
g. Section 933 Evaluation Report, East Rockaway Inlet, NY, USACE, NYD, 1992. Grab samples collected for the purpose of channel dredging disposal alternative development show that the shoaled material is too fine for hurricane and storm damage reduction alternatives, although the material is placed on the beach each time it is dredged.

Figure B-3



Median diameter (mm), surface sediment samples. (Reproduced from Special Report 15, Page 45, Marine Science Research Center, State University of New York.)

Figure B-4


FAR ROCKAWAY
Beach Area B
BORROW AREA 3
(FAR ROCKAWAY OFFSHORE)
BEACH FILL
CONTRACT NO.2
ARVERNE
Beach Area A
GRASSY BAY
HEAD OF BAY
ROCKAWAY PARK
Beach Area C
OCEAN
ATLANTIC
BORROW AREA 2
(ROCKAWAY OFFSHORE)
CANARSIE
BERGEN BEACH
CHANNEL
ROCKAWAY PT.
SCALE IN FEET
5000 0 5000 10000 15000
Sheepshead Bay
MANHATTAN BEACH
ROCKAWAY INLET
BORROW AREA 1
(EAST BANK SHOAL)
LOWER NEW YORK BAY
Coney Island Ck.
ISLAND
Rockaway 934 Study.
1974 GDM
Borrow Area Locations

h. Atlantic Coast of New York City, Rockaway Inlet to Norton Point, Coney Island Area, Shore Protection Project, Final General Design Memorandum, USACE, NYD, 1992. Two borrow areas were identified as part of this evaluation on the East Bank Shoal Analysis as suitable for fill at Coney Island (named Northern and Southern Borrow Areas). However the material in these borrow areas is too fine for use on Rockaway Beach.

i. Cable Route Survey, 2002 (Unpublished). Alpine conducted a cable route survey from Hempstead Bay, NY, across the New York Bight to Lower New York Harbor, Raritan Bay and up into Upper New York Harbor and the Hudson River to midtown Manhattan. As part of this survey, Vibracore samples were collected along the route. Most of the cores were shallow, mainly 10 to 15 feet since the cable only needs to be buried 5-6 feet below the sea floor. Sediments in the areas of core samples taken in Jones Inlet and Hempstead Bay (HB cores) may have potential as borrow material. In New York Bight (NYB Cores) sediments may also have borrow material potential based on the observed core descriptions and the limited grain size analysis data.

j. Sandy Hook and Sea Bright, NJ, Vibracore Sampling, 1983 (Unpublished). Vibracore sampling conducted in 1983 in the area of Sandy Hook Include core logs and penetration graphs for 12 cores, along with grain size curves of all samples analyzed, histograms of Sea Bright Borrow Area composites of samples and Sandy Hook Spit Channel cores, along with grain size curves for composite samples of cores. An examination of the median sizes shows there is potential borrow material at most of the core locations.

k. Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet, Beach Erosion Control Project, Section I-Sea Bright to Ocean Township, NJ, Design Memorandum, USACE, NYD, 1989. Of the 1985 group of cores, 8 of the 20 sampled locations were found to be potentially suitable or marginal for borrow sand use in the Rockaway Beach project.

l. Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet, Beach Erosion Control Project, Section II-Asbury Park to Manasquan, NJ, Design Memorandum, USACE, NYD, 1995. Of the 1988 group of cores, about 15 of the 30 sampled locations were found to be potentially suitable or marginal for borrow sand use in the Rockaway Beach project. Of the 1989 group of cores, about 14 of the 22 sampled locations were found to be potentially suitable or marginal for borrow sand use in the Rockaway Beach project.

9. Potential Upland Sediment Sources. An upland source using trucks to convey beach fill to a project can be a cost effective alternative for small projects. However with large projects, the operational expense for the heavy equipment is often prohibitive and the environmental impact on the local communities may be prohibitive as well. However, if offshore sources are not available within reasonable traveling distance to the project site, it may be feasible to bring sand from upland suppliers by barge transfer. This could be the case if the sand suppliers have access to the waterways of Long Island Sound, the south shore of Long Island, Raritan Bay, New York Harbor or the Hudson River. Sand conveyed by barge in bulk can be fluidized and piped to the beach in the same manner that an offshore cutterhead dredge pumps sand ashore. The sources investigated are described below, and the locations are shown on Figure B-5. Potential sites that warrant further investigation are shown in Table B-1.

a. Amboy Aggregates, South Amboy, NJ. This company of one of the largest suppliers of aggregate in the Unites States and the largest in the New York metropolitan area. One of its largest sources of sand and gravel is the channels leading into the New York Harbor (Ambrose, Chapel Hill, and Sandy Hook Channels, etc.). Ten dredging of these channels not only provides Amboy Aggregates with a commercial source of sand, but also provides benefit to the Federal government by providing maintenance dredging for navigation projects. Amboy has a large processing plant in South Amboy, NJ that is capable of sorting dredged material into gradations needed by the construction industry. Recently, Amboy has begun importing coarse sediments from Canada, due to the scarcity of them in the channels. Samples collected in 2000 varied in mean grain size from 0.26 to 0.56 mm, with a composite having a mean of 0.32 mm and sorting ratio of 1.15 in phi units, and were described as dark gray, fine to medium, poorly sorted, mainly quartz, but with small shell fragments (characteristic of marine sands).

b. R.W. Vogel, Barnegat, NJ. The samples collected were from the Jackson, NJ processing plant, and were described as light tan, moderately sorted, medium quartz sand, with a mean grain size varying from 0.59 to 0.71 mm, with a composite of 0.63 mm and a sorting ratio of 1.11 in phi units.

c. Herbert Sand and Gravel, Howell, NJ. The raw material consists of a yellowish tan, micacious bank run sand with high silt content. The mean grain size of the samples varied from 0.12 to 0.29 mm, with a composite of 0.16 mm.

d. Empire Sand and Gravel, Westbury, NY. Eliminated from consideration due to insufficient quantities.

e. European Express, Inc., Kings Park, NY. Eliminated from consideration due to insufficient quantities.

f. Horan Sand and Gravel Corp., Syosset, NY. Mean grain size varied from 0.41 to 0.85 mm, with a composite of 0.66 mm and a standard deviation of 1.26 in phi units.

g. Hubbard Sand and Gravel, Inc., Bayshore, NY. Samples collected contained over 40% material finer than a #230 ASTM mesh (0.063 mm).

h. Ranco Sand and Stone, Manorville, NY. Mean grain size varied from 0.48 to 1.31 mm, with a composite of 0.63 mm and a standard deviation of 0.84 in phi.

i. Sand, Stone, Soil, and Rock, Lindenhurst, NY. Eliminated from consideration due to insufficient quantities.

j. American Sand and Gravel, Deer Park, NY. Eliminated from consideration due to insufficient quantities.

k. East Coast Mines, Limited, East Quogue, NY. Material is described as coarse fine sand. The mean grain size was 0.61 mm, and the standard deviation was 1.11 in phi units.

Table B-1 Characteristics of Upland Sand Sources for Rockaway Beach

Name of Quarry	Location	Mean Size (mm)	Standard Deviation (ø)
Amboy Aggregates	South Amboy, NJ	0.32	1.15
R.W. Vogel	Barnegat, NJ	0.63	1.11
Horan Sand and Gravel	Bayshore, NY	0.66	1.26
Ranco Sand and Gravel	Manorville, NY	0.63	0.84
East Coast Mines	East Quogue, NY	0.61	1.11

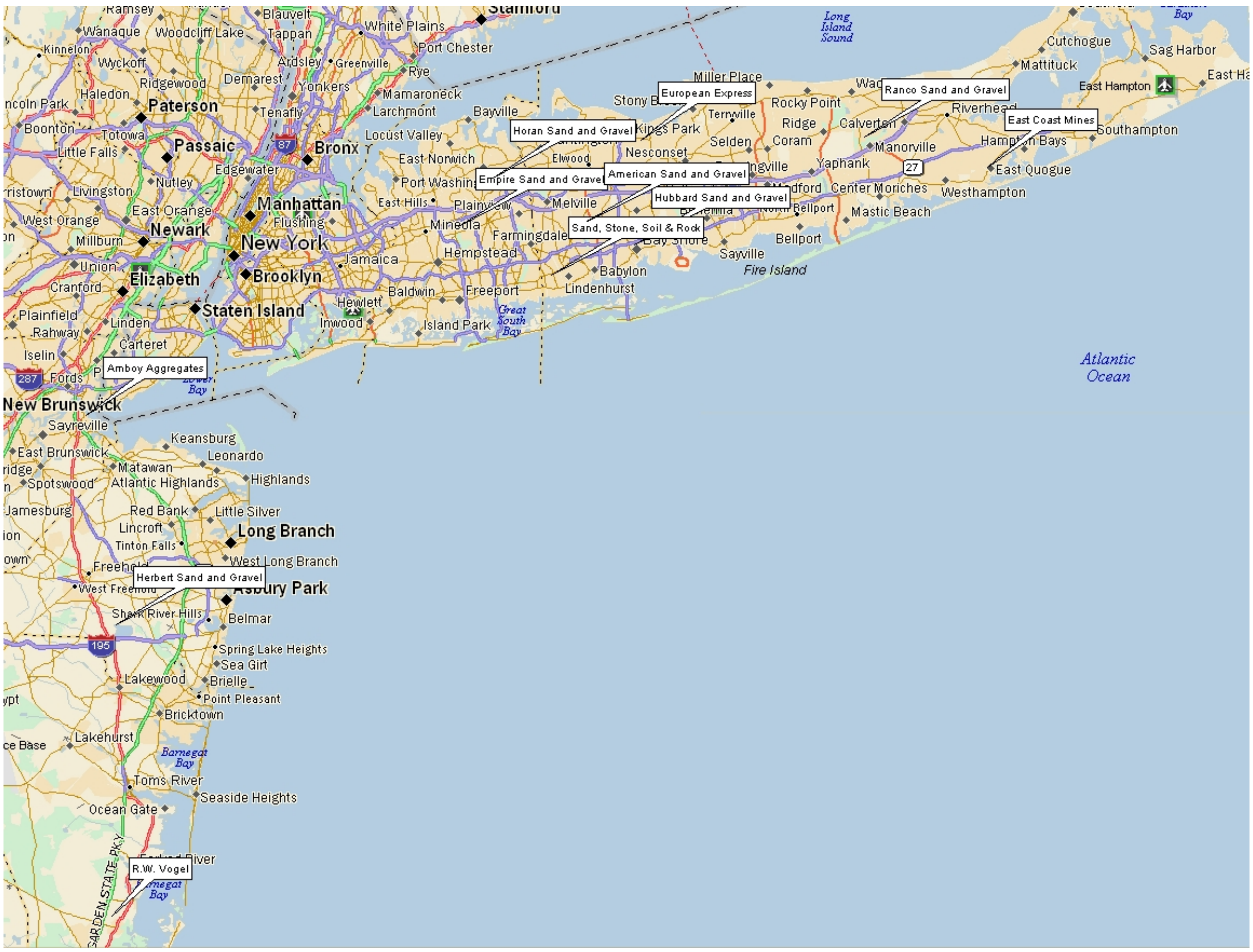


Figure B-5: Location of Potential Upland Sand Source Quarries

10. Sediment Evaluation. Eroded beaches that are in need of nourishment are considered to have remnant sediments of a grain size distribution that is more stable and in better equilibrium. Native beach sediments must be matched with similar grain size of borrow material so that the beach fill (initial and renourishment quantities) will reasonably endure over the required project life by being similar to more stable grain size distribution. In order to determine this representative sediment, samples of native (i.e., pre-fill) beach were collected and analyzed for grain size distribution. Beach sample parameters derived from the grain size distribution (GSD) curves are then compared mathematically using methodology from the USACE Shore Protection Manual, 1984 with the GSD curves of the borrow area sediments to determine the adjusted fill factor (Ra) and stability factor (Rj) of potential borrow sediments.

11. Native Beach Sediment Data. Native beach sediment samples were collected in 1961 and 1974 in pre-fill beach areas. The 1961 data consists of a summary of mean grain size, sorting coefficient, and a skewness coefficient, from which the 25th and 75th percentile grain sizes can be back calculated, and from that the 16th and 84 percentiles (required by current methodology) can be extrapolated. However, the 1974 data presents the raw grain size data, encompassing the 16th and 84th percentile. A comparison of the 1961 and 1974 mean grain size results shows, on average, the sediment neither becoming more coarse or more fine; therefore the more comprehensive 1974 data was used to estimate the native beach sand characteristics.

12. Beach Sand Model Development. The 1986 monitoring report (unpublished) contains the following on-offshore spatial sediment composite information: Berm/Backshore, Mean High Water/Mean Tide Level/Mean Low Water, and -6/-12/-18/-24 ft. NGVD. Typically, beach fill equilibrates in shallower water; therefore, the -6/-12/-18/-24 ft. NGVD composite data was omitted from the model. The alongshore composite information was developed (in the monitoring report) for Beach Area A, which extends from B110th to B46th Streets; Area B, which extends from B46th to B19th Streets; and Area C, which extends from B149th to B100th Streets. As fill is proposed potentially in all three of these areas, all three areas were included in the model. The individual beach area sediment characteristics are shown in Table B-2.

13. Final Beach Model. The final beach model is determined by composition of all raw data (omitting the -6, -12, -18, -24, -30 ft. NGVD samples) for each beach area and re-computing the statistics as outlined on pages 4-16 of the USACE Shore Protection Manual, 1984. The Rockaway Native Beach Model based on the mathematically mixed composition of all samples of the three beach areas (excluding deep samples) is shown on Table B-3 below, and is 0.29 mm mean grain size, and standard deviation of 0.52 in phi units. Figure B-6 shows the resulting native model grain size distribution curve.

Table B-2

Average Values of the Rockaway Beach Samples by Beach Area

Beach Area	Sample Location	Phi 16 (ϕ_{16})	Phi 50 (ϕ_{50})	Phi 84 (ϕ_{84})	Mean Grain Size (ϕ)	Mean Grain Size (mm)	Standard Deviation (ϕ)
A (B110th-B46th)	Berm/Backshore	1.27	1.74	2.20	1.74	.30	0.46
	MHW/MTL/MLW	1.09	1.74	2.27	1.70	.31	0.59
	-6, -12, -18, -24, -30 ft. NGVD	1.55	2.50	3.46	2.50	.18	0.96
B (B46th to B19th)	Berm/Backshore	1.31	1.79	2.29	1.79	.29	0.49
	MHW/MTL/MLW	.43	1.71	2.33	1.49	.36	0.95
	-6, -12, -18, -24, -30 ft. NGVD	1.71	2.57	3.40	2.56	.17	.085
C (B149th to B110th)	Berm/Backshore	1.37	1.83	2.37	1.85	.28	0.50
	MHW/MTL/MLW	1.31	1.83	2.54	1.90	.27	0.62
	-6, -12, -18, -24, -30 ft. NGVD	1.55	2.87	3.57	2.67	.16	1.01

14. Potential Nearshore Borrow Sources. Sources investigated included the navigation channels and inlets including Rockaway Inlet, East Rockaway Inlet, Jones Inlet, and the Jamaica Bay Channels. The bay channels were ruled out in the Atlantic Coast of Long Island, East Rockaway Inlet to Rockaway Inlet, NY, General Design Memorandum, USACE, NYD, 1974 and the Section 933 Evaluation Report, East Rockaway Inlet, NY, USACE, NYD, 1992 analyses, due to environmental sensitivities. Furthermore, bay sediments tend to be much too fine for ocean beach stability. East Rockaway Inlet sediments are currently placed on the beach downdrift (Beach Area B), however, are much too fine for stability. Rockaway Inlet sediments are also too fine for suitability on ocean beaches.

15. Potential Offshore Borrow Sources. The following criteria were used to select offshore areas for further investigation: suitable grain size (coarser than 0.30mm); sufficient volume (greater than 75,000 contiguous cy), proximity (as close as possible to fill area for cost purposes, not close enough to adversely affect the local wave conditions, and in a minimum of 30 feet water depth); and free from environmental constraints, fishing interests, cables, pipelines, shipping lanes, etc.. Two potential sites were short-listed based on their available size, suitability, and environmental considerations. The sites are summarized as follows and are shown in Figure B-7:

Table B-3
Native Beach Model Characteristics

Mean (ϕ)	1.79
Mean (mm)	0.29 mm
Standard Deviation (ϕ)	0.52

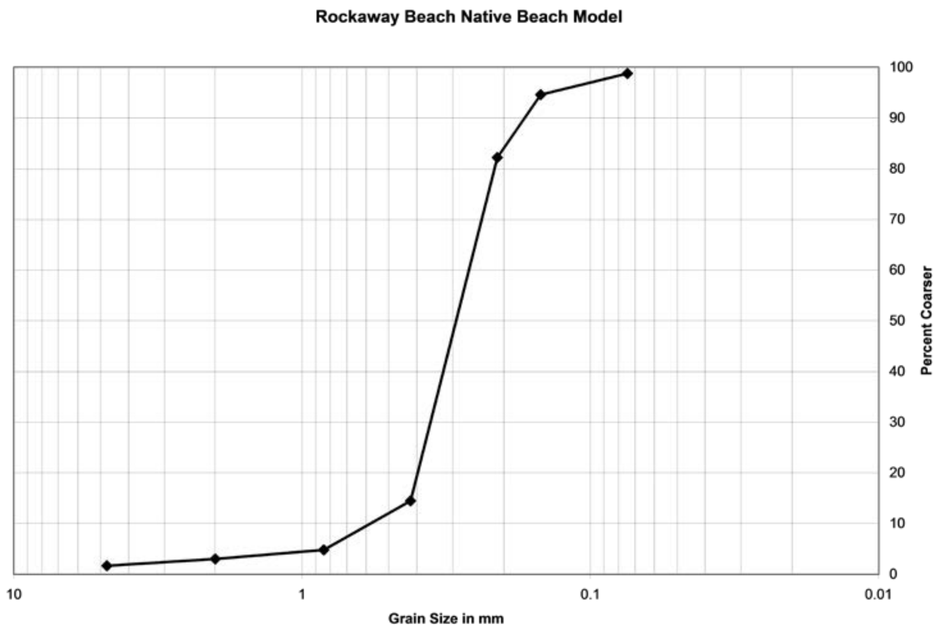


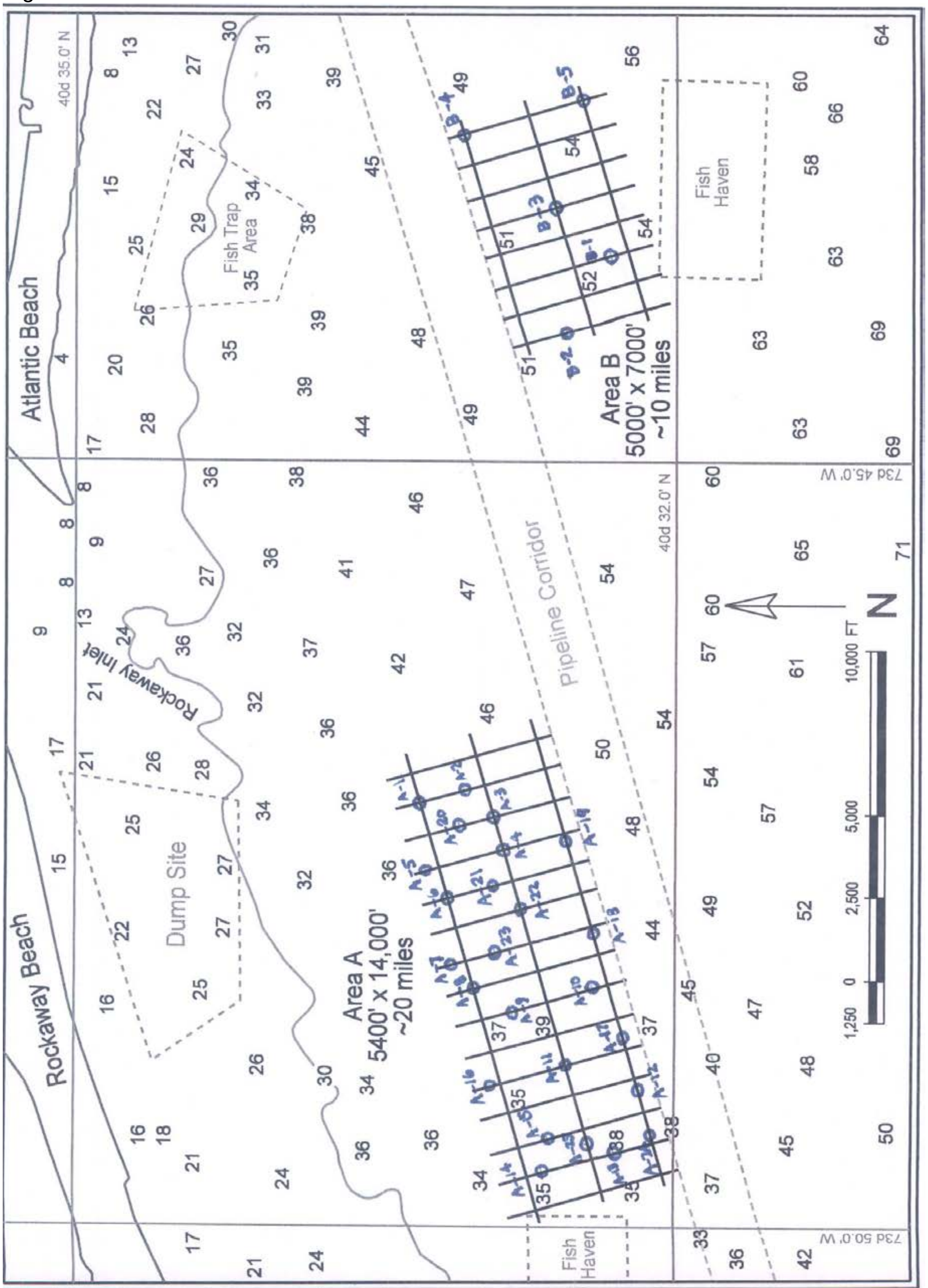
Figure B-6 Native Model Grain Size Distribution

a. Area A, located approximately 2 miles offshore of Rockaway Beach, immediately east of a formally designated fish haven, and immediately north of a gas pipeline corridor.
b. Area B, located approximately 2 miles to the east of Area A, approximately 2 miles offshore of Long Beach Island (Atlantic Beach), immediately south of the gas pipeline corridor, and immediately to the north of another fish haven.

16. Offshore Borrow Source Phase I Data Collection. Alpine Ocean Seismic Survey Inc. performed a seismic, hydrographic, and magnetometer surveys at the two potential borrow areas as part of the initial field investigation. The purpose of this survey was to define by seismic methods, which portions of the potentially promising areas appeared to be most suited as a source of sand by mapping the geologic sequence as interpreted from the seismic reflection records. Fieldwork was carried out aboard the R/V Atlantic Twin between 29 October 2002 and 3 November 2002. Twenty nautical miles of data collection was performed in Area A, and ten in Area B (north-south spacing of 1000 feet, east-west of 2000 feet). Details and results of the geophysical and hydrographic operation, equipments used, and interpretation of the seismic data (including graphical cross sections of each line) are shown in the Alpine Report. Potential vibracore locations were selected based on the interpretation, and are described below.

17. Offshore Borrow Source Phase II Data Collection (Vibracores). Data collected in the previous phase was analyzed, and 30 potential vibracore locations were selected (20 within area A and 10 within Area B). However, the nature of the sediments found in the first five cores collected in Area B seemed for the most part fine-grained, therefore the remainder of the cores (25) were collected in Area A. Details of the coring operation are contained in the Alpine Report, including core penetration graphs, core photographs, and descriptive geological logs. Seismic plan and core locations are shown in Figure B-7.

Figure B-7: Plan for Seismic Data Collection



18. Core Sediment Sampling. Sediment samples were collected at each distinct lithological layer in each core, for a total of 143 samples. Each sample was analyzed using scales and sieve stacks, and grain size distribution data was recorded for each sample. Mean grain size and standard deviation were measured using the same USACE Shore Protection Manual, 1984 method utilized for the native beach model. Sample characteristics are shown on Table B-4 for Area B and Table B-5 for Area A. Composite core characteristics are shown on Table B-6.

Table B-4: Area B Sediment Characteristics

Core ID	Sample ID	Layer in Core in ft.	Phi 16	Phi 50	Phi 84	Mean Grain Size in phi	Mean Grain Size in mm	Standard Deviation in phi
B-1	1	0-1.8	1.05	2.19	2.99	2.08	0.24	0.97
	2	1.8-8.1	1.02	2.17	2.85	2.02	0.25	0.91
	3	8.1-13	1.34	2.40	2.96	2.24	0.21	0.81
	4	13-19.2	1.58	2.33	2.96	2.29	0.20	0.69
B-2	1	0-3	-0.83	0.41	1.46	0.34	0.79	1.14
	2	3-4.6	0.28	1.23	2.13	1.21	0.43	0.93
	3	4.6-9.6	0.94	1.44	2.28	1.55	0.34	0.67
	4	9.6-14.5	0.55	1.13	1.86	1.18	0.44	0.66
	5	14.5-17.8	-1.10	0.66	1.42	0.33	0.80	1.26
B-3	1	0-1.6	-3.22	-0.56	1.34	-0.82	1.76	2.28
	2	1.6-3.1	2.31	3.32	4.80	3.48	0.09	1.24
	3	3.1-5.4	1.10	2.36	3.04	2.16	0.22	0.97
	4	5.4-6.9	-0.64	1.70	2.91	1.32	0.40	1.78
	5	6.9-14	-0.07	1.48	2.51	1.31	0.40	1.29
	6	14-18.6	1.12	1.51	2.03	1.56	0.34	0.46
B-4	1	0-4.4	0.33	1.26	2.04	1.21	0.43	0.86
	2	4.4-9.1	1.21	2.40	3.14	2.25	0.21	0.97
	3	9.1-14.2	2.03	2.57	3.39	2.67	0.16	0.68
	4	14.2-18.1	1.12	2.07	3.15	2.11	0.23	1.01

Note: Core B-5, peat and silt, no samples taken.

Table B-5: Area A Sediment Characteristics

Core ID	Sample ID	Layer in Core in ft.	Phi 16	Phi 50	Phi 84	Mean Grain Size in phi	Mean Grain Size in mm	Standard Deviation in phi
A-1	1	0-1.5	2.71	3.26	4.05	3.34	0.10	0.67
	2	1.5-5	0.60	1.21	2.33	1.38	0.38	0.87
	3	5-10	1.05	1.91	2.60	1.85	0.28	0.78
	4	10-15	0.51	1.33	2.28	1.37	0.39	0.89
	5	15-20	1.03	1.83	2.45	1.77	0.29	0.71
A-2	1	0-5	0.65	1.52	2.45	1.55	0.34	0.90
	2	5-10.4	0.88	1.59	2.43	1.65	0.32	0.78
	3	10.4-16.4	-0.61	0.95	2.00	0.70	0.62	1.30
	4	16.4-18	1.92	2.38	2.84	2.38	0.19	0.46
A-3	1	0-1.2	2.61	3.21	3.82	3.21	0.11	0.60
	2	1.2-5	-1.53	0.30	1.98	0.25	0.84	1.75
	3	5-10	-0.94	0.85	2.07	0.66	0.63	1.51
	4	10-15	-1.33	0.67	1.74	0.36	0.78	1.54
	5	15-20	-1.98	0.57	1.74	0.11	0.93	1.86
A-4	1	0-1.5	1.16	2.08	2.72	1.99	0.25	0.78
	2	1.5-5	-2.18	0.01	1.69	-0.16	1.12	1.94
	3	5-10	-2.49	-1.47	1.18	-0.93	1.90	1.84
	4	10-15	-1.93	-0.37	1.24	-0.35	1.28	1.58
A-5	1	0-1	1.38	2.88	3.44	2.57	0.17	1.03
	2	1--2.5	-1.65	0.62	2.13	0.37	0.78	1.89
	3	2.5-5	0.58	1.50	2.29	1.46	0.36	0.86
	4	5-10	0.14	1.48	2.27	1.30	0.41	1.07
	5	10-15	0.88	1.68	2.35	1.63	0.32	0.73
	6	15-20	1.09	1.90	2.53	1.84	0.28	0.72
A-6	1	0-3.3	1.02	1.65	2.36	1.67	0.31	0.67
	2	3.3-7	*-4.80*	-1.24	1.60	-1.48	2.79	3.20
	3	7-10	-1.92	0.97	2.48	0.51	0.70	2.20
	4	10-13.3	0.11	1.45	2.08	1.21	0.43	0.98
	5	13.3-17.5	-1.50	0.87	2.23	0.53	0.69	1.87
A-7	1	0-2.4	2.58	3.19	3.76	3.18	0.11	0.59
	2	2.4-3.2	-3.38	-1.01	1.80	-0.86	1.82	2.59
	3	3.2-5.1	0.68	1.26	1.93	1.29	0.41	0.62
	4	5.1-7.2	-3.64	-1.33	1.71	-1.09	2.12	2.68
	5	7.2-13	1.54	2.08	2.54	2.05	0.24	0.50
	6	13-19.5	1.19	1.78	2.34	1.77	0.29	0.58
A-8	1	0-1.5	1.20	3.00	3.44	2.55	0.17	1.12
	2	1.5-3	-1.94	0.90	2.12	0.36	0.78	2.03
	3	33-10	2.08	2.42	2.87	2.46	0.18	0.40
	4	10-15	2.15	2.55	2.92	2.54	0.17	0.38
	5	15-20	2.12	2.45	2.88	2.48	0.18	0.38
A-9	1	0-2	2.27	3.16	3.80	3.07	0.12	0.77
	2	2-5	1.63	2.10	2.49	2.07	0.24	0.43
	3	5-10	1.54	2.11	2.56	2.07	0.24	0.51
	4	10-15	1.03	1.56	2.14	1.57	0.34	0.56
	5	15-19	2.80	3.28	3.79	3.29	0.10	0.50

Table B-5, continued: Area A Sediment Characteristics

Core ID	Sample ID	Layer in Core in ft.	Phi 16	Phi 50	Phi 84	Mean Grain Size in phi	Mean Grain Size in mm	Standard Deviation in phi
A-10	1	0-5.5	2.57	3.17	3.61	3.12	0.12	0.52
	2	5.5-6.7	-2.25	-0.17	1.97	-0.15	1.11	2.11
	3	6.7-10.5	1.05	1.65	2.28	1.66	0.32	0.61
	4	10.5-11.7	-3.92	0.38	1.90	-0.55	1.46	2.91
	5	11.7-14.5	1.90	2.27	2.70	2.29	0.20	0.40
A-11	1	0-2.3	1.00	1.94	3.30	2.08	0.24	1.15
	2	2.3-8.2	-1.42	1.16	1.93	0.56	0.68	1.67
	3	8.2-12.5	1.04	1.43	1.94	1.47	0.36	0.45
	4	12.5-17.8	-1.15	0.40	1.29	0.18	0.88	1.22
	5	17.8-19.8	0.66	1.31	1.98	1.32	0.40	0.66
A-12	1	0-3.7	2.66	3.16	3.48	3.10	0.12	0.41
	2	3.7-4.6	-2.46	-0.25	1.55	-0.39	1.31	2.00
	2a	4.6-5.4	1.58	2.39	2.90	2.29	0.20	0.66
	3	5.4-7.2	-3.04	-1.48	0.17	-1.45	2.73	1.61
	4	7.2-13	1.45	2.32	2.88	2.22	0.22	0.71
	5	13-20	1.70	2.46	2.91	2.35	0.20	0.61
A-13	1	0-3.1	1.65	2.80	3.39	2.61	0.16	0.87
	2	3.1-4.1	-1.65	-0.48	1.56	-0.19	1.14	1.60
	3	4.1-6.0	1.01	1.53	2.20	1.58	0.33	0.60
	4	6-11	-1.05	0.73	1.97	0.55	0.68	1.51
	5	11-15	-1.73	-0.57	1.57	-0.25	1.19	1.65
	6	15-20	-2.10	1.10	2.13	0.38	0.77	2.12
A-14	1	0-2.7	-0.43	1.58	2.23	1.13	0.46	1.33
	2	2.7-6.7	-1.15	0.57	1.87	0.43	0.74	1.51
	3	6.7-12	0.92	1.63	2.25	1.60	0.33	0.67
	4	12-17	0.34	1.45	2.20	1.33	0.40	0.93
A-15	1	0-2.3	-2.01	1.15	2.44	0.53	0.69	2.23
	2	2.3-7	1.06	1.75	2.38	1.73	0.30	0.66
	3	7-12	1.00	1.50	2.24	1.58	0.33	0.62
	4	12-17.5	-0.82	1.03	1.73	0.64	0.64	1.28
	5	17.5-20	1.58	2.06	2.57	2.07	0.24	0.49
A-16	1	0-0.8	1.40	3.12	3.50	2.67	0.16	1.05
	2	0.8-1.6	1.16	1.75	2.34	1.75	0.30	0.59
	3	1.6-5.2	1.67	2.09	2.48	2.08	0.24	0.41
	4	5.2-10.5	1.15	1.65	2.13	1.64	0.32	0.49
	5	10.5-15.2	0.77	1.50	2.05	1.44	0.37	0.64
	6	15.2-17.7	0.82	1.37	2.05	1.41	0.38	0.61
A-17	1	0-4	2.64	3.21	3.71	3.19	0.11	0.54
	2	4-5.1	-2.48	-0.23	2.19	-0.18	1.13	2.34
	3	5.1-10	1.51	1.84	2.30	1.88	0.27	0.39
	4	10-15.2	-2.44	0.55	1.72	-0.06	1.04	2.08
	5	15.2-17.5	0.77	1.62	2.30	1.56	0.34	0.77
	6	17.5-18	2.16	2.66	3.12	2.65	0.16	0.48

Table B-5, continued: Area A Sediment Characteristics

Core ID	Sample ID	Layer in Core in ft.	Phi 16	Phi 50	Phi 84	Mean Grain Size in phi	Mean Grain Size in mm	Standard Deviation in phi
A-18	1	0-3.4	2.65	3.21	3.72	3.19	0.11	0.53
	2	3.4-4.6	-3.25	-1.11	0.92	-1.15	2.22	2.08
	3	4.6-7	1.47	2.04	2.65	2.06	0.24	0.59
	4	7-10.5	0.06	1.36	2.12	1.18	0.44	1.03
	5	10.5-15	1.01	1.57	2.18	1.59	0.33	0.58
	6	15-20	1.12	1.58	1.97	1.56	0.34	0.43
A-19	1	0-2.5	2.69	3.16	3.71	3.19	0.11	0.51
	2	2.5-4	-3.90	-2.10	-0.49	-2.16	4.47	1.71
	3	4-8.4	-0.84	0.98	1.82	0.65	0.64	1.33
	4	8.4-14	1.69	2.22	2.72	2.21	0.22	0.52
	5	14-20	1.60	2.09	2.50	2.06	0.24	0.45
A-20	1	0-7	-0.83	1.01	1.73	0.45	0.73	1.28
	2	7-12	-0.15	0.63	1.25	0.55	0.68	0.70
	3	12-17.5	0.39	1.05	1.77	1.08	0.47	0.69
A-21	1	0-3.6	0.57	1.25	1.95	1.26	0.42	0.69
	2	3.6-10.6	-0.98	0.04	1.10	0.06	0.96	1.04
	3	10.6-16	0.58	1.27	1.98	1.28	0.41	0.70
A-22	1	0-1.2	2.36	2.97	3.82	3.09	0.12	0.73
	2	1.2-2.2	-3.44	-2.17	-0.55	-2.00	4.00	1.45
	3	2.2-8	1.18	1.72	2.25	1.72	0.30	0.53
	4	8-15.4	1.22	1.73	2.24	1.73	0.30	0.51
	5	15.4-17.6	-1.33	-0.44	1.20	-0.06	1.05	1.26
A-23	1	0-4.8	0.83	1.62	2.34	1.59	0.33	0.76
	2	4.8-7	-0.93	0.29	1.11	0.09	0.94	1.02
	3	7-12	0.89	1.46	2.14	1.51	0.35	0.63
	4	12-17.4	1.01	1.59	2.30	1.65	0.32	0.64
A-24	1	0-5	2.14	2.68	3.14	2.64	0.16	0.50
	2	5-6.4	-1.18	1.03	1.83	0.33	0.80	1.50
	3	6.4-10	1.23	1.77	2.34	1.78	0.29	0.55
	4	10-15	1.11	1.72	2.40	1.76	0.30	0.64
	5	15-20	1.21	1.72	2.33	1.77	0.29	0.56
A-25	1	0-1.2	0.08	2.55	3.08	1.90	0.27	1.50
	2	1.2-4.8	-0.50	0.92	1.77	0.73	0.60	1.13
	3	4.8-9.8	1.35	1.95	2.46	1.92	0.26	0.55
	4	9.8-15	-0.21	1.44	2.33	1.19	0.44	1.27
	5	15-20	0.58	1.46	2.32	1.45	0.36	0.87

19. Compatibility Analysis. The suitability of sediments from potential borrow sites considered as a source of supply for beachfill were evaluated by use of the techniques and mathematical equations presented and discussed by James, W.R., “Techniques of Evaluating Suitability of Borrow Material for Beach Nourishment”, Technical Memorandum No.60, pp.81, US Army Corps of Engineers, CERC, 1975 and Hobson, R.D., “Review of Design Elements for Beach Sand Evaluation”, Technical Paper 77-6, pp.51, US Army Corps of Engineers, CERC, 1977 in the USACE Shore Protection Manual, 1984. The publications provided the source for the development of computer program to evaluate two numbers, the Overfill Factor, Ra, and the Renourishment Ratio, Rj. New York District suitability criteria divide sediment into three categories: suitable, marginal and unsuitable. The Ra and Rj ranges for these criteria are listed in Table B-7 below.

Table B-6: Composite Core Characteristics

Core ID	Sample ID	Length of Core in ft.	Phi 16	Phi 50	Phi 84	Mean Grain Size in phi	Mean Grain Size in mm	Standard Deviation in phi
B-1	Composite	19.2	1.20	2.28	2.95	2.14	0.23	0.88
B-2	Composite	17.8	-0.28	1.04	1.90	0.89	0.54	1.09
B-3	Composite	18.6	-0.28	1.76	3.19	1.55	0.34	1.73
B-4	Composite	4.4	0.33	1.26	2.04	1.21	0.43	0.86
A-1	Composite	20	0.74	1.68	2.55	1.66	0.32	0.90
A-2	Composite	18	0.51	1.45	2.43	1.47	0.36	0.96
A-3	Composite	20	-1.37	0.73	2.05	0.47	0.72	1.71
A-4	Composite	15	-2.21	-0.51	1.71	-0.34	1.26	1.96
A-5	Composite	20	0.73	1.65	2.43	1.60	0.33	0.85
A-6	Composite	17.5	-1.91	1.16	2.19	0.48	0.72	2.05
A-7	Composite	19.5	no composite computed due to fine overlayer					
A-8	Composite	20	no composite computed due to fine overlayer					
A-9	Composite	19	no composite computed due to fine overlayer					
A-10	Composite	14.5	no composite computed due to fine overlayer					
A-11	Composite	19.8	-0.62	1.18	1.93	0.83	0.56	1.28
A-12	Composite	20	no composite computed due to fine overlayer					
A-13	Composite	20	no composite computed due to fine overlayer					
A-14	Composite	17	-0.28	1.40	2.16	1.10	0.47	1.22
A-15	Composite	20	0.58	1.49	2.27	1.45	0.37	0.85
A-16	Composite	17.7	1.07	1.68	2.33	1.69	0.31	0.63
A-17	Composite	18	-0.19	1.75	2.95	1.51	0.35	1.57
A-18	Composite	20	no composite computed due to fine overlayer					
A-19	Composite	20	no composite computed due to fine overlayer					
A-20	Composite	17.5	-0.24	0.88	1.63	0.70	0.62	0.94
A-21	Composite	16	-0.08	0.88	1.78	0.85	0.55	0.93
A-22	Composite	17.6	0.60	1.64	2.29	1.44	0.37	0.84
A-23	Composite	17.4	0.59	1.44	2.22	1.40	0.38	0.81
A-24	Composite	20	no composite computed due to fine overlayer					
A-25	Composite	20	0.54	1.56	2.40	1.50	0.35	0.93

TABLE B-7 SEDIMENT STABILITY CRITERIA

Ra	Classification	Rj
1.00 - 1.20	Suitable	0.00 - 1.00
1.20 - 1.30	Marginal	1.00 - 1.10
1.30 - ++	Unsuitable	1.10 - ++

20. The Overfill Factor, Ra. This factor predicts the amount of overdredge of a given borrow material which will be required to produce after natural sorting. Losses due to the dredging processes are in addition to those natural sorting losses. The more desirable Ra factors are those closest to 1.00. An Ra factor of 1.0 to 1.1 is considered as representing the most suitable material. An extra fill volume of ten percent or less produces the desired sediment volume on the beach for Ra values between 1.0 to 1.1. A Ra factor of 1.1 to 1.3 means that an extra fill volume of up to thirty percent would be required to produce the

post sorting loss design beachfill volume. For this project, the limits for suitability based on Ra factor are between 1.0 and 1.2.

21. The Renourishment Ratio, Rj. This factor is a measure of the stability of the placed borrows material relative to the native sands. The more desirable Rj factors are those closest to or less than 1.0. An Rj ratio of 1.0 means the native and borrow sediments are of equal stability, having very similar grain size distributions. A renourishment factor of one-third (Rj = 0.33) means in theory that the borrow material is three times as stable as the natural beach sands, or that the renourishment with this borrow material would be required one-third as often as the native-like sediments. Beach nourishments are based on Rj of 1.0 to be conservative even if their Rj may be less than 1.0. For this project, the limits for suitability based on Rj ratio are between 0.0 and 1.00.

22. Compatibility Results. Results for Area B showed that two cores were suitable for placement on Rockaway Beach: Core B-2 to 17.8 ft depth below grade (Ra=1.06, Rj=0.03), and Core B-4 to only 4.4 feet below grade (Ra=1.04, Rj=0.14). Results for Area A showed that 16 cores were marginal to suitable to their full depth (on average 18 feet below grade): A-1 through A-6, A-11, A-14 through A-17, A-20 through A-23, and A-25 (average Ra=1.15, average Rj=0.5). Compatibility results are shown in Table B-8.

Table B-8: Compatibility Results

Core ID	Sample ID	Length of Core in ft.	Native Mean Grain Size in phi	Native Mean Grain Size in mm	Native Standard Deviation in phi	Borrow Mean Grain Size in phi	Borrow Mean Grain Size in mm	Borrow Standard Deviation in phi	sb/sn	mb-mn/sn	Ra	Rj	Compatibility
B-1	Composite	19.2	1.79	0.29	0.52	2.14	0.23	0.88	1.68	0.67	1.78	0.78	Unsuitable
B-2	Composite	17.8	1.79	0.29	0.52	0.89	0.54	1.09	2.10	-1.74	1.06	0.03	Suitable
B-3	Composite	18.6	1.79	0.29	0.52	1.55	0.34	1.73	3.33	-0.45	1.43	0.00	Unsuitable
B-4	Composite	4.4	1.79	0.29	0.52	1.21	0.43	0.86	1.65	-1.12	1.04	0.14	Suitable
A-1	Composite	20	1.79	0.29	0.52	1.66	0.32	0.90	1.74	-0.26	1.21	0.28	Marginal
A-2	Composite	18	1.79	0.29	0.52	1.47	0.36	0.96	1.85	-0.62	1.15	0.16	Marginal
A-3	Composite	20	1.79	0.29	0.52	0.47	0.72	1.71	3.29	-2.54	1.13	0.00	Marginal
A-4	Composite	15	1.79	0.29	0.52	-0.34	1.26	1.96	3.77	-4.09	OK	0.00	Suitable
A-5	Composite	20	1.79	0.29	0.52	1.60	0.33	0.85	1.63	-0.36	1.15	0.31	Marginal
A-6	Composite	17.5	1.79	0.29	0.52	0.48	0.72	2.05	3.94	-2.52	1.19	0.00	Marginal
A-7	Composite	19.5											
A-8	Composite	20											
A-9	Composite	19											
A-10	Composite	14.5											
A-11	Composite	19.8	1.79	0.29	0.52	0.83	0.56	1.28	2.46	-1.85	1.09	0.01	Suitable
A-12	Composite	20											
A-13	Composite	20											
A-14	Composite	17	1.79	0.29	0.52	1.10	0.47	1.22	2.35	-1.33	1.13	0.03	Marginal
A-15	Composite	20	1.79	0.29	0.52	1.45	0.37	0.85	1.63	-0.66	1.09	0.22	Suitable
A-16	Composite	17.7	1.79	0.29	0.52	1.69	0.31	0.63	1.21	-0.18	1.08	0.66	Suitable
A-17	Composite	18	1.79	0.29	0.52	1.51	0.35	1.57	3.02	-0.54	1.37	0.01	Unsuitable
A-18	Composite	20											
A-19	Composite	20											
A-20	Composite	17.5	1.79	0.29	0.52	0.70	0.62	0.94	1.80	-2.11	1.02	0.04	Suitable
A-21	Composite	16	1.79	0.29	0.52	0.85	0.55	0.93	1.79	-1.80	1.03	0.05	Suitable
A-22	Composite	17.6	1.79	0.29	0.52	1.44	0.37	0.84	1.62	-0.67	1.09	0.23	Suitable
A-23	Composite	17.4	1.79	0.29	0.52	1.40	0.38	0.81	1.57	-0.74	1.07	0.23	Suitable
A-24	Composite	20											
A-25	Composite	20	1.79	0.29	0.52	1.50	0.35	0.93	1.79	-0.56	1.14	0.19	Marginal

23. Borrow Area Delineation. The compatible/marginal cores form roughly three groupings; one on the west side and one on the east side of Area A (Borrow Areas A-West and A-East, respectively); one on the west side of Area B (Borrow Areas B-West). Their use as potential borrow areas is discussed below.

24. Borrow Area A-West. Seismic profiles were used to delineate potential borrow material surrounding suitable/marginal cores A-11, A-14, A-15, A-16, and A-23. The resulting boundary coordinate points in NAD83 Long Island Lambert State Plane coordinates are shown in Table B-9, with the area being roughly rectangular in shape approximately 4,800 feet from east to west, and 4,000 feet from north to south. The average dredging depth is approximately 18 feet below grade. Due to numerous magnetic anomalies detected during the magnetometer investigation in this vicinity, a diver investigation is recommended prior to dredging to determine the nature of the anomalies. If the anomalies are small enough and without cultural impact, a hopper dredge with a screen could be utilized. In this case, it is estimated that the borrow area could supply approximately 9 million cubic yards (assuming 1V:3H side slopes and 25% of material to be unusable). If the anomalies are not small enough, or have cultural significance and the anomalies may not be disturbed, the borrow area could still supply approximately 4 million cubic yards (assuming a minimum 200 ft buffer surrounding each anomaly and 1V:3H side slopes and 35% of the material to be unusable). The average overfill factor for this area is approximately 1.08. The area is shown on Figure B-8

25. Borrow Area A-East. Seismic profiles were used to delineate potential borrow material surrounding suitable/marginal cores A-1 through A-6, and A-20 through A-22 (A-23 was ruled out due to localized anomalies on its seismic record). The recommended area is roughly rectangular (5,000 feet in the alongshore direction by 4,000 feet in the on-offshore direction. The coordinates are shown on Table B-9. The average overfill factor for this delineation is approximately 1.15. The area is shown on Figure B-8. The approximate depth of suitable materials is 17 feet. The volume contained in this area is approximately 8 million cubic yards (assuming 1V:3H side slopes and omitting approximately 25% for poor material interlayer found while dredging). Either a hopper dredge or a cutterhead dredge may be used for this area.

26. Borrow Area B-West. Seismic profiles were used to delineate potential borrow material surrounding suitable/marginal core B-2. The recommended area is roughly a 1,200 by 1,200 feet box. The coordinates are shown on Table B-9. The average overfill factor for this delineation is approximately 1.06. The area is shown on Figure B-8. The approximate depth of suitable materials is 17.8 feet. The volume contained in this area is approximately 1 million cubic yards (assuming 1V:3H side slopes and omitting approximately 25% for poor material interlayers found while dredging). A cutterhead dredge would be the most efficient for this area. Environmental investigation must be performed on this area prior to use.

27. Volumes Identified. A minimum of 13,000,000 and a maximum of 18,000,000 cubic yards were identified for use as borrow material for the East Rockaway Inlet to Rockaway Inlet Section 934 Project next three nourishment operations and for the Reformulation Study as part of this investigation. The requirements of the Section 934 Project are 10,000,000 cy. The remaining 3-8,000,000 cy are adequate for the first beach fill operation of the Reformulation. Further investigation must occur prior to any Reformulation renourishments, from sources such as offshore, channel, or upland, to gain the remaining estimated 22,000,000 to 27,000,000 to cy ballpark needed for the full reformulation project duration.

Table B-9

Borrow Area Coordinates
(NAD83 State Plane, Long Island Lambert System)

Borrow Area	Corner	Northing in feet	Easting in feet
A-West	1	137,150	1,031,900
A-West	2	139,100	1,031,050
A-West	3	140,500	1,035,900
A-West	4	136,650	1,037,000
A-West	5	136,100	1,034,150
A-East	1	137,750	1,040,850
A-East	2	141,550	1,039,750
A-East	3	143,100	1,044,100
A-East	4	141,700	1,044,900
A-East	5	138,550	1,043,450
B-West	1	136,950	1,057,900
B-West	2	138,100	1,057,600
B-West	3	138,400	1,058,750
B-West	4	137,250	1,059,100

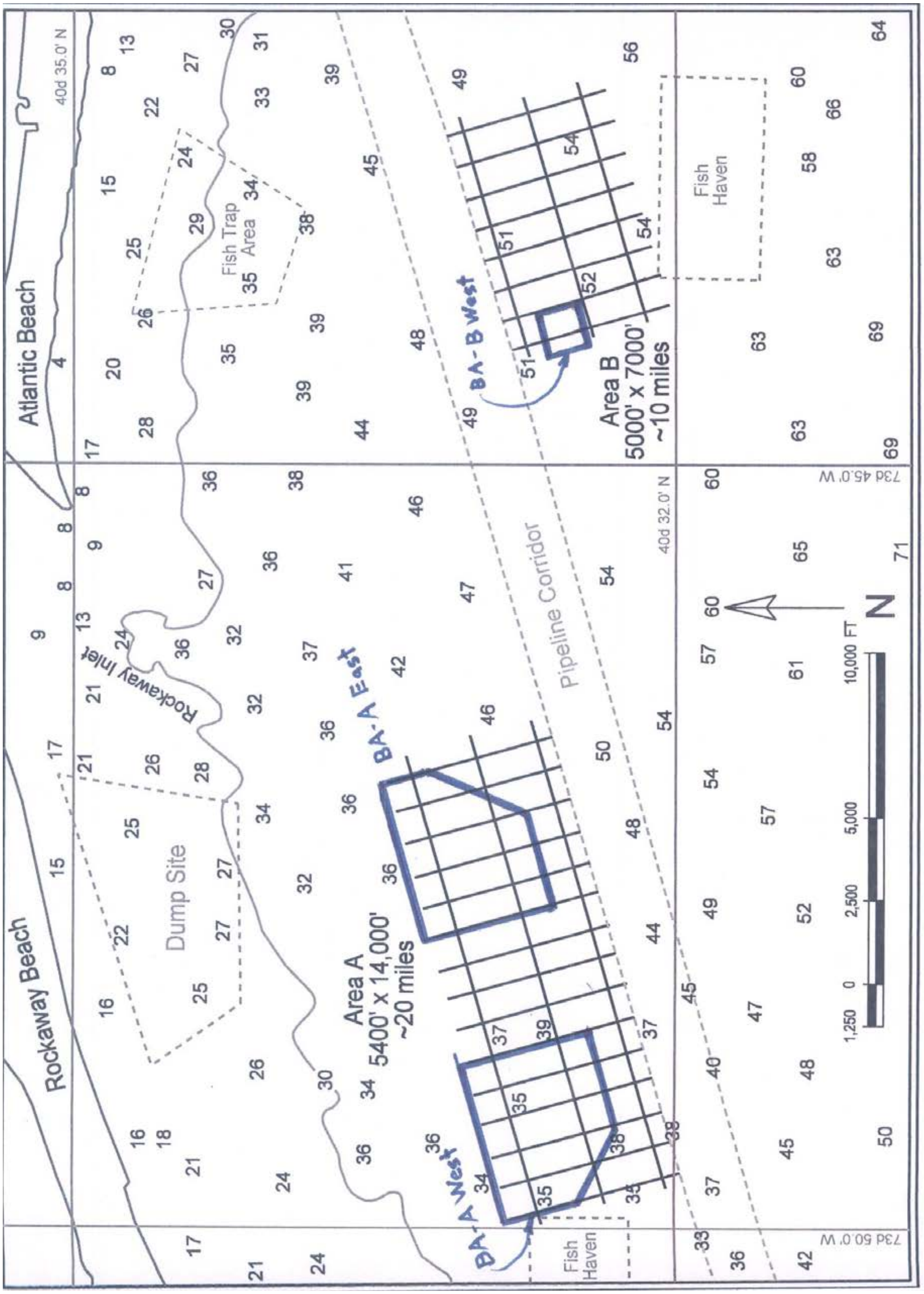


Figure B-9: Borrow Area Location Map

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