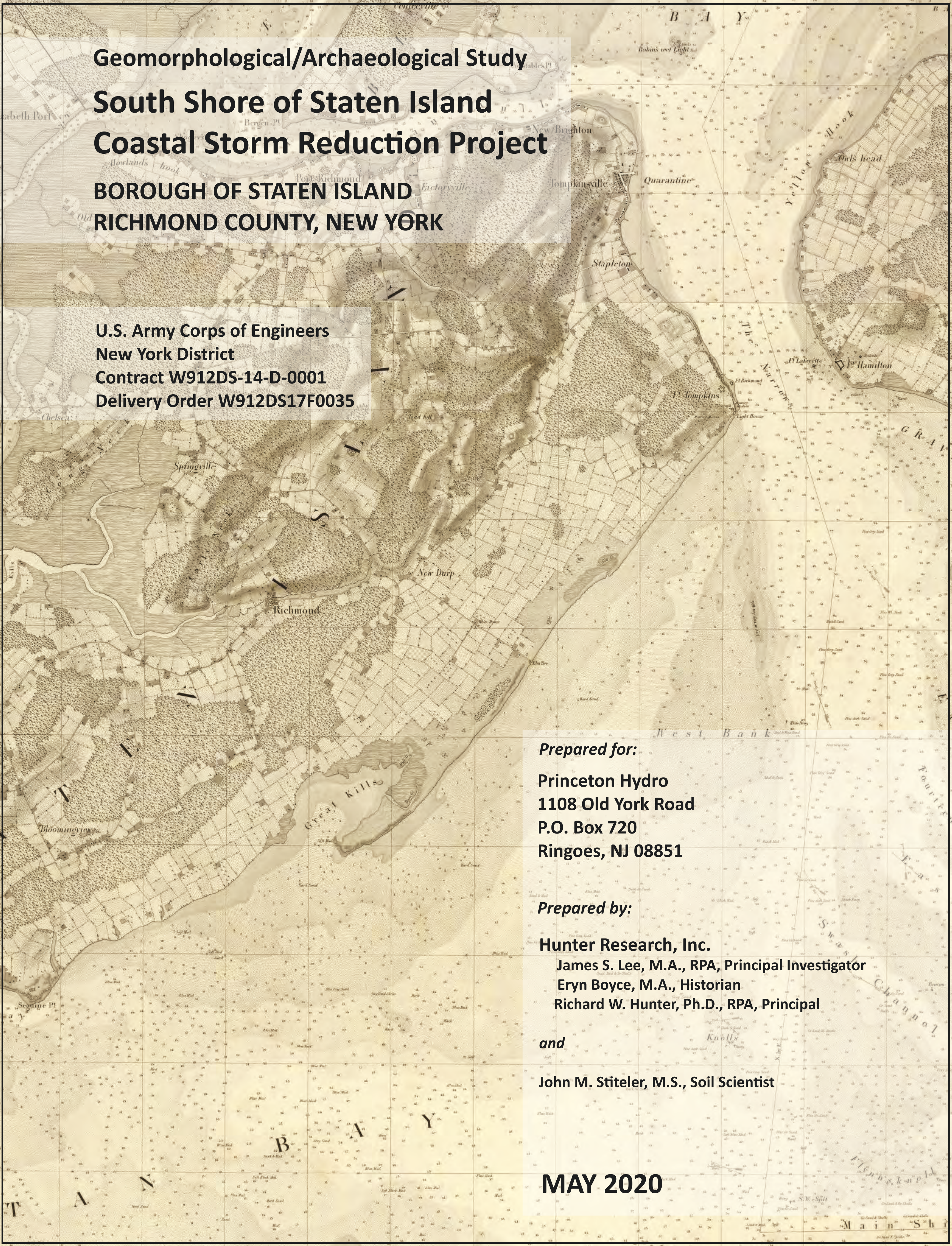

Geomorphological/Archaeological Study

South Shore of Staten Island Coastal Storm Reduction Project

BOROUGH OF STATEN ISLAND
RICHMOND COUNTY, NEW YORK

U.S. Army Corps of Engineers
New York District
Contract W912DS-14-D-0001
Delivery Order W912DS17F0035

Prepared for:

Princeton Hydro
1108 Old York Road
P.O. Box 720
Ringoes, NJ 08851

Prepared by:

Hunter Research, Inc.
James S. Lee, M.A., RPA, Principal Investigator
Eryn Boyce, M.A., Historian
Richard W. Hunter, Ph.D., RPA, Principal

and

John M. Stiteler, M.S., Soil Scientist

MAY 2020

HUNTER RESEARCH

GEOMORPHOLOGICAL/ARCHAEOLOGICAL STUDY
SOUTH SHORE OF STATEN ISLAND
COASTAL STORM REDUCTION PROJECT
BOROUGH OF STATEN ISLAND
RICHMOND COUNTY, NEW YORK

DRAFT

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MAY 2020

MANAGEMENT SUMMARY

A geomorphological/archaeological study was carried out in connection with proposed South Shore of Staten Island Coastal Storm Reduction Project in the Borough of Staten Island, Richmond County, New York. This work was carried out by Hunter Research, Inc. under contract to Princeton Hydro for the New York District of the U.S. Army Corps of Engineers (USACE) as part of project compliance with Section 106 of the National Historic Preservation Act of 1966 and related federal regulations. John Stiteler, Soil Scientist, worked as a subcontractor to Hunter Research, providing geomorphological services.

Work tasks completed as part of this study involved the following: background and historical research; preparation of a site health and safety plan; geoarchaeological monitoring of the excavation of borings; sediment testing; data analysis; and preparation of this report. This study was performed as a sequel to an earlier, broad-based Phase I feasibility study completed by Panamerican Consultants, Inc. in 2005 and specifically addressed through geoarchaeological analysis the potential for deep-buried prehistoric archaeological resources along the project alignment. In addition, the work scope included historical research and analysis of the Lake tide mill site in Great Kills.

Fieldwork entailed the project geomorphologist/archaeologist monitoring 29 of 38 split-spoon borings and 14 Geoprobe borings at various location along the 5.3-mile-long project alignment. Core samples were submitted for radiocarbon dating (28 dates assayed), pollen analysis, macrobotanical analysis and particle size analysis, with specialist reports in each case being appended to this report.

Geomorphological/archaeological assessment indicates that there are substantial portions of the project alignment that hold little to no potential for yielding intact buried land surfaces and significant prehistoric or historic archaeological remains. However, three locations have been identified, where there exists some prospect of prehistoric and/or historic archaeological resources surviving within the project's Area of Potential Effect (APE). These locations are as follows:

- An area measuring roughly 225 feet southwest/northeast by 100 feet southeast/northwest on the southeast side of Hylan Boulevard, northeast of Mill Creek, where a developed subsoil was identified in alluvial soils and may have prehistoric archaeological potential. Further investigation of this area will be complicated by the existence of contaminated soils within the depth range and horizontal limits of the zone of archaeological interest.

- A somewhat longer section of the project alignment extending from the southwestern end of Cedar Grove Beach to the southeastern corner of Miller Field where intermittent evidence of a buried A horizon and a thin but relatively stable soil profile were observed. This area is considered to have both prehistoric and historic archaeological potential. Historic archaeological potential is concentrated around the southeast end of New Dorp Lane where evidence could survive of two 19th-century lighthouses and a lighthouse keeper's station, at least two turn-of-the 20th-century hotels, bathhouses and a hospital, as well as possible earlier features from the late 17th and 18th centuries.

- An area measuring roughly 400 feet southwest/northeast by 300 feet southeast/northwest on the northeast side of Ocean Avenue at the base of the upland at the southwestern end of Fort Wadsworth. This area is considered to have both prehistoric and historic archaeological potential with resources of interest perhaps lying at depths of up to ten feet below the present ground surface. Historic archaeological potential may include Contact period and early historic remains associated with Oude Dorp, the first European permanent settlement on Staten Island established in the early 1660s.

For each of these locations, recommendations are offered for further study as part of continuing project compliance with the Section 106 process. All three of these locations lie within the limits of the Gateway National Recreation Area and further study involving archaeological excavation will require issuance of Archaeological Resources Protection Act (ARPA) permits by the National Park Service.

The site of the Lake tide mill will not be affected by the proposed project. No further study of this site is considered necessary.

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ACKNOWLEDGMENTS

Hunter Research and John Stiteler gratefully acknowledge several U.S. Army Corps of Engineers staff archaeologists at the New York District who, from 2017 until 2020 successively administered the work described in this report: Lynn Rakos; Nancy Brighton; Carissa Scarpa; and Anna Jansson. All provided unfailing assistance in providing project-related materials, overseeing research and fieldwork, and coordinating our activities with project engineers and various agency officials. We also worked collaboratively with several staff from the Army Corps' Baltimore District in the field and laboratory, conducting core drilling and analyzing samples. Our thanks are extended to David L. Tucker, Geotechnical Engineer, John Blackson, Matt Cook and Genet Tulu of the drill crew, and R. Estes and D. Ray of the Materials and Instrumentation Unit, who undertook particle size analysis of several soil samples. We also acknowledge Geoff Goll of Princeton Hydro for his firm's assistance in administering this project as the prime contractor.

Thank are due to the staffs of the New York State Historic Preservation Office, the New York City Landmarks Preservation Commission, the Staten Island Museum and the Staten Island Historical Society, who assisted this study by providing access to relevant archival and research materials.

A number of specialists lent their expertise to this study. We gratefully acknowledge the contributions of Beta Analytic Inc (radiocarbon dating), John Jones (pollen analysis) and Justine McKnight (macrobotanical analysis).

The bulk of the work completed for this study was carried out by John Stiteler, who reviewed the relevant background research materials, monitored the borings in the field, analyzed and interpreted the recovered soils data, arranged for specialist analyses, and wrote much of this report. Overall direction for this project was provided by Richard Hunter and several other Hunter Research staff played a critical role in its completion. Background research for this survey was performed by Eryn Boyce and James Lee. The report graphics were drafted by Evan Mydlowski. Final report coordination and assembly were undertaken by James Lee. This report was jointly authored by John Stiteler, James Lee, Eryn Boyce and Richard Hunter. Final editing was carried out by Richard Hunter.

Richard W. Hunter, Ph.D., RPA
Principal

John Stiteler, M.A., Soil Scientist

Chapter 1

INTRODUCTION

A. PROJECT DESCRIPTION AND SCOPE-OF-WORK

This report presents the results of a geomorphological/archaeological study carried out in connection with the South Shore of Staten Island Coastal Storm Reduction Project in the Borough of Staten Island, Richmond County, New York (Figure 1.1). This study was carried out by Hunter Research, Inc. and John Stiteler, Soil Scientist, under contract to Princeton Hydro for the New York District of the U.S. Army Corps of Engineers (USACE) as part of project compliance with Section 106 of the National Historic Preservation Act of 1966 (as amended through 1992) and the Advisory Council on Historic Preservation Procedures for the Protection of Historic and Cultural Properties (36 CFR Part 800). The work has been conducted in the project's Preconstruction Engineering and Design (PED) phase in accordance with a Programmatic Agreement (PA) signed in 2016 by the U.S. Army Corps of Engineers, New York District, the National Park Service and the New York State Historic Preservation Office (NYSHPO).

The South Shore of Staten Island Coastal Storm Reduction Project will involve the construction of flood risk management features consisting primarily of a buried seawall and armored levee along a majority of the Fort Wadsworth to Oakwood Beach reach of the Staten Island shoreline (Figure 1.2). This linear construction element will serve as the first line of defense against coastal surge flooding and wave forces. The flood risk management measures are divided into four sections, from southwest to northeast, as follows:

- Reaches A-1 and A-2 – construction of an earthen levee 3,400 feet in length with a crest elevation of 16.9 feet NAVD88
- Reach A-3 – construction of a vertical floodwall 1,800 feet in length with a crest elevation of 19.4 feet NAVD88
- Reach A-4 – construction of a buried seawall 22,700 feet with a crest elevation of 19.4 feet NAVD88

In addition, the project incorporates an interior drainage plan, which includes:

- Acquisition and preservation of 301 acres of open space
- Excavation of a 188-acre pond with removal of phragmites monoculture and seeding/re-planting of ponds with native vegetation, creating 46 acres of emergent wetland habitat
- Construction of tide gates and gate chambers along the project alignment
- Raising of three roads: Seaview Avenue (at Father Capodanno Boulevard), Kissam Avenue and Mill Road
- Other minor interior drainage measures in accordance with the Minimum Facility Plan as defined in the Final FR/EIS

The scope-of-work for the geomorphological/archaeological study laid out six tasks: a review of previous research coupled with supplementary targeted background research on the Lake tide mill site at the southwestern end of the project alignment; preparation of a health and safety plan; monitoring of the excavation

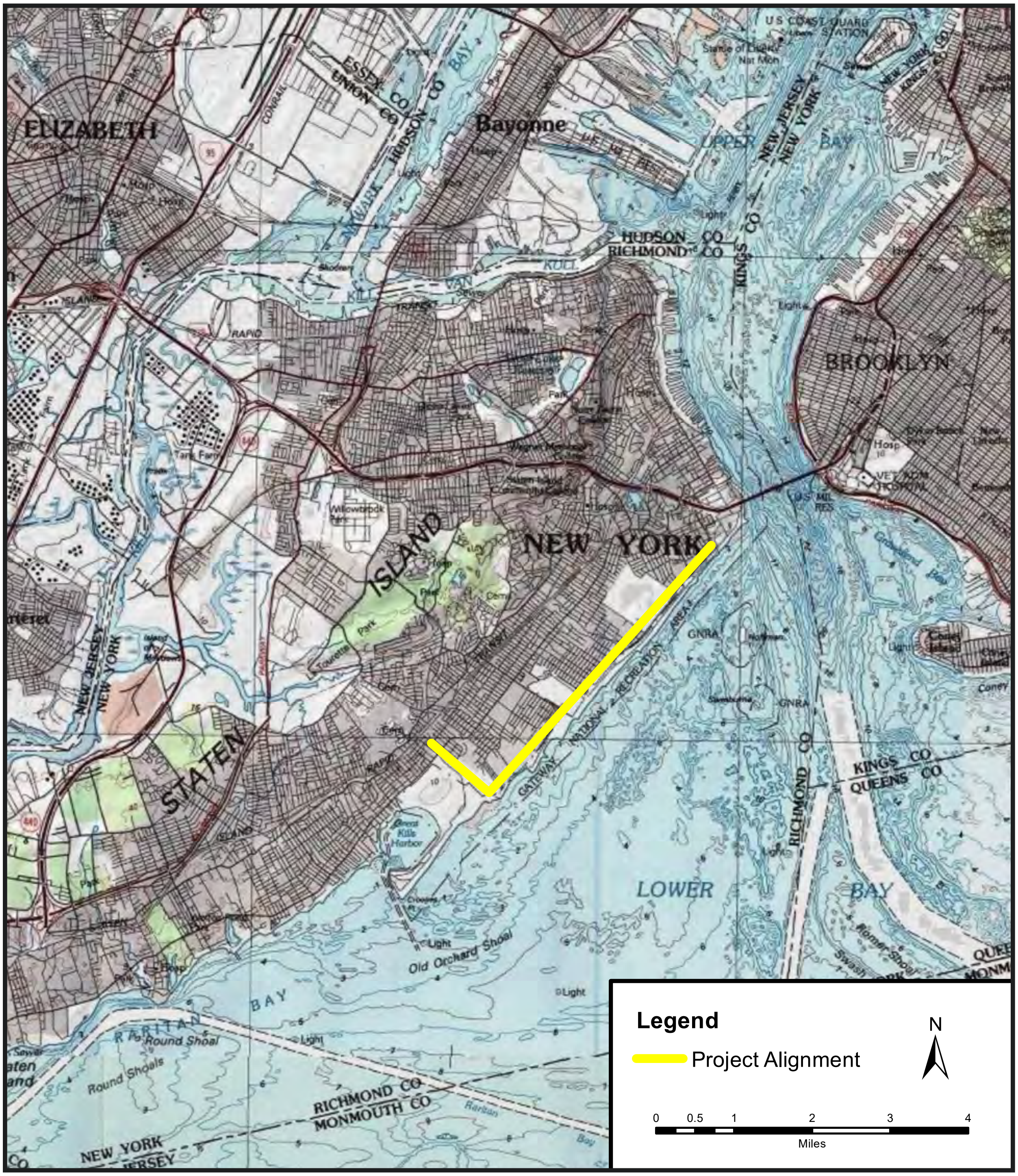

Figure 1.1. Location of Project. Source: National Geographic Society 2013.

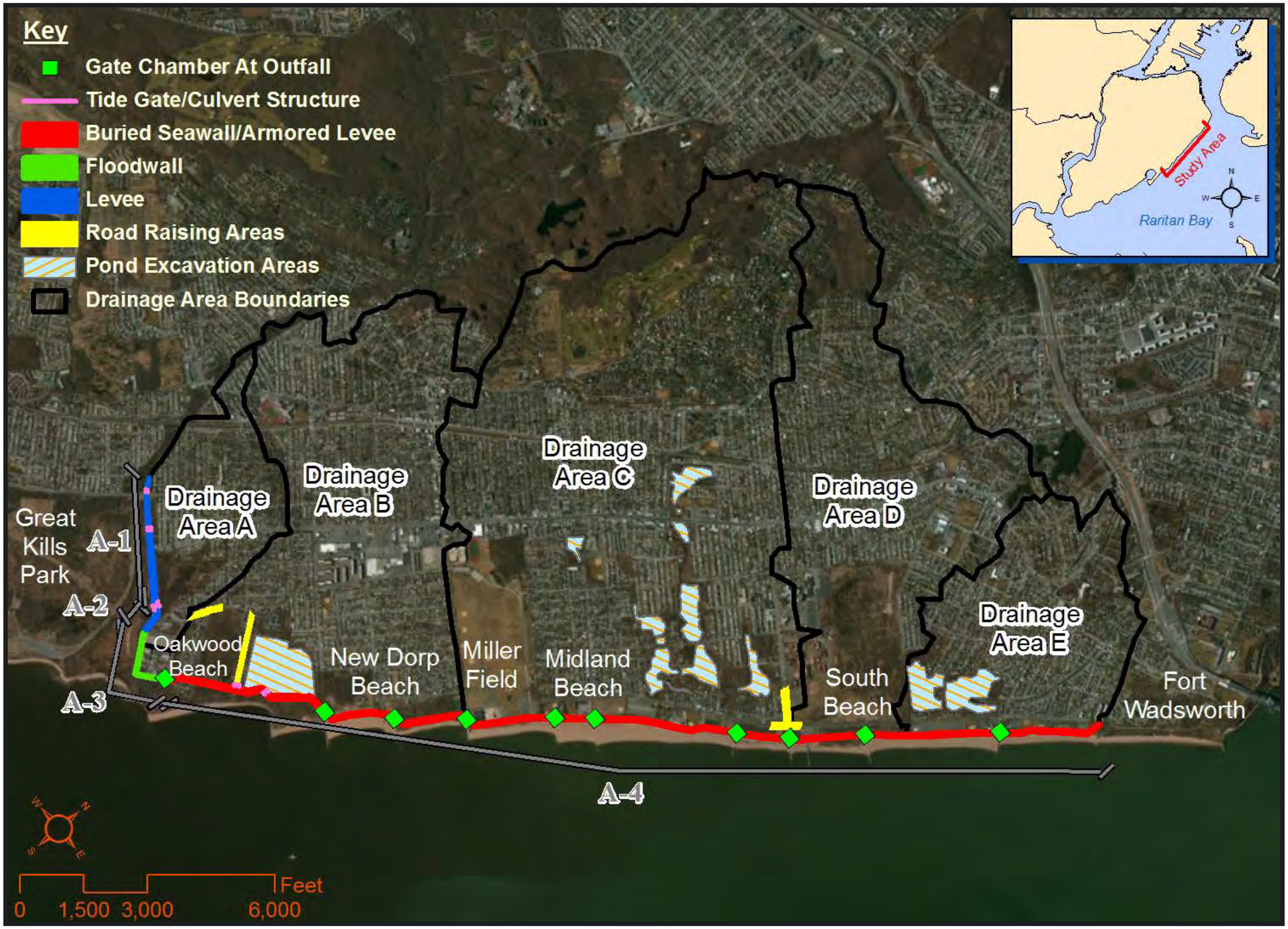

Figure 1.2. Key Aerial Photograph Showing Location of Project Alignment. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

of borings by the project geomorphologist; sediment testing; data analysis; preparation of this report; and project management (Appendix A). This study represents one in a series of successive cultural resource surveys and assessments relating to the South Shore of Staten Island Coastal Storm Reduction Project and its predecessor projects extending back into the late 1970s, which are detailed below in Section C of this chapter.

The main focus of the current study was a geomorphological and archaeological assessment of the potential for deeply buried landforms and associated Native American sites within the Area of Potential Effect (APE) along the project alignment. This assessment, conducted by a qualified geoarchaeologist experienced in the fields of geomorphology and archaeology, entailed gaining a familiarization with other recent paleogeographic studies of the Staten Island shoreline and monitoring of a series of project-specific geotechnical borings. As a separate task, historical research was also conducted into the historic Lake tide mill site, located within or close to the APE in the Oakwood Beach area. This task entailed primary archival research, historic map analysis and site inspection.

The contract agreement for this work is dated August 18, 2017. Fieldwork was carried out at various times, as access to property and winter weather permitted, between August and November of 2018 and in April and May of 2019. Background research was performed at various times over the fall of 2018 and intermittently over the fall and winter of 2019-2020. Senior Hunter Research personnel who were responsible for undertaking these investigations met the federal standards for qualified professional historians and archaeologists as specified in 36 CFR 66.3(b)(2) and 36 CFR 61. James Lee served as Principal Investigator for this work, while John Stiteler, Soil Scientist, working as an independent subcontractor to Hunter Research, provided geomorphological expertise. Eryn Boyce, Principal Historian, undertook the bulk of the historical research with assistance from Richard Hunter, who also served as Project Manager.

B. PREVIOUS RESEARCH AND PRINCIPAL SOURCES OF INFORMATION

The South Shore of Staten Island Coastal Storm Reduction Project and its predecessor projects has been the subject of several previous cultural resource surveys, although the current study represents the first time that detailed geomorphological investigations have taken place along the Fort Wadsworth to Oakwood Beach section of the Staten Island shoreline. Beginning in the late 1970s, a reconnaissance-level cultural resource survey was performed as part of what was then referred to as a beach erosion control and hurricane protection project, assembling and preliminarily evaluating baseline historical and archaeological information for this section of shoreline (Lipson *et al.* 1978). Concurrently, the National Park Service inventoried cultural resources in the Gateway National Recreation Area, identifying a number of Native American sites, including one Paleo-Indian fluted point find spot, in the Great Kills Park area, just south of the current project alignment (John Milner Associates 1978). In the mid-1990s, the earlier cultural resources reconnaissance was updated with particular attention being given to historic map analysis and recommendations were made for follow-up studies (Rakos 1994). An initial investigation at the southern Oakwood Beach end of the alignment identified a Native American site that was subsequently destroyed by private development (Rakos 1996) and then the entire project alignment was the subject of a Phase I cultural resource survey (Panamerican Consultants, Inc. 2005).

This latter survey, which provides the underpinning for the current study, included both archaeological testing and historic architectural survey, resulting in recommendations for more targeted archaeological and geomorphological investigations involving borings at selected locations along the project alignment/shoreline and in interior areas where drainage improvements are planned. No Native American archaeological sites were identified, but concern was expressed that deep-buried land surfaces with associated archaeological remains might survive below marsh deposits in the littoral zone. This conclusion was generally supported by a broader-based geomorphological study performed for the New York and New Jersey Harbor Navigation Project (Schuldenrein *et al.* 2014 [see below for further discussion]).

Over the past half century, a variety of other cultural resource investigations has been carried out in northeastern Staten Island in the vicinity of the current project. The vast majority of these have been Phase IA-level archaeological documentary studies, which have not included in-field archaeological testing, and none have identified critically important archaeological resources. A series of studies were performed in an around the Oakwood Beach Wastewater Treatment Plant in the 1980s and early 1990s in connection with water control and sewerage improvements (e.g., Greenhouse Consultants 1990), while, more recently, Phase IA studies have been completed for the South Beach and Oakwood Beach watersheds as part of the New York City Bluebelt Program (Historical Perspectives 2011a, 2011b), for the rehabilitation of Cedar Grove Beach (Historical Perspectives 2010), for reconstruction and drainage improvements along South Beach (AKRF 2014) and for Ocean Breeze Park (Chrysalis 2008).

Turning more specifically to the topic of geomorphological and archaeological research, a review of the pertinent literature indicates that minimal geoarchaeological fieldwork has been conducted on Staten Island and none on the terrestrial portions of the South Shore. In conjunction with a study of several proposed pipeline routes on the northwest corner of the island, an archaeological survey was conducted from 2010 to 2013 by the Public Archaeology Laboratory (PAL), based in Pawtucket, Rhode Island. This setting, which includes parts of the neighborhoods of Richmond Terrace, Mariners Harbor and Graniteville, is bordered to the north by the Kill Van Kull and on the west by the Arthur Kill; this is a relatively sheltered area, not subject to the high wave energy which impinges on the Atlantic shore setting of the current study. Much of the area also lies at elevations between 10 and 20 feet amsl, i.e. greater than the general elevations of the current project alignment. As an adjunct to the PAL survey, 52 geoarchaeological borings were recommended in areas where conventional shovel testing was deemed inadequate (Chernau 2012).

As of late 2012, 31 geoarchaeological borings had been conducted, all monitored and analyzed by personnel from Geoarchaeological Research Associates (GRA) (Chernau 2011b). Fill was ubiquitous throughout the study area and in many cases extended to the limit of boring at 20 feet bs. In 24 of the borings, fill extended to the base of excavation at 20 feet bs or was underlain by peat, estuarine deposits, sands showing no evidence of soil development, high-energy fluvial or shoreline deposits, or some combination of these (Chernau 2011a; 2011b; 2012). The material identified beneath fill in these borings was considered not to be archaeologically sensitive. Paleosols were identified beneath fill in three borings (RCH-4H-ARC-8; RCH-4H-ARC-13; RCH-6-ARC-1); in six other borings "possible paleosols" were identified beneath fill or examination of the cores was reported to "suggest the presence of intact Holocene soils that could contain pre-contact cultural deposits, although these soils are for the most part deeply buried below the project pipeline vertical APE" (Chernau 2011b; 2012). Opening elevations amsl for the borings were not reported in the reports reviewed for this study.

Several sampling programs employing split-spoon borings and vibracores have been conducted in the Lower Harbor offshore from the current project alignment (La Porta *et al.* 1999; Schuldenrein *et al.* 2014). In addition to fieldwork conducted in 2006 for the Schuldenrein *et al.* study, the comprehensive report collated and incorporated previous Geoarchaeological Research Associates coring results and those of other researchers (Wagner and Siegel 1997 and La Porta *et al.* 1999). In the La Porta *et al.* study, the testing area closest to the project alignment was conducted in an area designated Lower Bay Zone 2, just offshore from the Oakwood Marsh and New Dorp Upland zones of the current study. A total of eight vibracores and split-spoon borings were conducted in an area approximately one mile to three miles from the shore. The researchers concluded that "[t]he shades of brown coloring of much of the sediments suggests that they are reworked glacial outwash associated with [Merguerian and Sanders 1994] Till IV; gray silts and fine-grained sands that are likely post-glacial in age are relatively thin (<3 feet). The brown color and coarse nature of the sands suggests the presence of a thick wedge of glacial outwash occurring throughout the section. There appears to be very little preservation of intact Holocene sediments within these cores."

The Lower Bay Zone 1 of the La Porta *et al.* study was located southwest of Zone 2, offshore from the Tottenville neighborhood of Staten Island and near the head of Raritan Bay. The testing program in Zone 1 comprised a total of seven split-spoon borings and vibracores. Recovery in the upper portion of three vibracores and one boring (B-110) each consisted of 20 to 30 feet of "dark gray, homogeneous silty clay or clay with rare shell fragments, topped by a thin layer (<3 feet) of black, organic, foul-smelling mud." Recovery in the remaining three borings was "somewhat sandier and siltier." Below 30 feet, recovery in all borings consisted of sands, silts and clays. In interpreting the borings, the researchers state that "Core B-110 exemplifies the presence of intact Holocene to Pleistocene sediments at extremely shallow depths, possibly to as much as 30 feet. The siltier/sandier units below 30 feet may be interpreted as Late Pleistocene outwash; however, all other core samples taken below 30 feet indicate reworked Cretaceous and Tertiary pollen, suggesting the presence of an unconformity, or severe channel scour and headland erosion, possibly coincident with the Last Glacial Maximum (prior to possible human occupation). The presence of intact Holocene sediments at shallow depths, as indicated in core B-110, sheds supportive light on current models of headland erosion of archaeological sites during periods of slow-rising sea level (Belknap and Kraft 1977, 1981). Those culturally sensitive areas contiguous with barrier islands and marine transgressive lagoon sequences may contain intact and sealed cultural deposits."

For the Schuldenrein *et al.* study, a total of nine cores were taken in two transects of vibracore borings conducted across lower Raritan Bay, from Seguine Point on Staten Island to Conaskonk Point (Union Beach), New Jersey and from just south of Great Kills Harbor, Staten Island to Keansburg, New Jersey. The stratigraphy of the Seguine Point borings consisted of: marine sands; bedded sands and gravel exhibiting stacked fining-upward sequences "which may be associated with glacio-fluvial conditions"; possible glacial till or diamict (observed in only one boring; and deeply weathered Upper Cretaceous sands, silts and clays. The report states that "No paleosols or textural unconformities which would suggest preserved stable surfaces during this depositional period were observed." The stratigraphy of the Keansburg transect consisted of: reworked marine sands, silts and clays; possible reworked beach sand (observed in only one core); sands and weathered clays associated with alluvial and colluvial settings along a submerged reach of creek (observed in only one boring); stacked fining-upward sequences of sand and gravel analogous to the possible glacio-fluvial deposits in the first transect; and highly weathered Cretaceous sands.

Schuldenrein *et al.* note that the south shore of Staten Island – the setting of the current study – is the high wave energy shore of the bay. They assign most of the area offshore from the current project alignment a low archaeological sensitivity, i.e., a low potential to contain submerged preserved surfaces. They assign a moderate archaeological sensitivity to the area offshore from the Oakwood Marsh Zone – a bathymetrically shallow area known as the Old Orchard Shoal – because of the potential for the "shoal" to be a remnant of a drowned barrier island. This is the same area characterized by La Porta *et al.* as having only a thin cap of post-glacial sediment over glacial outwash.

Finally, the Lake tide mill, the subject of site-specific historical research under the current work scope, while certainly a well-known site in the Oakwood Marsh from the early 18th through the early 20th centuries, has not been previously studied in detail. As part of the current study, deeds and surrogates' records were examined to establish a sequence of land ownership, while other primary and secondary sources (e.g., newspapers, tax and census records, published and manuscript materials) were reviewed to flesh out the land use history of the mill and mill property. The bulk of this research was conducted online and in person at the Staten Island Museum and the Staten Island Historical Society. Particular attention was given to historic maps and aerial photographs, the most informative of which are reproduced in Chapter 4B below and have been of assistance in pinning down the location of the mill. A more general history of the project alignment is provided in Chapter 4A as context for the geomorphological/archaeological analysis.

C. GEOMORPHOLOGICAL/ ARCHAEOLOGICAL RESEARCH METHODS

This geomorphological/archaeological study centered on the monitoring and analysis of a series of geotechnical borings excavated at intervals along the project alignment and in selected locations in the interior drainage areas. The boring procedure involved the recovery of 38 cores using a truck-mounted split-spoon coring rig operated by the Baltimore District, U.S. Army Corps of Engineers, Field Exploration Unit. Twenty-nine of the 38 borings were observed, and the resultant core samples examined, by the project geomorphologist. Fourteen Geoprobe borings, excavated to a lesser depth of between 15 and 30 feet, were similarly observed and the soil samples examined. Limited judgmental manual bucket augering was also conducted in selected locations by the project geomorphologist and most of the accessible portions of project alignment and interior drainage areas were visited on foot

The soil profile at each sampling location was described using standard field parameters (Munsell color, soil texture, soil structure, rock fragment content, presence of redoximorphic features, etc.) (Appendix B). Particular attention was paid to those characteristics pertinent to the archaeological potential of the study area (e.g., age of the sediments, depositional dynamics, the potential for the presence of deeply buried cultural material and the presence of buried developed surfaces (Ab horizons) within the sediment column.

Following field examination of the soil cores obtained through the various extraction methodologies, subsamples of the sediments were retained for further analysis as deemed appropriate by the project geomorphologist. These samples were labeled as to provenience and depth and appropriately preserved for specialized analysis. Following completion of the fieldwork, samples were prioritized as to their potential to yield data relevant to the study and submitted as appropriate for further testing. Analyses were conducted for radiocarbon dating (Appendix C), pollen analysis (Appendix D), macrobotanical analysis (Appendix E), diatom paleoenvironmental analysis (Appendix F) and soil particle size (Appendix G); all these analyses were conducted by outside specialists.

D. CURRENT STUDY AREA CONDITIONS

The study area is located along the southeastern (seaward) edge of Staten Island, the southernmost borough of New York City and a municipal entity that is co-terminous with Richmond County. The island is largely residential but is also home to light industry and shipping facilities, most notably along its north and western shores that border the Kill Van Kull and the Arthur Kill respectively. Staten Island is the least densely populated of the five New York City boroughs; thousands of acres of open area are set aside as county, state and national parkland and include large areas of coastal salt marsh, inland wetlands, and steep and rocky areas at the heart of the island.

The Atlantic Ocean coastline of Staten Island trends southwest to northeast and the project study area, extending from Great Kills Park to Fort Wadsworth, roughly corresponds to the northeastern half of the island's shoreline (Figures 1.3a-b; Photographs 1.1-1.8). At the southwestern end of the study area, the project alignment extends southeastward down the former Mill Creek drainage corridor from Hylan Boulevard to the Oakwood Beach Wastewater Treatment Plant. This section of the project alignment, where a 3,400-foot-long earthen levee is planned, marks the northeastern margin of Great Kills Park, an element of the Gateway National Recreation Area. The wastewater treatment plant dominates the southwestern end of the project alignment and will be protected by a floodwall on its southwestern and southeastern sides. The majority of the project alignment between Hylan Boulevard and the Oakwood Beach Wastewater Treatment Plant is characterized by contaminated soils resulting from the burning and dumping of medical and other waste, which prevented geomorphological/archaeological soil testing. The contaminated soils extend from depths of two to up to ten feet below the present ground surface and contain contaminants such as arsenic, lead, PAHs, PCBs, dioxins/Furans, Radium-226, Thorium-232 and Uranium-238.

Following the project alignment northeastward along the shoreline, the current landscape consists of a series of barrier beaches, separated by stone-rubble, timber and/or concrete groynes which presently help to retain and prevent the erosion of sand (Figure 1.3a; Photograph 1.1). Under the project plans, the shoreline from the wastewater treatment plant to Fort Wadsworth will be protected by a buried seawall topped with an armored levee interspersed with short stretches of floodwall. The wastewater treatment plant sits within an area of partially reclaimed marshland that extends northeastward as far as Ebbitts Street and is retained on its seaward side by Oakwood Beach and Cedar Grove Beach. Although formerly lined with beach cabins and other resort structures, this section of shoreline is devoid of buildings as a result of coastal storm damage and subsequent demolition activity. The marshland, referred to throughout this report as the Oakwood Marsh, will be replaced northeast of Kissam Avenue by a pond, while segments of Kissam Avenue and Mill Road will be raised (Figure 1.3a; Photographs 1.2 and 1.3).

Northeast of Cedar Grove Beach, the shoreline from Ebbitts Street to Midland Avenue, which includes New Dorp Beach and the southern end of Midland Beach, encases a zone of upland, referred to throughout this report as the New Dorp Upland (Figure 1.3a; Photographs 1.4 and 1.5). New Dorp Lane, which runs perpendicular to the shore down the axis of the upland is bordered by the residential neighborhood of

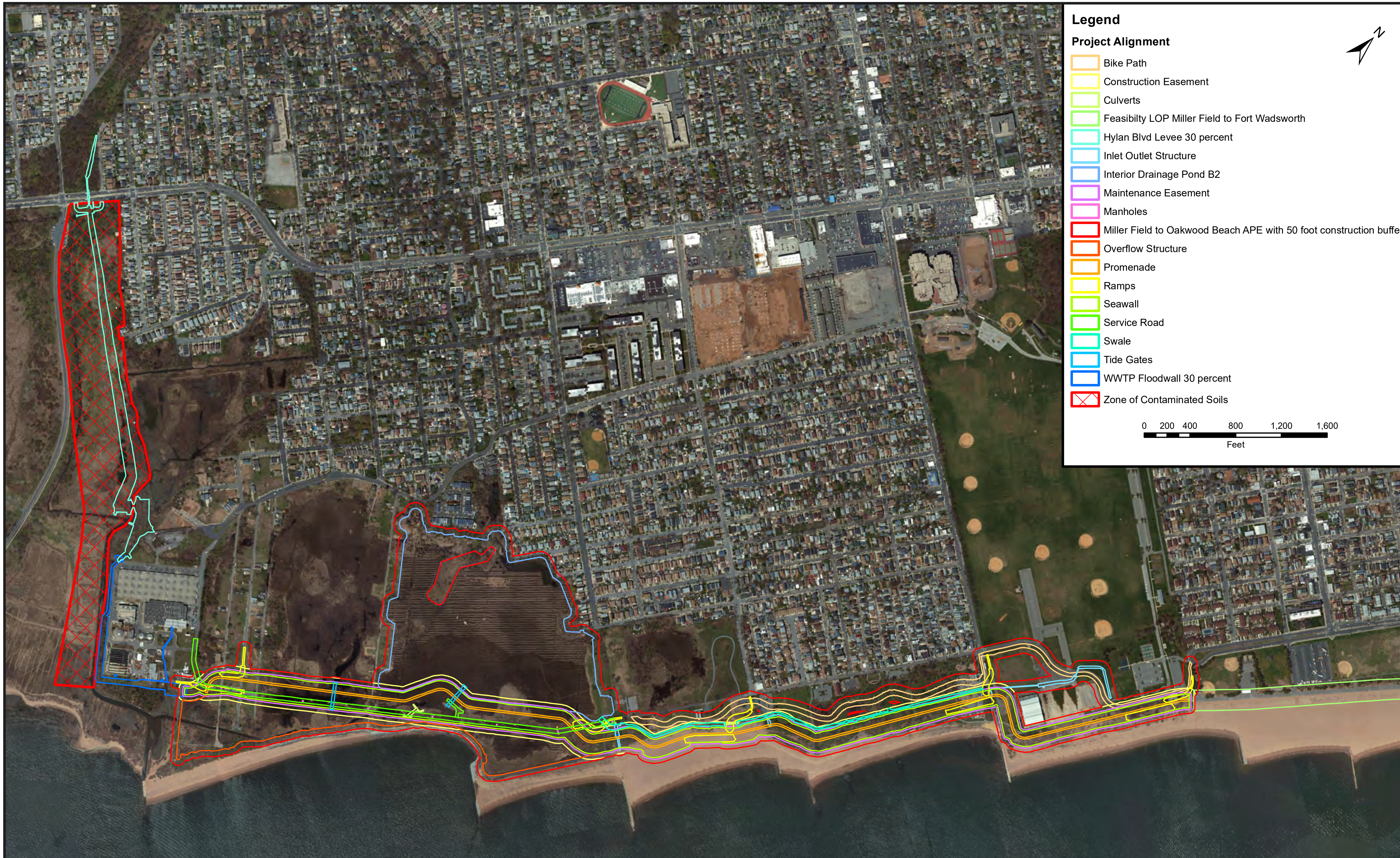

Figure 1.3a. Aerial Photograph Showing Project Alignment Details (Southwest Portion). Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

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Figure 1.3b. Aerial Photograph Showing Project Alignment Details (Northeast Portion). Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

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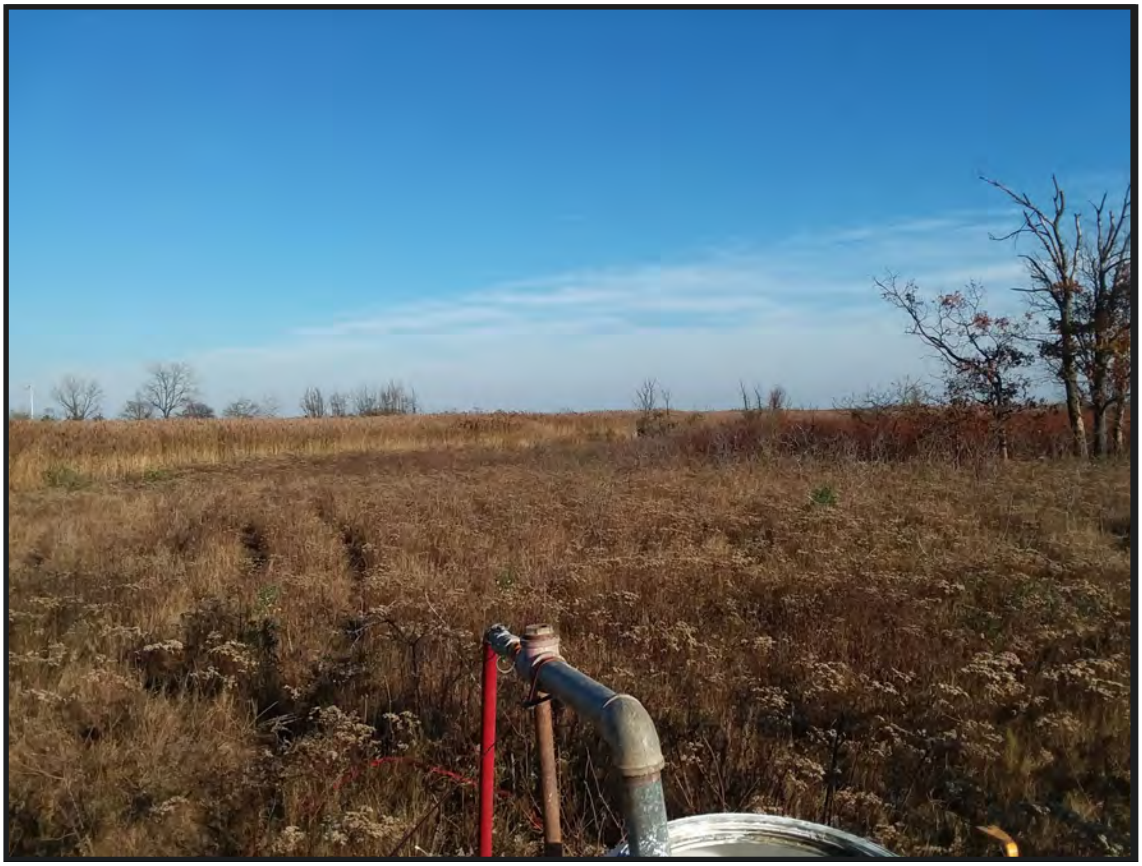
Photograph 1.1. General view of the northeastern end of the project alignment looking northeast toward the Verrazzano Narrows Bridge and Fort Wadsworth from the southern end of Sand Lane near drill hole DH29 (Photographer: John Stiteler, August 2018).

Photograph 1.2. General view of the northeastern end of the project alignment looking southwest along South Beach from the southern end of Sand Lane near drill hole DH29 (Photographer: John Stiteler, August 2018).

Photograph 1.3. General view of the central section of the project alignment looking northeast along Midland Beach from the northeast corner of Miller Field near drill hole DH19 (Photographer: John Stiteler, September 2018).

Photograph 1.4. General view of the central section of the project alignment looking southwest along Midland Beach towards New Dorp Beach from the northeast corner of Miller Field near drill hole DH19 (Photographer: John Stiteler, September 2018).

Photograph 1.5. General view of the central section of the project alignment looking northeast from New Dorp Beach near drill hole DH16 toward the southeast corner of Miller Field (Photographer: John Stiteler, August 2018).



Photograph 1.6. General view of the southwestern end of the project alignment looking northeast across the Oakwood Beach marsh from near drill hole DH11 (Photographer: John Stiteler, November 2018).

Photograph 1.7. View looking southeast showing the southeastern end of Kissam Avenue and the location of drill hole DH10 (Photographer: John Stiteler, November 2018).

Photograph 1.8. General view of the southwestern end of the project alignment looking northeast from the northeast corner of Great Kills Park toward the Oakwood Beach Wastewater Treatment Plant and the locations of drill holes DH7 and DH8A (Photographer: James Lee, May 2019).

New Dorp Beach to the southwest and by Miller Field, a former U.S. Army coastal air station, now part of the Gateway National Recreation Area. Again, there were formerly numerous cabins and other larger beachfront structures, recently destroyed, on the shoreward side of Cedar Grove Avenue.

Northeast of Miller Field, the shoreline along the remainder of the project alignment as far as Fort Wadsworth comprises two long stretches of congruous beachfront, Midland Beach and South Beach, which are paralleled by Father Capodanno Boulevard (Figure 1.3b; Photographs 1.6-1.8). Landward of this highway is an expansive area of partially filled marshland that was historically drained by New Creek. Owing to residential and commercial development in this area, the present-day drainage pattern bears little resemblance to its historic predecessor. The residential neighborhoods of Midland Beach, South Beach/ Ocean Breeze and Arrochar occupy much of the former marshland, portions of which remain as preserved land (e.g., South Beach Wetlands) and made parkland (e.g., Ocean Breeze Park). The project plans envisage several excavated ponds within the area of the former New Creek drainage system (Figure 1.2).

Chapter 2

PALEOENVIRONMENTAL CONTEXT

A. BEDROCK GEOLOGY

The northwestern (landward) half of Staten Island is formed on conglomerate, sandstone, siltstone, and shale of Triassic age (Newark Group); intrusive diabase of Jurassic age; and, most prominently, serpentinite of Ordovician age. The diabase is a part of the more extensive Palisades Sill, exposed along much of the lower Hudson River valley. Serpentinite makes up the highest point on the island, Todt Hill. Unconsolidated deposits of Upper Cretaceous and Upper Pleistocene age make up a skirt extending southwest, southeast, and northeast around this bedrock core. Marine coastal plain deposits of Upper Cretaceous age, belonging to the Raritan Formation, are present southeast of Todt Hill extending beneath the project alignment to the Atlantic shoreline and beyond, as well as west and southwest toward the Arthur Kill (Figures 2.1 and 2.2).

The Raritan Formation on Staten Island differs somewhat from the extensive formation westward in New Jersey and consists of stratified white, light- to dark-gray, and red beds and lenses of clay, silt, and sand. The characteristics of the Raritan Formation on Staten Island have not been fully explored, but Soren (1988) notes that "the upper clay member of the Raritan Formation is known to overlap the Lloyd Sand Member in western Long Island … and seems to overlap the Lloyd in Staten Island." The Lloyd Formation, a product of deltaic and braided stream deposition, consists of "fine- to coarse-grained discontinuous sand and gravel beds with interbedded clay and silt; the sand and gravel beds may contain varying amounts of interstitial clay and silt. The sand grains are generally clear or white, but may also be gray or yellow. They may contain trace amounts of heavy minerals and, locally, lignite and iron oxide concretions" (Garber 1986). Soren (1988) reports that the greatest known thickness of the Cretaceous Raritan Formation on the island is 270 feet near Huguenot, in the south central portion of the island, though it may reach thicknesses of as much as 400 feet. The Raritan Formation on Staten Island is unconformably underlain by bedrock units and unconformably overlain by Upper Pleistocene deposits (Figures 2.2 and 2.3).

B. LATE PLEISTOCENE/HOLOCENE GEOMORPHOLOGY

Glaciology: Based on the known limits of Pleistocene glaciation to the west, the study area has been near or within the furthest extent of continental glacial ice at least three times over the last 2.4 million years. The most recent glacial advance reached its maximum extent at the southern tip of modern Staten Island and Perth Amboy, New Jersey, 20,000 and 22,5000 years before the present (BP). This ice was part of the leading edge of the Hudson-Mohawk Lobe of the Late Wisconsinan (Woodfordian Stage) continental ice mass (Figure 2.4). It is noted here that researchers are not in agreement on the exact timing, sequence, and mechanics of the events at the last glacial maximum or in the early stages of ice recession. Views on the timing of events such as release of water from glacial lakes may differ by thousands of years and there may be disagreement as to whether events such as certain glacial re-advances did in fact occur. The reconstruction given below attempts to integrate differing views, but is by no means comprehensive.

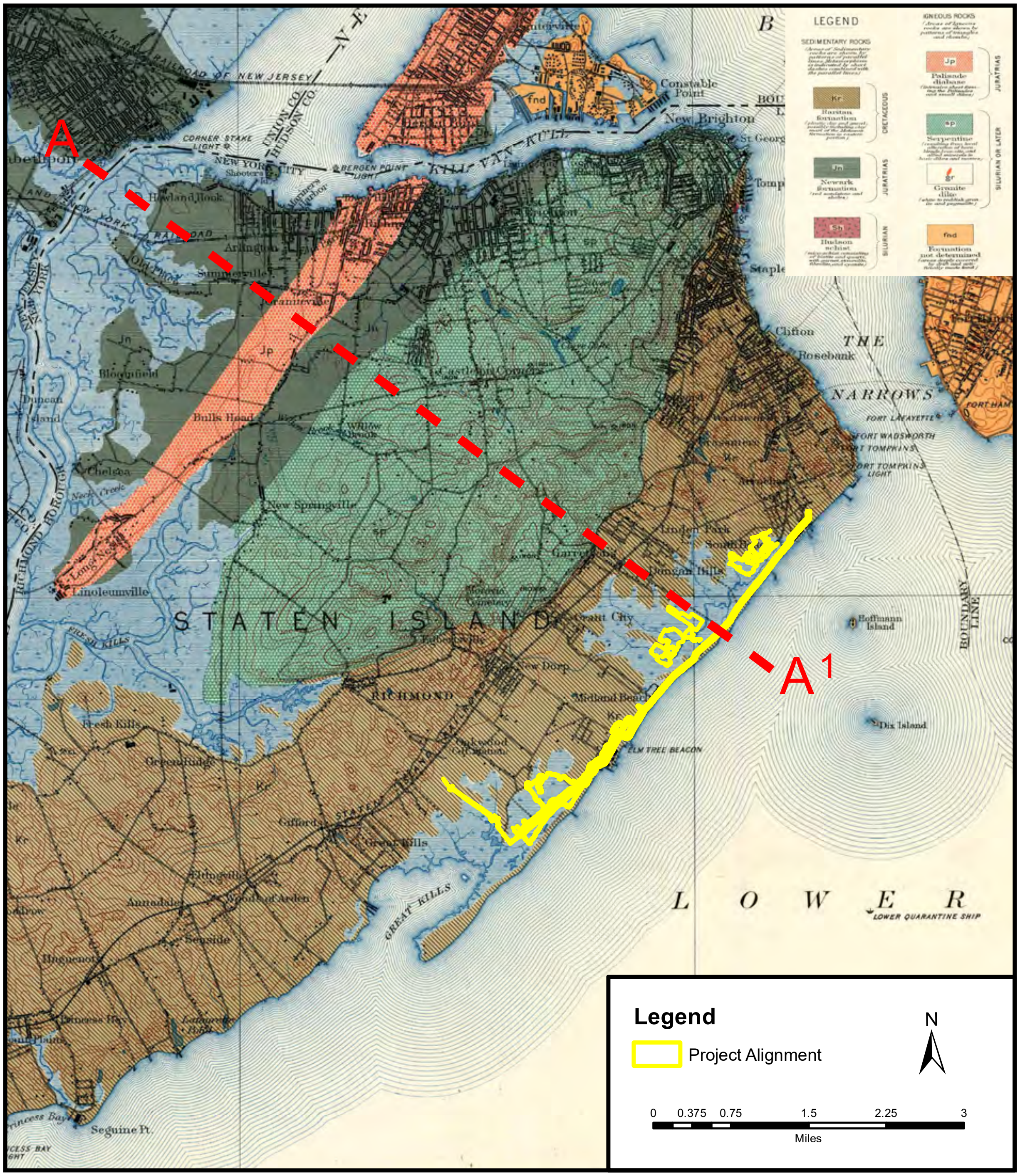


Figure 2.1. Bedrock Geology of Northeastern Staten Island. Source: U.S. Geological Survey, National Geologic Map Database. See Figure 2.2 for geological cross-section.

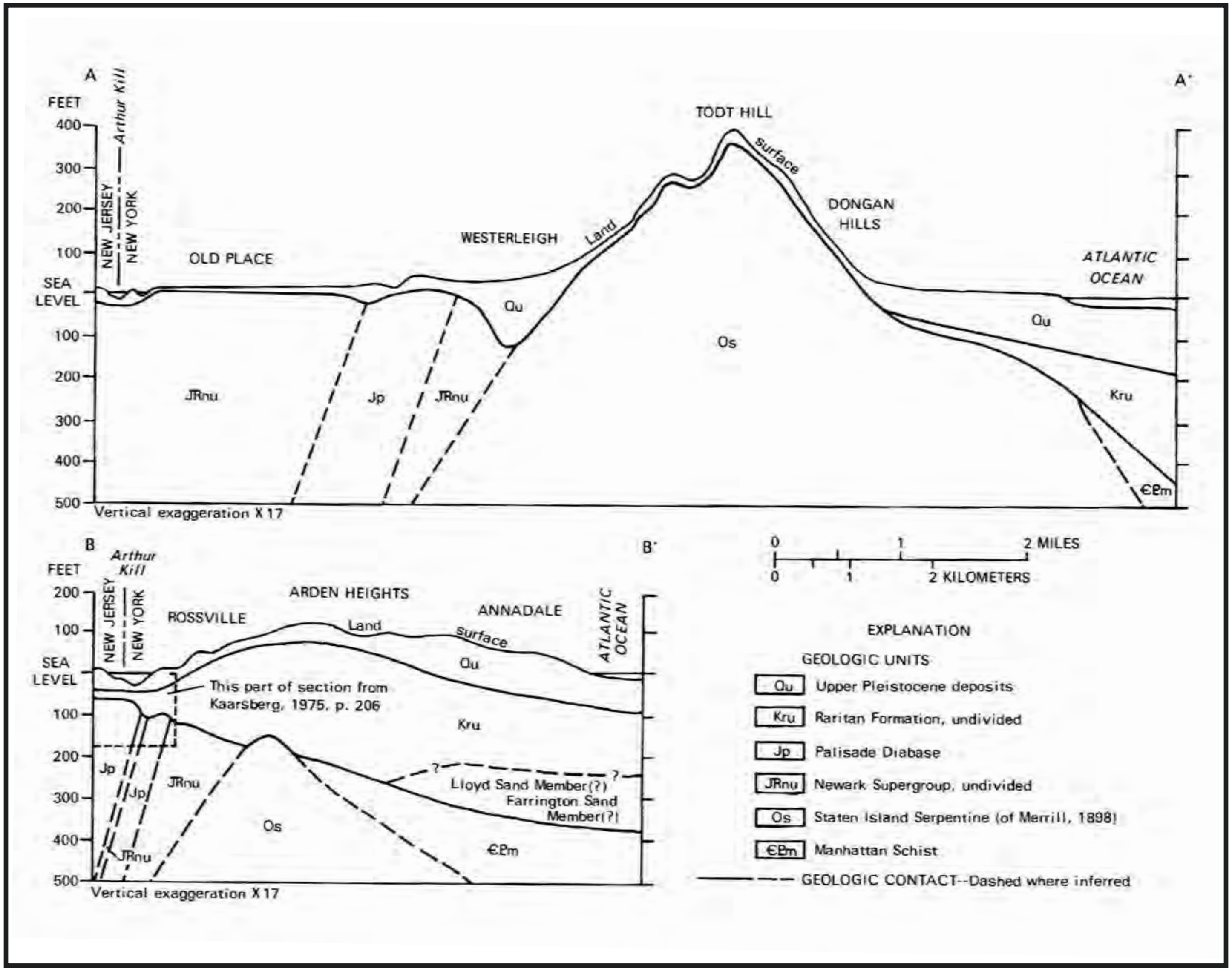


Figure 2.2. Geological Cross-Section of Northeastern Staten Island. Source: Soren 1988:7. See Figures 2.1 and 2.3 for location of geological cross-section A – A1.

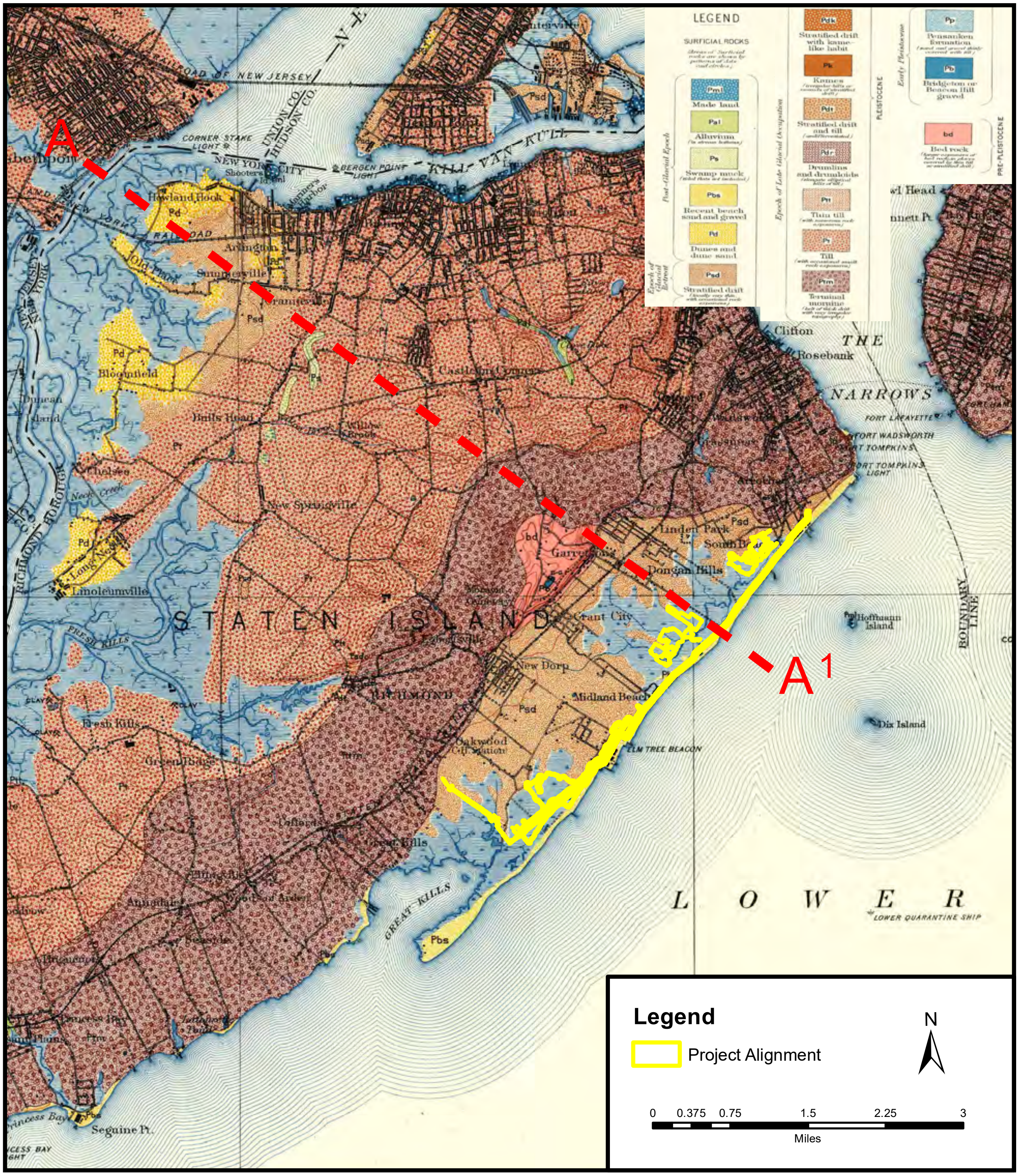


Figure 2.3. Geology of Northeastern Staten Island. Source: U.S. Geological Survey, National Geologic Map Database. See Figure 2.2 for geological cross-section.

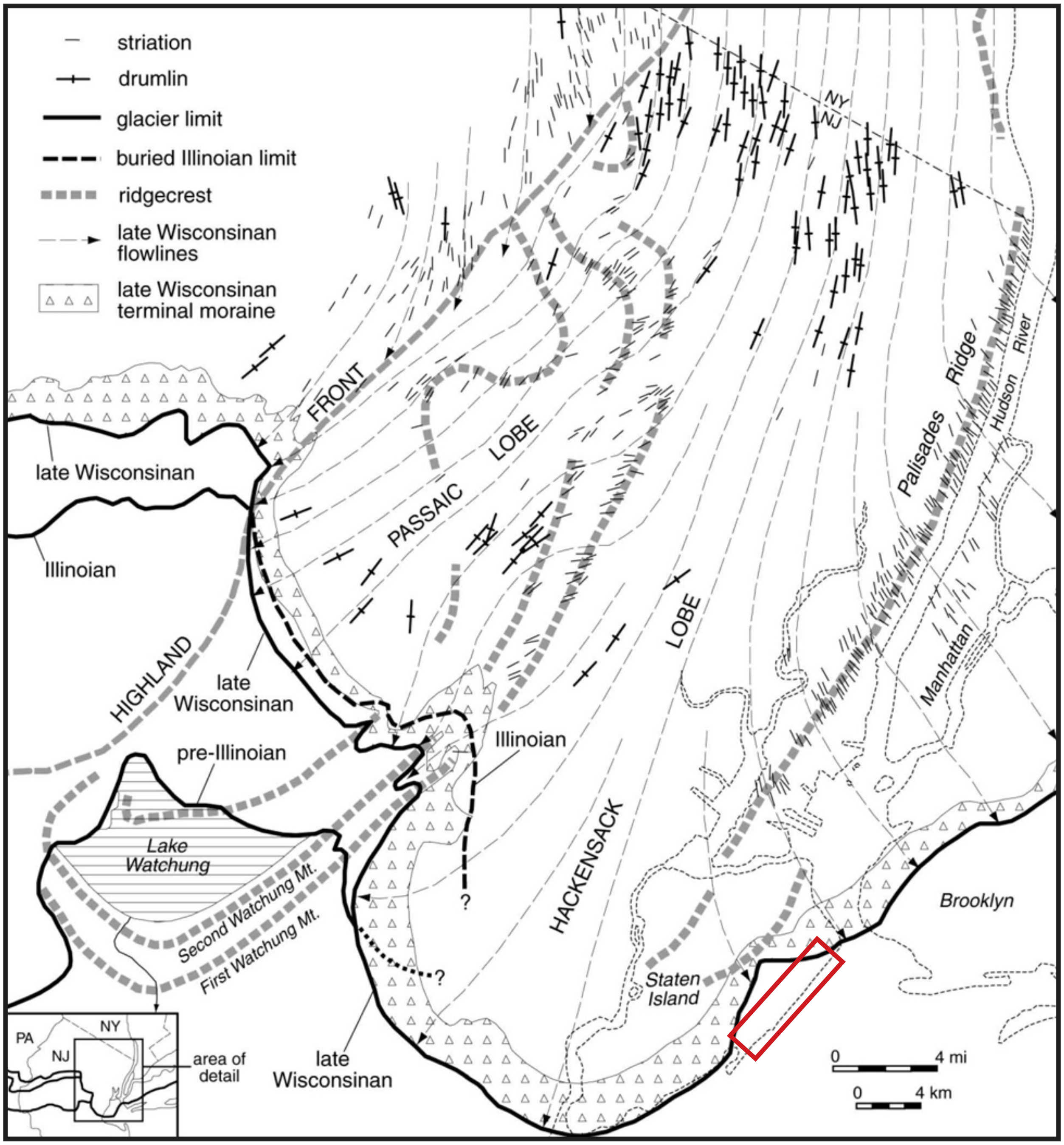


Figure 2.4. Late Wisconsinan Glacial Limits in the Lower Hudson Valley. Source: Stanford 2010. Project limits outlined in red.

The effects of continental glaciation go far beyond even the vast surface manifestations of erosion and deposition. Because immense volumes of global water were temporarily contained in world-wide continental ice masses at the last glacial maximum, global eustatic sea level fell by as much as 390 to 425 feet (Fairbanks 1989; Peltier 2002; Clark *et al.* 2009) and the exposed coastal plain in the area of New York City and northern New Jersey extended as much as 60 miles east of the present shoreline, to the edge of the Continental Shelf.

Advancing glacial ice scoured the relatively soft sedimentary rock of the Stockton Group from the lower Hudson River valley and the Newark Group rock from the nearby ancestral Hackensack and Passaic River valleys, while overriding and rounding the more resistant schists underlying Manhattan and the diabase of the Bergen Ridge, Laurel Hill, and other high points across the river to the west. A broad, high, continuous terminal moraine formed at the ice limit, a product of ongoing delivery of sediment-laden ice to the wasting ice front. The terminal moraine is visible as prominent landforms in Perth Amboy and Metuchen, New Jersey. On Staten Island it makes up an irregular axial ridge from the southwest end of the island, along the lower elevations of the southeast flank of Todt Hill, and terminating on the northeast corner of the island at the Narrows, the reach of harbor between the Upper and Lower New York Bays (Figure 2.3). While ice reached almost to the summit of Todt Hill, it does not appear to have overtopped it; the continuous moraine along its eastern base appears to have been formed by converging flow around the base of the upland (Stanford, personal communication 2019). Across the Narrows, the moraine manifests as the landform which lends its name to Bay Ridge, Brooklyn and continues northeast as the long, high ridge of the Ronkonkoma Moraine on Long Island.

As a result of this most recent glaciation the surficial geology of Staten Island is dominated by glacial drift of Upper Pleistocene (Late Wisconsinan) age (Figure 2.3). The glacial material mantles the bedrock units and Raritan Formation deposits with the exception of some Raritan outcrops in the western and northern portions of the island and exposures of serpentinite on Todt Hill. South and east of the terminal moraine the drift consists largely of glacial outwash, primarily stratified fine to coarse sand and gravel. Outwash underlies the flat area of eastern Staten Island from Amboy Road and Richmond Road to the shore between Arrochar and Great Kills Park. The outwash deposits are thickest (about 125 feet) along the eastern shore between New Dorp Lane and Arrochar (Soren 1988).

Wasting of the glacial mass and recession of the ice margin from the Perth Amboy area commenced at around 20,000 years BP (Stanford and Harper 1991). The resulting meltwater was confined between the terminal moraine and the receding ice front and formed a series of transient proglacial lakes which filled the scoured troughs of the Passaic, Hackensack and Hudson River valleys (Figure 2.5). As the ice mass continued to recede to the north, low points in the ridges separating the parallel troughs were exposed and served as spillways, allowing water to move from one lake to another and ultimately to flow through eroded breaches in the moraine. The transitioning boundaries and water levels of the proglacial lakes over time is reflected in the names applied to the lakes.

The initial lake, which occupied the Arthur Kill, Newark Bay, and the upper New York Bay lowlands, has been designated Lake Bayonne. Waters of Lake Bayonne overtopped the moraine and created an outlet to the coastal plain at what is now the Richmond Valley on Staten Island and later near Perth Amboy in the position of what is now the Arthur Kill (Stanford and Harper 1991). Ongoing erosion of the outlet at Perth Amboy allowed creation of an outlet chan-

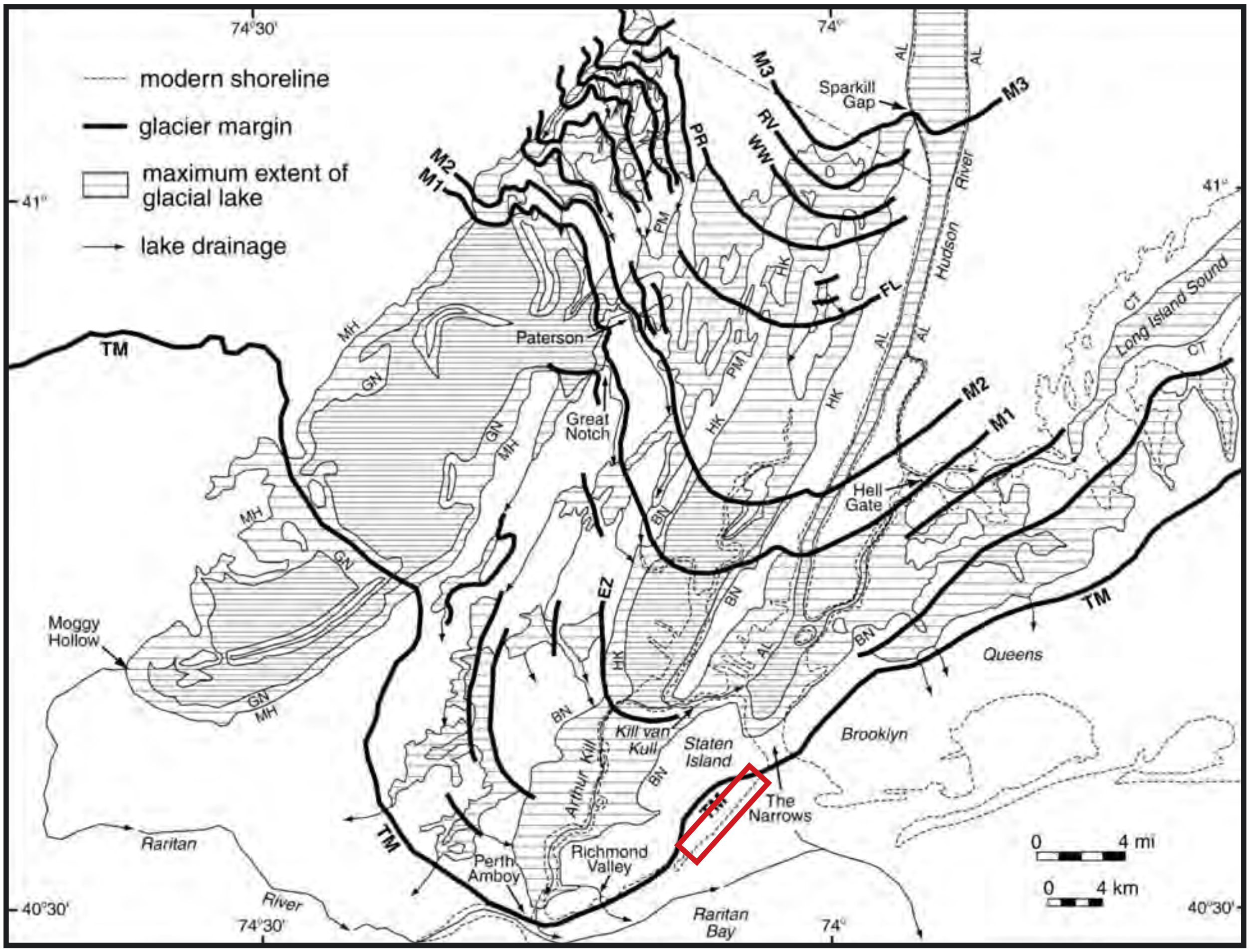


Figure 2.5. Glacial Lakes and Ice Margins during the Late Wisconsinan Retreat. Source: Stanford 2010. Project limits outlined in red. Key to lakes by abbreviations on their shorelines: AL=Albany; BN=Bayonne; CT=Connecticut; HK=Hackensack; PM=Paramus; MH=Passaic, Moggy Hollow stage; GN=Passaic, Great Notch stage. Ice margins are: TM=terminal moraine; M1=last ice margin before Lake Bayonne lowers to form lake Albany, Hell Gate stage, in the Hudson valley, and before Lake Passaic lowers from the Moggy Hollow stage to the Great Notch stage; M2=last ice margin before Lake Passaic, Great Notch stage drains, and before spillway erosion establishes stable Lake Hackensack; M3= last ice margin before Lake Hackensack lowers through Sparkill Gap into Lake Albany. Recessional ice margins marked by large deltas or plains are: EZ-Elizabeth; FL=Fair Lawn; PR=Paramus; WW=Westwood; RV=Rivervale.

nel within what is now the Arthur Kill. At Tremley Point, the channel downcut through till, outwash and recently deposited lake sediments until it encountered the diabase sill that forms the Bergen Ridge and the Palisades. Downcutting of the outlet was effectively stopped at that level and the lake level stabilized upstream in the Hackensack trough. The proglacial lake which subsequently occupied the trough is referred to as Lake Hackensack.

Ongoing ice recession exposed an outlet at Hell Gate, allowing the lowering of the lake level in the Hudson River valley and differentiating the meltwater body there as Lake Hudson. The water level in Lake Hudson was about 40 feet lower than that in Lake Hackensack and over time a spillway was eroded between the two bodies along the present course of Kill Van Kull, allowing some drainage from Lake Hackensack into Lake Hudson. Eventually, ice recession northward up the Hackensack trough exposed a water gap at Sparkill, allowing relatively complete drainage of Lake Hackensack into the lower Hudson Valley (Stanford and Harper 1991).

Drainage of meltwater impounded in the lower Hudson Valley finally occurred with the breaching of the terminal moraine at the point now called the Narrows, possibly as a result of catastrophic release of meltwater from the Great Lakes basin. The timing of the breakthrough at the moraine is not precisely defined; Donnelly *et al.* (2005) place it at around 13,350 years BP. An immense amount of meltwater from the lower Hudson Valley – and almost certainly from glacial lakes to the north and northwest – released through the breached moraine flowed southeast for 90 miles to the contemporaneous shoreline at or near the edge of the exposed continental shelf. Over much of this distance the meltwater flowed down an existing ancestral Hudson River valley which had been incised into the exposed coastal plain during repeated Pleistocene marine regressions. The channel was active prior to the terminal Wisconsinan outburst, carrying flow produced by precipitation and meltwater flows over the course of the Middle to Late Wisconsinan period (Thieler *et al.* 2007). However, prior to the terminal Wisconsinan, the course of the Hudson River followed a paleo-valley cutting through the present location of the borough of Queens. The reach immediately below the Narrows, adjacent to the current study area, dates to the time of the breaching of the moraine there (Stanford, personal communication 2019). The flow through the breach at the Narrows dramatically deepened and broadened the ancestral river valley; this now-submerged landscape feature is referred to as the Hudson Shelf Valley. The channel reach immediately below the Narrows lies at a general elevation of around 100 feet (30 m) below current sea level (Thieler *et al.* 2007).

As the ice receded from the terminal moraine on what is now Staten Island and Long Island, flow over and seepage beneath and through the moraine produced an outwash plain extending from the base of the terminal moraine eastward across the exposed coastal plain. On Staten Island, apart from the Richmond Valley, which carried meltwater west toward the Arthur Kill, there are no well-defined meltwater channels, suggesting that the flow that produced the outwash plain in the study area was produced by widespread flow of meltwater draining from the glacier surface or subglacially, including flow from the area of Long Island.

In the initial period following ice recession from the terminal moraine the land area now called Staten Island was not yet a true island. The outwash plain extending east from the vicinity of Todt Hill was contiguous with that extending east from what is now Long Island. To the north and west lay extensive glacial lakes. Within several thousand years of the beginning of ice recession, erosion of the moraine at Perth Amboy allowed flow from Glacial Lake Bayonne through what is now the Arthur Kill west of Todt Hill, while spillway drainage from Glacial Lake Hackensack to Glacial Lake Hudson created the current course of the Kill Van Kull to the north of Todt Hill. The ancestral Raritan River flowed through the sub-aerially exposed area that now forms Raritan Bay, south of Todt Hill. With the failure of the moraine at the Narrows the newly formed channel of the ancestral Hudson River was established and Todt Hill and its surrounding outwash apron were completely circumscribed, becoming a true island; the confluence of the ancestral Hudson and Raritan River channels lay just north of the current location of Sandy Hook, New Jersey (Stanford, personal communication 2019). The island at that time would have encompassed around twice its current land area, extending south and east of the current limits.

In the immediate post-glacial period the outwash-covered coastal plain lying east of Staten Island was a windswept region of very low relief, cut by minor channels and subject to a periglacial climatic regime, as was Staten Island itself. Vegetation of the outer coastal plain, as well as that of Staten Island, the inner coastal plain, the Piedmont, and other areas inland in close proximity to the receding ice front would have been that characteristic of the modern sub-polar tundra – largely grasses and low shrubs, probably including some alder and willow in stream hollows and valleys. Fertility on the recently-exposed coastal plain was likely low as soils would have been sand-dominated and low in nutrients, including soil carbon. This would have been especially true with greater proximity to the continental margin, where soils had been subaerial for a shorter time and thus subject to less weathering and less accumulation of soil carbon. With ongoing ice recession and the beginning of climatic amelioration, forests composed largely or entirely of spruce – broken by numerous wetlands – began to colonize the former glaciated and periglacial settings, including Staten Island and coastal areas to the north and west. With further amelioration of the climate, vegetative succession extended over millennia to pine-dominated forests and ultimately to mixed hardwoods (see Section C of this chapter for a more detailed review of post-glacial vegetative succession).

Post-glacial Drainage: Within a short time following the beginning of ice recession, 1st- and second-order streams draining the upland formed by the face of the terminal moraine and adjacent unglaciated areas began to incise the outwash plain, flowing initially to the ancestral Raritan River and, following failure of the moraine at the Narrows and establishment of the reach of the ancestral Hudson River east of Todt Hill, also to that trunk stream. Some of these low-order streams probably occupied hollows and courses established by meltwater flow over or beneath the moraine. With the breakthrough at the Narrows and the formation of the Hudson River channel below it, all drainage from within the study area would have flowed to the new channel. The head of the outwash plain lies at general elevations of 50 to 70 feet above mean sea level (amsl); headwater reaches of most first-order streams within the study area originate at elevations of 150 to 250 feet amsl. These streams thus have a high gradient in the upper reaches, falling 100 to 200 feet over a short distance and acquiring considerable energy before encountering an abrupt reduction in gradient at the upper limits of the outwash plain. The head of the now-submerged ancestral Hudson River channel offshore from modern Staten Island, the Christiansen Basin, lies at an elevation of around 100 feet below mean sea level (bmsl) (Thieler *et al.* 2007), providing a drop in elevation of 150 to 170 feet from the head of the outwash plain to the trunk stream, a distance of one to three miles.

Over time, incision of the sandy, unconsolidated outwash by these streams almost certainly proceeded fairly rapidly and the hollows of even first-order streams would have been wide due to slumping and failure of the unconsolidated banks. Initially, however, incision would have been impeded by the presence of permafrost in the periglacial setting. Almost by definition large amounts of outwash would not have been emplaced until ice recession began; however, even the wasting, receding ice front would have exercised immense climatic control over the region so that periglacial conditions would have prevailed in the Staten Island area for as much as several millennia following construction of the outwash plain. Stream incision initially may have been largely confined to the thawed upper zone, slowing as frozen sediments were encountered at depth. A second impeding factor may have been the presence of Cretaceous clays of the Raritan Formation. As noted above, Soren (1988) has stated that thickness of the outwash between New Dorp Lane and Arrochar, at the northern limit of the study corridor, may reach 125 feet. However, the underlying Cretaceous material may well exhibit an undulating, irregular surface. Testing for this study encountered dense clay tentatively identified as part of the Raritan Formation at 35 feet below surface (25 feet bmsl) and extending to the limit of testing at around 55 feet below surface at 1.5 miles north of New Dorp Lane. Dense clay yielding radiocarbon dates of greater than 43,500 years BP and containing exclusively Cretaceous pollen was also encountered at depths ranging from 48 to 88 feet below surface (44 to 77 feet bmsl) at Oakwood, near the southern end of the project alignment. Streams encountering these dense, very firm clays would have been greatly impeded in their ability to incise. Stream hollows draining to the ancestral Hudson River channel may thus have not exhibited a linear gradient but rather a stepped profile. Streams occupying these hollows probably initially tended to flow in relatively straight channels, with only shallow meanders.

Sea Level Rise: With the continued wasting of the Late Pleistocene ice sheets of North and South America and Eurasia, world-wide sea-level began to return to pre-glacial levels. Coastal plains that had been exposed for millennia, such as the Atlantic Coastal Plain flanking the Hudson Shelf Valley, were, over time, again inundated by marine waters (Figure 2.6).

Because of several complicating factors, sea level rise and inundation of the coastal plain did not necessarily occur in a linear, straightforward fashion, either spatially or temporally. The complicating factors include: variations in eustasy (world-wide sea level) resulting in part from ongoing catastrophic releases of meltwater stored in massive but ultimately transient glacial lakes; and isostasy – effects such as crustal depression caused by the weight of glacial ice and subsequent rebound of the crust following removal of the ice load. The presence of the enormous weight of a continental ice mass causes the surface of the Earth's crust to deform and warp downward, forcing the fluid mantle material to flow away from the loaded region. As the load is removed by ablation of the ice mass, the removal of the weight from the depressed land allows uplift or rebound of the surface (isostatic rebound) and the return flow of mantle material back under the deglaciated area. Due to the extreme viscosity of the mantle, it takes many thousands of years for the land to reach isostatic equilibrium, returning to more or less its pre-glacial state. A related phenomenon is a forebulge effect – a temporary elevation of the crust in areas just beyond the glacial limit, caused by the migration of the viscous mantle material. In most coastal areas, the Earth's surface was (and, to a lesser extent, still is) rising over the course of many millennia following ice recession even as sea level was rising, complicating the process of reconstructing rates of coastal inundation. Similarly, subsidence of areas formerly elevated through a forebulge effect allows for accommodation of large volumes of marine waters, further making the rate of relative sea level rise less than linear. Needless to say, rates of relative sea level rise vary, dependent on location.

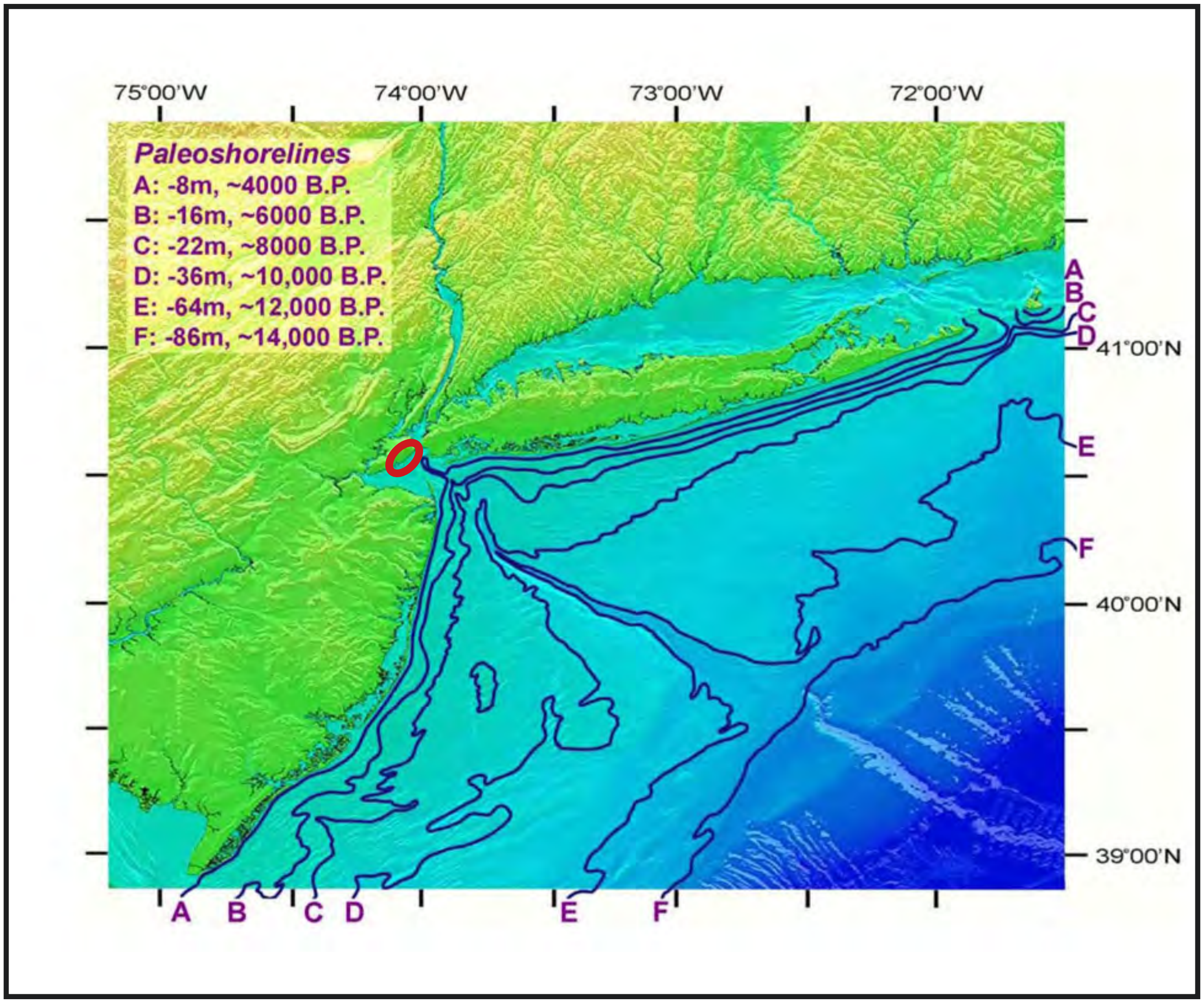


Figure 2.6. Generalized Shorelines in the New York Bight, 4,000 to 14,000 Years Ago. Source: Merwin 2010:Figure 5. Project area circled.

A number of sea-level rise curves have been produced, including several for the mid-Atlantic, New England, and New York City coastal regions (e.g., Belknap and Kraft 1977; Rampino and Sanders 1980). These curves rely largely on radiocarbon dating of peat and other organic material recovered through coring of now-inundated coastal surfaces in the near offshore and correlation of those dates with depth below modern sea level. A complete review of the various constructed curves is beyond the scope of this report but there is broad agreement in their general conclusions. Schuldenrein *et al.* (2006; 2014) have taken a comprehensive approach, correlating coring and radiocarbon data from several projects conducted by those authors in the New York Bight, as well as similar data and preserved cores produced in studies by other researchers. Broadly describing the results of the study, the authors state that they show "a rapid rise in relative sea level at a rate of approximately 9 mm/yr (0.5 inches/yr) from at least 9000 cal yrs B.P. until about 8000 cal yrs B.P. when the rate of rise diminished to a consistent 1.5 – 1.6 mm/yr (0.06 inches/yr), from 7000 cal yrs B.P. until the present" (Schuldenrein *et al.* 2014).

By the middle Holocene, marine transgression resulting from rising world-wide sea levels was raising the base level of the streams flowing through the current study area. Schuldenrein *et al.* (2014) place sea level at 25 feet below modern mean sea level at 5,000 years BP. This contrasts sharply with around 400 feet at the Last Glacial Maximum and is considerably less even than the local base level formerly provided for these streams by the ancestral Hudson River channel. One result of the decreased gradient would have been a tendency for the streams to transition to a more meandering channel form, with increased lateral incision and floodplain construction. Bed aggradation would also have been taking place beginning in this period, undoing some of the earlier channel incision. At this point, the lowest reaches of the local streams would have been tidally influenced, estuarine settings. This transitional zone migrated up-system with ongoing sea level rise as areas that were initially estuarine settings became completely inundated. As barrier islands (discussed below) impinged on the coastline, flow from the tributary streams draining the eastern side of Staten Island was partially impounded landward of the islands, forming lagoons which were connected to the ocean through tidal inlets, creating brackish conditions. The Schuldenrein team depicts the land/marine margin within the study area at 1,000 years BP at basically the same location as seen today.

Barrier Islands: A common feature in settings of transgressing marine shorelines is the presence of barrier islands – low, narrow, subaerial landforms lying parallel to the coastline at distances of tens of meters to several kilometers offshore and separated from the mainland by a lagoon or "back bay" (Figure 2.7). Barrier island formation along the New York-New Jersey coast may have begun with depositional nuclei along the Late Pleistocene low-stand shoreline at the time of the Last Glacial Maximum (Ritter 1986), with the original sand ridges migrating landward with the advancing post-glacial shoreline.

Barrier islands are made up of distinct geomorphic zones (Ritter 1986). On the seaward side are low-gradient beaches that are in a constant state of change during storms and periods of large swells. This face is divided into zones based on elevation and the wave dynamics that take place there. The lower and middle shoreface are submerged at all times and are differentiated by the amount of wave energy expended there. The upper shoreface is the zone most affected by breaking waves and is generally submerged even at low tide. The foreshore is exposed at low tide and is also constantly affected by wave energy. At a slightly higher elevation is the backshore, the highest and most stable part of the island. This area is frequently the site of dunes and may be sparsely vegetated. The boundary between the foreshore and backshore may be marked by a flat berm. Landward from the back-

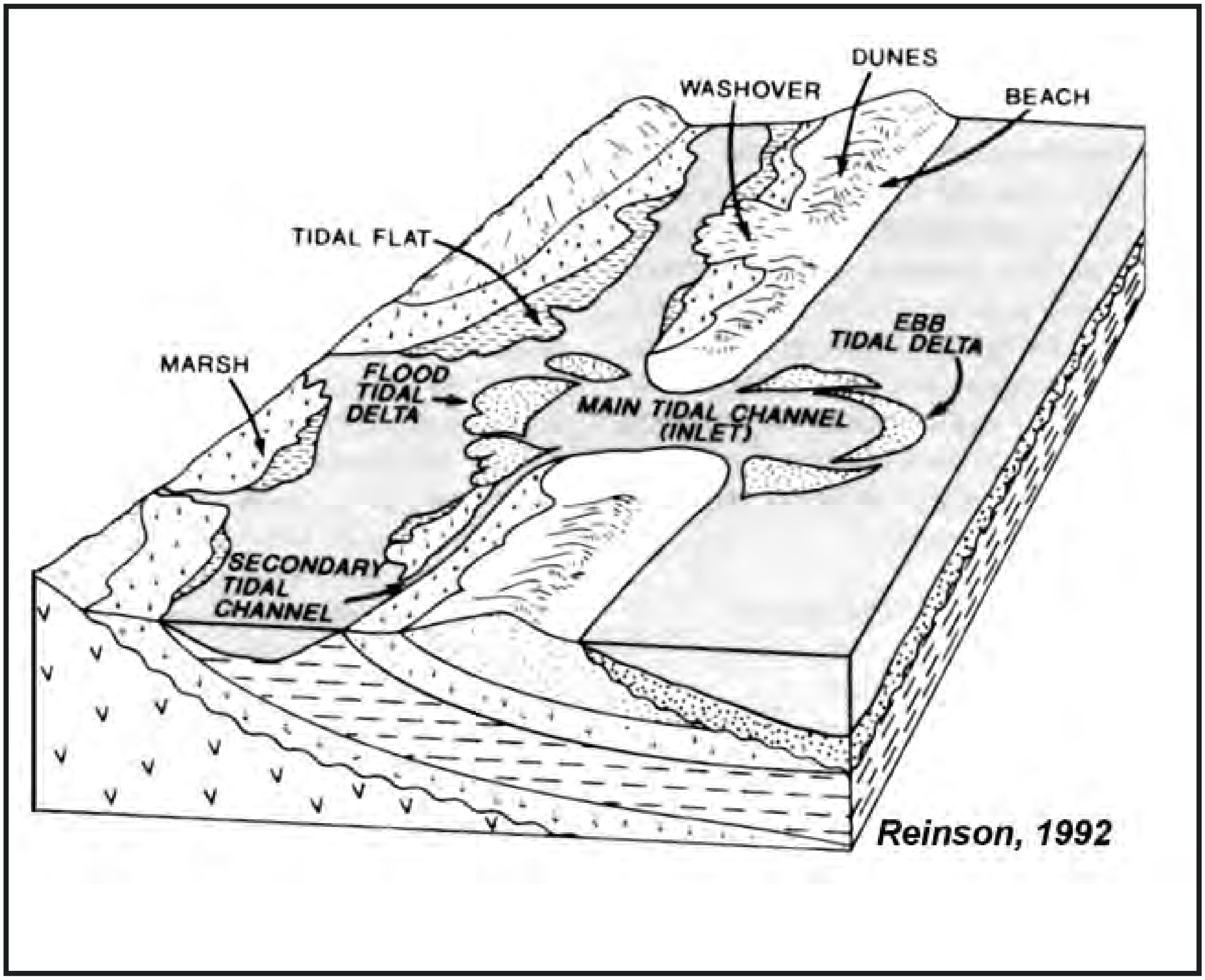


Figure 2.7. Schematic Diagram of Barrier Island Formation. Source: Reinson 1992.

shore and dunes, a flat or very gently sloping surface ("backbarrier") borders the lagoon, which is directly bounded by tidal flats and/or salt marsh.

Like all coastal settings, barrier islands are dynamic, unstable features in both the short and middle-to-long term. In the short term, the islands are constantly undergoing reworking by waves and wind. Additionally, storm-generated waves or tidal surges may produce breaches which are then kept open by tidal flows. Tidal inlets may migrate laterally over time, moving in the direction of longshore currents and reworking all of the subaerial portion and at least part of the submerged portion of the island (Kumar and Sanders 1974). The inlets also contribute to the dynamism of the system as incoming tidal flows deposit sand within the lagoon, constructing a feature designated as a flood tidal delta. These inlets are exposed at low tide and may become the substrate for salt marsh within the lagoon (Godfrey 1976), thus altering the lagoon edge from open water body to marshland.

In the middle-to-long term, these islands are migrating landward, transgressing over the adjacent lagoons. During severe storms, waves repeatedly wash over the low islands, a process called overwash. Overwash can extend the length of an island or can be localized. In the former case, sand is washed from the length of the backshore or dunes and deposited on the tidal flats or within the lagoon. Where overwash is channelized it often produces a geomorphic feature called a washover fan, either on the tidal flat or within the seaward edge of the lagoon, sometimes accreting on fan deposition from earlier storms. Over time, the position of the island moves landward as it essentially "rolls" in that direction.

Growth and persistence of barrier islands is largely governed by two factors: rate of sea level rise and sediment supply. Two schools of thought have developed regarding the relationship between the islands and sea level rise. The prevailing view, shoreface retreat, envisions a process by which, as sea level rises, the landforms migrate continuously landward and the former position becomes submerged. In this erosive process, the sediments underlying the island and the backbarrier are completely reworked. The second school envisions a step-wise process in which a barrier island remains in place, growing in height, as sea level rises. During this period the lagoon expands and deepens. At some point the rising sea overtops the backshore, drowning the island in place, and the surf zone advances to the landward side of the lagoon, forming a new barrier island there and beginning the process of lagoon formation landward from the new barrier. Although the action of waves and currents will rework some of the overridden island's sediments, the basal facies of the transgressive landform may be preserved.

The role of the rate of sea level rise and sediment supplying these processes has been investigated and discussed by Kraft (1971). In Kraft's view, slow sea level rise favors destruction of the sediment record of marine transgression as barrier islands and all associated sediments are completely reworked. Rapid rise of the sea would tend to favor local retention of at least some portion of the sedimentary record because the advancing surf zone – the most dynamic and erosive part of the transgressing front – would have less time to rework the backbarrier sediment, in part because the surf zone might tend to advance rapidly across the existing lagoon. Rampino and Sanders (1981) have proposed that the barrier islands now flanking the coast of southern Long Island probably became established about 2 km offshore of their present position around 7,000 years ago during an interval of rapid sea-level rise. The authors propose that this shore and barrier complex was created when the barrier shoreline overstepped landward from a former position some 5 km offshore. During the past 6,000 years, an interval of slower submergence, the barriers have migrated landwards by continuous shoreface retreat (Kumar and Sanders 1974; Rampino and Sanders 1981). This model may be inferred to apply also to the current Staten Island coastal study area.

Based on coring of coastal Long Island, Rampino and Sanders identify four main stratigraphic units formed in barrier island/lagoon settings: brackish-water to salt-marsh peat; lagoonal silty clays; backbarrier sands; and barrier island sands (Rampino and Sanders 1980). The peat is described as consisting of a unit in which "surficial sediment consists of thin, brown to gray fibrous peat (50 to 100% plant remains), commonly overlying and interbedded with gray organic silty clay containing plant material (<30% plant remains). Vegetation in the marsh area is primarily composed of *Spartina alterniflora* at the lagoon margins, with *Spartina patens*, *Distichlis spicata*, and lesser amounts of *Salicornia sp*. on the high-marsh surface. The landward brackish-water fringes of the marshes are marked by stands of *Phragmites communis*" (Rampino and Sanders 1980). They note that while the peat stratum may reach thicknesses of up to 2 m (6.6 feet), the thickness along the lagoon/backbarrier margin is generally thin, with a maximum thickness of around 20 inches.

The lagoonal sediments are described as consisting "predominantly of silty clays; toward the enclosing barrier islands, increasing amounts of sand are present" (Rampino and Sanders 1980), with the sand introduced through washover events or the proximity of tidal inlets. In some cores taken close to the barriers, the lagoonal silty clays were found to be interbedded with back- barrier sands. The clays are described as heavily reduced, evidenced by an olive-gray to black color and the strong odor of hydrogen sulfide.

The backbarrier-sand stratigraphic unit of Long Island is described by Rampino and Sanders as medium-gray to olive gray fine- to coarse-grained sand, containing shells and occasional layers of organic silt. These sands are found directly behind the barriers and thicken towards the barriers, reaching thicknesses up to 20 feet. Some of this accumulation is a product of tidal delta formation. The great majority, however, is deposited through sheet washover, including tidal delta formation, when during great storms "large gaps are often eroded through the barriers and fan-like bodies of sand are deposited by the ocean waters pouring into the lagoons" (Rampino and Sanders 1980). These authors note that "Sanders and others (1970) report the presence of oxidized brown sands overlying gray sands in backbarrier environments in southern Long Island. They suggest that these brown sands were brought into the lagoons by tidal inflow and washover and believe that these brown-over-gray sands may be incorporated as such into the geologic record. However, in the present study the color of the Holocene sands landward of the present barriers was found to be predominantly gray. Directly behind the barrier islands, thin (less than 5 cm) bands of brownish sands were found within the gray backbarrier sands with no obvious textural difference between the two. These brown sands appeared to be in the process of being reduced and mixed with the gray sands by the action of burrowing organisms" (Rampino and Sanders 1980).

The barrier-island sands stratigraphic unit has been described by Rampino and Sanders for Long Island (1980) and for Fire Island by Kumar and Sanders (1974). These sands are characterized as fine- to coarse-grained sands with some gravel (usually less than 10%) in places and containing shells. Rampino and Sanders found that the Long Island (Jones Beach) barrier sands extended to depths greater than 100 feet below the surface. Kumar and Sanders reported on the influence of migrating tidal inlets on the stratigraphic record. For Fire Island, they describe tidal inlet channel floors consisting of a lag of pebbles and large shells at depths up to 33 feet below mean sea level, overlain by a vertical sequence of inlet sediments produced as a result of differences in depositional environment with depth and position in tidal inlets. These tidal inlets migrate laterally along the island in response to longshore transport of sand. Kumar and Sanders estimate that this lateral migration may typically be responsible for reworking sediments beneath 20 to 40% of the length of individual barrier islands and estimate that in their Fire Island study area the extent of reworking is toward the upper end of that range (Kumar and Sanders 1974). Rampino and Sanders note that "it is expected that beneath barrier-island segments with migrating tidal inlets, a prism of inlet-filling sand with a thickness equal to the depth of the inlet scour will be preserved. Beneath barrier island segments without migrating inlets, the barrier sand body has a flat lower boundary" and that "the modern barrier-island sand prisms of inlet-fill origin cut deeply into the underlying Pleistocene and Upper Cretaceous deposits" (Rampino and Sanders 1980). The modern barrier sands grade seaward into shore-face and offshore sands. To the landward, the barrier sands grade into backbarrier tidal delta and washover sands.

C. LATE PLEISTOCENE/HOLOCENE VEGETATIONAL SUCCESSION AND SOIL DEVELOPMENT

Chronostratigraphy, a key concept of paleoenvironmental reconstruction, is based on the premise that the types and amounts of pollen at various levels in stratified soils document patterns of plant distribution through time and that changes in plant distribution are largely the result of climate change. A zone or stratum within soil that is characterized by a specific suite of pollen types is referred to as a chronostratigraphic zone or chronozone.

Two models of chronostratigraphy are commonly used in the northeastern United States – the Blytt-Sernander model and the Pollen Zone model. The Blytt-Sernander model was developed through the study of Danish peat bog formation in the late 19th and early 20th centuries (Blytt 1876; Sernander 1908), while the Pollen Zone model was developed in New England during the first half of the 20th century (Deevey 1939; Davis 1965). Both models subdivide the late Pleistocene and Holocene into a series of chronozones of varying duration (Table 2.1). While the Blytt-Sernander system uses names that imply the dominant climatic conditions in northern Europe (e.g., Boreal and Atlantic), the chronostratigraphic system for New England refers to the subdivisions based on the dominant types of pollen present in the strata. From oldest to youngest, these are the Herb (Zone T); Spruce (Zone A-1 to A-4); Boreal (Zone B); Oak and Hemlock (C-1); Oak and Hickory (C-2); and Oak and Chestnut (C3) pollen zones (Deevey 1939; Davis 1965:386-397). Pollen Zone C-3 has subsequently been divided into two parts (C-3a and C-3b), with Zone C-3b referring to a later (upper) zone that contains more spruce and pine pollen (Table 2.1).

The Pleistocene epoch occurred between 2.6 million years BP and 10,000 years BP. During this time four major periods of glaciation occurred in northern North America: two Pre-Illinoian; Illinoian; and Wisconsin (Crowl and Sevon 1999:224). Each of the four glacial episodes is separated by a relatively warm interglacial period. Alternating cooler and warmer intervals within a glacial period are referred to as stadials and interstadials, respectively. The interglacial period prior to the Wisconsin is known as the Sangamon stage. The Holocene epoch, which started at the end of the Wisconsin glaciation at around 10,000 years BP, represents the latest interglacial period.

In both glacial and periglacial landscapes, large amounts of sediment are introduced into stream valleys. During each of the interglacial periods streams tended to proceed through a series of stages starting with a braided pattern of multiple, shifting channels and ending with channel stabilization, stream entrenchment and associated vertical accretion. It is during the latter stages of stream development that

Years B.P.	Blytt-Sernander Climatic Episodes	Pollen Zones	Forest Type	Climatic Conditions	Fluvial Conditions	Genetic Stratigraphic Horizons	Archaeological Cultural Periods	Stratigraphic Discontinuities
Present	Modern							
500	Neo-Boreal "Little Ice Age"	C-3b	Spruce-Pine Rise	Cool moist to cool dry	Alluviation	A-C	Late Woodland	
	Pacific							
1,000	Neo-Atlantic			Warm moist	Floodplain stability	Owasco Paleosol		
1,500	Scandic	C-3a	Oak Hemlock Chestnut	Cool moist	Alluviation	Weak Bw/BC/C	Middle Woodland	Little Ice Age Disconformity 750 B.P.
2,000								
2,500	Sub-Atlantic			Warm moist	Floodplain stability	Fox Creek Paleosol	Early Woodland	Scandic Disconformity 1750 B.P.
3,000								
3,500	Sub-Boreal	C-2	Oak Hickory	Warm dry	Severe to modest later channel migration (small tributaries) with alluviation dominant over incision along major tributaries; zonal flow and Bermuda High	Bw	Transitional Archaic	
4,000								Sub Boreal
4,500			Mid-Point Hemlock Decline			Ab (Incipient)		
5,000					Atlantic II Increased rates of vertical accretion	Bw	Late Archaic	Disconformity 4200 B.P.
5,500						Ab (Incipient)		
6,000				Warm and slightly moister				
6,500	Atlantic	C-1	Oak Hemlock		Atlantic I Slow continuous vertical accretion, strong soil weathering/ development of Bw, Bt Btx, Bx	Bw, Bt, Btx, Bx		
7,000							Middle Archaic	
7,500								
8,000								
8,500	Boreal					A (Incipient)		
9,000		B	Pine Oak	Warm dry	Zonal circulation and rapid alluviation	BC/CB/C, lamellae bands (stacked A-C horizons)		
9,500	Pre-Boreal						Early Archaic	
10,000								
10,500	Younger Dryes	A-4	Spruce Pine	Cool dry	Initiation of meandering Braided	C		
11,000	Allerod							YD Disconformity 10,900 B.P.
	Intra-Allerod Cold Period (IACP)		Spruce Pine		Renewed vertical accretion, absent on low terraces due to erosion during YD			
11,500								
12,000	Allerod	A-3/A-2				A-B horizon development		
	Older Dryas							
12,500	Bolling		Spruce Parklands				Paleoindian	
13,000	Oldest Dryas							
13,500								
14,000		T	Tundra	Warm and wet	Braided conditions	Lateral accretion/ outwash	PreClovis	Late Wisconsin Disconformity
14,500								

Table 2.1. Correlation of Geological, Paleoenvironmental and Archaeological Timelines. Source: Vento 2015:25.

floodplains and terraces were formed. The speed at which these events occurred depended on the local topography, climate and the floral environment of the time. The various stages of stream development for the late Pleistocene and Holocene are described below. It should be kept in mind that the events described below were superimposed on (and therefore influenced by) a landscape that underwent similar stages of stream and landform development during previous interglacial periods.

The last major expansion of the Late Wisconsinan (Laurentide) ice sheet took place beginning in the Late Wisconsin stage at about 23,000 years BP and culminated in a maximum ice advance at approximately 18,000 – 20,000 years BP. After 18,000 years BP a climatic period began which progressed with a slow ice sheet recession characterized by several ice re-advances which lasted from *circa* 15,000 years BP to the beginning of the Holocene at around 10,000 years BP (Watts 1983:300). Within the Blytt-Sernander model these periods are referred to as the: Oldest Dryas (stadial); Bolling (interstadial); Older Dryas (stadial); Allerod (interstadial, which includes an inter-Allerod cold period); and Younger Dryas. These correspond to Pollen Zones A-2 to A-4 (Davis 1965). Although it has been well established that widespread extinction of large mammals occurred during the transition from the Allerod to the Younger Dryas, the cause of the die-off continues to be a topic of debate and may include one or more of the following: human predation (e.g., Martin 1967, 1984, 2005); disease (e.g., MacPhee and Marx 1997); environmental change (e.g., Guthrie 2006); or comet impact (Firestone and Topping 2001; Firestone *et al.* 2007; Kennett et al. 2009; Paquay *et al.* 2009; Surovell 2009).

Although not directly applicable to the current study area, microbotanical data from a number of locations in Pennsylvania provide insights into the floral community of the Mid-Atlantic and southern New England during the late Pleistocene. These include Rose Lake in Potter County, Kings Gap Pond #1 and Crider's Pond in Cumberland County, Longswamp in Berks County, and Tannersville Bog in Monroe County. At Longswamp, at approximately the same latitude as the current study area but immediately south of the late Wisconsin ice front in eastern Pennsylvania, tundra vegetation with grasses, ericaceous shrubs, and dwarf birch was present, suggesting a cold, dry and windy environment (Watts 1979). Similar vegetation, with no evidence for spruce ("generally perceived to be one of the first arboreal plants to colonize deglaciated regions" [McWeeney and Kellogg 2001:193]) or other trees, was present at Kings Gap Pond #1, less than 30 minutes latitude south of Staten Island but 90 miles south of the maximum extent of Wisconsinan ice, between 16,080 and 14,410 years BP (Delano *et al.* 2002). However, evidence of a non-tundra, spruce forest was present at this time at Crider's Pond, in a similar setting in Cumberland County, 17 miles to the southwest, in sediments as old as 15,000 years BP (Watts 1979). Pollen cores from Crider's Pond indicate that this area, more than 90 miles south of the glacial boundary, was dominated by spruce (*Picea sp*), dwarf birch (*Betula grolandulosa*), and various herbs between 15,000–13,000 years BP (Watts 1979). By around 13,000 years BP jack pine (*Pinus banksiana*), balsam fir (*Abies balsamea*), and speckled alder (*Alnus rugosa*) were present, forming a diverse environment containing both tree and shrub species. Red spruce (*Picea rubens*) was present by 11,500 years BP with white pine (*Pinus strobus*) appearing shortly thereafter (Watts 1979).

The Younger Dryas stadial, which occurred at the end of the Pleistocene, marks a world-wide reversal of the warming climate of the Allerod interstadial. Although the pollen record at Browns Pond in the central Appalachians of Virginia suggests a brief cold reversal at 12,260 years BP possibly correlating with the Older Dryas (Kneller and Peteet 1999), the absence of evidence for climatic reversal between 11,000–10,000 years BP at this location suggests that the cooling effects of the Younger Dryas may not have extended as far south as Virginia (Kneller and Peteet 1999).

Because of the large volume of sediment load inherited by the transport-limited rivers, it was not until the terminal Younger Dryas that the braided stream channels began to accrete vertically to form floodplains. Where present, alluvial sediments that date to the terminal Younger Dryas form coarse-grained C horizons.

It was during the terminal Pleistocene, about 13,500 years BP, that humans are believed to have arrived in the Northeast. Microbotanical remains indicate that the terrestrial environment of this region at that time would have included both boreal and deciduous tree species. Deciduous species would have initially been restricted to floodplains and other favorable settings before gradually expanding into more diverse settings.

Pre-Boreal (10,000–9,000 Years BP): The Pre-Boreal chronozone (lower part of Pollen Zone B) is the first climatic interval of the Holocene. The biotic environment of south-central Pennsylvania from *circa* 10,000 – 9,000 years BP was characterized by a closed forest comprised of pine, fir, oak, hemlock, alder and birch. Although the Laurentide ice sheet had receded to the north, weather patterns were still influenced by ongoing deglaciation. At this time the dominant atmospheric circulation pattern for North America was zonal (west to east), which resulted in an increased frequency of cyclonic storms (Knox 1983:30-31; Vento et al. 2008:16). At this time eastern Canada remained covered by a massive glacial ice sheet, and the sea level was still approximately 66 feet below its present elevation (Conners 1986).

Changes in forest composition in eastern Pennsylvania and the lower Northeast in general around 10,000 years BP suggest that the opening of the Holocene was marked by near modern climatic conditions (Davis 1983). Delcourt and Delcourt (1981) have documented the presence of conifer-oak forests in the Middle Atlantic region at 10,000 years BP that included cold-adapted, mesic species such as birch, elm, ash, ironwood, maple and beech. Oak and hickory pollen are well-represented at 10,000 years BP at Browns Pond in Virginia. Hemlock was present in central Pennsylvania by 9,600 years BP (Watts 1979:462).

Although the data suggest that the Pre-Boreal forest likely contained a substantial component of temperate hardwoods, these species were probably restricted to favorable topographic and edaphic niches, initially occurring as patches within a predominantly coniferous forest. Eisenberg (1978) suggests that during the early post-glacial period oak was also adapted to drier upland sites where soil formation was more advanced. In the southern section of the modern conifer-hardwoods found on the Appalachian Plateau, deciduous species have migrated northward along major valleys and their tributaries (Braun 1950), a situation that may resemble the early to mid-Holocene immigration of deciduous species along stream valleys from glacial refugia in the south.

The frequency of cyclonic storms during the Pre-Boreal phase resulted in frequent flooding and the slow but continuous vertical accretion on floodplains and low terraces (Knox 1983:26-41; Vento *et al.* 2008). Floodplain instability during this time is associated with the formation of Bw/BC horizons along rivers and larger streams of the Northeast (Vento and Rollins 1989; Vento *et al.* 1992; Vento *et al.* 2008).

Boreal (9,000–8,000 Years BP): The Boreal chronozone (upper half of Pollen Zone B) marks the beginning of a warm period that lasted from *circa* 9,000–4,500 years BP that has been referred to variously as the North American climatic optimum, the Altithermal, and the Hypsithermal period (Deevey and Flint 1957). Climatic regimes of the Hypsithermal include the warm and dry Boreal episode (9,000–8,000 years BP) and warm and wet Atlantic episode (8,000–4,500 years BP).

During this climate period there was a dramatic expansion of white pine into both uplands and lowlands (Watts 1979). Because pine is an excellent temperature and moisture indicator, it reveals that the climate was both warmer and drier than it had been during the previous thousand years or at any time since (Davis 1983). The increase in pine pollen during the Boreal climatic episode defines important aspects about the prevailing climate and biotic environment. Watts notes that "pines flourish on acid sandy soils where natural fires are frequent and where competition for the larger canopy-forming deciduous trees is restricted," adding that "pines become established on sites where forest has been destroyed by fire, storm blowdowns, or forest clearance, all of which make light gaps" (Watts 1979:462). Although oak, hickory, beech and elm were present they did not reach their peak distributions until *circa* 5,000 years BP (Prentice *et al.* 1991:Figure 6).

The warm, dry Boreal climate had a detrimental effect on ponds and low-order streams. Oxidized soils containing damaged or destroyed pollen at sites from Georgia to New Jersey, (including Quicksand Pond, Bartow County, Georgia; Cranberry Glades, Pocahontas County, West Virginia; Big Pond, Bedford County, Pennsylvania; Panther Run, Mifflin County, Pennsylvania; Longswamp, Berks County, Pennsylvania; and Szabo Pond, Middlesex County, New Jersey) indicate that the ponds and bogs dried out more frequently during the mid-Holocene Hypsithermal than in subsequent times (Watts 1979:263). By 6,500 years BP the last remnant of the Laurentide ice sheet had melted on the Quebec-Labrador Plateau, and the Atlantic Ocean had reached its current level (Conners 1986:Table 1; Delcourt and Delcourt 1986:34).

The dominant atmospheric circulation pattern during the Boreal episode was zonal (Knox 1983:30-31). Although thunderstorms were relatively common under this climatic regime, the presence of the glacial ice in northeastern Canada prevented major precipitation events (i.e., hurricanes) from reaching the northern Appalachians until after *circa* 6,000 years BP (Vento *et al.* 2008:23). Thunderstorms of the Boreal episode resulted in frequent forest fires and rapid alluviation (sediment aggradation) along streams. Typical soil profiles associated with this time period consist of a thick Bw/BC horizon capped by an incipient A horizon along major rivers in the Northeast (Vento *et al.* 2008:19).

Atlantic (8,000–4,500 Years BP): A rapid decrease in pine and an accompanying increase in both oak and hemlock *circa* 8,000 years BP marks the transition from the drier conditions of the Boreal climatic phase to moister conditions of the Atlantic climatic phase (Pollen Zone C-1; Prentice *et al.* 1991:Figure 6; Vento *et al.* 2008:17). The Atlantic to Pacific periods (Pollen Zones C-1 to C-2) were dominated by a mixed zonal-meridional atmospheric circulation pattern (Knox 1983:30-31; Vento *et al.* 2008:16). Meridional (south to north) circulation patterns are associated with heavy, persistent rains and substantial floods.

Although mast-bearing trees continued to increase in abundance during the Atlantic episode, they did not reach their historic levels until the late Holocene or Neoglacial period (i.e., post-5,000 years BP). Chestnut, an exceedingly slow migrant, does not occur in central Pennsylvania until around 5,500 years BP. Many of the arboreal species that became dominant at this time (e.g., oak and chestnut) provided fruits and nuts known to have been used both by humans and by faunal species hunted by humans, such as deer, elk, bear and other small mammals (Davis 1976). Changes in the weather patterns and ground cover resulted in slower but more continuous alluvial aggradation and the formation of two sets of stacked Bw and incipient Ab horizons on the terraces of larger rivers (Vento *et al.* 2008:19). The development of Ab horizons reflects greater land surface stability.

Sub-Boreal (4,500–3,000 Years BP): The beginning of the Sub-Boreal climatic episode (Pollen Zone C-2) marks the end of the Hypsithermal and the beginning of the Neoglacial period (Vento *et al.* 2008:4). Forest of this time was dominated by oak and hickory, and there is a marked reduction in pine, birch and alder (Prentice *et al.* 1991:2047). A dramatic decline in hemlock that began around 5,000 years BP (Haas and McAndrews 2000:81) continued throughout this interval.

The Sub-Boreal climatic episode is associated with the formation of mottled Bw horizons and/or C horizons along larger streams in the Mid-Atlantic region (Vento and Rollins 1989; Vento *et al.* 1992; Vento *et al.* 2008). The presence of coarse-grained vertical and lateral accretionary deposits at deeply stratified sites in the Susquehanna and Delaware river valleys and elsewhere document the increased frequency of large storms after 6,000 years BP (Vento and Rollins 1989; Vento *et al.* 1992; Vento *et al.* 2008). Similar stratigraphic evidence in the northern Midwest supports the idea of more frequent large floods after 6,000 years BP (Knox *et al*. 1981). Not surprisingly, the incision of the Pre-Boreal and Boreal valley-fill deposits in most areas of these basins occurred about 6,000 years BP coincident with increased meridional circulation in summer, a condition which promoted cyclonic storms by the lifting/mixing of warm-moist Gulf air masses by cool-dry air masses out of Canada (Grissinger *et al.* 1981; Vento and Fitzgibbons 1987).

There are competing hypotheses to explain the reduction of hemlock during the Sub-Boreal interval. Knox (1983), Vento and Rollins (1989), and Vento *et al.* (1992; 2008) suggest that the decline of hemlock and its continued suppression during the Sub-Boreal (*circa* 4,500–3,000 years BP) indicate that warm and dry conditions prevailed at this time. Hemlock is an accurate indicator of drought because of its shallow root system and sensitivity to atmospheric humidity (Fowells 1965; Haas and McAndrews 2000).

The researchers cited above argue that this drying pattern is the result of meridional stabilization of the sub-tropic high zone over the Mid-Atlantic or the increased occurrence of warm-dry zonal flow (much like conditions in the 1930s). This pattern caused a reduction in vegetative cover and greater surface run-off, which promoted vertical accretion on low terraces within stream basins. Although others have proposed that the hemlock decline was the result of disease or insect infestations (e.g., Bhiry and Filion 1996; Davis 1981; Filion and Quinty 1993), most of the evidence suggests that the decline can be attributed to drought (e.g., Haas and McAndrews 2000; Niering 1953; Valero-Garces *et al.* 1997; Yu *et al.* 1997). Whether the overall climate during this period was warm and dry, or more similar to today's, it is clear that the rapid deposition of coarse sediments along rivers and streams during the Sub-Boreal period was the result of frequent cyclonic storms that caused severe to moderate lateral channel migration of tributaries, with alluviation dominant over incision along major streams.

Sub-Atlantic (3,000–1,750 Years BP): The climate of the Sub-Atlantic chronozone (lower Pollen Zone C-3a) was warmer and moister than the preceding interval (Table 2.1). In most respects the climate and forest composition of this late Holocene period was very similar to that present at the time of European contact. Like most of the Ridge and Valley province, the forest at that time was characterized as an association of oak and chestnut, with local variations due to slope and altitude. Ridge tops were typically dominated by scarlet, black and chestnut oaks, the upper slopes by red oak; the lower slopes by white oak, red oak, hickory and hemlock, and the valley floors and river terraces by white oak, sugar maple, hemlock, white pine and pitch pine (Braun 1950). Chestnut was a dominant species, though it has been eliminated due to the chestnut blight of the early 20th century. The forest contained pockets of other climax associations that reflected the region's mountainous character and altitudinal variations (Braun 1950). Of these, the mixed mesophytic cove forests would have been particularly well developed.

The warm and moist conditions during the Sub-Atlantic allowed for long-term floodplain stability and subsequent A-horizon development (Table 2.1). Floodplain stability indicates that the effects of meridional circulation and resulting pattern of frequent cyclonic and convectional storms was much reduced during this time. A return in the abundance of hemlock pollen from its low levels during the Sub-Boreal suggests lower rates of evapotranspiration and more effective precipitation.

Scandic (1,750–1,200 Years BP): The forest during the Scandic period (middle Pollen Zone C-3a) appears to have been similar to that of the preceding Sub-Atlantic phase. Cooler and moister climatic phases such as the Scandic (1,750–1,200 years BP), as well as the subsequent Pacific (700–500 years BP) and Neo-Boreal (500–50 years BP) phases, effectively arrested A-horizon development while the increased frequency of tropical storms (hurricanes) led to increased runoff, floodplain instability, and the formation of Bw and BC horizons on floodplains and low terraces.

Neo-Atlantic (1,200–700 Years BP): The Neo-Atlantic is associated with the latter half of the Middle Woodland period. The forest during the Neo-Atlantic period (upper Pollen Zone C-3a) was similar to that of the preceding Sub-Atlantic and Scandic phases. As during the Sub-Atlantic, an increase in floodplain stability during the warm moist Neo-Atlantic period resulted in the formation of an Ab horizon along larger streams.

Pacific to Modern (700–150 years BP): The forest type associated with the Pacific (700–500 years BP), Neo-Boreal (500–50 years BP), and Modern (50 years BP–present) periods (Pollen Zone C-3b) was similar to that of the preceding Sub-Atlantic through Neo-Atlantic stages but with an increase in spruce and pine. Nearly all of the original forest-cover in the Northeast was removed by the end of the 19th century as a result of lumbering and agricultural activities. The forests of today are exclusively secondary communities which bear little resemblance to the original forest association (Casselberry and Paull 1967; Gifford and Whitebread 1951).

The Neo-Boreal marks the return of cooler conditions to the northern hemisphere. The weather patterns resulted in pronounced winter cooling and summer droughts. As during the earlier Scandic episode, the cool-moist climate of the Pacific and Neo-Boreal periods effectively arrested A-horizon development while the increased frequency of tropical storms resulted in rapid deposition and Bw horizon formation on floodplains and low terraces.

D. HISTORIC PERIOD ENVIRONMENTAL SETTING

Historic maps, dating from around 120 years after the first permanent Dutch settlement on Staten Island, show the study area as a mix of coastline beach, extensive coastal marshes and some areas of fast land (e.g., Taylor and Skinner 1781 [see below, Figure 4.1]). The area at the extreme northeastern end of the project alignment is depicted as the base of the upland now occupied by Fort Wadsworth ("Fort" on the 1781 Taylor and Skinner map); the upland is a segment of the terminal moraine immediately adjacent to the Narrows. Beginning at the base of the upland, the maps show an extensive marsh or wetland stretching to the southwest, fed by numerous streams draining the uplands to the northwest, including the southeastern side of the moraine. A gap in the beach at the mouth of the stream network suggests tidal flow in and out of the marsh.

Southwest of this marsh, a broad area of fast land approximately 1.25 miles wide is shown straddling a lane or road in the location now occupied by New Dorp Lane. The dry land is depicted on the Taylor and Skinner map as being divided into agricultural fields with scattered trees; the same map shows several buildings along the lane and a side road (Mill Road) extending southwest to Mill Creek within the Great Kills marsh. Southwest of the fast land, coastal swamp extends to the Great Kills embayment; on all maps, a narrow spit-like neck of fast land extends southwest for some distance along the southeastern edge of the Great Kills wetland. The Taylor and Skinner map appears to depict the northeastern portion of this spit as fast land, merging into beach to the southwest and southeast. The configuration of beach, streams, and wetlands in both the northeastern and southwestern portions of the project alignment strongly suggest that the "beaches" are actually a line of transgressing barrier islands which have accreted onto the coast of Staten Island, forming "barrier beaches."

The 1781 Taylor and Skinner map indicates the presence of at least 14 first-order streams immediately northwest of and flowing across the project alignment (see below, Figure 4.1). The majority of these are depicted as originating on the face of the moraine to the northwest of the project alignment. In this area, the first-order streams combine to form second-order streams between the head of the outwash plain below the moraine and the modern coastline; ultimately, four of these second-order streams combine to form a watercourse labeled "New Creek" on later maps. One second-order stream draining the moraine and the landscape below it flows to the Great Kills embayment and on later maps (e.g., Dripps 1872 [see below, Figure 4.5]) is labeled "Mill Creek." Additionally, two first-order streams are depicted near the southwest end of the project alignment, flowing southwest more or less parallel to the coastline and joining to form a second-order stream ("Bass Creek") that flows to the Great Kills embayment.

Mid-19th-century maps of Staten Island indicate that virtually no development had taken place along the marshy coastal areas (e.g., Butler 1853 [see below, Figures 4.3]). A U.S. Coast Survey map of 1844 shows the marsh surrounding New Creek as having been subdivided into fields, although this may simply reflect harvesting of marsh grass for bedding and fodder rather than true agriculture (see below, Figure 4.2). Other U.S. Coast Survey maps for this period also show an unimproved road extending from the base of the Fort Tompkins (later Fort Wadsworth) upland to near the mouth of New Creek (e.g., U.S. Coast Survey 1861; 1866). A dozen or more structures are shown along the road, but these do not appear on the 1853 Butler map and were most likely informal structures such as fishing shacks.

By 1853, as shown by the Butler map, a score of houses stood on the fast land at New Dorp (see below, Figure 4.3), while by 1859, as indicated by the Walling map of that year, a lighthouse had been constructed near the beach at the end of New Dorp Lane, replacing a large elm tree which had formerly served as a navigational aid (see below, Figure 4.4b). Southwest of the dry land at New Dorp, very little development was occurring along the coast during this period. The 1853 Butler map shows a structure labeled "Mrs. Peersoll" at the northeastern end of the narrow spit of land lying between the shoreline and the coastal marsh extending from Great Kills. An "L" shaped wharf projects from the beach nearby. Near the southwest end of the spit are two structures labeled "Loveridge." Two other structures labeled "Loveridge" stand a short distance to the northwest, within the marsh. The 1859 Walling map also shows a structure labeled "Mrs. Peersoll" and two structures labeled "Fish Houses" at the Loveridge location.

The first clear evidence of filling of the New Creek marsh is shown on the 1872 Dripps map (see below, Figure 4.5). It shows Evergreen, Burgher and Atlantic Avenues (all still extant today) extending to a wharf on the coastline just northeast of the mouth of New Creek. It should be noted that later maps (e.g., Beers 1887 [see below, Figure 4.6a]; U.S. Coast Survey 1895) do not show these improvements, although they do indicate that the marsh was much diminished in area from that shown on earlier maps. Late 19th-century maps show the presence of numerous drainage ditches within both the marsh surrounding New Creek and that north of Great Kills, apparently reflecting an attempt to drain the wetlands (U.S. Coast Survey 1889; 1895 [see below, Figures 4.26 and 4.28]). No tide gates or other control structures are indicated on these maps, although these may have existed. Turn-of-the century topographic maps (U.S. Geological Survey 1900, [see below, Figures 4.7 and 4.29]; 1905) continue to show extensive coastal marsh within the New Creek drainage and northeast of Great Kills, with no development aside from the presence of several unimproved roads within the New Creek marsh.

By 1917, the entire beachfront within the majority of the study corridor had been commercially developed, with improvements consisting largely of amusement parks, hotels, bungalows and other vacation and recreation-related structures. The vacation area was serviced by the Southfield Beach Railroad, just northwest of Seaside (now Father Capodanno) Boulevard. Development was most pronounced from the northeastern limit of the project alignment at the base of the Fort Wadsworth upland southwest of the end of Sea (now Lily Pond) Avenue) to Buel Avenue, two blocks southwest of Seaview Avenue. Most of the northeastern portion of the salt marsh lying in the New Creek drainage had been filled, allowing development from a boardwalk along the landward edge of the beach to as far northwest as the northwestern side of Seaside Boulevard. Extensive development, including the laying out of streets and residential lots, had taken place between Seaview and Buel Avenues, inside a large meander near the mouth of New Creek. The debouchure of the creek lay to the southeast of the block between Seaview and Liberty Avenues. Large expanses of land northwest of Seaside (Father Capodanno) Boulevard within the marshy New Creek drainage are still shown as undeveloped at that time (Bromley 1917 [see below, Figures 4.9a-c]).

For a quarter mile southwest of this, development was limited to campsites; hotels, casinos and a boardwalk; and then more campsites extending to the northeastern edge of the George W. Vanderbilt estate (Miller Field). From the southwestern edge of the estate, at New Dorp Lane, to around Ebbitts Avenue (now Ebbitts Street), development again picked up for a short distance and included not only campgrounds but also a block of residential structures, a hotel, bath house, and gymnasium, all within a stone's throw of the water's edge (Bromley 1917 [see below, Figures 4.9c-e]). The stretch of development immediately northeast of the Vanderbilt estate, the estate itself, and the residential area and large structures southwest to Ebbitts Avenue roughly demarcate the area shown as fast land lying between two coastal marshes as shown on the 1781 Taylor and Skinner map (see below, Figure 4.1).

Southwest of Ebbitts Avenue, development was limited to a single line of bungalows along the beachfront, extending to near Promenade Avenue (now Fox Lane), just northeast of the present-day location of the Oakwood Wastewater Treatment Plant. The bungalows were closely spaced immediately southwest of Ebbitts Avenue and sparser further to the southwest (Bromley 1917 [see below, Figures 4.9e-g]). This area corresponds to that depicted on the 1781 Taylor and Skinner map as a narrow neck of fast land transitioning southward to a sandy spit (see below, Figure 4.1).

Filling of marshy areas, facilitating residential and commercial development, continued through the mid- and late 20th century, particularly in the post-World War II era. A 1947 topographic map shows the marsh within the New Creek drainage to be confined to the north-central portion of its former extent, bounded on the southwest by Cromwell Avenue and on the north-east by Vulcan Street (U.S. Geological Survey 1947). Currently, much of that area is still open marshland and brush, including Ocean Breeze Park and the South Beach Wetlands, which extend well northeast of Vulcan Street to Sand Lane. The same map shows that drainage to the ocean was still via an open New Creek debouchure at the end of Seaview Avenue, as does a 1955 edition of the same topographic series (U.S. Geological Survey 1955). By 1966, no open confluence was present, with discharge from the New Creek drainage apparently confined to a pipe running offshore (U.S. Geological Survey 1966).

Chapter 3

PREHISTORIC CULTURAL BACKGROUND

Prehistoric human occupation within the dynamic and mobile post-glacial environment detailed in Chapter 2 is the primary focus of this chapter. Human occupation of the Middle Atlantic region of the United States had begun by 11,000 to 10,500 years BP within a boreal forest composed primarily of pine and birch that shifted, as temperatures warmed, to pine and oak (Dent 1991; Stewart 1990, 1991). Similar vegetation cover extended throughout much of the region, although the presence of favorable microenvironments arising due to topography, solar exposure and surface water (ponds, lakes, and rivers) exerted a considerable influence on prehistoric subsistence and adaptations.

Evidence of Paleo-Indian occupation on the Coastal Plain of New Jersey, generally in the form of isolated fluted point sites (Kraft 1977a; Cavallo 1981; Custer *et al.* 1983), reflects the presence of early human groups in the region. The point distribution is affected by the bias of non-systematic surface collection activity, but nevertheless provides some indication of the nature of Paleo-Indian adaptations. It is generally accepted that these points and associated finds are indicative of hunting and game processing activities (Bonfiglio and Cresson 1978). Similar tool assemblages from the late Paleo-Indian site of Turkey Swamp near the boundary between the Inner and Outer Coastal Plains in Monmouth County, New Jersey, are interpreted as reflecting the same activities (Cavallo 1981).

As indicated in the discussion of transgressing sea levels, Staten Island was not a coastal location at the time of Paleo-Indian occupation. Thus, evidence of a Paleo-Indian human presence on Staten Island would not relate directly to a coastal environment, but rather to the exploitation of inland forest/riverine habitats (Edwards and Merrill 1977). Paleo-Indian activity on Staten Island is manifested in isolated fluted point finds in the central and southern portions of the island and by two sites along the Arthur Kill – the Port Mobil site and the Charlestown Beach site, both located roughly four to five miles to the northwest of the project alignment. There is also a single Paleo-Indian find spot near the Great Kills Yacht Club located less than a mile from the southwest end of the corridor, but no other information is available for this unnamed site (A085-01-163) (Table 3.1). The Port Mobil site was identified within a tank farm located 1,000 feet from the Arthur Kill. Now in an area that is heavily disturbed, the site was originally situated on high sandy ground along an eroding slope at an elevation between 20 and 40 feet above present-day sea level. The Port Mobil site has yielded eight fluted points, end and side scrapers, and unifacial tools (Kraft 1977b; Eisenberg 1978; Ritchie 1980; Pagano 1985). By contrast, the Charlestown Beach site was detected eroding from a peat layer at the edge of the Arthur Kill. This site has never been fully described, but a site form was prepared by Professor Bert Salwen in 1967. The site has yielded at least 10 Paleo-Indian fluted points to collectors, including examples of Clovis and Cumberland types. Numerous phases of prehistoric occupation are indicated, including the more recent Early and Middle Woodland periods (Pagano 1985).

Paleo-Indians inhabited a region with a rich fauna. The mammoth, oriented to more open habitats, may have occupied the area prior to the arrival of humans, while the forest mastodon was more certainly a contemporary of early Paleo-Indians. Deer and possibly caribou also would have been common species

Table 3.1. Prehistoric Sites.

Site Name	Site #	Type	General Periods	Notes	Source
VanDeventer-Fountain-Mouquin House Site	A085-01-007	Short duration hunting or gathering camp	Middle through Late Woodland and Historic	Debitage, ceramics, thermally altered rock, projectile points and bifaces	Louis Berger & Associates, Inc. 1990:VII-2
Fort Wadsworth, US Army Reservation	A085-01-031	n/a	Prehistoric and Historic	"Lenape" site in the vicinity of Ft. Wadsworth. Staten Island Institute of Arts and Sciences has artifacts in collection. May be same as A085-01-167 (ACP: Rich-21)	Parker 1922:Plate 211; John Milner Associates 1978:57
Walton-Stillwell House Site	A085-01-027	n/a	Late Archaic through Contact Period	A pits identified in the yard of a historic house with 17th-century European and Native American artifacts	Boesch 1994:116
Crooke's Point	A085-01-162	n/a	Prehistoric	"Small collection of artifacts"	Boesch 1994:118
Isolated Fluted Point	A085-01-163	Isolated find	Paleo-Indian	Isolated find of a fluted point	Ritchie 1965:5
Std-0	A085-01-164	Shell midden	Prehistoric	Flint waste flakes observed by Skinner, shell heap. May be same as Std-Gk	Skinner 1909:17
Std-Gk	A085-01-165	Village site	Contact Period	"area occupied for approximately 16 years by the Nayack natives when they moved from Long Island." May be same as Std-0	Bolton 1934:152, 156
Lake's Mill Site/ACP: Rich-27	A085-01-166	Shell midden	Prehistoric		Parker 1922:685
Fort Wadsworth/Rich-21	A085-01-167	n/a	Prehistoric	Parkers says there is a Lenape site in the vicinity of Ft. Wadsworth. Staten Island Institute of Arts and Sciences has artifacts in collection. May be same as A085-01-031	Boesch 1994:108
Isolated Cultural Remains	A085-01-169	n/a	Prehistoric	Remains not described. Accurate location not provided	Parker 1922:Plate 211; John Milner Associates 1978:58
Midland Beach	n/a	n/a	Prehistoric	Artifacts including chert biface collected in 1900	Boesch 1994:117

roaming in the early Holocene forests. The proximity of a riverine habitat would have supported aquatic resources, both animal and plant in nature.

Many scholars working the field of Middle Atlantic human prehistory have combined the Early Archaic period with the Paleo-Indian period and view the two time frames as a broad Late Pleistocene/Early Holocene adaptational continuum (e.g., Gardner 1974; Custer 1989, 1994). Regardless of whether one favors a sharp or gradual transition, four stratified and dated Archaic sites have been found in southern Staten Island and excavated by avocational archaeologists. These are the Richmond Hill site, the Old Place site, the Hollowell site and the Ward's Point site. Of these, the Richmond Hill site is the closest to the project alignment, located approximately two miles northwest of the southern end of the project corridor, while another Early Archaic resource, the unstratified Goodrich site, is situated near the northern end of the island.

In the interior of Staten Island, at the Richmond Hill site, a modern humus and a stratum with undatable cultural material sealed a layer of reddish-brown gravelly sand and clay that yielded examples of Kirk-type, Palmer, Hardaway (Early Archaic) and LeCroy (Middle Archaic) projectile points. Most of the cultural materials in this layer were associated with a hearth that yielded a radiocarbon date of 9,360 +/- 120 years BP, the earliest radiometric date yet recorded for human occupation within the current limits of New York City (Ritchie and Funk 1971). While this is the closest site, its habitation was clearly oriented to the west towards the Fresh Kills wetlands.

The Old Place site is located at the eastern end of the Goethals Bridge approach, approximately five miles northwest of the project alignment. This location lies just off the terminal moraine that represents the southernmost maximum extent of the Wisconsinan ice advance. The excavators recognized the site as a series of three or four cultural layers within a tan-colored sand near the swamp edge. The deepest layer contained Stanly, LeCroy and Kirk points and hearth charcoal dating 7,260 +/- 140 years BP. Ritchie and Funk (1971:49) consider this date to be appropriate for the Stanly points but too recent for the earlier forms. The Goodrich site, located roughly three miles north of the northern end of the project alignment, is a multi-component site reportedly dating from the Early Archaic through the Late Archaic periods. No definite site limits have been determined for this site, and the New York State Museum site file information is largely silent on the site's stratigraphy and artifact yield.

The Hollowell site is located well to the south of the project alignment at the base of a low sand rise near Ward's Point. This multi-component site contained three prehistoric strata: a Late Woodland stratum; a Late Archaic/Early Woodland stratum with Vinette I ceramics and a Vosburg point; and a layer of brown mottled sand that yielded 24 points including Kanawha, Stanly and Eva types (Middle Archaic). A charcoal sample from the brown sand was dated to 3,110 +/- 90 years BP, an assay that seems more likely to be derived from intrusive charcoal originating in the overlying Late Archaic/Early Woodland occupation (Ritchie and Funk 1971).

The nearby Ward's Point site is located on a low sand knoll at the southern tip of Staten Island and produced a stratigraphic sequence similar to that observed at the Hollowell site. An Early/Middle Archaic stratum was overlaid by early Middle Woodland and Transitional layers and a Late Woodland shell midden. The base cultural layer comprised a mottled reddish-brown sand that contained Kirk (Early Archaic), Kanawha and LeCroy (Middle Archaic) points, as well as two hearths from which charcoal yielded radiocarbon dates of 7,260 +/- 125 and 8,250 +/- 140 years BP (Ritchie and Funk 1971).

Hypothetical reconstructions of the Middle Atlantic coast between 6,000 and 8,000 years ago suggest that estuarine areas were approaching their current locations along the coastline. Tidal salt marshes appear to have emerged in advance of the transgressing shoreline of New Jersey and Long Island by around 5,000 years ago, and the shoreline achieved its current location approximately 3,000 years BP (Kraft 1977:Figure 27). Climatic conditions were warm and somewhat moister than in the preceding Boreal phase, with oak and hemlock as dominant vegetation species (Deevey 1952; Dent 1979), but perhaps with pine persisting in coastal areas.

This time period coincides with the emergence of another archaeologically-defined human adaptational phase, the Middle Archaic. Material culture changes during the Middle Archaic include the appearance of ground stone tools in addition to flaked stone artifacts. There is also a shift in the dominant raw materials utilized for tools – away from cryptocrystalline rocks toward a wider range of rock types, including rhyolite and argillite – which may be suggestive of increasing mobility in the landscape and also possibly of changes in social organization. Archaic sites in the southern portion of the Middle Atlantic have been type-cast as macro-band and micro-band base camps in areas of "maximum habitat overlap" (Custer 1989, 1994). Such areas typically include interior freshwater swamps and bay/basin loci. Coastal tidal salt marshes and estuarine environments also would have been food resource-rich habitats available for exploitation.

Native American occupation sites producing cultural materials datable to the Middle Archaic are generally considered to be rare on Staten Island (Pagano 1985; Boesch 1994). The four stratified sites discussed above produced Early Archaic side-notched points (Hardaway) as well as stemmed (Stanly) points, two broadly diagnostic forms that span as much as 2,000 years of occupation in the southeastern United States, which may help to explain the difficulty in recognizing Middle Archaic occupation (Ritchie and Funk 1971). Other possible explanations for this mixture of points may be found in geomorphological changes affecting soil accumulation rates across Staten Island or in micro-stratigraphic changes that were not recognized during the excavations.

Changes in climate commencing about 4,600 years BP produced the warmest and driest conditions of the current post-glacial period, with oak and hickory becoming dominant tree species. This climatic shift appears to roughly coincide with the emergence of the archaeologically-defined Late Archaic phase. This phase is characterized by different diagnostic lithic forms and an increase in the number of base camps. According to Boesch, Late Archaic occupations are more commonly found near estuarine environments (such as the Pottery Farm, Bowman's Brook, Smoking Point and Goodrich sites) and along larger interior streams (Sandy Brook, Wort's Farm and Arlington Avenue sites) (Boesch 1994:11). Most of these sites are located along the western side of the island. The only identified Late Archaic material recovered close to the current project alignment is the prehistoric component of the Walton Stillwell House site (A085-01-0027) that included large side-notched points and full-grooved axes found in pits with more recent prehistoric and Contact period material. This site is located close to the northeastern end of the project limits.

The appearance of cache pits and ceramic storage vessels, a key characteristic of the successive Transitional and Early/Middle Woodland periods, indicates a greater degree of sedentism among Native Americans in the Middle Atlantic region. Custer (1989) has argued for an adaptational continuum spanning the Late Archaic through the Middle Woodland periods, which he labels Woodland I in the southern coastal Middle Atlantic. Evidence for long-distance trade and exchange is manifested in the presence of Adena cultural materials from the Ohio River Valley at habitation and mortuary sites dating from around 2,500 to 2,000 years BP. Increasing exploitation of estuarine resources in coastal areas is noted during the period of Adena influence.

Transitional period components are present at the Pottery Farm, Ward's Point, Old Place and Travis sites on the western side and southern end of the island but no distinctive Transitional sites have been documented within a one-mile radius of the project alignment (Boesch 1994:12). Neither has evidence of Early Woodland occupation been found within a one-mile radius of the project alignment, although many sites on Staten Island have Early Woodland components, most notably at the Pottery Farm, Old Place and Rossville sites.

Warm and dry climatic conditions began to yield to a cooler, moister, more modern climate with oak and chestnut vegetation about 2,000 years BP, which is roughly coincident in some areas of the Middle Atlantic with the waning of Adena influence. The majority of sites dating to this period, referred to as the Middle Woodland, are located near estuaries. The more significant sites with this component include the Huguenot, Cutting, Pottery Farm and Page Avenue North sites (Boesch 1994:12). Excavations at the VanDeventer/Fountain House, located within Fort Wadsworth a few hundred feet from the northeastern end of the project alignment, also yielded evidence of Middle through Late Woodland period occupation including lithic debitage, a Rossville projectile point, ceramics sherds and thermally altered rock (Table 3.1). The site was characterized as a small hunting and gathering camp (Louis Berger & Associates, Inc. 1990).

By 1,000 years BP the trade and exchange network influence had disappeared, and the archaeologically-defined Late Woodland period, or Woodland II phase, emerges. Increasing evidence of sedentism is manifested in the expanded use of storage facilities and more permanent house structures. Increased gathering of shellfish and the harvesting of plants reflect an intensification of food procurement evidently related to population growth. The emergence of agricultural production is also related to this sedentary settlement pattern, which was maintained until European contact. Material culture of this period is distinguished by several distinctive ceramic forms and small triangular projectile points, the latter evidently indicative of bow-and-arrow technology (Custer 1989).

Late Woodland occupation has been documented at numerous sites on Staten Island, including many of those already mentioned (e.g., the Hollowell, Ward's Point, Bloomfield/Watchogue and Old Place sites). One additional important site deserves mention. This is the Bowman's Brook site, also referred to as the Milliken site, which is located near the northwest corner of the island, approximately four miles from the project alignment. This site was occupied throughout the Woodland period and is the type site for two well-known ceramic decorative styles. The site was initially recorded in the site files of 1904 (Set A), later supplemented with information produced by Alanson Skinner and then again by Bert Salwen (Skinner 1909; Salwen 1967).

Because of Staten Island's position adjacent to New York harbor it was the location of some of the earliest Native American and European interactions in the region. Starting in the early 17th century the Dutch established a trading post on the island. These interactions, especially with Dutch settlers, became increasingly contentious and deadly, and between 1639 and 1655 three separate attempts were made to establish a permanent settlement on the island. It was not until 1661 that the first permanent Dutch settlement was established at Oude Dorpe (Old Village) by Dutch, Walloon and French Huguenot families at South Beach at the northeastern end of the project alignment. By the end of the 18th century, Native Americans, decimated by disease and crowded out by settlers, had largely departed Staten Island. Excavations at the Walton-Stillwell House (A085-01-027), part of the site of Oude Dorpe, have identified mid-17th-century artifacts in association with Native American artifacts. Artifacts included shell, bone, Native American ceramics and triangular, chert arrowheads. These materials were found in pits that also yielded Flemish-style ceramics and Louis XIII coin dated 1638 that predate the house, which was built *circa* 1668. The house, which is no longer standing, was located on top of a bluff approximately 30 feet above sea level and pits were found around the house and also at the base of the bluff closer to the shoreline (Anderson and Sainz 1965). As mentioned above, earlier Native American components were also identified at this site.

In addition to those mentioned above, there are nine other sites that are located within or near the project alignment (Table 3.1). With the exception of one site, all were identified during the late 19th or early 20th centuries and very little detail is available. A "Lenape" site was reported in the vicinity of Fort Wadsworth (probably site A085-01-031 and/or A085-01-167), although no additional information is provided (Parker 1922:Plate 211; John Milner Associates 1978:57). Moving to the southwest, artifacts, including a chert biface, were reportedly found at Midland Beach by members of a British Museum expedition in 1900 (Boesch 1994:117). Detailed locational data are not available. Isolated cultural remains were also identified on the site of the Vanderbilt estate, which in 1919-21 was converted into the U.S. Army coastal defense airbase known as Miller Field (A085-01-169), although information regarding their character and the exact location of their discovery are not provided (Parker 1922:Plate 211; John Milner Associates 1978:58). Three sites, all associated with what appears to be a single Native American shell midden, were identified just beyond the southern end of the project alignment (A085-01-164, A085-01-165, and A085-01-166). These are all likely the same Woodland period site, reported separately by Alanson Skinner, Reginald Bolton and Arthur Parker. Skinner reported observing flint waste flakes and a shell heap near Lake's Mill at a site he called the Oakwood site (Skinner 1909:17). Parker simply describes a shell heap at Lake's Mill where he discovered, "a few shells …. No pottery or relics occur, but a few flint flakes are found" (Parker 1922:685). Finally, Bolton identifies this area as being occupied for 16 years by the Nayacks after they moved from Long Island (Bolton 1934:152, 156).

In 1995, an archaeologist with the U.S. Army Corps of Engineers, New York District tested the alignment of a proposed levee at Oakwood Beach (U.S. Army Corps of Engineers 1996). Testing along the southwestern side of Dugdale Road north of the Oakwood Beach Wastewater Treatment Plant yielded four pieces of debitage from four shovel tests. No diagnostic artifacts were recovered and the site was destroyed a year after the survey. These finds may be associated with the Lake's Mill/Oakwood site reported above. Finally, a small collection of prehistoric artifacts were found at Crooke's Point (A085-01-162), although no further detail is provided in the site files.

Chapter 4

HISTORICAL BACKGROUND

A. OVERALL HISTORY OF THE PROJECT ALIGNMENT

The first well documented European encounter with Staten Island occurred in 1524 when the Italian explorer Giovanni da Verrazzano anchored his ship, *La Dauphine,* off the island's Atlantic coastline. Historians generally agree that the name Staten Island originated approximately 85 years later with the English explorer Henry Hudson, who first sighted the island when he sailed into the Lower New York Bay in 1609 while in the employ of the Dutch East India Company. At that time he christened it Staaten Eylandt in honor of the Estates General, which governed the Netherlands. Although the Dutch established permanent settlements at what became Albany and Manhattan in the 1620s under the aegis of the Dutch West India Company, who sent groups of French settlers to engage in the fur trade for the company, they did not attempt to establish a permanent settlement on Staten Island until the 1630s (Lundrigan and Navarra 1997:7; Dickenson 2003:11-12).

In 1639, David Pietersz de Vries received land rights on Staten Island and established a settlement near Tompkinsville in the northeastern part of Staten Island. This location was also known as "The Watering Hole" due to the presence of a fresh spring there that supplied vessels with water on their return voyages to Europe. The settlement failed within two years, however, when the Lenni Lenape attacked the settlement in retaliation for having been wrongfully accused of stealing pigs belonging to the settlers. Two subsequent attempts by Cornelius Melyn to establish settlements near Fort Wadsworth in 1642 and 1650 also failed within only a few years due to conflicts with the Lenni Lenape precipitated by the mistreatment of the Native Americans by the Dutch colonial government and Dutch settlers (Lundrigan and Navarra 1997:7; Dickenson 2003:12-15; Panamerican Consultants, Inc. 2005:3-21).

European colonists established the first permanent settlement on Staten Island in 1661, when Governor Peter Stuyvesant granted land on the island to a group of Dutch and French settlers under the leadership of Pierre (Peter) Billou (Dickenson 2003:17). Eventually known as Oude Dorp, or Old Town, this settlement stood along Old Town Road, which followed the present alignment of Olympia Boulevard and Robin Road in South Beach at the northern end of Staten Island approximately 1,200 feet west of the project alignment (Panamerican Consultants, Inc. 2005:3-21). In 1664, Oude Dorp housed between 12 and 14 families and consisted of a wooden blockhouse surrounded by several wooden houses (Panamerican Consultants, Inc. 2005:3-21). That same year, the British seized control of New Amsterdam from the Dutch and Staten Island became part of the West Riding of Yorkshire in the province of New York. Oude Dorp was renamed Dover by the English (Leng and Davis 1930:108-112; Lundrigan and Navarra 1997:7).

Efforts to colonize Staten Island intensified under British control, and, beginning in 1670, Governor Francis Lovelace ordered dozens of lots to be laid out on the north, east and south shores of Staten Island. Toward the southern end of the project alignment, for example (in the vicinity of the Lake tide mill), Jacques Guyon secured a patent for a large tract of land that included the neighborhood of Oakwood. During the ensuing decades, the British colonial government issued dozens of new land patents, and new settlers slowly arrived on Staten Island. During the 1670s, a new settlement known as New Dorp, or New Town, appeared on the east side of Staten Island approximately 1.5 miles west of the project site in the vicinity of the intersection of Richmond Road and Amboy Road. By 1679, approximately 100 families occupied the island, displaying a mix of Dutch, English and French surnames (Leng and Davis 1930:117, 125; Steinmeyer 1950:13-14; Dickenson 2003:19).

In 1683, the British convened the first Provincial Assembly of New York, which enacted a law to reorganize the province's civic structure. The law established Staten Island and the neighboring Shooter's Island and Island of Meadows as a separate entity within the province of New York and organized them into the County of Richmond. Richmond County represented one of New York's original counties and was named in honor of the Duke of Richmond, the brother of England's King Charles II. The settlement of New Dorp, which was also known as Stony Brook, became the county seat (Bayles 1887:90-91; Leng and Davis 1930:128; Lundrigan and Navarra 1997:7; Dickenson 2003:28; Jackson 2010).

In 1688, the British divided Richmond County into four administrative precincts that generally corresponded to Staten Island's natural features and were known as the North, South and West divisions and the "Lordship or manner of Cassiltowne," the latter encompassing 5,100 acres of land in northwestern Staten Island, roughly opposite Bayonne, which had been granted to Governor Thomas Dongan in 1687 (Leng and Davis 1930:128; Jackson 2010). These precincts were designated, respectively, as the townships of Northfield, Southfield, Westfield and Castleton in 1788 by the New York State Legislature (Morris 1898:114; Lundrigan and Navarra 1997:7). The project alignment was located entirely within Southfield Township until 1866, when the village of Edgewater was formed from the northern portion of the township. Edgewater's boundaries incorporated the current neighborhoods of Stapleton, Tompkinsville and Clifton and the northern terminus of the project alignment. In 1898, Staten Island became a borough within New York City and all of its villages and townships were dissolved (Jackson 2010).

During the decades following the creation of Richmond County in 1683, Staten Island developed at a relatively slow pace. The British continued to grant land patents to settlers in fractions and multiples of 80 acres, and by 1708 the entirety of Staten Island had been divided into approximately 166 farmsteads and two large estates known as the Manor of "Cassiltowne," which belonged to Governor Thomas Dongan, and the Manor of Bentley, which belonged to Captain Christopher Billopp and encompassed 1,600 acres of land in southwestern Staten Island roughly opposite Perth Amboy and South Amboy. The population of Staten Island rose accordingly, growing from 727 people in 1698 to 1,889 people in 1737 and to around 3,000 in 1776 on the eve of the Revolutionary War (Steinmeyer 1950:18-19; Dickenson 2003:20). Enslaved Africans constituted between 10% and 20% of Staten Island's population during this period (Steinmeyer 1950:18-19). A transportation network also developed on Staten Island during this period, with ferries providing access from the island to lower Manhattan and to settlements and towns on Long Island and in New Jersey, and a nascent network of roads connecting the isolated hamlets and farms scattered across the island with the new administrative and government center established at Richmond (Richmondtown) in 1729 (Dickenson 2003:28-29).

A Map of New York and Staten Island published by George Taylor and Abraham Skinner in 1781 captures this transportation network and the predominantly rural and agricultural landscape that Staten Island still retained more than a century after Europeans had established the first permanent settlement at Oude Dorp (Figure 4.1). Unsurprisingly, Richmond represented Staten Island's main population center during this period, although New Dorp, which is not identi-

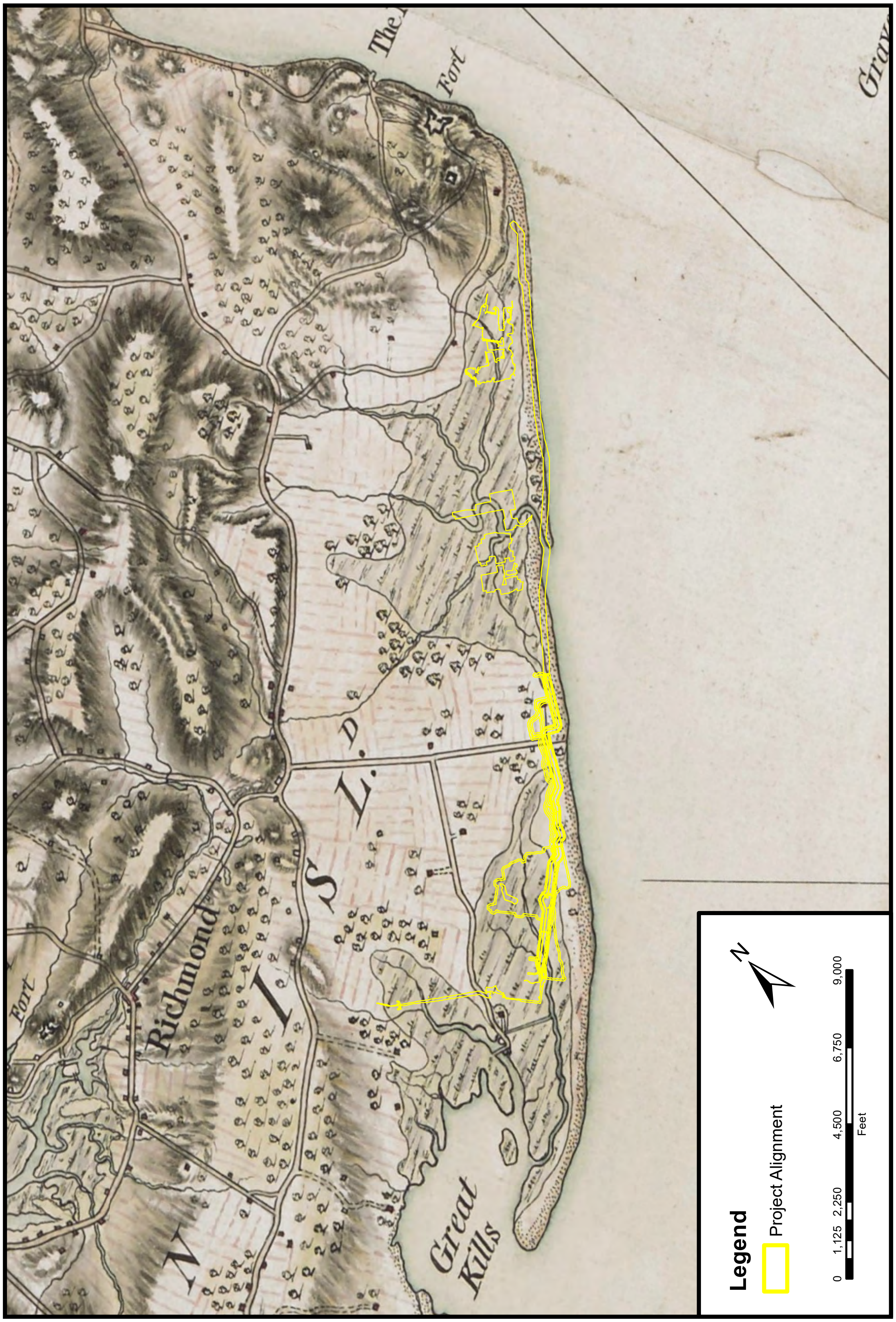


Figure 4.1. Taylor, George and Abraham Skinner. Detail of *A Map of New York and Staten Island*. 1781.

fied by the 1781 Taylor and Skinner map, remained one of the larger settlements on the island. In contrast to the dense clusters of buildings at Richmond and New Dorp, the south shore of Staten Island remained sparsely developed in the late 18th century, with the project alignment primarily running through undeveloped beaches and marshland. Three roads were located within close proximity to or passed through the project alignment. At the northern terminus of the project alignment, Old Town Road curved northeast from Richmond Road towards the Narrows on a path that corresponded with the present alignment of Quintard Street, Olympia Boulevard and Robin Road. Two dwellings stood on the southeast side of Old Town Road in the vicinity of the project alignment, including a dwelling constructed by Thomas Walton in 1668 east of the present location of Ocean Avenue (Panamerican Consultants, Inc. 2005:3-21). Toward the southern end of the project alignment, New Dorp Lane and Mill Street ran directly through the project alignment. New Dorp Lane connected Richmond Road with the south shore of Staten Island and provided access to a one-story fieldstone dwelling constructed in 1677 by Obadiah Holmes, which is currently located at Historic Richmondtown and known as the Britton Cottage, and an 18th-century dwelling owned by R. Barnes (Panamerican Consultants, Inc. 2005:3-58, 3-59). Mill Street ran southwest from New Dorp Lane to the Great Kills and past the Lake tide mill (see below, Chapter 4B).

Apart from Richmond, Southfield Township remained predominantly rural and agricultural until the late 19th century. In fact, the majority of the project alignment ran through undeveloped marshland and farmland along the south shore of Staten Island. A series of mid- and late-19th-century maps illustrates the limited development that occurred in Southfield Township and on the south shore of Staten Island during this period (Figures 4.2-4.4). Within the vicinity of the project alignment, development was largely confined to two areas along Old Town Road and New Dorp Lane. According to the 1844 U.S. Coast Survey map, one structure stood within the boundaries of the project alignment on the beach southeast of Old Town Road (Figure 4.2). This likely represented either a fish house or another type of temporary structure, for it had disappeared by the time James Butler published his *Map of Staten Island, or Richmond County, New York* in 1853 (Figure 4.3). The 1844 U.S. Coast Survey map also incorrectly locates the Britton Cottage partially within the boundaries of the project alignment. This likely represented a mistake, for the Britton Cottage stood to the west of the project alignment at the southeast corner of New Dorp Lane and Cedar Grove Avenue (Panamerican Consultants, Inc. 2005:3-58). The 1844 U.S. Coast Survey map places the three neighboring dwellings on New Dorp Lane, including the Barnes House on the north side of the road, adjacent to and outside the project alignment boundaries. The elm tree depicted by both the 1844 U.S. Coast Survey map and the 1853 Butler map at the end of New Dorp Lane represented an important local landmark and reportedly served as "a mark for vessels coming and going from New York to Amboy and New Brunswick" during the late 18th and early 19th centuries (*A New And Correct Mapp of the County of Richmond* 1797; Panamerican Consultants, Inc. 2005:3-76).

Southfield Township continued to grow during the 1850s and 1860s, with the township's population more than tripling from 1,012 people in 1820 to 3,645 people in 1860 (Jackson 2010). Southfield Township grew more slowly, however, than the neighboring townships of Castleton and Northfield, whose populations exceeded 6,000 people in 1860, and development was largely confined to the villages of Stapleton and Clifton in the north of the township (Jackson 2010). By the 1850s, development in Southfield Township had begun to spread from Clifton towards the south shore of Staten Island. New roads were laid out north-

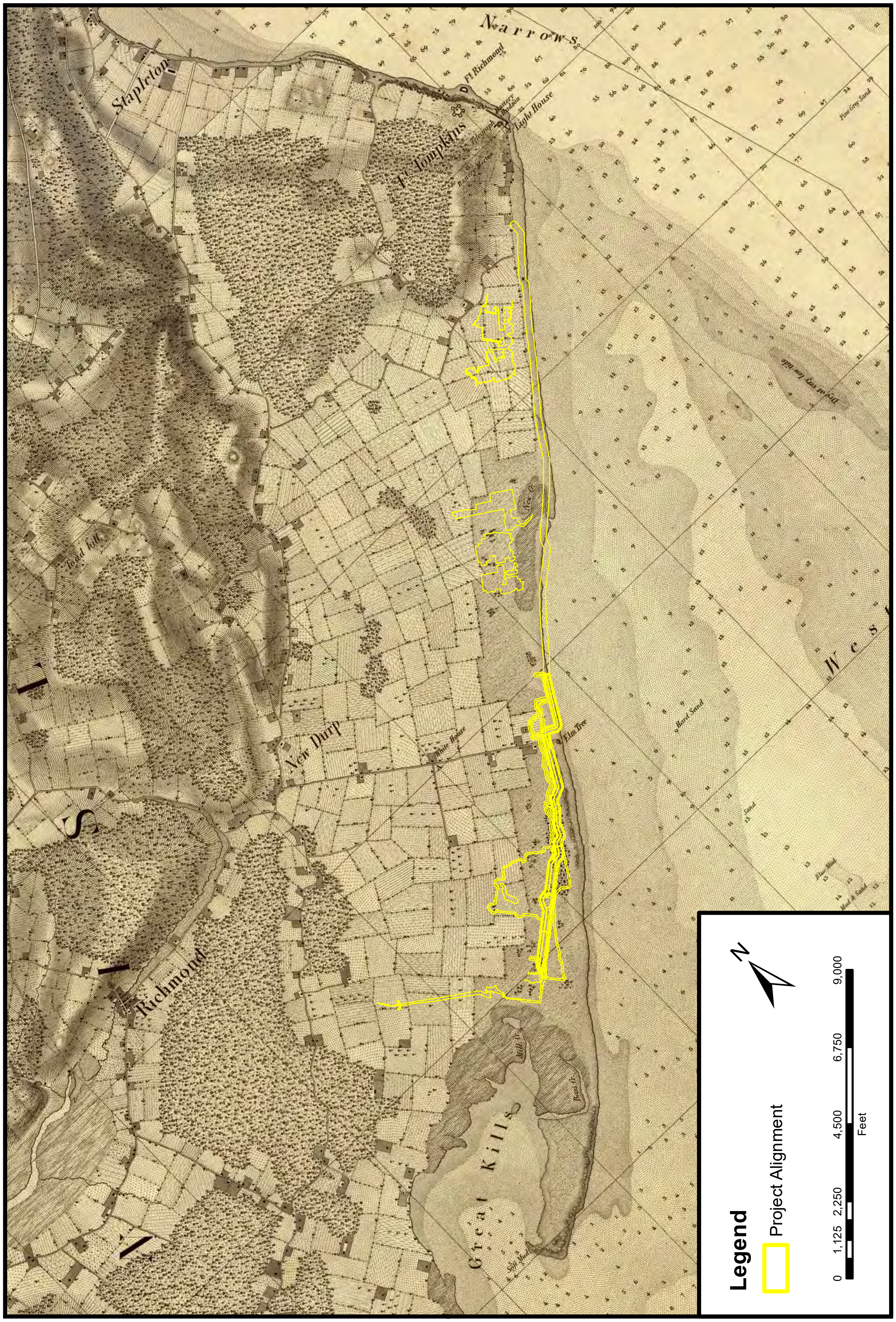


Figure 4.2. U.S. Coast Survey. Detail of *Map of New York Bay and Harbor and the Environs*. 1844.

Figure 4.3. Butler, James. Detail of *Map of Staten Island, or Richmond County, New York.* 1853.

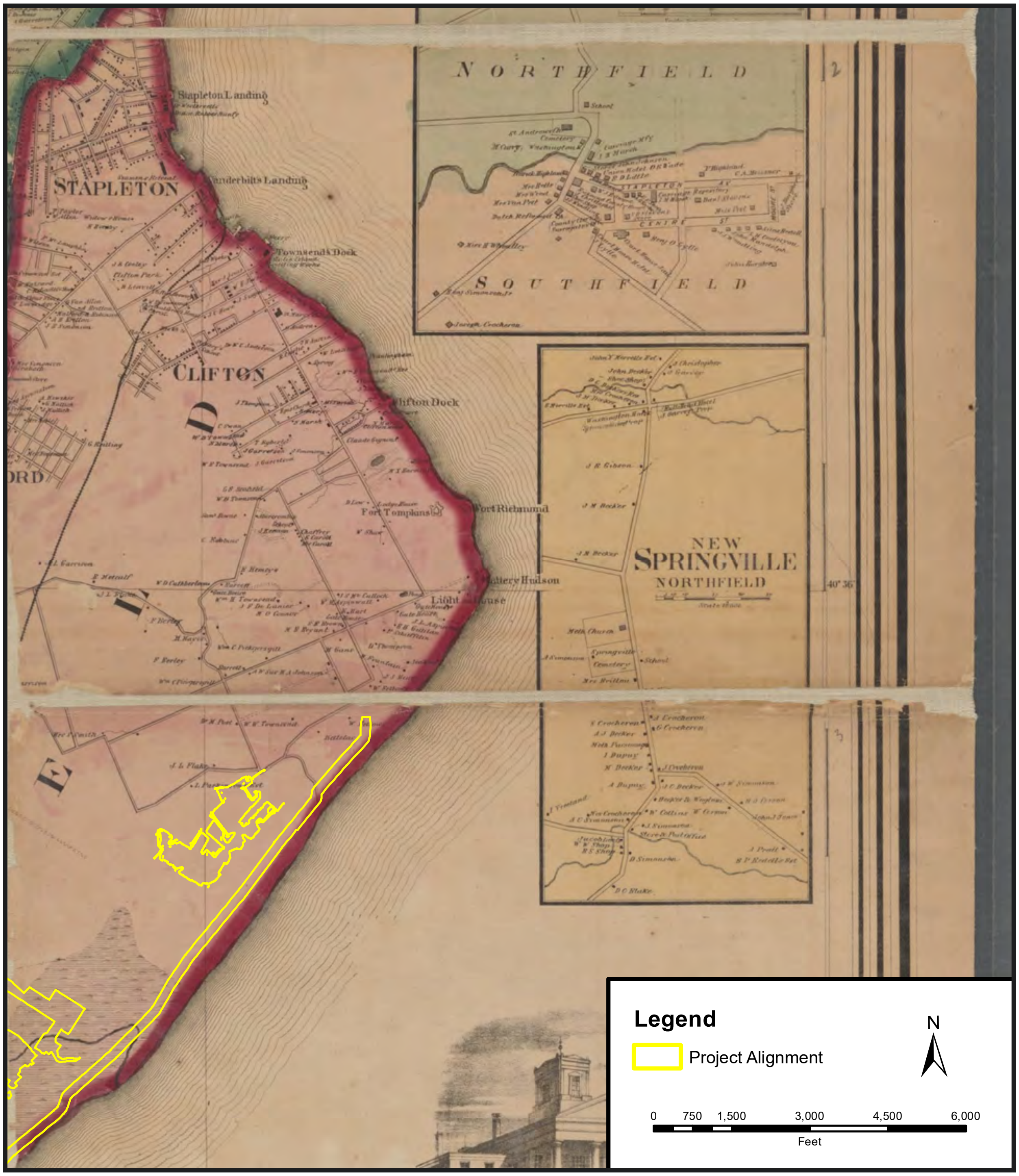


Figure 4.4a. Walling, H.F. Detail of *Map of Staten Island, Richmond County, New York*. 1859.

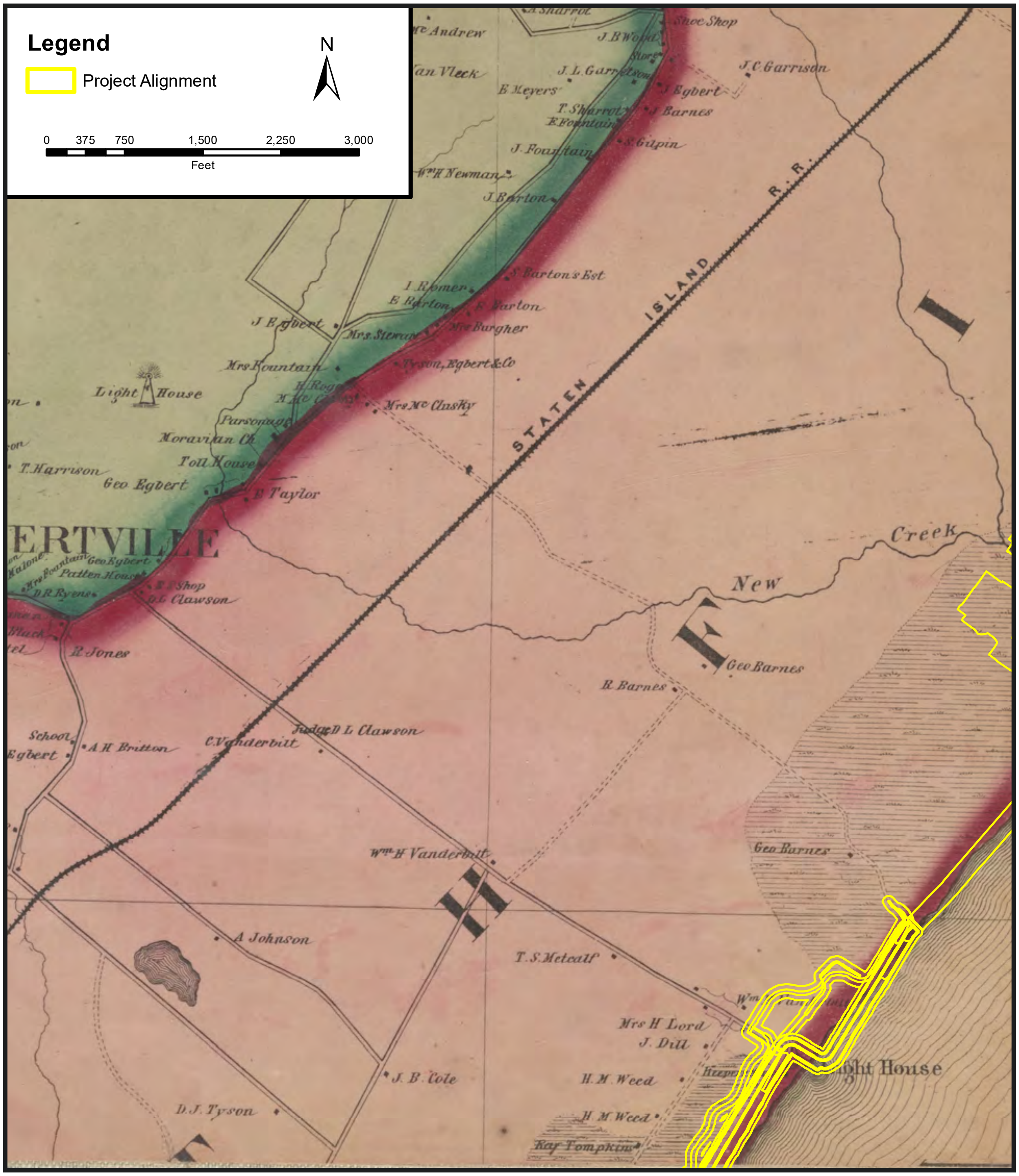


Figure 4.4b. Walling, H.F. Detail of *Map of Staten Island, Richmond County, New York*. 1859.

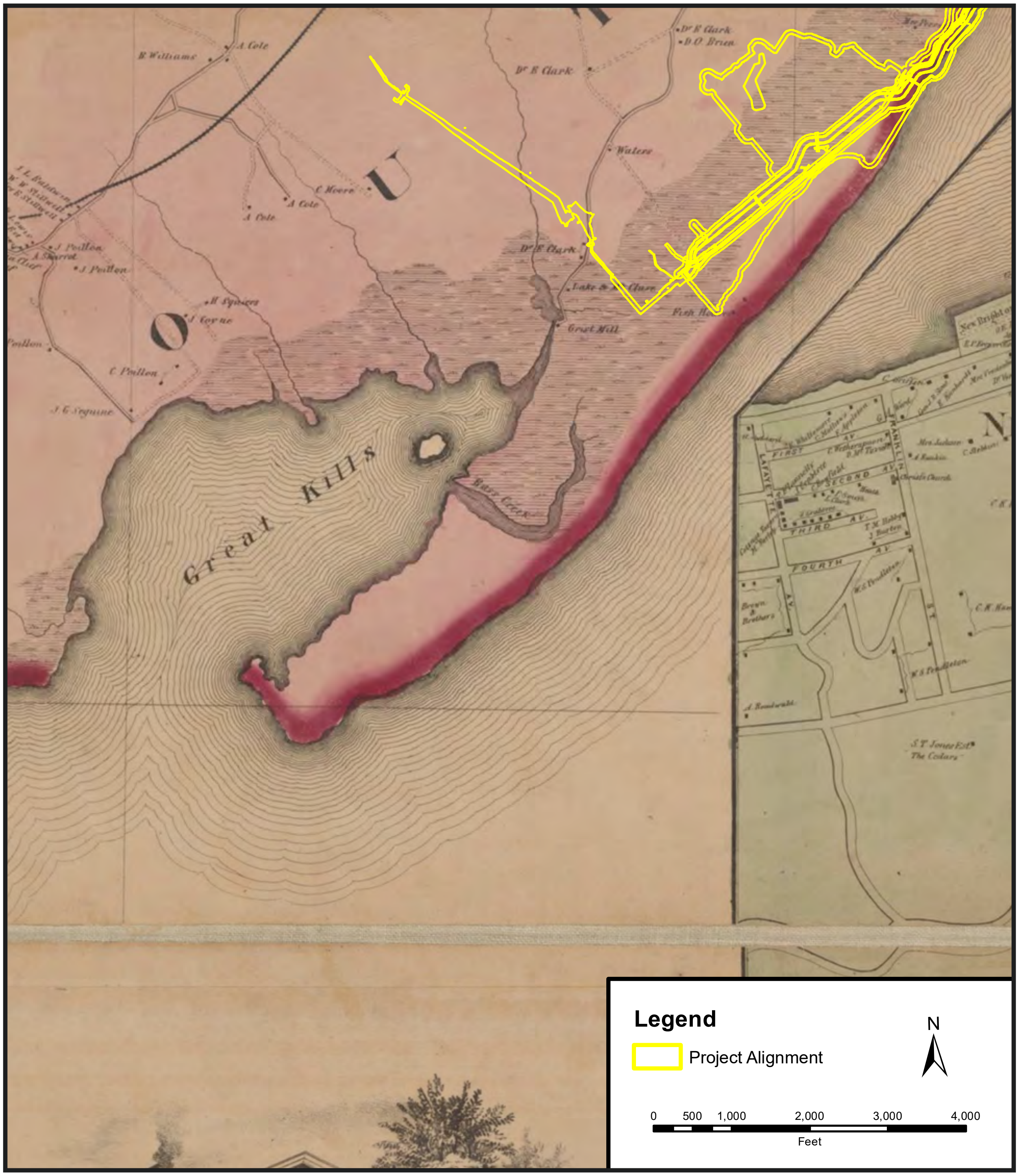


Figure 4.4c. Walling, H.F. Detail of *Map of Staten Island, Richmond County, New York*. 1859.

west of the project alignment in the area currently occupied by Fort Wadsworth, and new dwellings and large estates were constructed along these roads.

Based on the 1853 Butler map and H.F. Walling's *Map of Staten Island, Richmond County, New York*, which was published in 1859, the project alignment ran along the south shore of Staten Island to the east of a line of five houses located on the east side of Sea Avenue, which followed the current alignment of Lily Pond Avenue and Father Capodanno Boulevard (Figures 4.3 and 4.4a). The Walling map of 1859 identifies these houses as belonging to H. Fountain, J.J. Henry, W. Fellows (two houses) and Kettletas (Figure 4.4a). Between 1844 and 1850, a small settlement also developed in Southfield Township in the vicinity of the elm tree at the end of New Dorp Lane. Known as Oceana, this settlement encompassed seven dwellings located along New Dorp Lane and Cedar Grove Avenue in 1853 (Figure 4.3) (Morris 1898:412). To the southwest of Oceana stood a large cedar grove, which extended southeast towards the shore and occupied a large property that also contained a dwelling and a pier. While the dwelling remains unidentified on the 1853 Butler map, the 1859 Walling map labels the dwelling as the property of Mrs. Peersoll (Figures 4.3 and 4.4c). By 1859, Oceana contained eight dwellings, a lighthouse, which had been constructed on the south side of New Dorp Lane in 1856 and was known as the Elm Tree Light, and a dwelling for the lighthouse keeper (Figure 4.4b) (Panamerican Consultants, Inc. 2005:3-76). The name Oceana disappeared from popular usage after 1860 (Morris 1898:412). To the southwest of Oceana, two fish houses belonging to William Loveridge stood within the boundaries of the project alignment in 1853 and 1859 (Figures 4.3 and 4.4c).

As with the preceding decades, the rate of growth and development within Southfield Township was relatively stagnant during the 1860s and 1870s, despite the opening of the Staten Island Railway in 1860 (Jackson 2010). In fact, the population of Southfield Township actually dropped slightly from 5,082 people in 1870 to 4,980 in 1880 (Jackson 2010). The establishment of the village of Edgewater in 1866 removed an area of relatively dense development from the township's boundaries, and settlement within Southfield Township remained concentrated at Richmond and along Richmond Avenue during the ensuing decades. The *Map of Staten Island* published by M. Dripps in 1872 captures Southfield Township's predominantly agricultural landscape and shows that undeveloped farmland and marshland continued to surround the project alignment on the south shore of Staten Island (Figure 4.5). Several new streets that extended from Richmond Avenue through the project alignment to the shoreline had been laid out at Linden Park and Grant City by 1872, but no buildings or dwellings had been constructed along these new streets. The four dwellings on Sea Avenue, the Elm Tree Light and the neighboring buildings on New Dorp Lane and the Lake house and tide mill remained the only structures in the vicinity of the project alignment. By 1872, the small settlement on New Dorp Lane was no longer known as Oceana and contained the Elm Tree Light, approximately four dwellings, a hotel known as the Gangerrolf House and a club house (J.B. Beers & Co. 1874). This club house stood to the west of the project alignment at the intersection of New Dorp Lane and Cedar Grove Avenue and was associated with a private racecourse developed by William H. Vanderbilt, the son of Cornelius Vanderbilt, between 1859 and 1872. A grandstand and stables also stood on the property (Panamerican Consultants, Inc. 2005:3-63).

The pace of development within Edgewater Village and Southfield Township began to intensify during the 1880s as the first hotels and recreational facilities were constructed along the south shore of Staten Island (Figures 4.6a and 4.6b). The construction of a branch of the Staten Island Railway between Saint George and Arrochar in 1886 helped to spur this development (Panamerican Consultants, Inc. 2005:3-

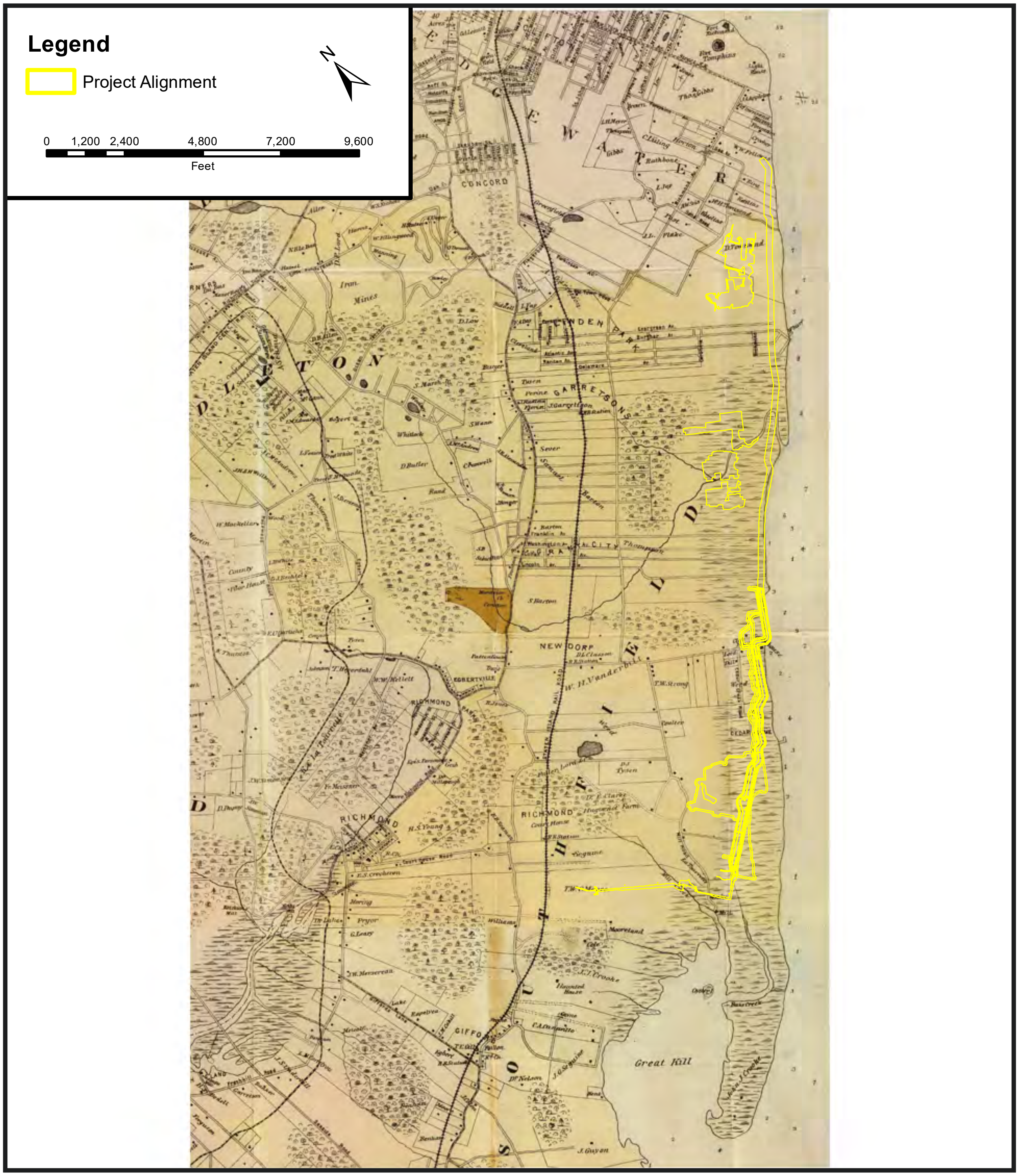


Figure 4.5. Dripps, M. Detail of *Map of Staten Island (Richmond Co.), N.Y.* 1872.

Figure 4.6a. J.B. Beers & Co. Detail of *Atlas of Staten Island, Richmond County, New York*. Section A. 1887.

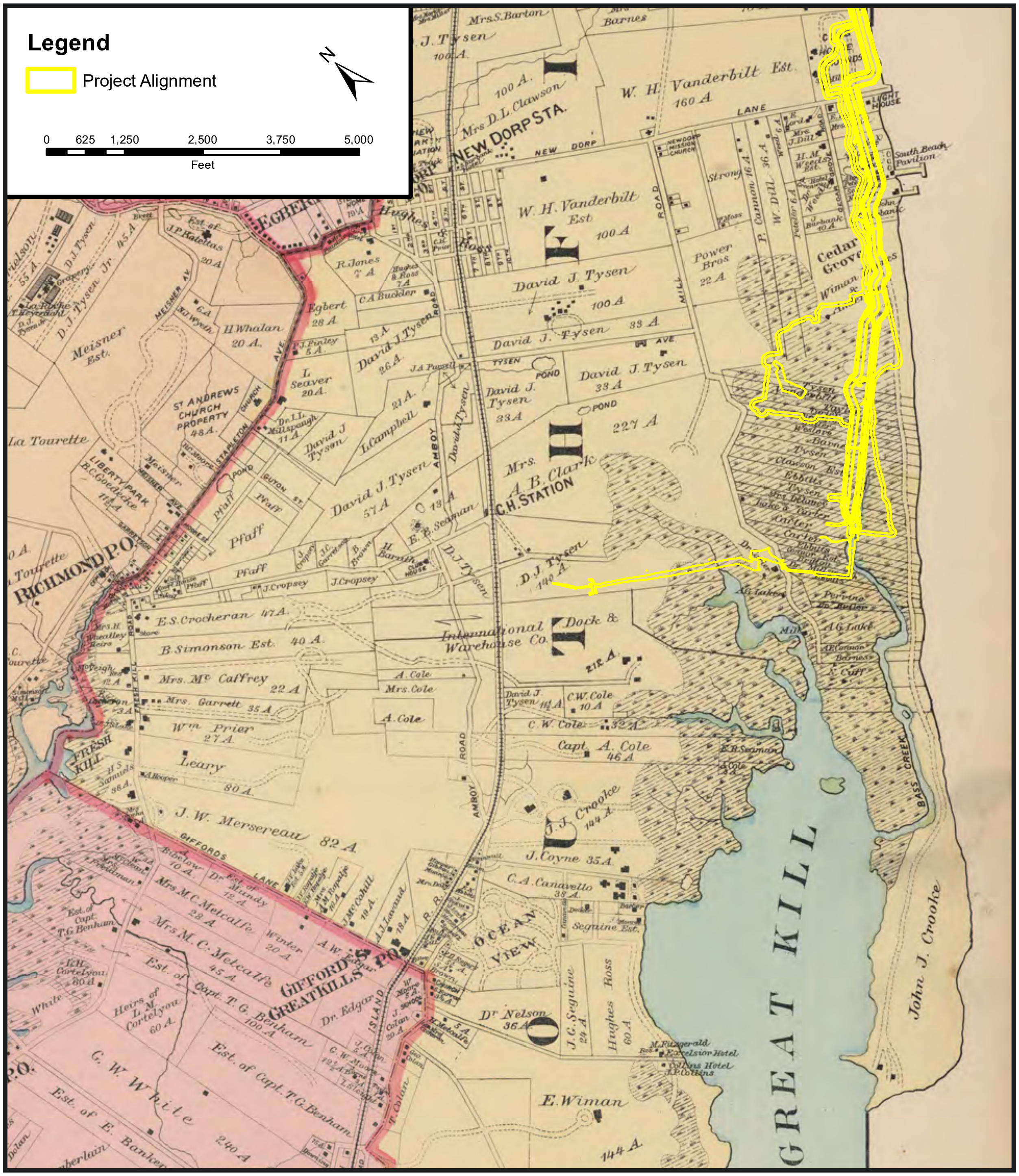


Figure 4.6b. J.B. Beers & Co. Detail of *Atlas of Staten Island, Richmond County, New York*. Section B. 1887.

23). Between 1874 and 1887, a road known as Seaside Boulevard was laid out near the northern terminus of the project alignment in Edgewater Village (Figure 4.6a). Seaside Boulevard followed the same route as Father Capodanno Boulevard, which runs along the south shore of Staten Island approximately 260 feet west of the project alignment. By 1887, two hotels stood on Seaside Boulevard. The *Atlas of Staten Island* published by J.B. Beers & Co. in 1887 identifies these hotels as the "Ocean House," which was owned by Tom Brown, and the "Bleak House," which was owned by J. Seguine (Figure 4.6a). Seaside Boulevard continued south into Southfield Township as an unfinished lane through marshland owned by Hodges, Mc. Roberts and Cameron. A dwelling located on the east side of Seaside Avenue, which the 1887 Beers atlas identifies as the property of Mrs. S.A. Burlele, stood within the boundaries of the project alignment. A resort also began to develop along Cedar Grove Avenue to the south of New Dorp Lane during this period (Figure 4.6b). In addition to the Gangerrolf House, which stood at the south end of Cedar Grove Avenue, two additional hotels stood along Cedar Grove Avenue in 1887. The Hotel Greenwald occupied a lot on the west side of Cedar Grove Avenue owned by Dr. Weed. It stood directly opposite the South Side Pavilion, a beachfront hotel owned and operated by the Peteler family. To the south of the South Side Pavilion stood the Sea Side Nursery, a beachfront facility constructed in 1881 to care for poor sick children (Panamerican Consultants, Inc. 2005:3-86). William H. Vanderbilt's racecourse still stood on the north side of New Dorp Lane to the west of the project alignment in 1887, but it was demolished by 1898 (Panamerican Consultants, Inc. 2005:8-63).

After 1887, the development of the south shore of Staten Island as a resort and amusement area proceeded quickly during the 1890s. The consolidation of Staten Island with New York City in 1898, which dissolved the island's four village and five town governments and organized them into wards within the Borough of Richmond, served as the primary driver behind this growth (Jackson 2010). As evidenced by the map of the *Staten Island Quadrangle* created by the U.S. Geological Survey in 1900, this development largely occurred in three distinct clusters at South Beach, Midland Beach and New Dorp Beach (Figure 4.7). As noted above, South Beach began to develop as a resort area during the 1880s with the construction of hotels on Seaside Boulevard at the northern end of the project alignment. By 1890, these hotels had been joined by additional hotels, dance pavilions, shooting galleries, a carousel and other amusements (Panamerican Consultants, Inc. 2005:3-23). During the 1890s, the South Beach Land Improvement Company acquired all of the beach south of Sand Lane and constructed a boardwalk on the property, renting space to entrepreneurs who opened bathhouses, merry-go-rounds and games along the boardwalk (Panamerican Consultants, Inc. 2005:3-23, 3-24). A number of hotels and other amusements, including two casinos and vaudeville establishments owned by William Nunley and Albert Hergenhan, opened between the boardwalk and Seaside Avenue in South Beach during the 1890s. In 1892, the Staten Island Railway extended its branch line from Arrochar to a station at Sand Lane in South Beach. This spurred further development in South Beach during the ensuing decade, and most of the available space between Seaside Boulevard and the boardwalk was occupied by hotels and recreational facilities by 1907 (Figures 4.8a and 4.8b). In 1906, a group of Staten Island businessmen opened an amusement park at the north end of the boardwalk in 1906. Known as Happyland, the amusement park housed a restaurant, a theater, a bar, a dance hall, an animal show, a scenic railway and other attractions (Panamerican Consultants, Inc. 2005: 3-29).

In contrast to South Beach, Midland Beach did not develop as a resort and area until the 1890s. This development occurred under the aegis of a subsid-

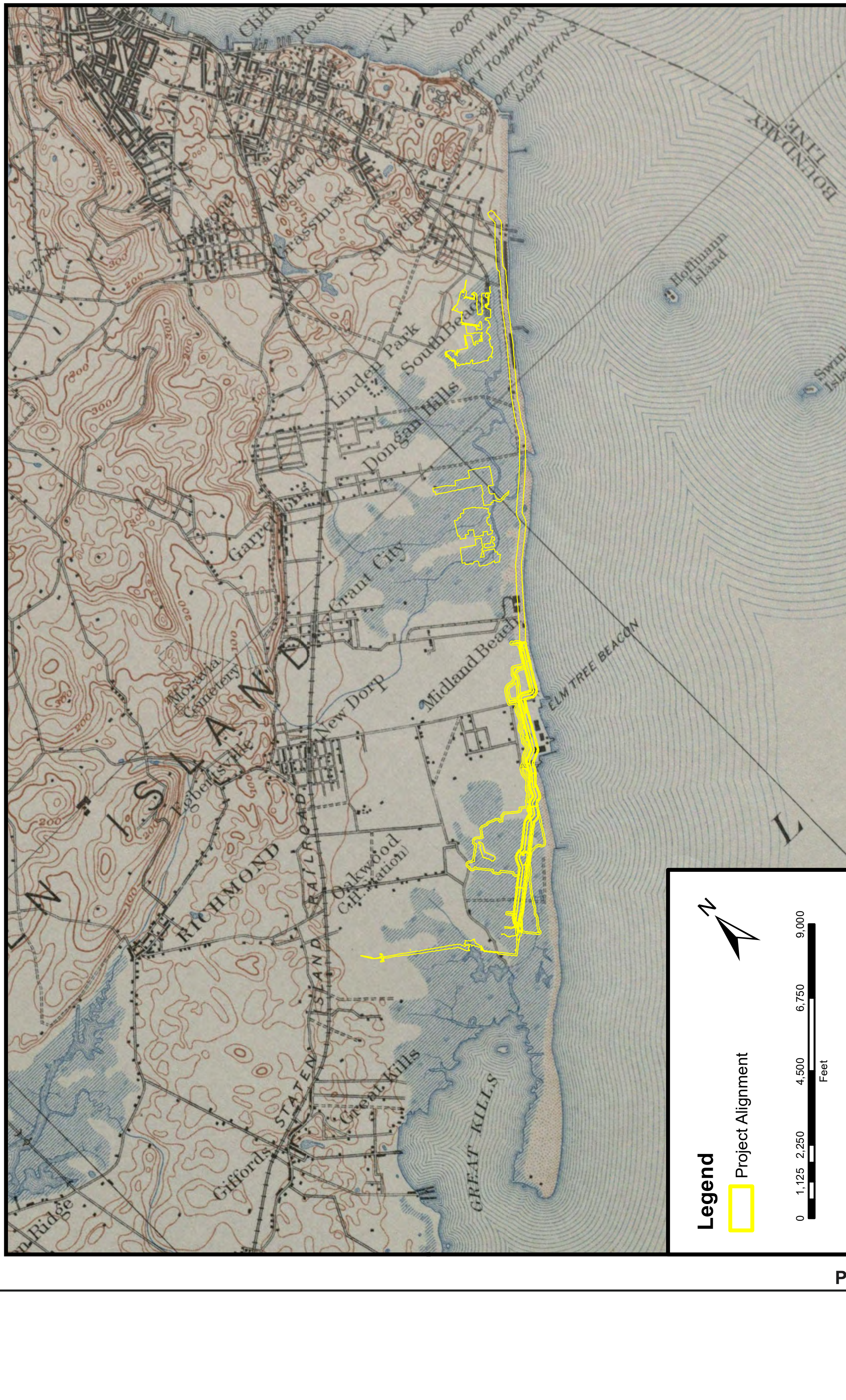


Figure 4.7. U.S. Geological Survey. Detail of *Staten Island Quadrangle*. 1913 [1900].

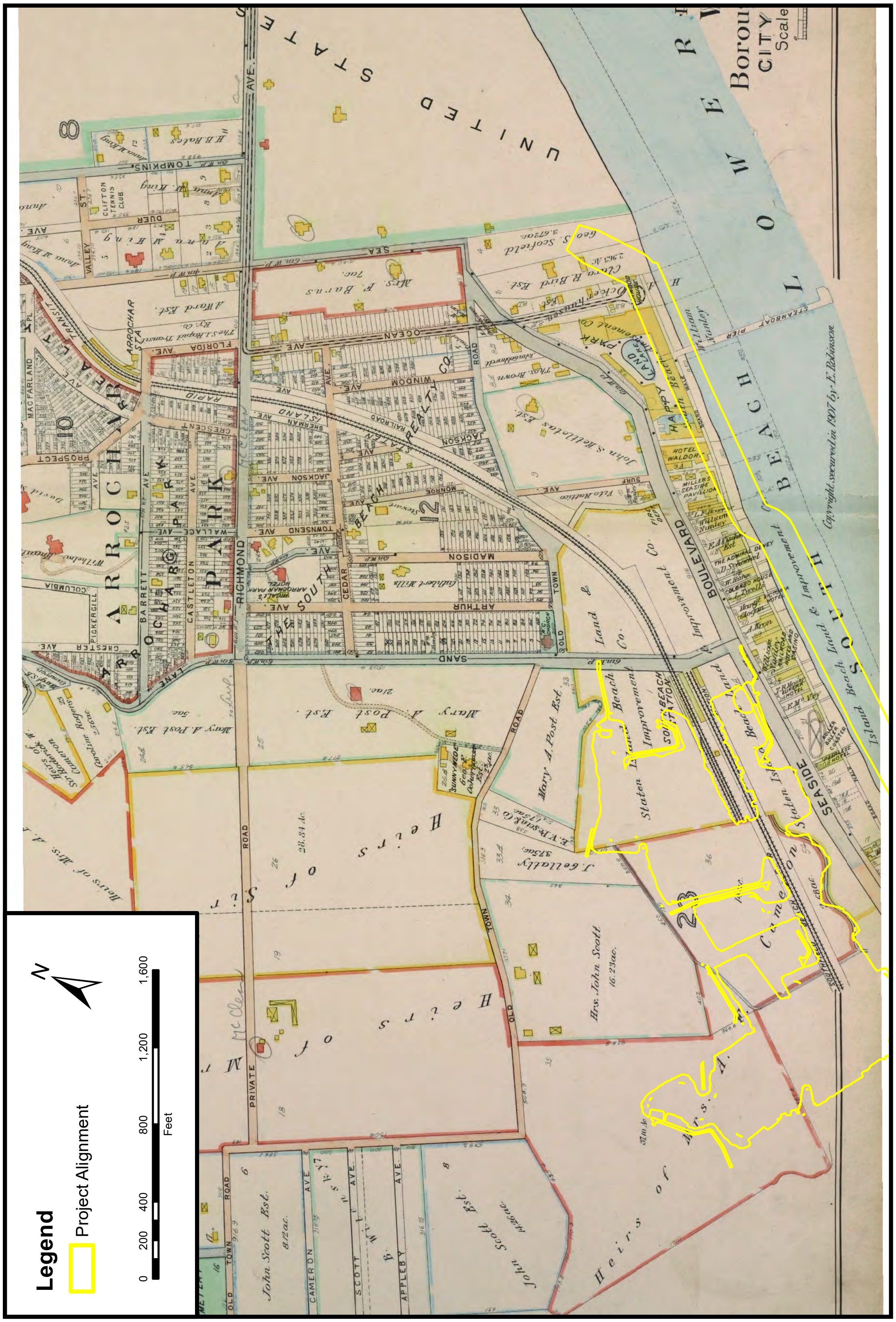


Figure 4.8a. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. Plate 14. 1907.

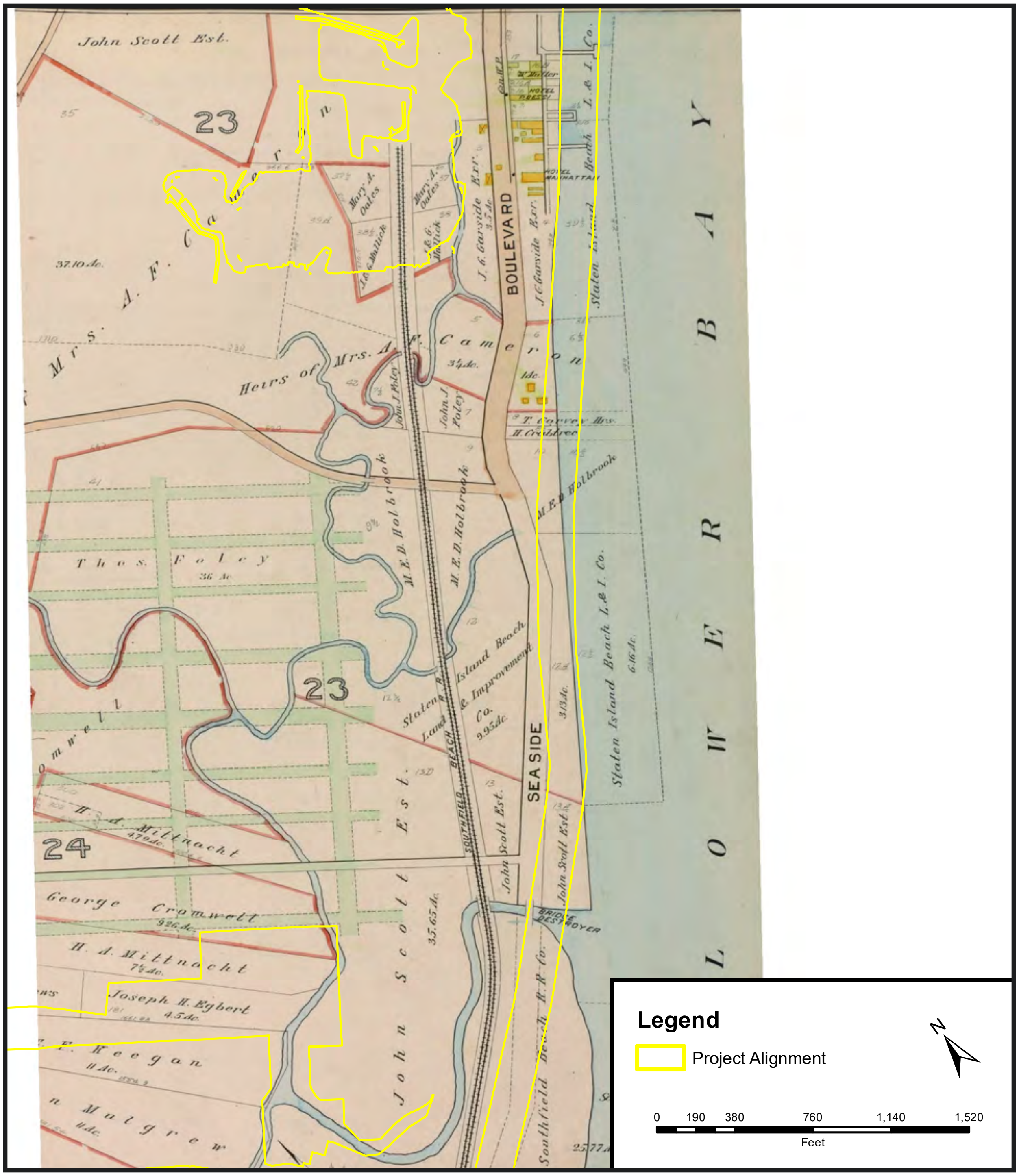


Figure 4.8b. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. Plate 15. 1907.

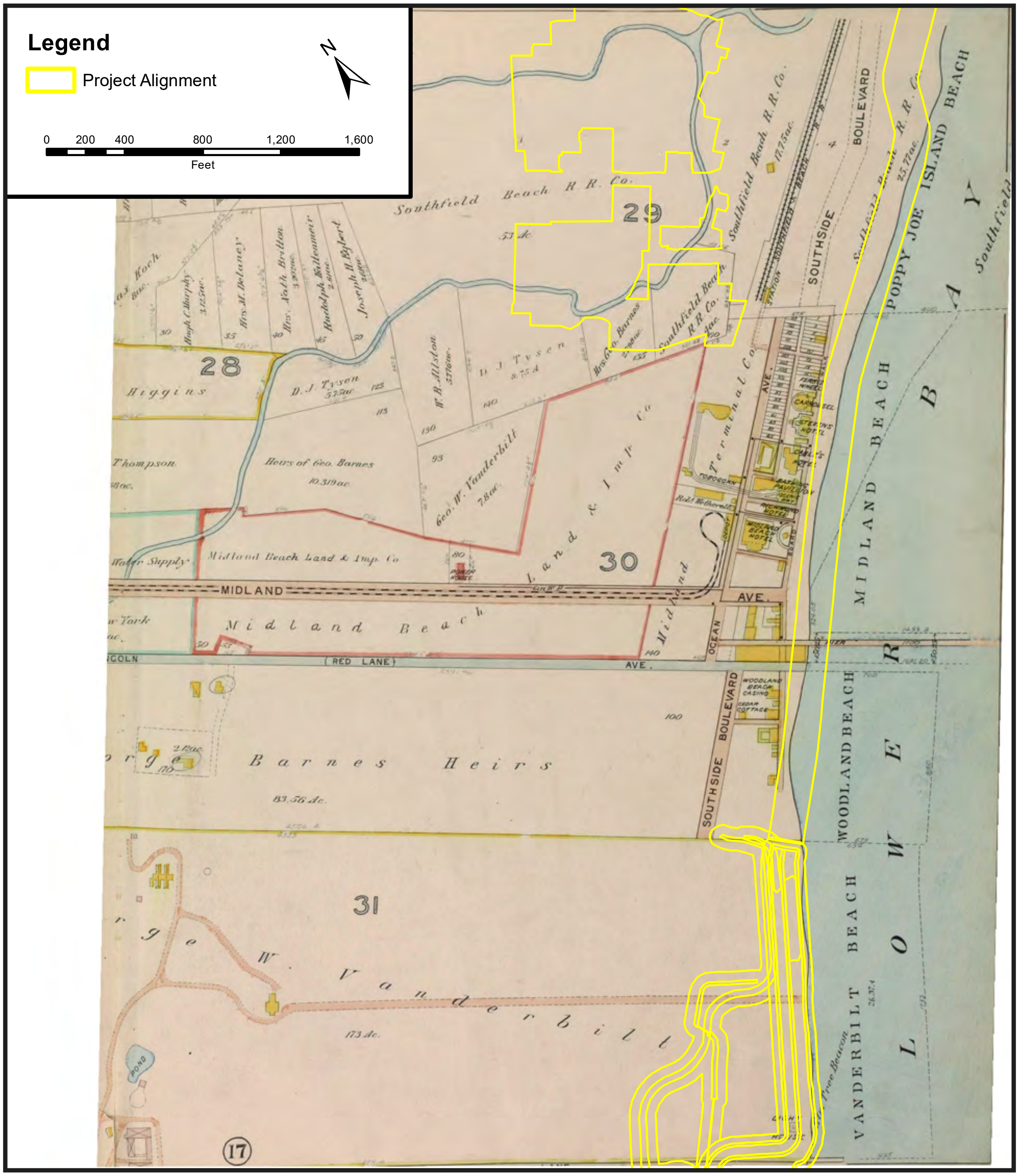


Figure 4.8c. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. Plate 16. 1907.

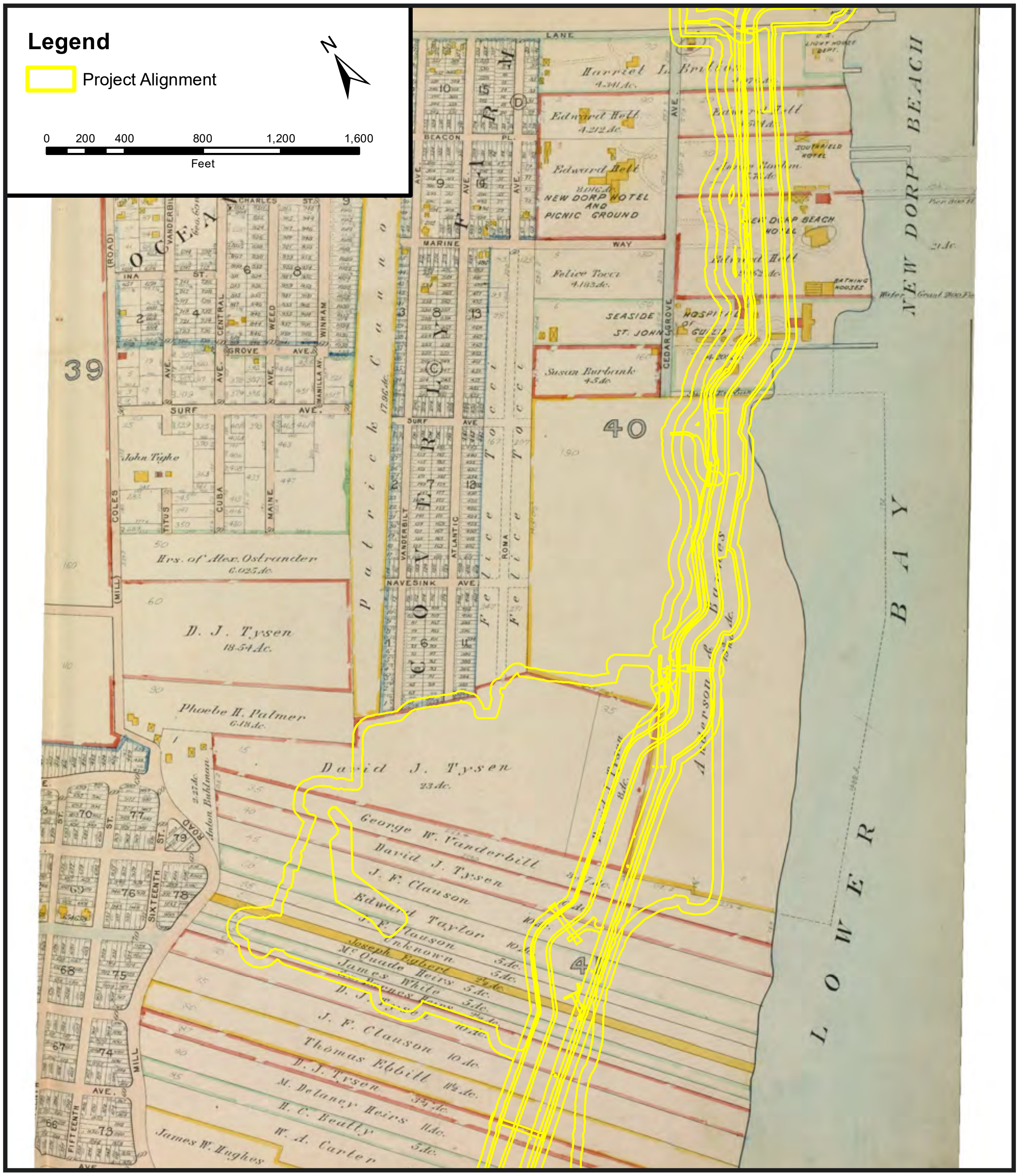


Figure 4.8d. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. Plate 17. 1907.

Figure 4.8e. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. Plate 18. 1907.

iary of the Midland Beach Railway Company, which installed trolley lines on Lincoln Avenue and Midland Avenue in 1896 to provide access from the Staten Island Railway station at Grant City to the beach. The company constructed a boardwalk along the beach, and the Midland Beach Hotel and Casino, a carousel and a Ferris wheel opened between the boardwalk and Ocean Avenue between 1897 and 1898. Additional hotels, including the Richmond Hotel and Cable's Hotel, a toboggan and a steamboat pier were constructed in Midland Beach during the final years of the 19th century. In 1901, the Southfield Beach Railroad Company established trolley service between South Beach and Midland Beach and constructed a station at the north end of Midland Beach where Ocean Avenue terminated. All of these structures appear on the *Atlas of the Borough of Richmond* published by E. Robinson and R.H. Pidgeon in 1907 (Figure 4.8c). Poppy Joe Island Beach, an undeveloped tract of land owned by the Southfield Beach Railroad Company and encompassing 25.77 acres, stood to the north of Midland Beach. Though Poppy Joe Island Beach was used for camping during the first decade of the 20th century, it remained undeveloped until the second decade of the 20th century. A casino, bathing pavilion and several wood-frame structures had been constructed to the south of Midland Beach at the southeast corner of Lincoln Avenue and Southside Boulevard by 1907 in an area designated Woodland Beach (Panamerican Consultants, Inc. 2005:3-43, 3-52).

While South Beach and Midland Beach developed on the same model as Coney Island during the 1890s and 1900s, New Dorp Beach remained relatively rural during this period. In contrast to dense network of hotels, casinos and other recreational facilities that lined the boardwalks in South Beach and Midland Beach, the hotels and recreational facilities at New Dorp Beach occupied large properties on the east and west side of Cedar Grove Avenue (Figure 4.8d). Several notable changes occurred in New Dorp Beach, however, during this period. In 1891, the Elm Tree Light was relocated to the north side of New Dorp Lane, where it stood in 1907. By 1907, the Sea Side Nursery, which was renamed the Sea Side Hospital of St. John's Guild in 1887, had drastically expanded its facilities with the purchase of the former Gangerrolf House property to the south, the erection of a rear wing on the main hospital building and the construction of several wood-frame buildings to the west of the hospital. In 1902, a fire destroyed the South Side Pavilion, and it was subsequently rebuilt as the New Dorp Beach Hotel by Edward Hett. Edward Hett also owned the New Dorp Hotel and Picnic Ground, which stood opposite the New Dorp Beach Hotel on a lot formerly occupied by the Hotel Greenwald. To the north of the South Side Pavilion/New Dorp Beach Hotel stood the Southfield Hotel, which had been constructed by Felix Boehm in the 1890s. In 1907, the land to the south of New Dorp Beach remained undeveloped and was divided into narrow lots of salt meadow (Figure 4.8d).

South Beach and Midland Beach remained popular resort and amusement destinations through the third decade of the 20th century. Although the Happyland amusement park closed in 1917 after only 11 years in operation and was subsequently destroyed by a fire later that year, South Beach still retained the dense network of hotels, casinos, bath houses and other recreational facilities that had developed between the boardwalk and Seaside Avenue during the preceding three decades. Midland Beach likewise continued to thrive during this period, and a roller coaster and a scenic railway were constructed to the east of Ocean Avenue prior to 1917. By 1917, wood-frame bungalows lined the shore at Poppy Joe Island Beach immediately north of the Midland Beach roller coaster and several bungalow colonies and campgrounds with names such as Camp Warren, Bungalow Town, Moore's Camp and Ocean Breeze had been established along the previously undeveloped shoreline between South Beach and Midland Beach. Woodland Beach also grew during this period, and wood-frame bungalows replaced its campsites between 1907 and 1917

(Panamerican Consultants, Inc. 2005:3-52). A series of maps published by George W. Bromley and Walter S. Bromley in their *Atlas of the City of New York, Borough of Richmond, Staten Island* and the Sanborn Map Company in its *Insurance Maps of Staten Island, Borough of Richmond, New York* in 1917 capture this changing landscape (Figures 4.9a-d) (Sanborn 1917).

Like South Beach and Midland Beach, New Dorp Beach thrived as a resort and amusement area into the third decade of the 20th century. In fact, the development that occurred in New Dorp Beach during this period radically altered the rural character that it had maintained until *circa* 1910 (Panamerican Consultants, Inc. 2005: 3-70). By 1917, a grid of new streets lined with small rectangular lots occupied by modest one-story, wood-frame bungalows had been constructed on the west side of Cedar Grove Avenue, replacing the New Dorp Hotel and Picnic Ground and the neighboring dwellings that had stood to the south of New Dorp Lane in 1907 (Figures 4.9e) (Sanborn 1917). This street grid extended to the east side of Cedar Grove Avenue, where it terminated at Bayview Place immediately adjacent to the Elm Tree Light lighthouse keeper's dwelling. A new bungalow colony, which the 1917 Bromley atlas identifies as the New Dorp Beach Camping Grounds, also appeared on the east side of Cedar Grove Avenue to the south of Waterside Street during this period. Felix Boehm made significant changes to his resort, Felix Boehm's Picnic Grounds, on the east side of Cedar Grove Avenue between 1907 and 1917. During this period, he constructed bathhouses, erected a wood-frame building that served as a gymnasium and housed a dance hall and a bowling alley and demolished the Southfield Hotel. The New Dorp Beach Hotel continued to operate during this period as Munger's Seaside Park. The Seaside Hospital of Saint John's Guild was also extensively renovated. Between 1909 and 1911, the hospital's original 1881 wing was demolished and four one-story diagonal wings of fireproof concrete and brick construction were added to the rear wing that had been erected in 1901. To the south of New Dorp Beach, a private bungalow colony known as the Cedar Grove Club and comprised of modest wood-frame bungalows arranged along the beach developed between 1910 and 1917 (Panamerican Consultants, Inc. 2005: 3-76 - 3-91). While additional clusters of wood-frame bungalows lined the shoreline in Oakwood Beach between Kissam Avenue and Fox Lane in 1917, undeveloped salt meadows and marshland continued to predominate (Figures 4.9f and 4.9g).

As previously noted, the south shore of Staten Island remained a popular resort and amusement destination into the third decade of the 20th century. As evidenced by a series of aerial photographs produced by the Fairchild Camera Company in 1924, the grid of residential streets and neighborhoods that currently characterizes the neighborhoods of South Beach, Midland Beach and New Dorp Beach was well established by 1924 (Figures 4.10a-d). Between 1917 and 1924, the number of bungalows and dwellings in these neighborhoods significantly increased. While undeveloped pockets of marshland still occurred, most noticeably between South Beach and Midland Beach and New Dorp Beach and Oakwood Beach, the south beach of Staten Island's suburban landscape was well established by the 1920s. This landscape included Miller Field, a coastal defense air station constructed by the federal government on the former Vanderbilt estate, which stood on the north side of New Dorp Lane, between 1919 and 1921 (Panamerican Consultants, Inc. 2005:3-68). Beginning in the 1920s, however, the resort and amusement areas along the south shore of Staten Island began to slowly decline in popularity. The pollution of New York Bay during this period lessened the recreational appeal of the area. This, coupled with a series of major fires in the 1920s and the construction of the Franklin D. Roosevelt Boardwalk in the 1930s, precipitated the demise of many of the hotels and private recreational facilities in South Beach and Midland Beach. In 1937, only a few bathhouses, rooming houses, a carousel and a hotel

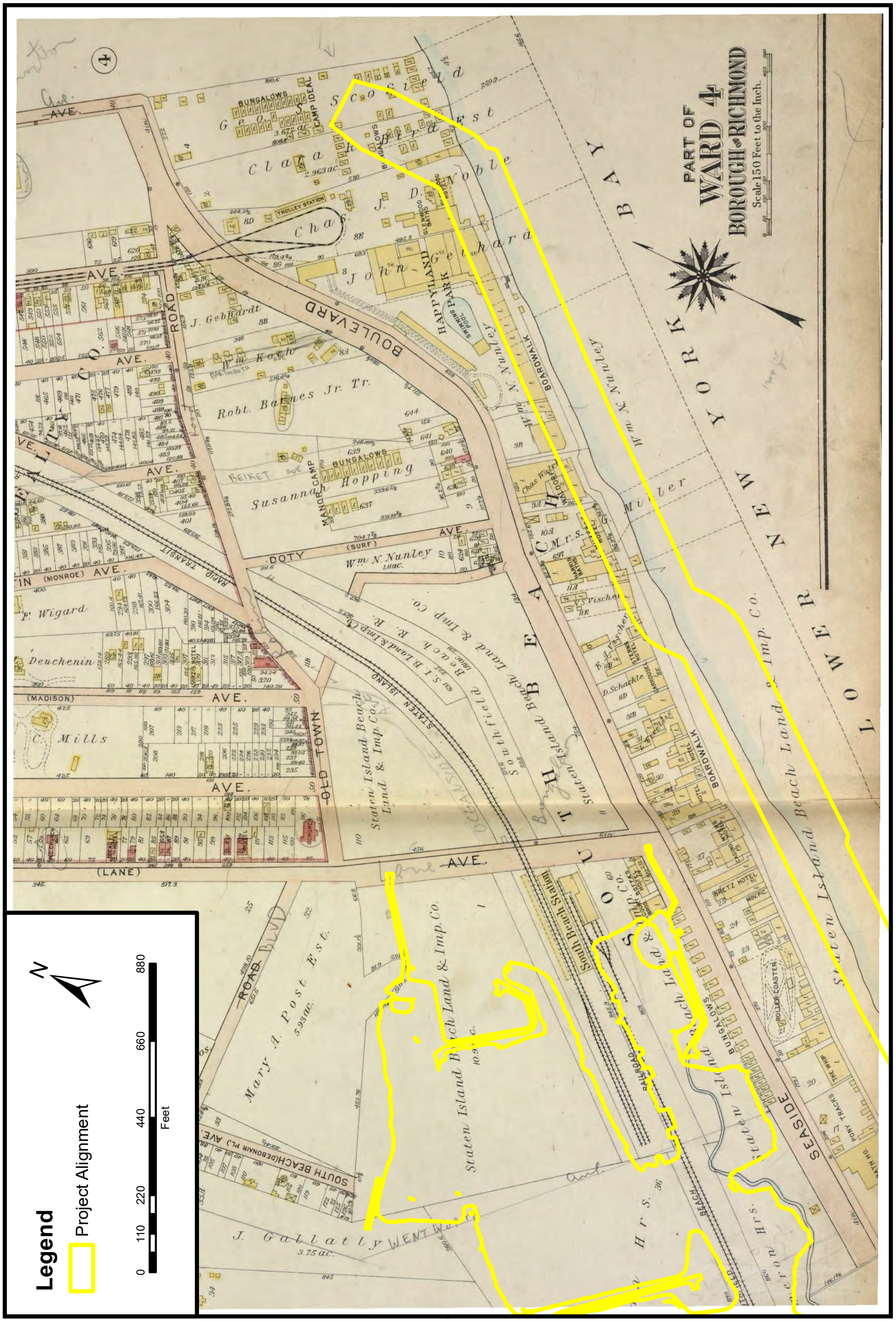


Figure 4.9a. Bromley, George W. and Walter S. Bromley. Detail of Plate 9. *Atlas of the City of New York, Borough of Richmond, Staten Island.*

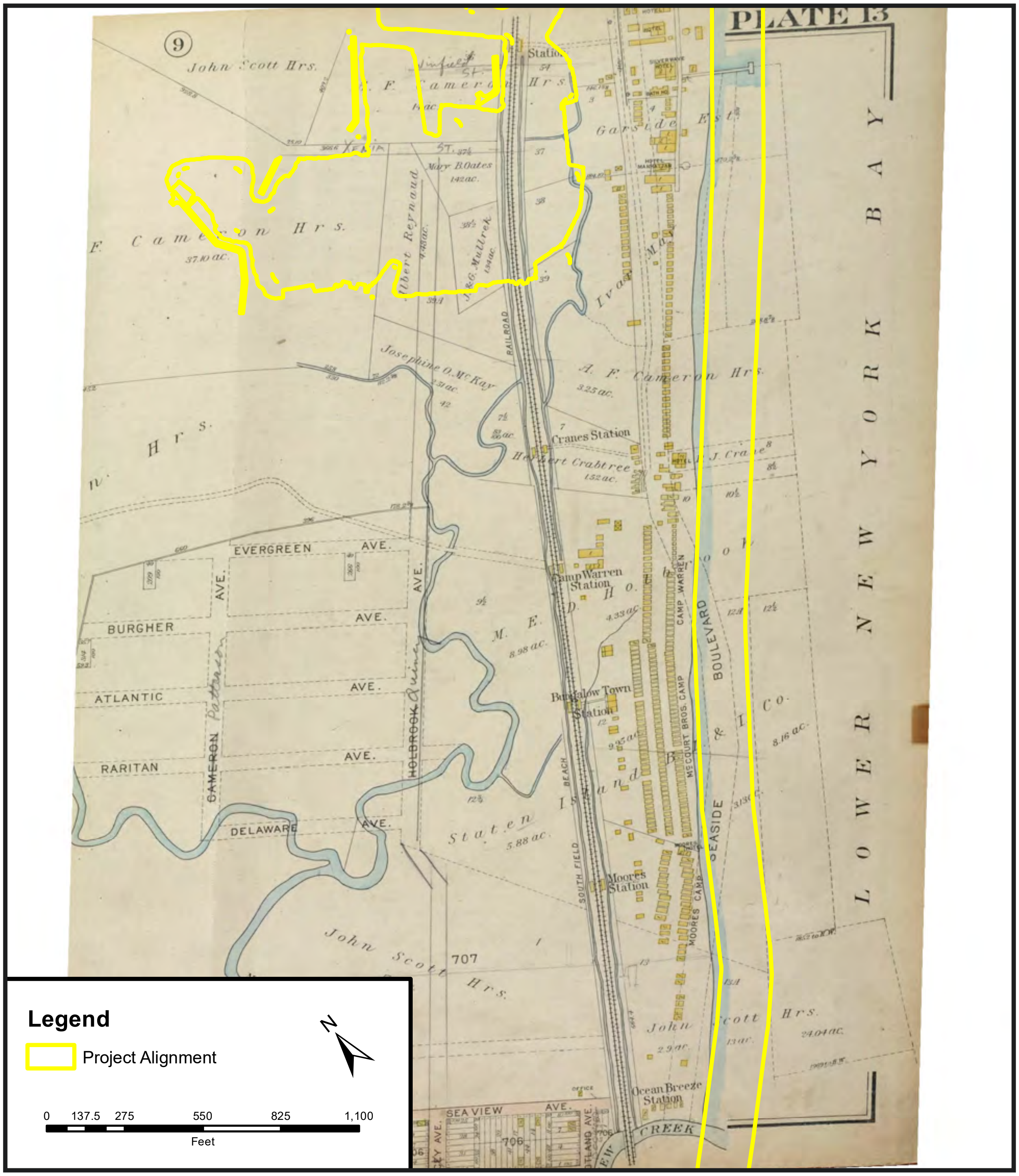


Figure 4.9b. Bromley, George W. and Walter S. Bromley. Detail of Plate 13. *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917.

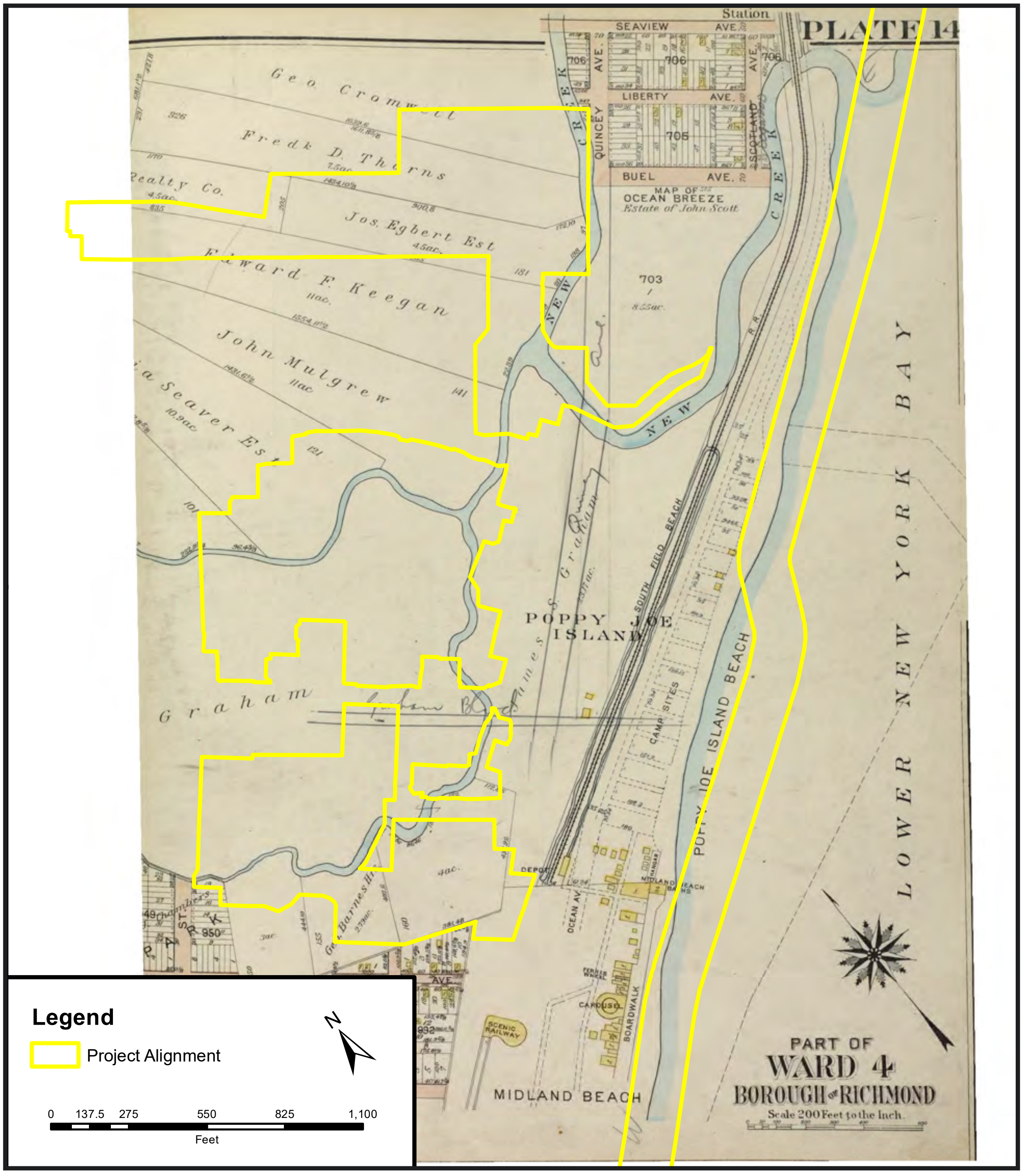


Figure 4.9c. Bromley, George W. and Walter S. Bromley. Detail of Plate 14. *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917.

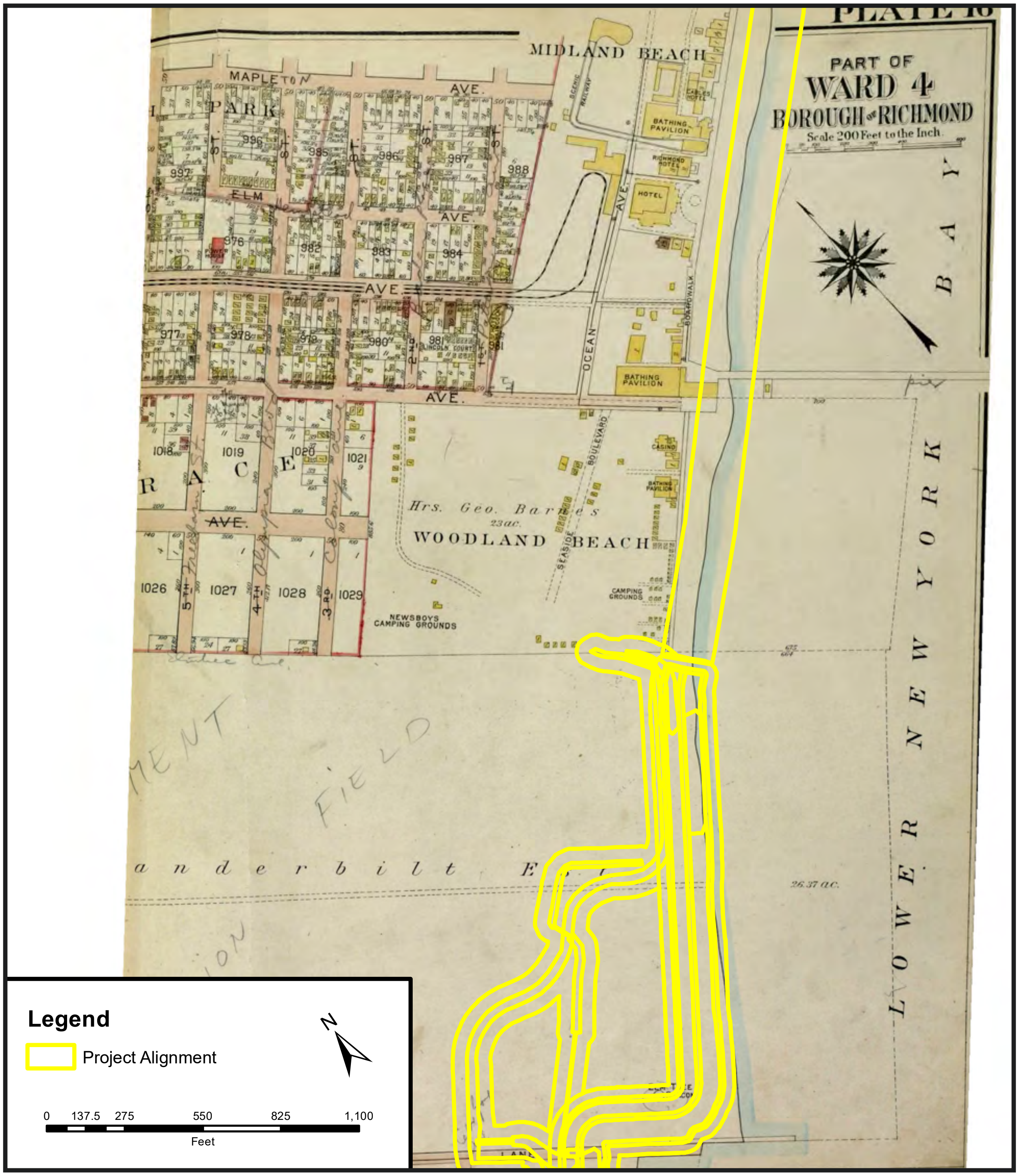


Figure 4.9d. Bromley, George W. and Walter S. Bromley. Detail of Plate 16. *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917.

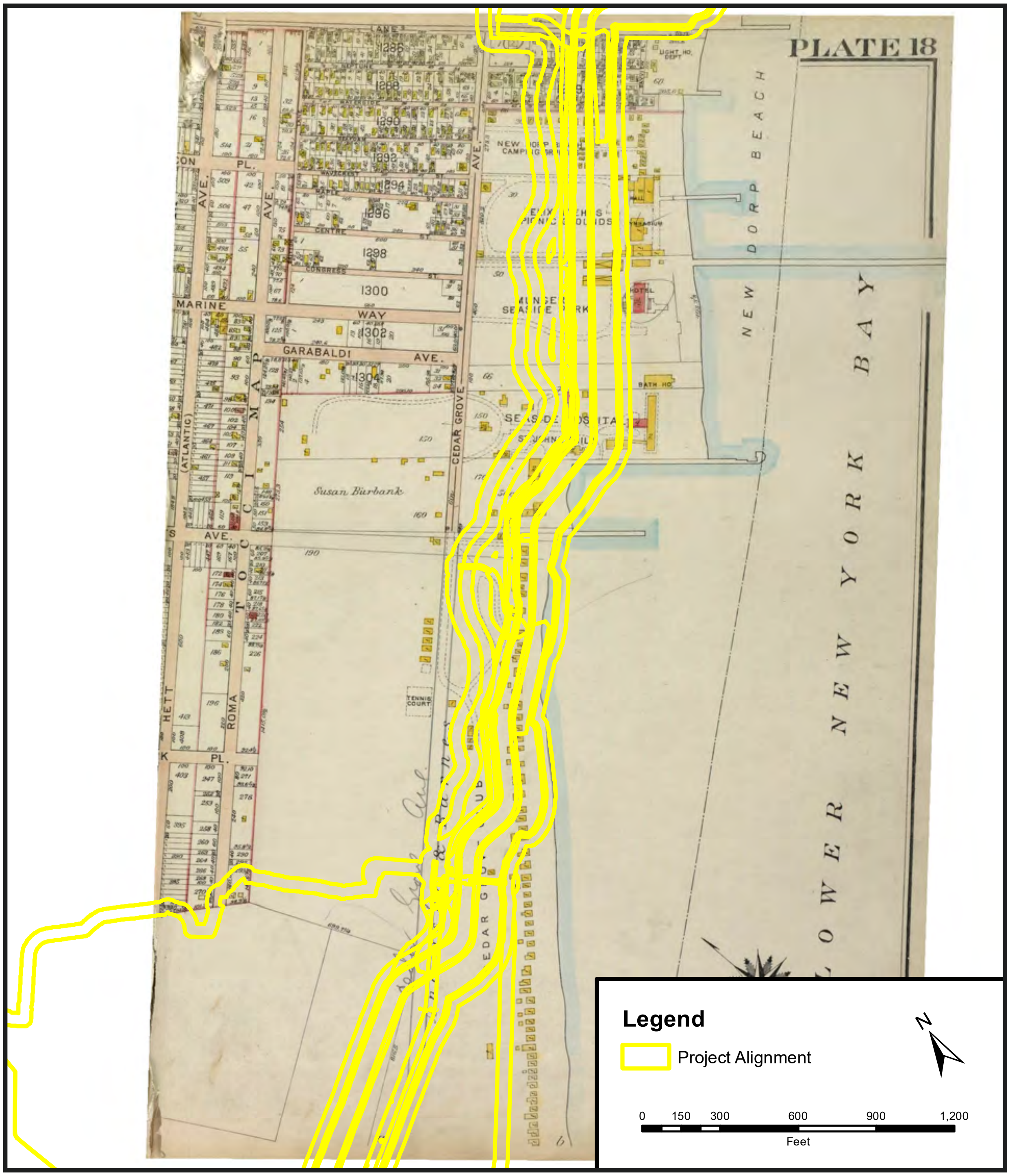


Figure 4.9e. Bromley, George W. and Walter S. Bromley. Detail of Plate 18. *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917.

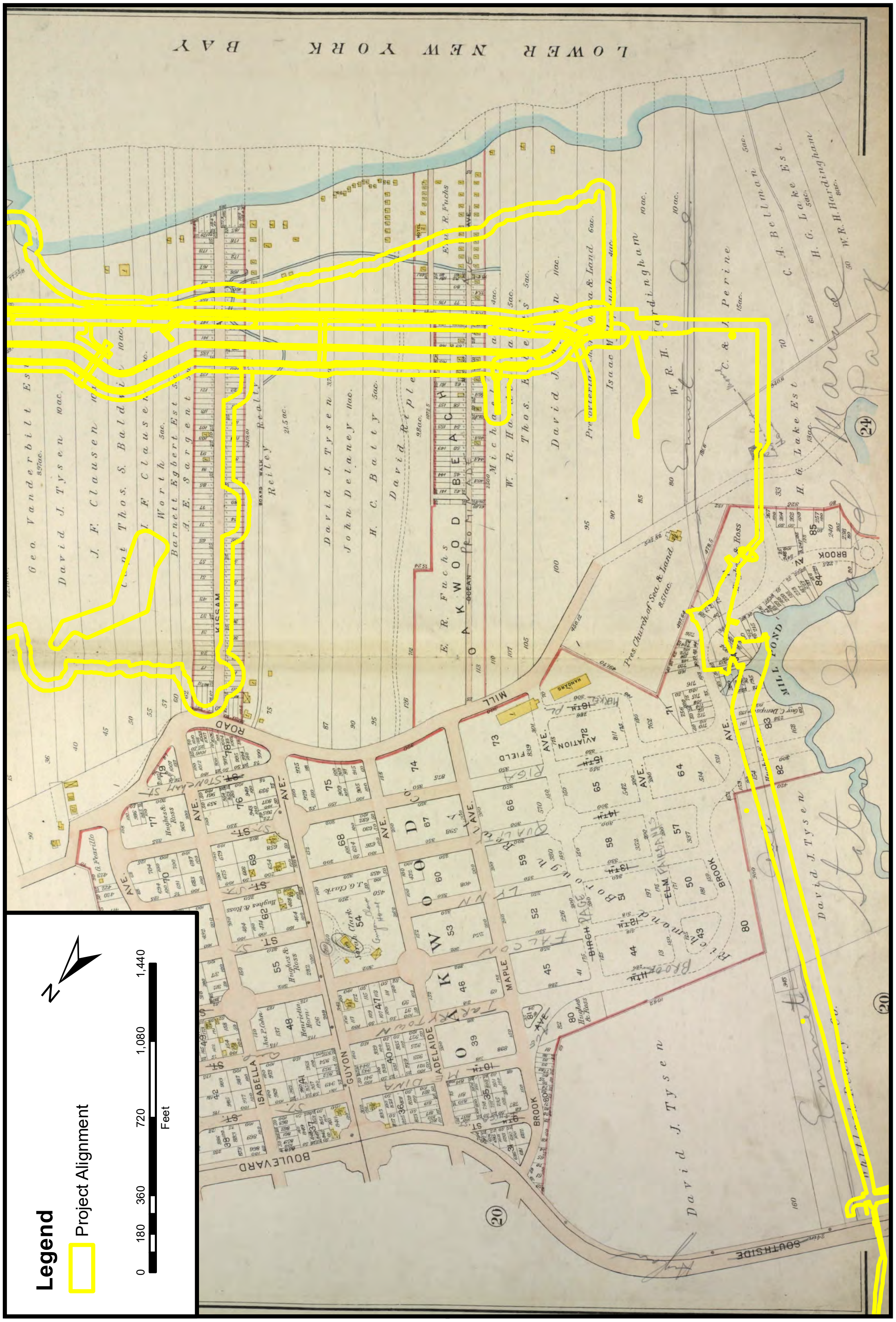


Figure 4.9f. Bromley, George W. and Walter S. Bromley. Plate 19. *Atlas of the City of New York, Borough of Richmond, Staten Island.* 1917.

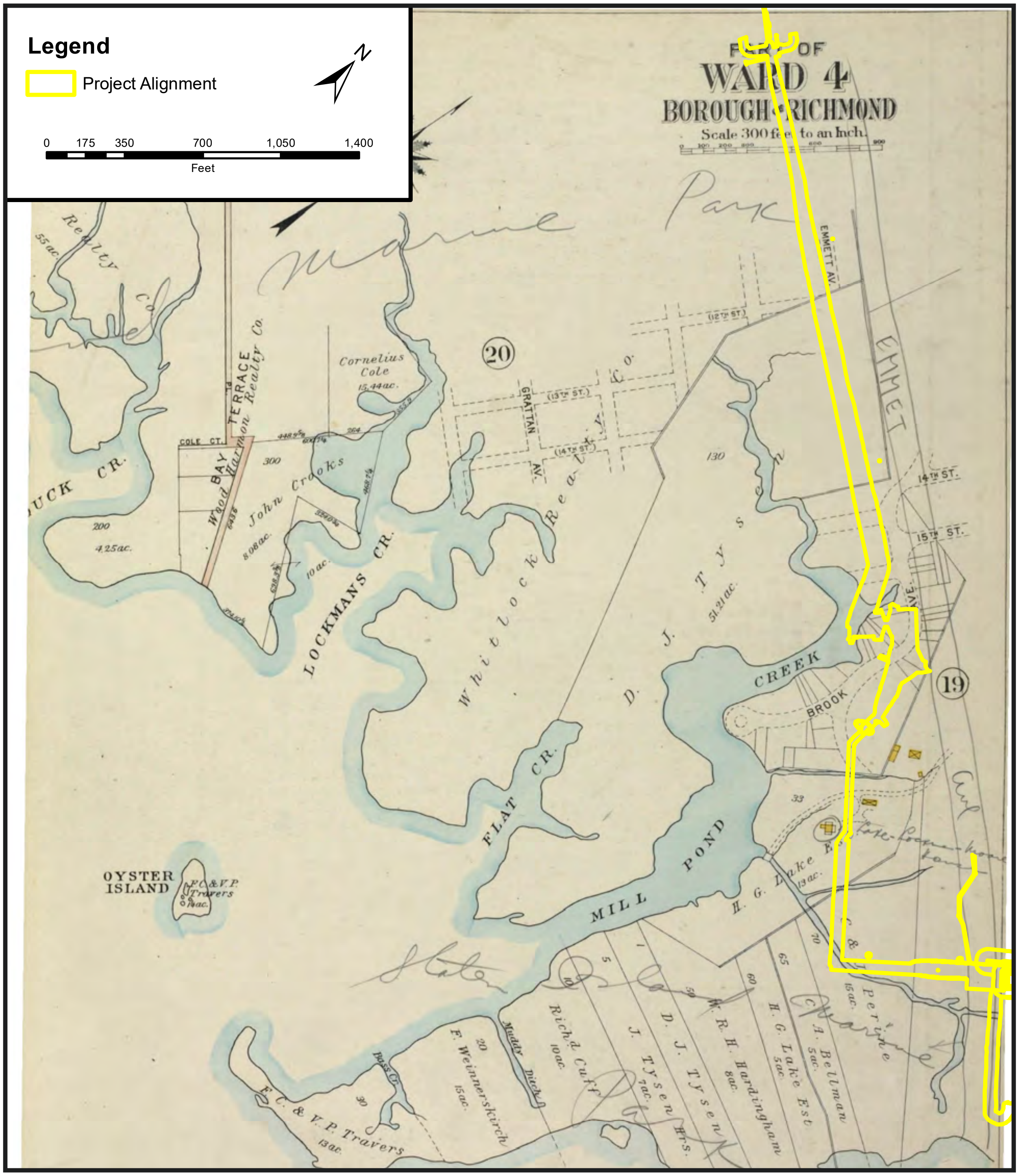


Figure 4.9g. Bromley, George W. and Walter S. Bromley. Detail of Plate 24. *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917.

Figure 4.10a. Fairchild Aerial Camera Company. Detail of Aerial 27B. Sectional Aerial Maps of the City of New York. 1924.

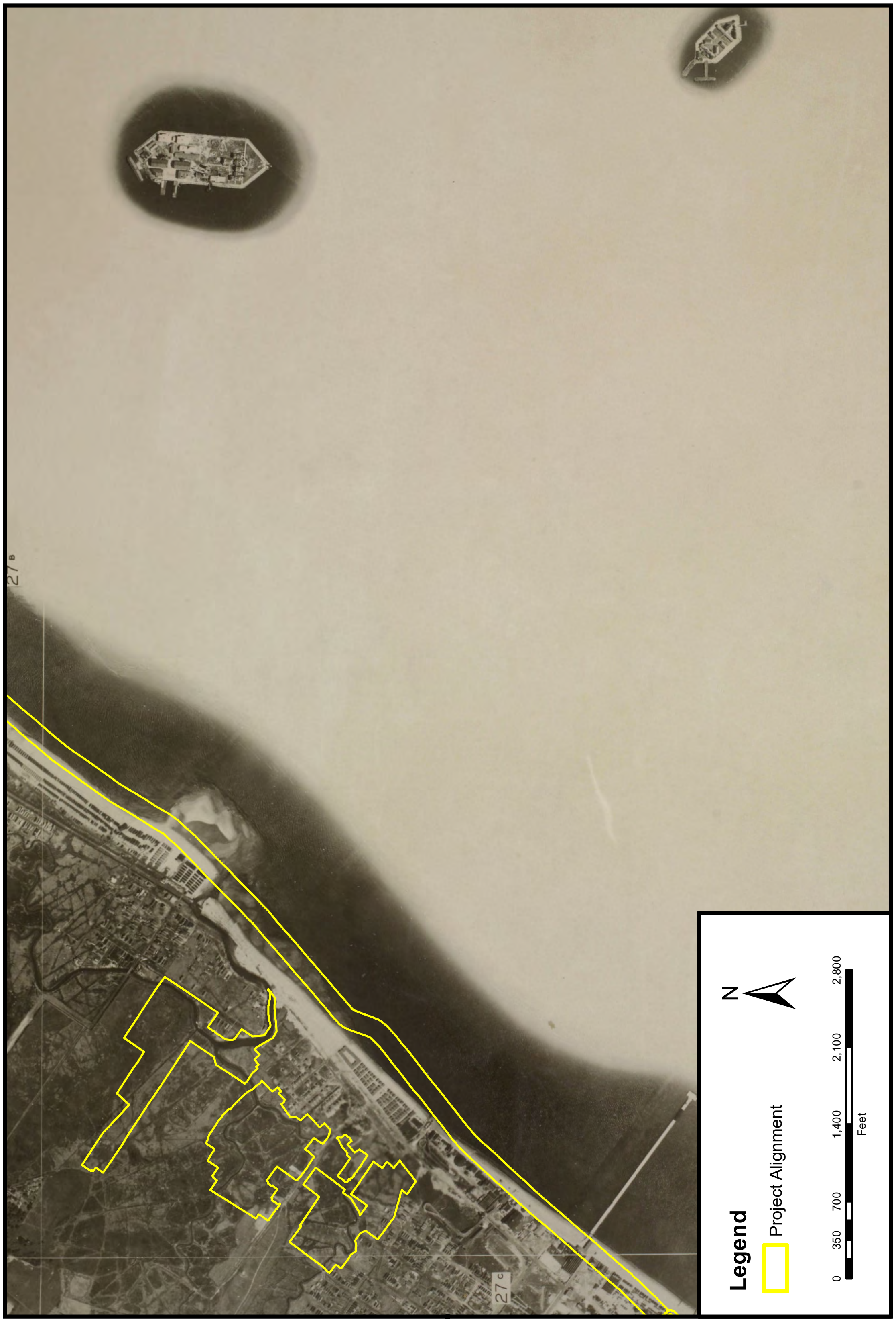


Figure 4.10b. Fairchild Aerial Camera Company. Detail of Aerial 27D. Sectional Aerial Maps of the City of New York. 1924.

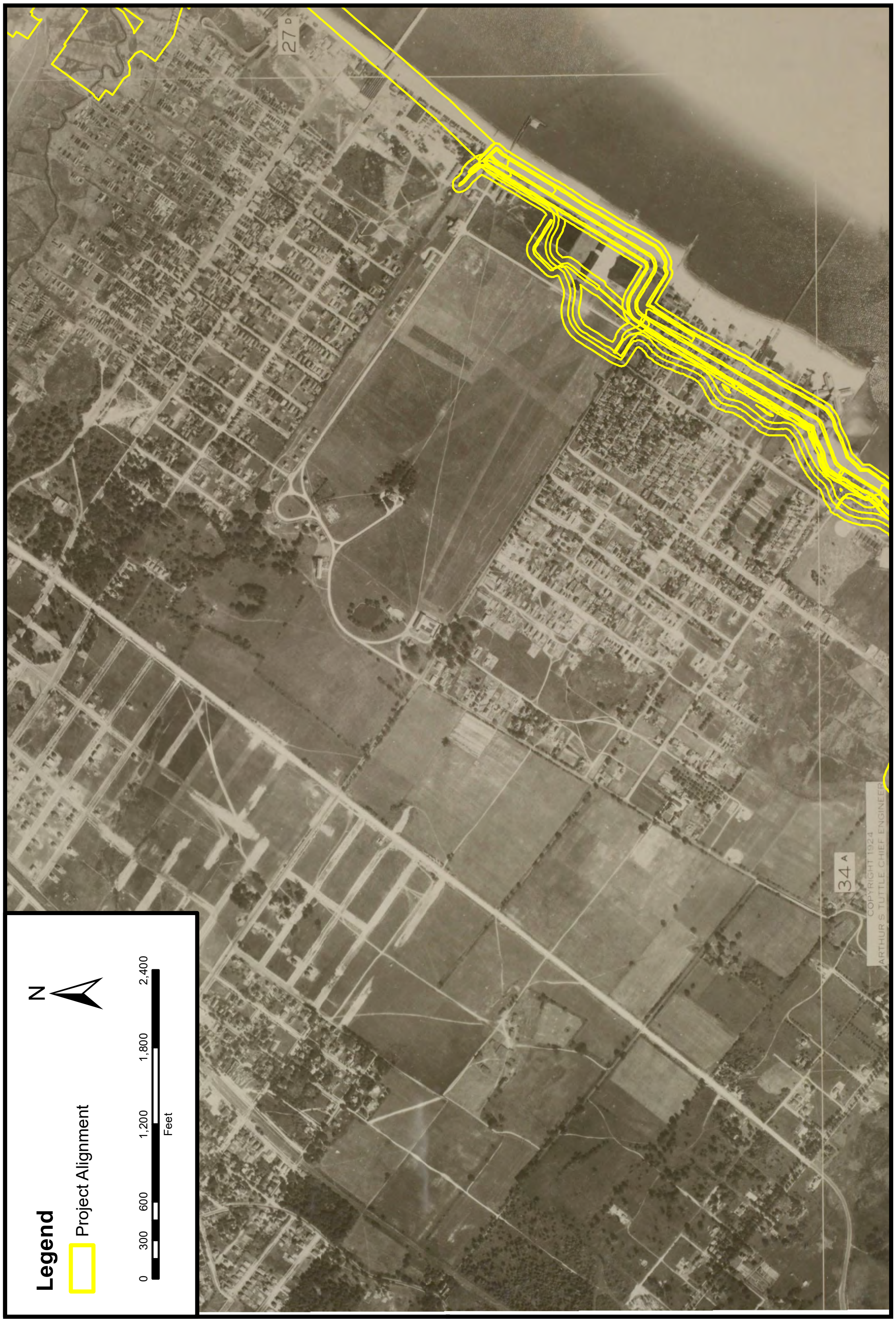


Figure 4.10c. Fairchild Aerial Camera Company. Detail of Aerial 27C. Sectional Aerial Maps of the City of New York. 1924.

Figure 4.10d. Fairchild Aerial Camera Company. Detail of Aerial 34A. Sectional Aerial Maps of the City of New York. 1924.

remained in operation in South Beach, while several bathhouses, a carousel and a roller coaster still stood in Midland Beach (Sanborn Map Company 1937; Panamerican Consultants, Inc. 2005:3-29). At New Dorp Beach, the Sea Side Hospital of St. John's Guild and the New Dorp Beach Hotel, which became known as Mandia's Hotel, remained open in 1937 (Sanborn Map Company 1937; Panamerican Consultants, Inc. 2005:3-88).

During the ensuing decades, the south shore of Staten Island underwent numerous changes as New York City slowly transformed the shoreline into public space. As previously noted, the construction of the Franklin D. Roosevelt Boardwalk effectively brought an end to the era of private resorts on the south shore of Staten Island. Designed to open the approximately 2.5 miles of shoreline and beach to the public, the Franklin D. Roosevelt Boardwalk was built by the Works Progress Administration between 1935 and 1937. It underwent extensive renovations and reconstructions in the 1950s and 1990s and currently extends from Ocean Avenue in South Beach to Greeley Avenue in Midland Beach (Gottlock and Gottlock 2013). Approximately 12 years later in 1949, New York City opened the Great Kills Park to the public as Marine Park. Originally planned in 1929, the approximately 523-acre park was formed from Crooke's Point, an area of upland located at the tip of the south shore of Staten Island more than a mile to the south of the project alignment, and reclaimed marshland, which included the site of the Lake house and the Lake tide mill, with more than 15 million yards of fill. In 1972, the Great Kills Park was incorporated into the Staten Island Unit of the Gateway National Recreation Area along with Miller Field, which was decommissioned by the federal government in 1969, and Fort Wadsworth, which is located immediately adjacent to the northern terminus of the project alignment (*The New York Times,* 23 April 1929; National Park Service 1976:113; National Park Service 1989:4). Between 1954 and 1966, New York City demolished the Sea Side Hospital of St. John's Guild at New Dorp Beach and the 20th-century bungalows that stood southeast of New Dorp Lane and Cedar Grove Avenue (Nationwide Environmental Title Research 1954, 1966). The Cedar Grove Club and its 20th-century bungalows survived until 2010, when the New York City Department of Parks and Recreation revoked its permit and demolished the bungalows (D'Elia, Wenus and Slepian 2012). The south shore of Staten Island sustained significant damage during Hurricane Sandy and many of the extant 20th-century bungalows and dwellings in Oakwood Beach were subsequently demolished (National Environmental Title Research 2012-2015; Gottlock and Gotllock 2013).

B. HISTORY OF THE LAKE TIDE MILL

The history of the Lake tide mill dates back to 1696, when Daniel Lake (I) acquired 270 acres of land on the Great Kills from Peter Billeau and Isaac Billeau (Table 4.1) (Richmond County Deed B/240; Richmond County Deed B/241). He also purchased an adjoining 80-acre tract of land from Peter Billeau (Figure 4.11) (Richmond County Deed B/240). Born to John and Anne Spicer Lake in Gravesend, Long Island, Daniel Lake (I) relocated to Staten Island with his family *circa* 1695 (Mullane and Johnson 1981:7). During the ensuing years, he amassed substantial landholdings near the Great Kills. However, shortly after acquiring the 270-acre parcel on the Great Kills from Peter and Isaac Billeau and the adjoining 80-acre parcel from Peter Billeau (Billous), Daniel Lake (I) sold the western half of the property to Joseph Holmes, his stepson, on March 3, 1696, retaining for himself the eastern half, including the future site of the Lake tide mill (Richmond County Deed B/242; McMillen 1951:1). The site of the tide mill remained in the Lake family during the next four generations, passing to Daniel Lake (I)'s son, Daniel Lake (II), his grandson, Daniel Lake (III) and his great grandson, Daniel Lake (IV) (McMillen 1951).

Table 4.1. Lake's Tide Mill Sequence of Ownership.

Transfer Date	Grantor	Grantee	Reference	Sale Price	Notes
4 February 1696	Peter Bilyou (Billeau)	Daniel Lake (I)	Richmond County Deed B/240	Illegible	A lot of land on the south side of Staten Island bordering land of Jacques Guyon containing 270 acres. This lot of land included what eventually became the Lake's Tide Mill property. Also, a lot of land on the south side of Staten Island containing 80 acres.
5 February 1696	Isaac Bilyou (Billeau)	Daniel Lake (I)	Richmond County Deed B/241	Illegible	A lot of land on the South side of Staten Island bordering land of Jacques Guyon containing 270 acres. This lot of land included what eventually became the Lake's Tide Mill property.
Unknown	Daniel Lake (I)	Daniel Lake (II)	Unknown	n/a	It is believed that Daniel Lake (I) devised the 270-acre property that he purchased from Peter and Isaac Billeau to his son Daniel Lake (II).
9 October 1727	Daniel Lake (II)	Daniel Lake (III)	Daniel Lake Will on file at New York Historical Society	n/a	Daniel Lake (II) devised his real estate to his sons Daniel Lake (III) and William Lake.
Uknown	Daniel Lake (III)	Daniel Lake (IV)	Unknown	n/a	It is believed that Daniel Lake (III) gave land that contained the Lake's Tide Mill property to his son Daniel Lake (IV). When Daniel Lake (III) died in 1792, he devised a salt meadow located adjacent to land owned by Daniel Lake (IV) and the mill creek to his son.
Unknown	Daniel Lake (IV)	Daniel Lake, Jr. and Cornelius Lake	Unknown	n/a	It is believed that Daniel Lake (IV) gave the Lake's Tide Mill property to his sons Daniel Lake, Jr. and Cornelius Lake. No deed for this transfer of ownership was recorded with the county.
2 May 1803	Daniel Lake, Jr. (mariner) and Margaret Lake and Cornelius Lake (miller) and Susannah Lake	Edward Beatty (merchant)	Richmond County Deed F/357	£1,000.00	Lot of land containing 13.3 acres with mill creek, mill pond, mill race and mill dam lying to the west and mill house, dwelling house, barn, outhouses and orchards.
21 July 1825	Edward Beatty	John Beatty, Jacob Beatty and James Beatty	Richmond County Will C/942	n/a	Edward Beatty named his sons John Beatty, Jacob Beatty and James Beatty and his friend Richard Corner as executors of his estate, devised his real estate and personal estate to them as tenants in common and granted them the right to sell his real estate and personal estate.
8 April 1826	John Beatty (miller) and Elizabeth Beatty, Cornelius Beatty (tanner and currier) and Ann Beatty, Jacob Lozier (mason) and Sarah Lozier, Jacob Beatty and Elizabeth Beatty and Isabella Eleanor Beatty	James Beatty	Richmond County Deed O/256	2,000.00	Lot of land containing 13.3 acres with mill creek, mill pond, mill race and mill dam lying to the west and mill house, dwelling house, barn, outhouses and orchards.
10 April 1834	James and Ann Beatty	James McLees (Monmouth, New Jersey)	Richmond County Deed V/433	1,800.00	Lot of land containing 13.3 acres with mill creek, mill pond, mill race and mill dam lying to the west and mill house, dwelling house, barn, outhouses and orchards. Also a lot of meadow containing 5 acres of land on the south side of the mill property. James McLees died intestate in 1835 and his property passed to his wife Rebecca Lewis McLees.
8 September 1854	Henry B. Metcalf, referee	Arthur G. Lake	Richmond County Deed 35/91	3,500.00	Lot of land containing 13.3 acres and mill creek, mill pond, mill race and mill dam. Also a 5.0-acre salt meadow at the Great Kills near the southeast end of the mill. Property sold at public auction due to order of Supreme Court of New York related to action of Tyler McClees and wife against William Loveridge and others. William Loveridge married Rebecca Lewis McLees in 1841.
29 November 1856	Arthur G. Lake	James McLees	Richmond County Deed 41/606	1,700.00	One undivided half part of a lot of land containing 13.1 acres and mill creek, mill pond, mill race and mill dam. Also in a 5.0-acre salt meadow at the Great Kills near the southeast end of the mill. James McLees was presumably the son of James and Rebecca McLees.
19 September 1860	George J. Greenfield, referee	Arthur G. Lake	Richmond County Deed 46/607	3,000.00	Lot of land containing 13.3 acres and mill creek, mill pond, mill race and mill dam. Also a 5.0-acre salt meadow at the Great Kills near the southeast end of the mill. Sold at public auction due to order of Supreme Court of New York in action of James McClees against Arthur G. Lake.

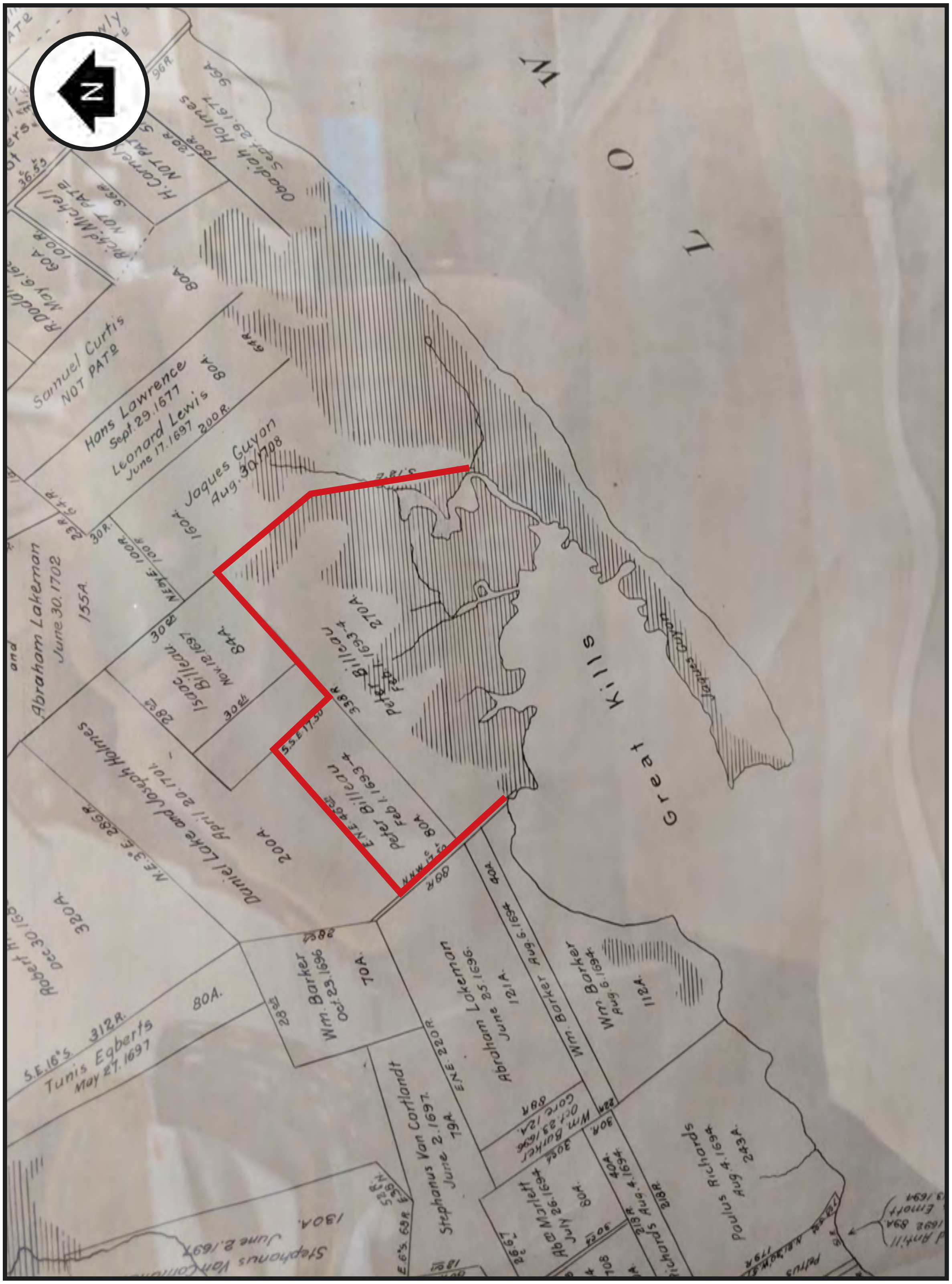


Figure 4.11. Skene, Frederick. Detail of *Map of Staten Island, Richmond Co., NY, showing the Colonial Land Patents from 1665 to 1712.* 1907. Original land parcels associated with the Lake tide mill outlined.

The date when the Lake tide mill was constructed remains unclear, although the available documentation suggests that it was built between 1709 and 1723, most likely by Daniel Lake (II). According to McMillen (1951:1, 4), a 1709 survey for the laying out of Mill Road, on which the Lake tide mill stood, did not mention the mill. In 1723, however, another survey of this road described it as running to the mill (McMillen 1951:4). A miller's house, known as the Lake house, was likely constructed at the same time as the tide mill. It stood northeast of the mill on the south side of Mill Road (McMillen 1951:4). Born *circa* 1684 in Gravesend, Long Island, Daniel Lake (II) was the first of two sons born to Daniel Lake (I) and Alice Stillwell Lake (Mullane and Johnson 1981:10). He died in 1727 and devised "all my lands and tenements where I now dwell" to his sons Daniel Lake (III) and Joseph Lake in his will, which was proved on October 9, 1727 (New York Historical Society Publication Fund 1903:54; Mullane and Johnson 1981:13-14).

Born on January 26, 1719, Daniel Lake (III) married Sarah Connor(s) (Daniel Lake Vertical File). The couple had eight children, and their eldest son, Daniel Lake (IV) was born in 1741. Daniel Lake (IV) worked as a miller, probably following in his father's footsteps. He apparently received the tide mill and the associated house and property from Daniel Lake (III) prior to 1790, possibly following his marriage to Ann Garrison Lake in 1762, for both men appear in the federal population census schedule of 1790 for Southfield (Mullane and Johnson 1981:19). According to the 1790 federal population census schedule, Daniel Lake (III), whom the census identified as Daniel Lake, Sr., headed a household that included one boy under the age of 16, likely a grandson, a woman, presumably his wife, and ten slaves. The household of Daniel Lake (IV), whom the census listed as Daniel Lake, Jr., included a boy under the age of 16, likely his son, a woman, presumably his wife Ann Garrison Lake, and a single slave (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1790). After his father's death on August 30, 1792, Daniel Lake (IV) inherited a salt meadow adjoining his land and Mill Creek, a silver broad sword and a slave named Thomas (Richmond County Will #24; Davis 1889).

Maps from this period show the Lake family's tide mill and the surrounding landscape. On the *Plan (No. 31) du Camp Anglo-Hessois dans Staten Island, New York*, which was created between 1780 and 1783, the tide mill appears at the end of Mill Road in a marshy area directly adjacent to the Great Kills (Figure 4.12). Although the map identifies the owners of the majority of the neighboring properties, including houses belonging to D. Lake and W. Lake, it does not provide the name of the owner of the tide mill or the miller's house, which stands slightly north of the mill on the west side of Mill Road. Likewise, *A Map of New York and Staten Island* published by George Taylor and Abraham Skinner in 1781 does not identify property owners, though it provides more detailed and accurate information about the tide mill and the surrounding landscape (Figure 4.13). In addition to the Lake house, which the map correctly locates on the east side of Mill Road, and the tide mill, the Taylor and Skinner map of 1781 also depicts the dam that spanned Mill Creek and which, at high tide, retained the millpond that powered the mill. By 1781, a ditch or canal connected Bass Creek to the millpond, providing additional water for the operation of the mill. *A Map of Staten Island during the Revolution, 1775-1783*, which was prepared by a Staten Island historian named Loring McMillen in 1933, lists Daniel Lake, Jr. (Daniel Lake IV) as the owner of the tide mill and the occupant of the Lake house (Figure 4.14). Interestingly, the ditch does not appear on the *New and Correct Mapp of the County of Richmond* published in 1797, although the Lake house, the tide mill, the millpond and Mill Road are all present (Figure 4.15).

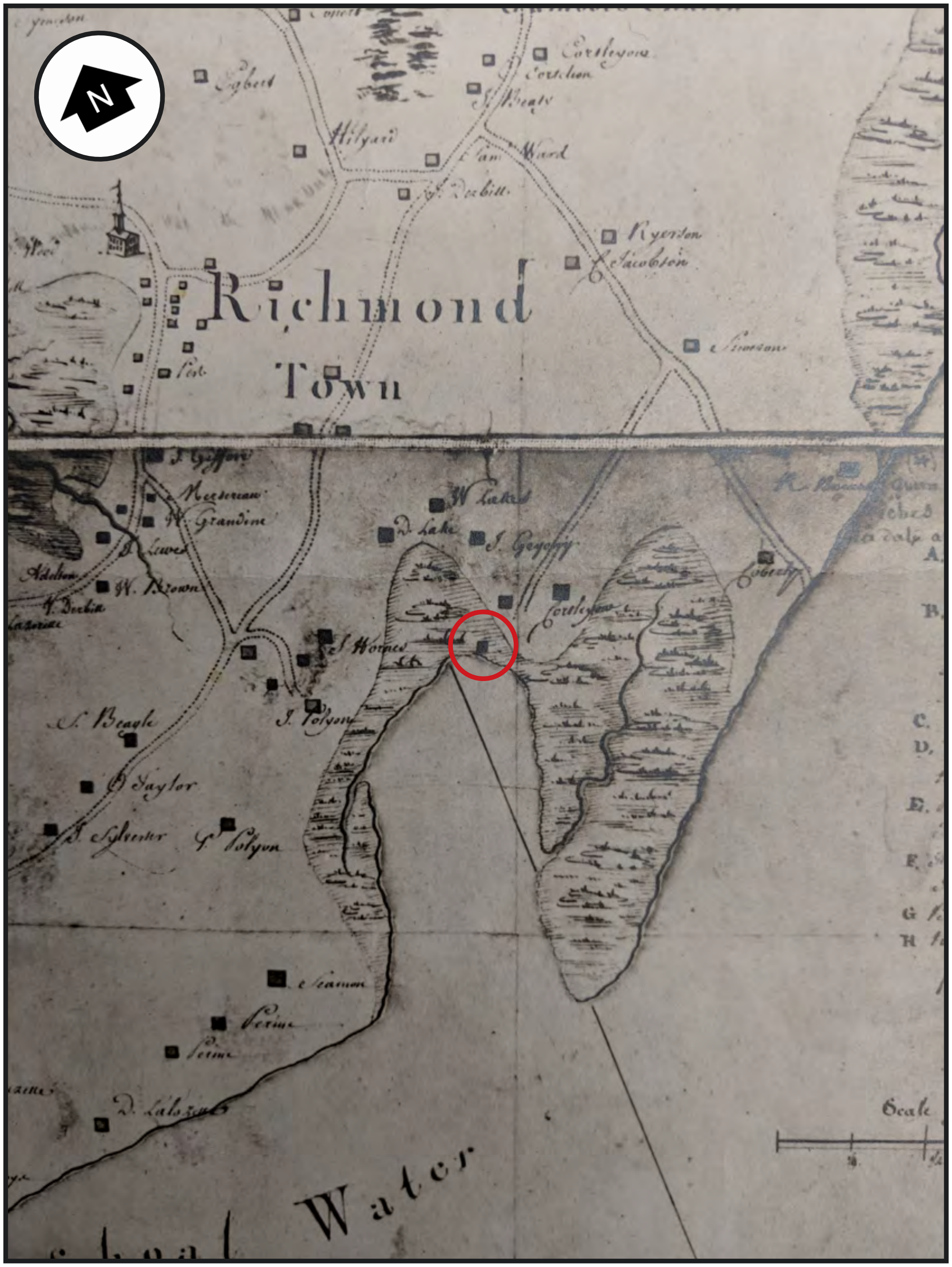


Figure 4.12. Detail of *Plan (No. 31) du Camp Anglo-Hessois dans Staten Island, New York*. 1780-1783. Lake tide mill circled.

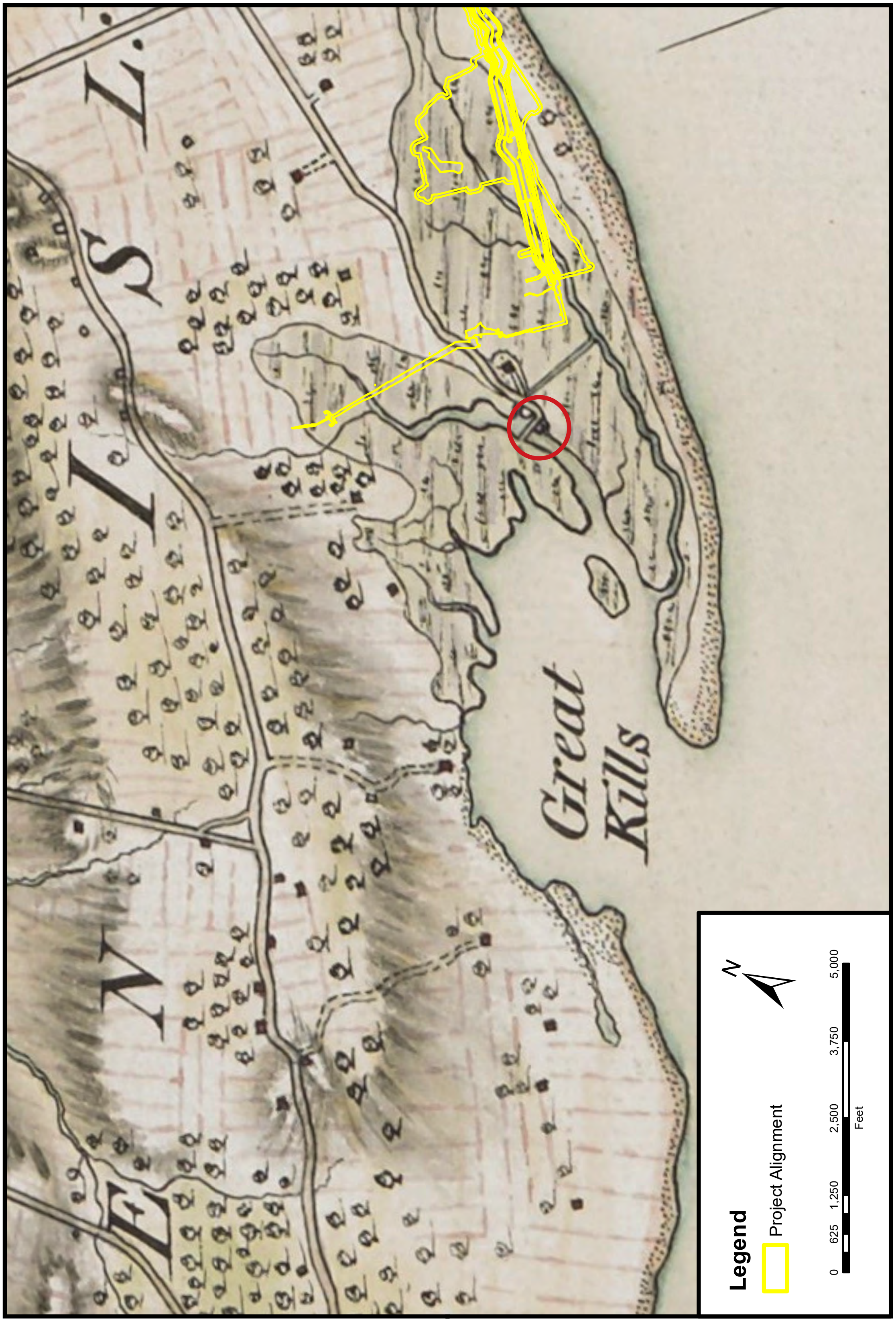


Figure 4.13. Taylor, George and Abraham Skinner. Detail of *A Map of New York and Staten Island*. 1781. Lake tide mill circled.

Figure 4.14. McMillen, Loring. Detail of *A Map of Staten Island during the Revolution, 1775-1783*. 1933. Lake tide mill circled.

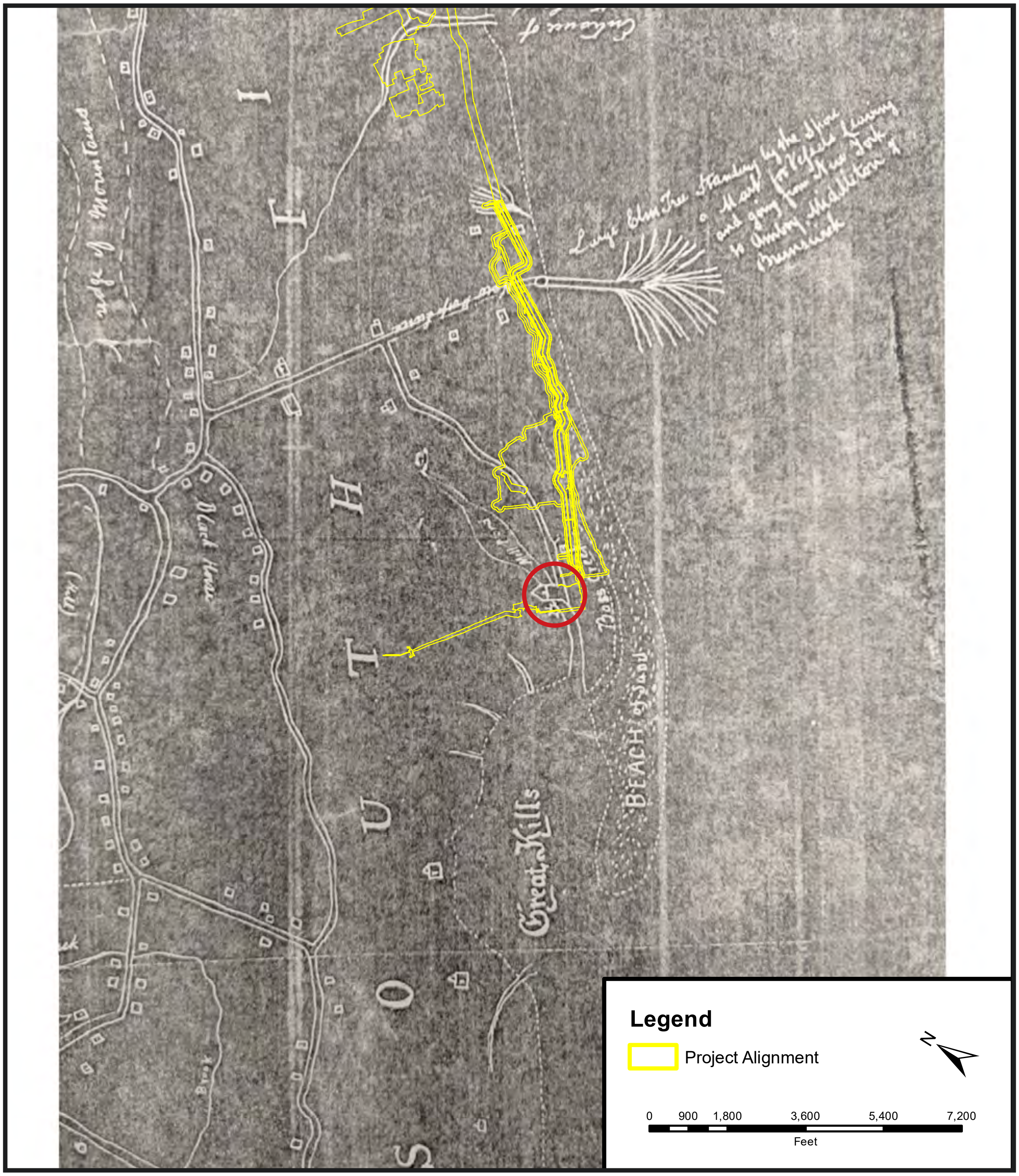


Figure 4.15. Detail of *A New and Correct Mapp of the County of Richmond*. 1797. Lake tide mill circled (note: this map has been rubber

In operational terms, the tide mill (a gristmill) ran on water power generated by trapping water from Mill Creek and Bass Creek at high tide behind the dam. The mill only operated on the outgoing tide when the miller raised a gate to release the water through the millrace to turn the mill wheel. Each high tide provided approximately five hours of milling time, which equaled a total of ten hours from the two high tides each day (McMillen 1951:4; Panamerican 2005:3-62). In contrast to non-tidal mills that would typically operate for longer periods using the more continuous flow of a river, enabling them to produce flour both for local inhabitants and regional markets, the Lake tide mill, at least initially, most likely functioned as a relatively small-scale "country" gristmill serving chiefly neighborhood farmers (McMillen 1951:4).

It appears that Daniel Lake (IV) continued to own and operate the tide mill and reside in the Lake house through 1792, when he inherited the salt meadow adjoining his property from Daniel Lake (III). Sometime during the next seven years, however, he transferred the property to his sons, Daniel Lake, Jr. and Cornelius Lake. This may have occurred in 1794, when Cornelius Lake married Susannah Androvette (Mullane and Johnson 1981:42). While both brothers evidently owned the property, it appears that Cornelius Lake occupied the Lake house and operated the tide mill in the 1790s and early 1800s (see below). Although Daniel Lake, Jr. reportedly worked as a miller, a road return from 1796 referred to Cornelius Lake as the miller and it was Cornelius that the New York State Comptroller's Office taxed for a house, mill and lot, valued at $1,650, in 1799 and 1800 (New York State Comptroller's Office 1799, 1800; McMillen 1951:4; Mullane and Johnson 1981:42). In contrast, Daniel Lake, Jr. only paid taxes on a house and lot valued at $200 in 1799 (New York State Comptroller's Office 1799). In 1800, Cornelius Lake headed a household that included a boy under the age of 10, likely his son, a boy between the ages of 10 and 16, possibly his son or a servant, a girl under the age of 10, presumably his daughter Sarah Ann Lake, a woman over the age of 45, presumably his wife Susannah Androvette Lake, and a slave (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1800).

Cornelius Lake and Daniel Lake, Jr. retained ownership of the tide mill, the Lake house and the surrounding property until 1803, when they decided to offer the property for public sale. The property contained a "valuable Grist Mill, with two run of stones, commonly known by the name of Lak's [sic] Mills," a house, a barn, 12 acres of land "consisting of Fresh and Salt Meadow" and a salt meadow (*Evening Post,* April 1, 1803:4). Daniel Lake, Jr. and Cornelius Lake advertised the tide mill as "conveniently situated for any person wishing to carry on the business of a Flour-Merchant, as the Mill goes by the tide, and the water is navigable for vessels drawing from six to seven feet" (*Evening Post*, April 1, 1803: 4). This may indicate that, in contrast to McMillen's characterization of it as a "country" mill, the Lake family, by the early 19th century, was operating the mill as a commercial enterprise and processing grain shipped in by coastal vessels from further afield (McMillen 1951:4). Edward Beatty, a merchant, purchased the tide mill property, which contained 13.3 acres and included the mill, the Lake house, a barn, outhouses and an orchard, from Daniel and Margaret Lake, Jr. and Cornelius and Susannah Lake for £1,000.00 on May 2, 1803 (Richmond County Deed F/357). The deed recording the transfer described Daniel Lake, Jr. as a mariner and Cornelius Lake as a miller, which strongly suggests that Daniel Lake, Jr. never operated the tide mill, although he may have been involved in grain and flour shipment (Richmond County Deed F/357).

Edward Beatty appears to have purchased the tide mill property for his eldest son John Beatty, who had married Elizabeth Lake in October 1797. Born on May 26, 1778, Elizabeth Lake was the daughter of William and Elizabeth Poillion Lake, the granddaughter of

Daniel Lake (III) and the cousin of Daniel Lake (IV) (Mullane and Johnson 1981:22). While the New York State Comptroller's Office taxed John Beatty for a house and farm in 1800, the baptismal record for his daughter Eleanora Beatty refers to him as a miller in 1804 (New York State Comptroller's Office 1800; New York Genealogical and Biographical Society 1907b: 116). A Richmond County deed of 1826 also describes John Beatty as a miller and a resident of the town of Southfield, where the tide mill was located (Richmond County Deed O/256). Edward Beatty died on July 17, 1825, and devised his real estate, including the mill property, to the executors of his estate, his sons John Beatty, Jacob Beatty and James Beatty, and his friend Richard Corner, as tenants in common, authorizing them to sell his property (*New York Observer,* July 23, 1825:3; Richmond County Will C/942; Bayles 1887:626). James Beatty, a carpenter from Castleton, Staten Island, purchased the tide mill property from his siblings, James and Elizabeth Beatty, Cornelius and Ann Beatty, Jacob and Sarah Lozier, Jacob and Elizabeth Beatty and Isabella Eleanor Beatty, for $2,000.00 on April 8, 1826 (Richmond County Deed O/256). The property contained 13.3 acres, the tide mill, the former Lake house, a barn, outhouses, orchards, gardens and a five-acre salt meadow (Richmond County Deed O/256).

It is unclear if James Beatty occupied the former Lake house and operated the tide mill after he purchased the property, although it appears that John Beatty continued to live on the property with his family. Both James Beatty and John Beatty appear in the 1830 federal population census schedule for the town of Southfield, which indicates that they occupied separate dwellings, and a Richmond County deed of 1834 refers to James Beatty as a carpenter (Richmond County Deed V/433). John Beatty headed a household that included a woman between the ages of 50 and 60, presumably his wife Elizabeth Lake Beatty, a boy between the ages of 5 and 10, a boy between the ages of 10 and 15, a boy between the ages of 15 and 20, a man between the ages of 20 and 30, a girl under the age of 5, three girls between the ages of 5 and 10 and a girl between the ages of 10 and 15, all presumably the couple's children (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1830). Born to Edward Beatty and Eleanor Cortelyou Beatty on November 16, 1800, James Beatty was 24 years younger than his brother John Beatty (New York Genealogical and Biographical Society 1907a: 45; New York Genealogical and Biographical Society 1907b:113). In 1830, James lived with his wife Ann M. Beatty, who was between the ages of 20 and 30, a man between the ages of 60 and 70, likely his father-in-law, and a woman between the ages of 40 and 50, likely his mother-in-law (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1830). Regardless of the identity of the occupant and operator of the tide mill, James Beatty maintained ownership of the property for only eight years.

James McLees, a resident of Monmouth County, New Jersey, purchased the tide mill from James and Ann M. Beatty for $1,800.00 on April 10, 1834 (Richmond County Deed V/433). The purchase included the 13.3-acre tract of land on which the mill sat, the former Lake house, a barn, outhouses, an orchard, gardens and the five-acre salt meadow (Richmond County Deed V/433). James McLees died intestate prior to August 11, 1835, and the tide mill passed to his widow, Rebecca Lewis McLees (Monmouth County Letters of Administration B/28). Rebecca Lewis McLees married William Loveridge, a basket maker from Gloucester, England, on Staten Island on April 6, 1841 (Wright 1909:199). After their marriage, the couple occupied the former Lake house with Rebecca McLees's children, while Loveridge operated the tide mill (Richmond County Deed 14/532). Between 1844 and 1854, William Loveridge purchased several salt meadow tracts in Southfield in proximity to the mill, which Richmond County deeds identified as his property (Richmond County Deed 14/532; Richmond County Deed 14/533; Richmond County Deed 27/59;

Richmond County Deed 32/675; Richmond County Deed 33/569). According to the 1850 federal population census schedule for Southfield, the 40-year-old William Loveridge worked as a miller and headed a household that included his wife Rebecca Loveridge, whose age was incorrectly given as 5, and her three children: Tyler McClees (20), who worked as a carpenter, Ann McClees (17) and James McClees (15) (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1850).

Despite this changing ownership, the tide mill and the surrounding landscape remained largely unchanged during the middle decades of the 19th century. The mill and milldam appear on a *Map of New York Bay and Harbor and the Environs* created by the United States Coast Survey in 1844 (Figure 4.16). They stood in a marsh surrounding the Great Kills bordered on the north and east by meadows and farmland. Interestingly, the 1844 Coast Survey map does not show Mill Road extending south to the tide mill and also does not depict the Lake house. This was likely an oversight since the tide mill, the house and the full length of Mill Road all appear on the *Map of Staten Island* published by James Butler in 1853 (Figure 4.17). In addition to the tide mill and the house, William Loveridge also owned two buildings that stood to the east of the mill property at the end of a lane that extended from Mill Road to the shore of New York Bay. While the 1853 Butler map did not list the purpose of these two buildings, H.F. Walling labels them as fish houses on the *Map of Staten Island* that he created in 1859 (Figure 4.18).

William Loveridge apparently lost ownership of the tide mill in 1854 following a lawsuit brought against him by his stepson, Tyler McClees (Richmond County Deed 35/91). Arthur G. Lake purchased the mill property at a referee sale for $3,500.00 on September 8, 1854 (Richmond County Deed 35/91). At that time, the mill property still contained 13.3 acres adjacent to the millpond, dam and millrace and held the rights to Mill Creek, the millpond, millrace and milldam. The sale also included a five-acre salt meadow near the southeast end of the mill property (Richmond County Deed 35/91). Loveridge, however, continued to operate the mill. The 1855 New York state population census schedule for Staten Island lists the 46-year-old miller as the head of a household that included his wife, Rebecca (58), his stepdaughter, Ann McClees (21), and Andrew Crawford (50), an Irish servant. The census reports that the Loveridge household occupied a frame dwelling valued at $5,000 (New York State Census, Southfield, Richmond, New York 1855).

By purchasing the tide mill, Arthur G. Lake returned the property to the descendants of Daniel Lake (I). Born on October 14, 1811, Arthur Gifford Lake was the fifth child of Daniel W. Lake and Mary Gifford Lake (Daniel Lake Vertical File; Lake Family Vertical File; Mullane and Johnson 1981: 43). Daniel W. Lake was the son of Captain William Lake, who served in the Revolutionary War, the grandson of Daniel Lake (III), the great grandson of Daniel Lake (II) and the great, great grandson of Daniel Lake (I) (Mullane and Johnson 1981). He married Catherine Johnson, who died without any children prior to 1850. In 1850, the 38-year-old Arthur G. Lake lived with his brother Dr. James S. Lake and worked as a fisherman (Mullane and Johnson 1981:49-50).

As noted above, despite purchasing the tide mill and the former Lake house in 1854, Arthur G. Lake does not appear to have initially occupied the property. Instead, he rented it to William Loveridge. According to the 1855 New York state population schedule for Staten Island, Arthur G. Lake (45) lived in Southfield in a frame dwelling valued at $500. He headed a household that included James Van Cleese (19) and Ann Bracken (22), an Irish servant. Neither Arthur G. Lake nor James Van Cleese listed an occupation (New York State Census, Southfield, Richmond, New York

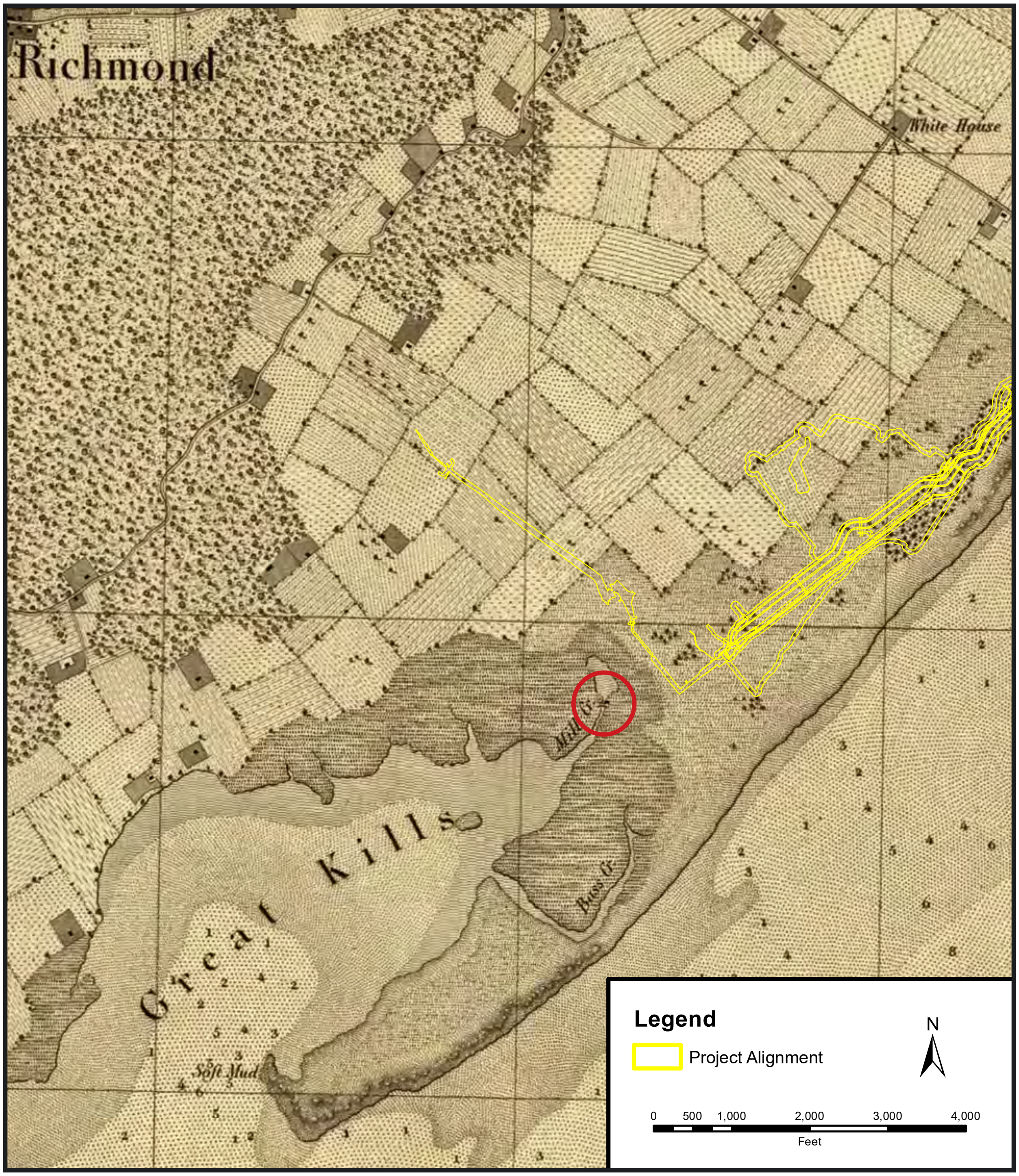


Figure 4.16. U.S. Coast Survey. Detail of *Map of New York Bay and Harbor and the Environs*. 1844. Lake tide mill circled.

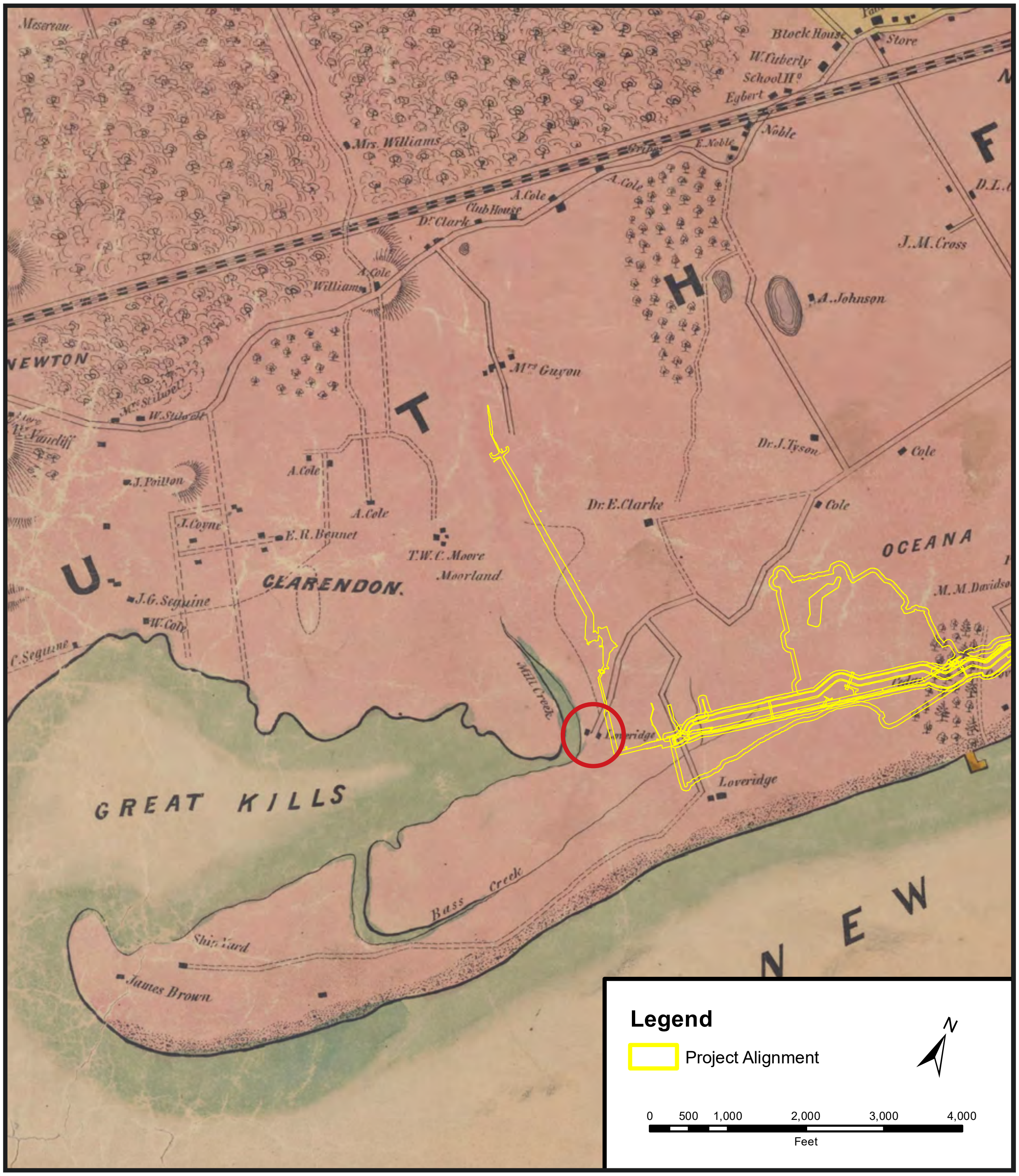


Figure 4.17. Butler, James. Detail of *Map of Staten Island, or Richmond County, New York*. 1853. Lake tide mill and Lake house circled.

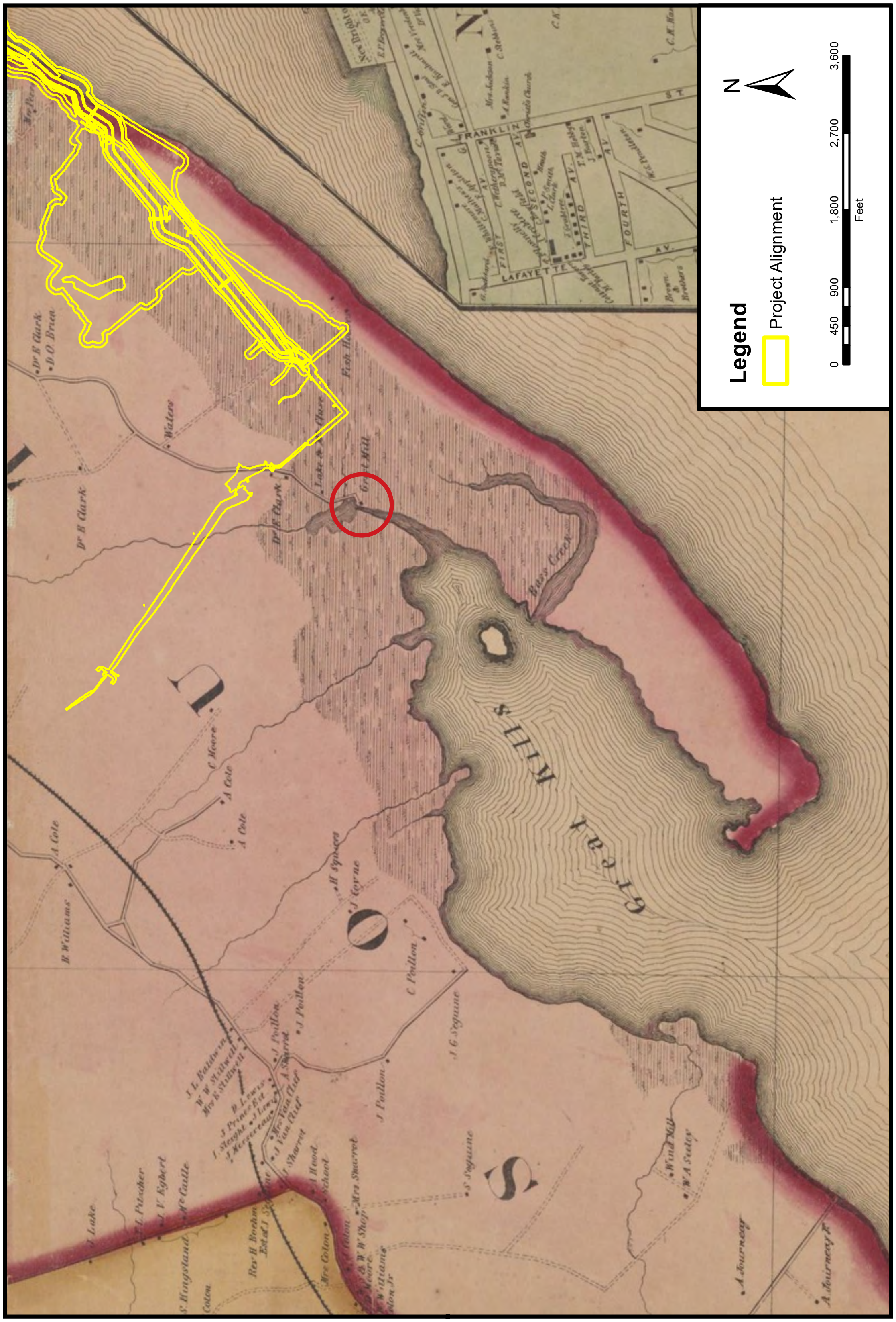


Figure 4.18. Walling, H.F. Detail of *Map of Staten Island, Richmond County, New York*. 1859. Lake tide mill circled.

1855). James Van Cleese was likely James McLees, the son of James and Rebecca Lewis McLees and the stepson of William Loveridge.

Arthur G. Lake sold one moiety, or undivided half part, of the tide mill property to James McClees for $1,700.00 on November 11, 1856 (Richmond County Deed 41/606). H.F. Walling recorded the split ownership of the mill property when he published his *Map of Staten Island* in 1859, labeling the Lake house as the property of Lake and McCluse [sic] (Figure 4.18). James McClees sued Arthur G. Lake in 1860. Due to a court ordered public sale resulting from the lawsuit, Arthur G. Lake again purchased the tide mill property at a referee sale for $3,000.00 on September 19, 1860 (Richmond County Deed 46/607). A review of Richmond County deeds indicates that Arthur G. Lake and his family retained ownership of the tide mill, the former Lake house and the surrounding property into the first decades of the 20th century.

It appears that Arthur G. Lake took possession of and began to operate the tide mill in or prior to 1860, likely following his marriage to Anna Gertrude Delaney, an Irish immigrant, in *circa* 1858/1859 (Mullane and Johnson 1981:49). The 1860 federal population census schedule for Staten Island lists the 45-year-old Arthur G. Lake as a miller and reports that he owned real estate valued at $2,400 and had a personal estate valued at $500. His household included his wife Anna Lake (21) and their son, Daniel Lake (1) (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1860). Interestingly, a 50-year-old miller named Arthur G. Lake also appears in the 1860 federal population census schedule for Brooklyn as the head of a household including a wife named Anny Lake (21) and a son named Daniel Lake (1) (U.S. Federal Census, Population Schedule, Brooklyn, Kings, New York 1860). While the similarities would suggest that this is the same person, it remains unclear whether Arthur G. Lake lived in both Staten Island and Brooklyn in 1860. Given the dates of the census records – the Brooklyn record dates from July 1860 and the Staten Island record dates from October 1860 – it is possible that Arthur G. Lake moved from Brooklyn to Staten Island (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1860; U.S. Federal Census, Population Schedule, Brooklyn, Kings, New York 1860). The 1865 New York State census gives Arthur G. Lake's age as 45 and identifies him as a farmer. He occupied a frame dwelling with his wife, Annie Lake (26) and their four children: Daniel Lake (6), Mary Lake (4), Ellen Lake (2.5) and John Lake (11 months) (New York State Census, Southfield, Richmond, New York 1865).

A series of maps help to document the changing ownership of the tide mill, the Lake house and the associated property in the mid- to late 19th century. A map of *New York Bay and Harbor* produced by the United Coast Survey in 1861 shows the tide mill and house at the end of Mill Road (Figure 4.19). The small building located immediately north of the Lake house on the east side of Mill Street likely represents the barn that stood on the mill property. It appears that the *Map of Staten Island* published by G.W. and C.B. Colton in 1866 copied information from the 1859 Walling map, for it also identifies the tide mill as a gristmill and incorrectly lists the owners of the Lake house as Lake and McCluse (James McLees); as noted above, Arthur G. Lake became the sole owner of the tide mill and house in 1860 (Figure 4.20). Both maps show the two fish houses that first appeared on the Butler map of 1853. By 1872, the fish houses had disappeared and the owner of the house is listed as "Lake" (Figure 4.21).

In their *Atlas of Staten Island,* published in 1874, J.B. Beers & Co. provide additional detail about the tide mill property, outlining its boundaries and listing it as containing 18 acres (Figure 4.22). A dyke or dam extended west from Mill Road around the tide mill to the western bank of the Mill Creek, and a road ran

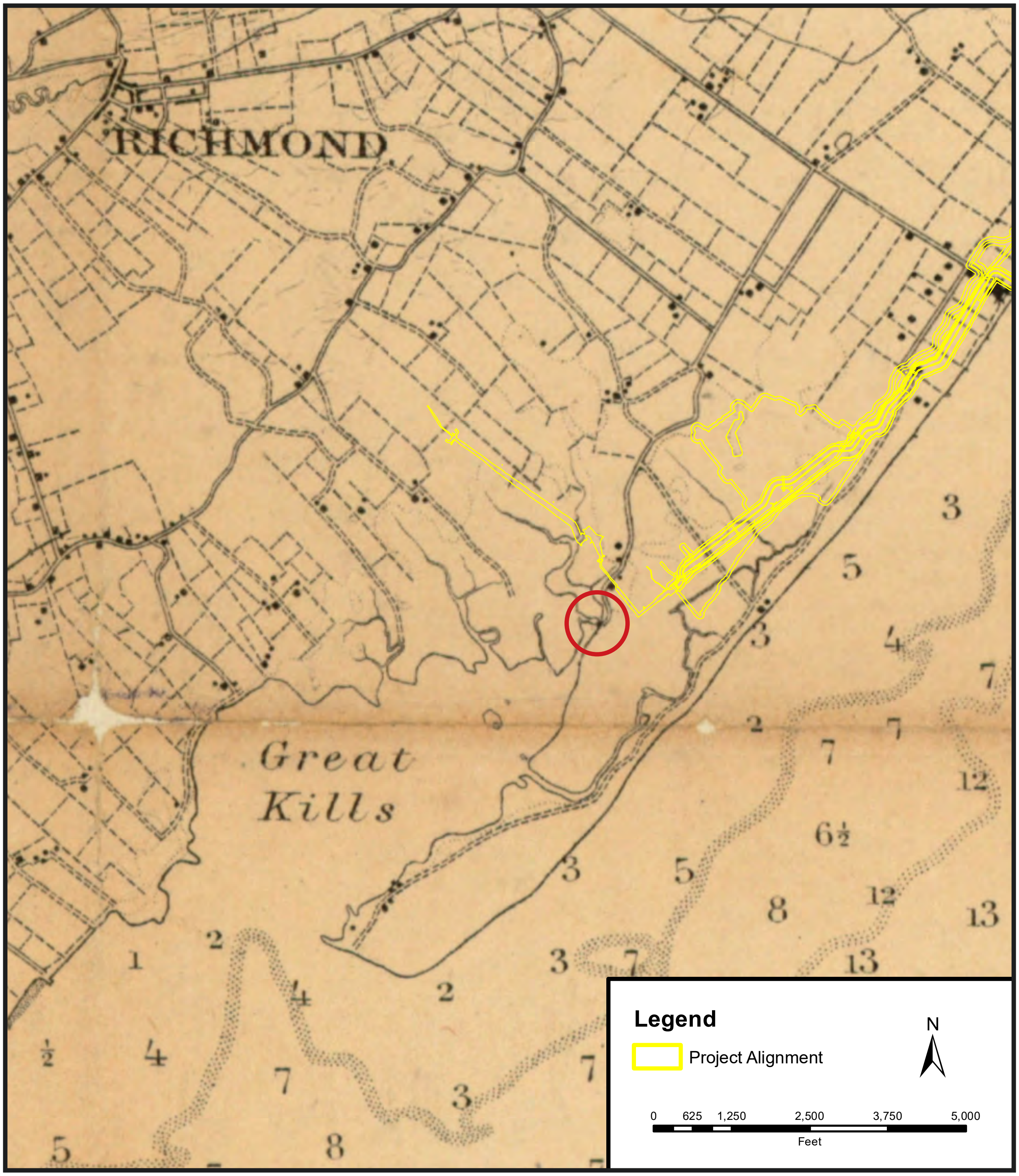


Figure 4.19. U.S. Coast Survey. Detail of *New York Bay and Harbor, New York*. 1861. Lake tide mill circled.

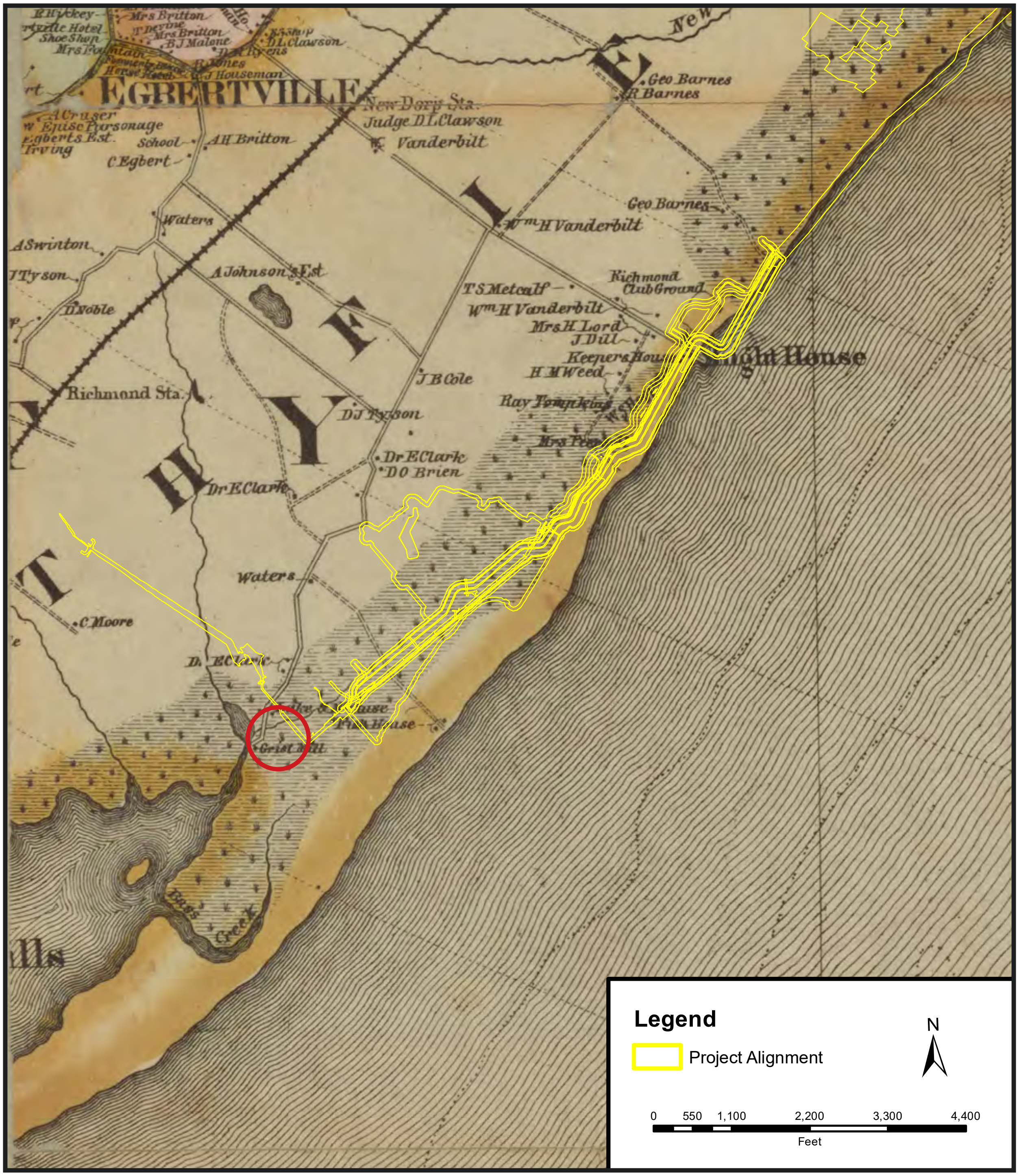


Figure 4.20. Colton, G.W. and C.B. Colton. Detail of *Map of Staten Island, Richmond County, New York*. 1866. Lake tide mill circled.

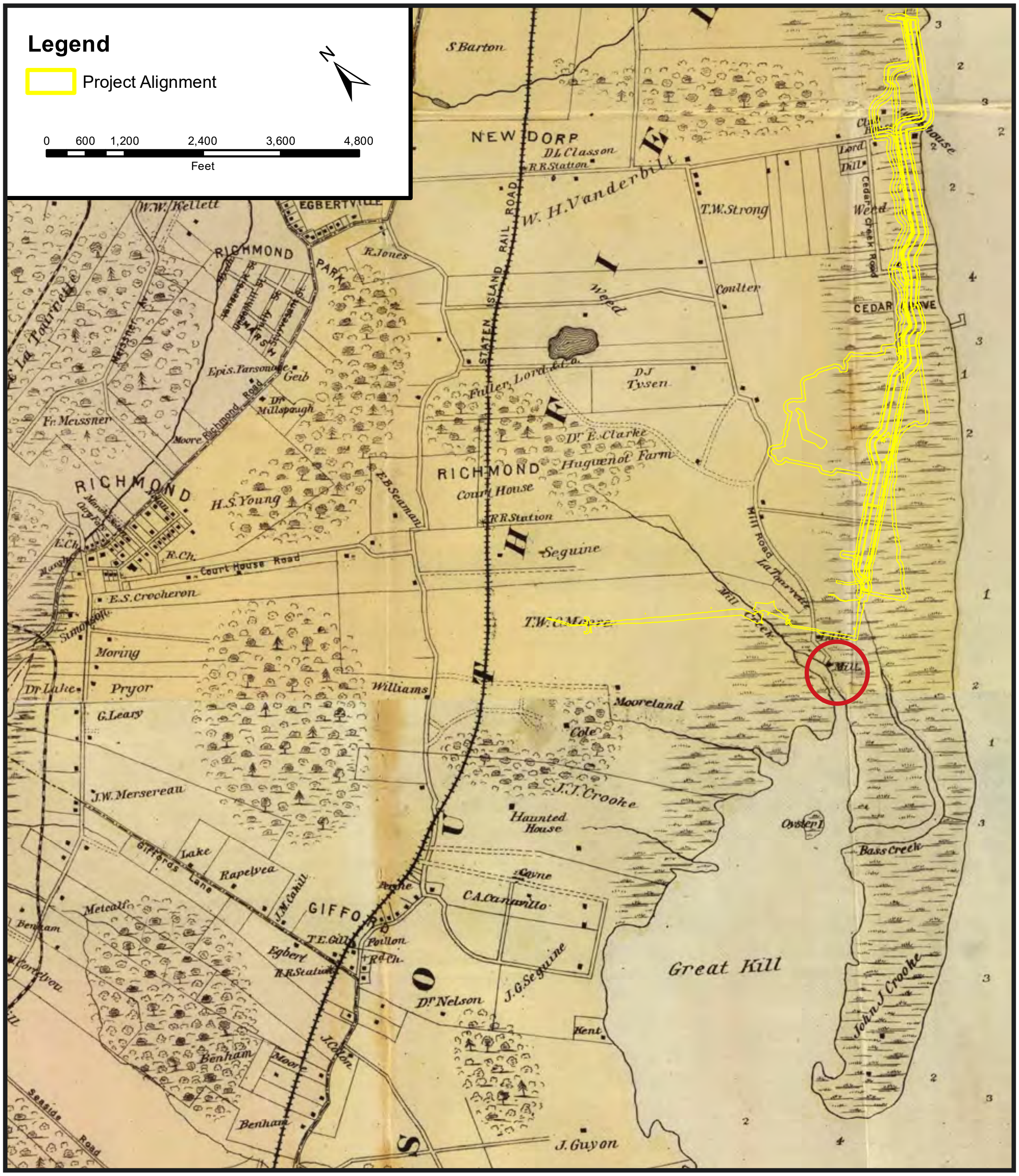


Figure 4.21. Dripps, M. Detail of *Map of Staten Island (Richmond Co.), N.Y.* 1872. Lake tide mill circled.

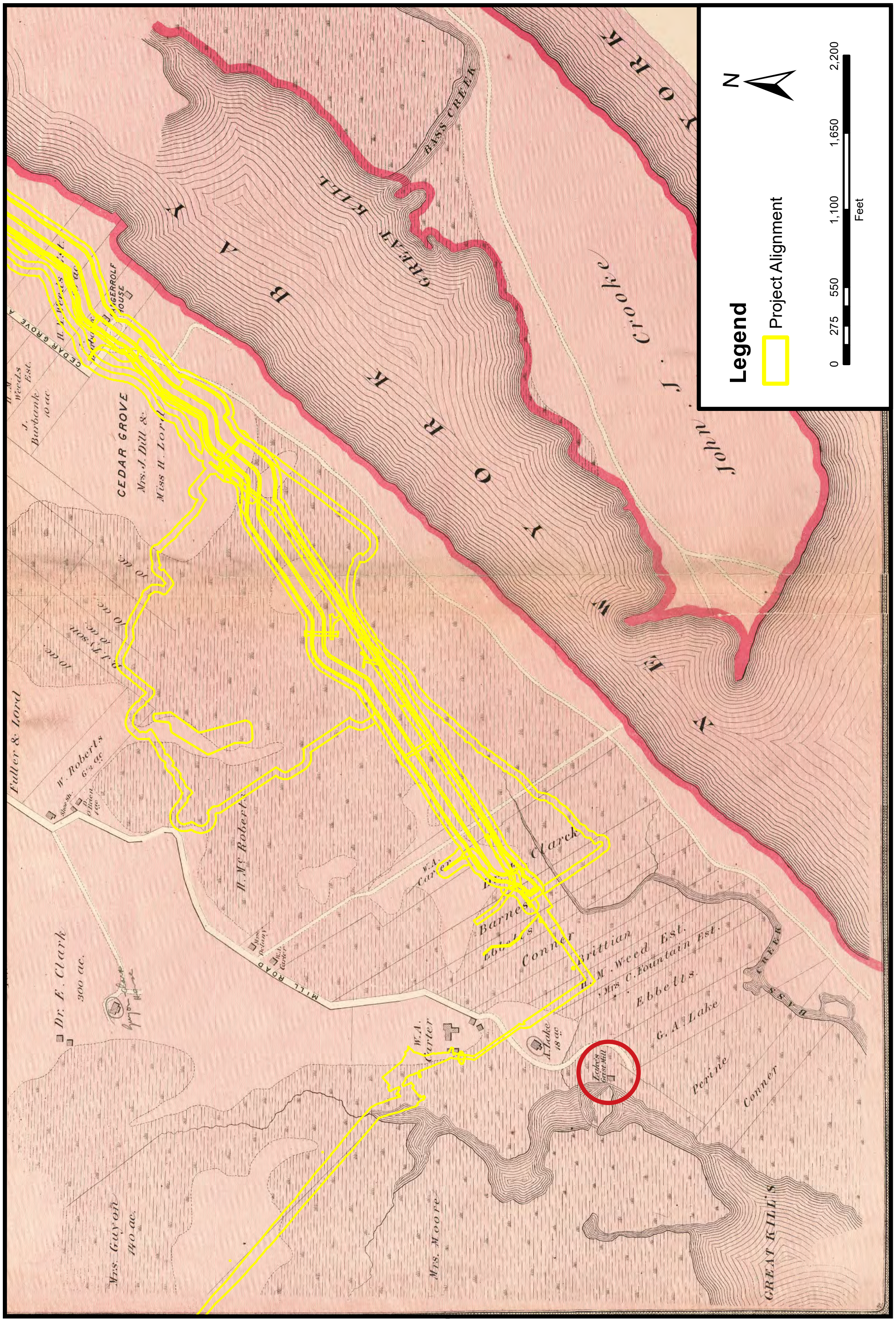


Figure 4.22. J.B. Beers & Co. Detail of *Atlas of Staten Island, Richmond County, New York*. 1874. Lake tide mill circled.

along the shore of the New York Bay extending south from Cedar Grove Avenue to John J. Crooke's land. This road appears on the map of *New York Bay and Harbor* prepared by the United States Coast Survey in 1882, which also shows the Lake house and its barn and the tide mill (Figure 4.23). Interestingly, the 1882 United States Coast Survey map indicates that the two fish houses remained standing on the shore of the New York Bay at the end of a lane extending east from Mill Road.

After purchasing the Lake house and the tide mill property in 1860, Arthur G. Lake continued to operate the tide mill during the 1870s and 1880s. He also supplemented his income by farming. In fact, the federal population census schedule for Staten Island of 1870 reports that Arthur G. Lake (54) was a farmer who owned land valued at $4,000. He headed a household that included his wife, Annie Lake (29) and their five children: Daniel Lake (11), Mary Lake (9), Ellie Lake (7), Annie Lake (3) and Arthur G. Lake (2) (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1870). According to the 1875 New York State census, Arthur G. Lake (62) again identified himself as a farmer. He occupied a frame house valued at $1,500 with his wife, Annie Lake (34), and their seven children: Daniel Lake (16), Mary Lake (14), Ella Lake (12), Annie Lake (8), Arthur Lake (6), Jane Lake (4) and John Lake (2 months). The household also included an Irish laborer named James Hutton (27) (New York State Census, Southfield, Richmond, New York 1875).

In 1880, however, the 60-year-old Arthur G. Lake listed his occupation again as miller (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1880). His household included his wife, Annie (Anna) Lake (39), and their eight children: Daniel W. Lake (21), who worked as a miller, Mamie Lake (19), Ella Lake (17), Anna Lake (13), Arthur Lake (12), James Lake (9), John Lake (7) and Janie Lake (4) (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1880). It appears that Arthur G. Lake was operating the tide mill as a "country" gristmill during the 1860s, 1870s and 1880s and only grinding grain for local farmers on a relatively small scale, for the mill appears in neither the 1870 nor the 1880 federal manufacturing census (U.S. Federal Census of Manufactures 1870; U.S. Federal Census of Manufactures 1880). Arthur G. Lake died at the age of 76 at the Lake house on April 22, 1887, and devised his real estate and personal property to his wife, Anna Lake, during her lifetime and then to his children and their heirs (*New York Herald*, April 24, 1887:16; Richmond County Will V/111). His will granted Anna Lake the right to divide the property between her children prior to her death (Richmond County Will V/111). The tide mill probably ceased operation prior to Arthur G. Lake's death in 1887. In 1890, the celebrated Staten Island historian William T. Davis reported that the mill had not been used in several years because there was nothing to grind (Davis, Davis Notebook).

The Lake tide mill stood idle for approximately a decade before the Lake family demolished the building. The *Atlas of Staten Island* published by J.B. Beers & Co. in 1887 shows the tide mill and the boundaries of the mill property, although it incorrectly locates the Lake house on the west side of Mill Road (Figure 4.24). Neither the tide mill nor the house appear on a map of *New York Bay and Harbor* created by the United States Coast Survey in 1889, but the map does show the dyke that surrounded the house and protected it from high tides (Figure 4.25). The absence of the Lake house and the tide mill likely resulted from a poor quality scan of the original map rather than from any mistakes made by the United State Coast Survey.

In 1891, W.R. Miller sketched a revealing view of the Lake tide mill (Figure 4.26). This evocative drawing shows the two-story, wood-frame, clapboarded mill building moderately intact several years after the

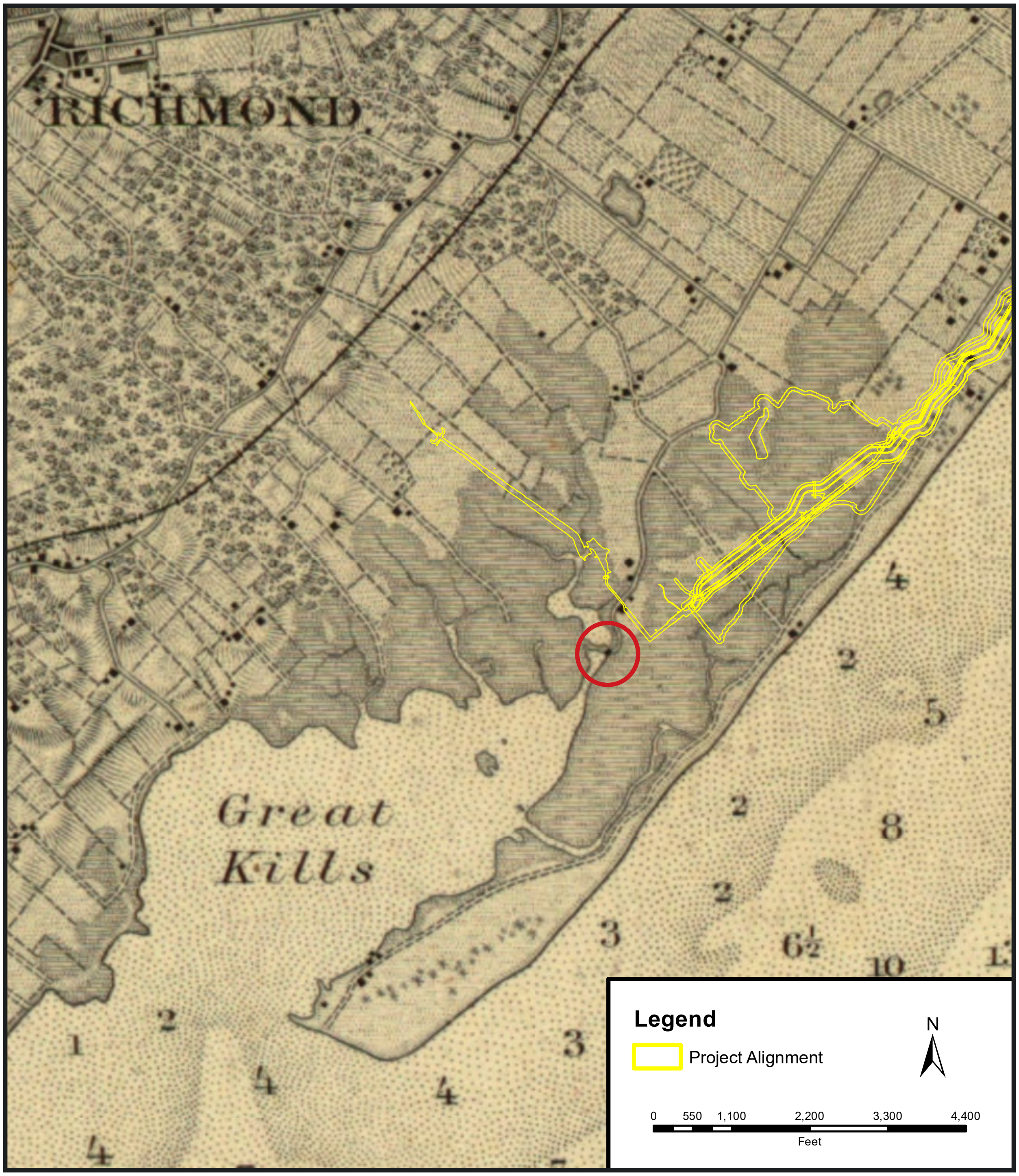


Figure 4.23. U.S. Coast Survey. Detail of *New York Bay and Harbor, New York*. 1882. Lake tide mill circled.

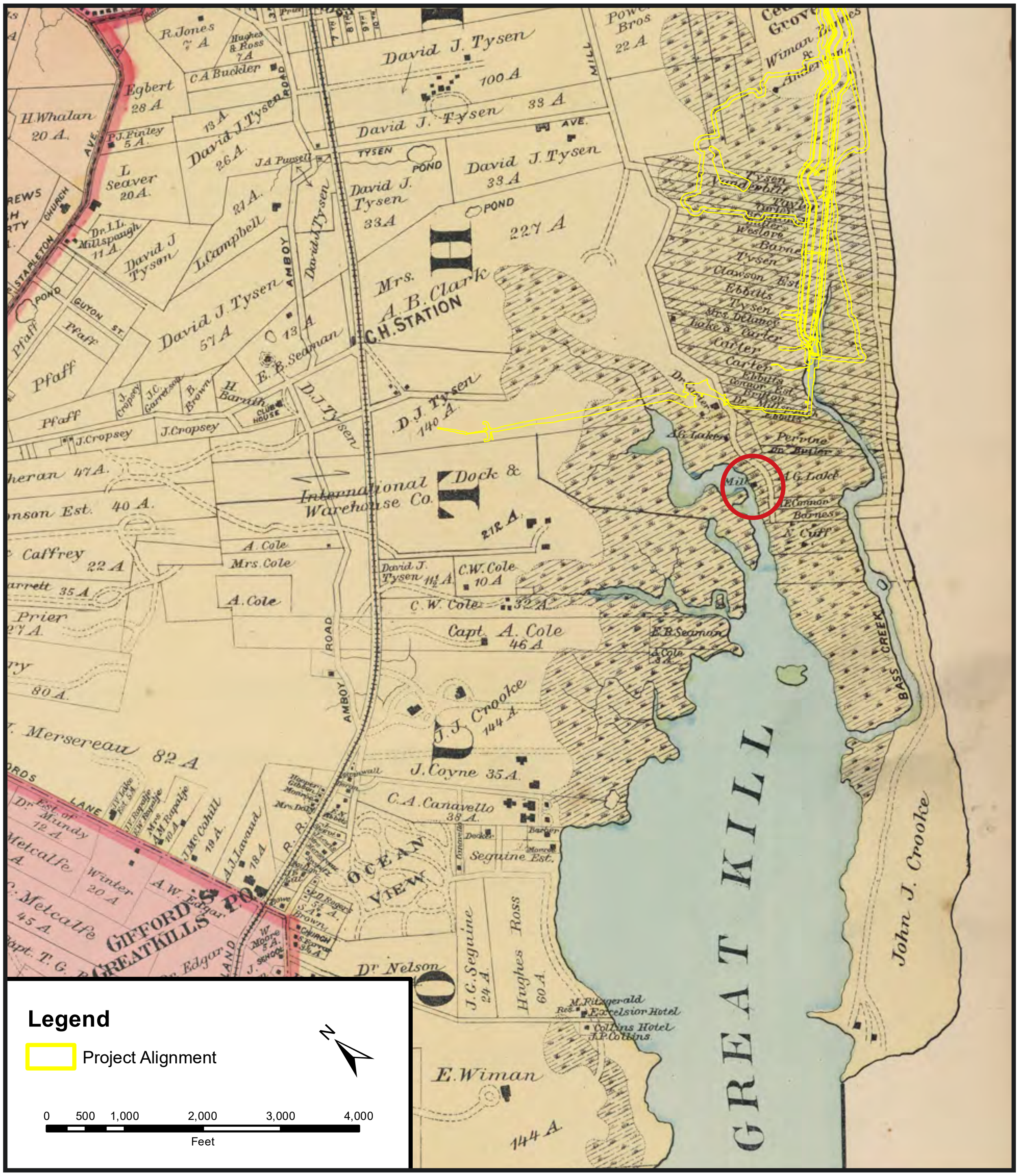


Figure 4.24. J.B. Beers & Co. Detail of *Atlas of Staten Island, Richmond County, New York*. 1887. Lake tide mill circled.

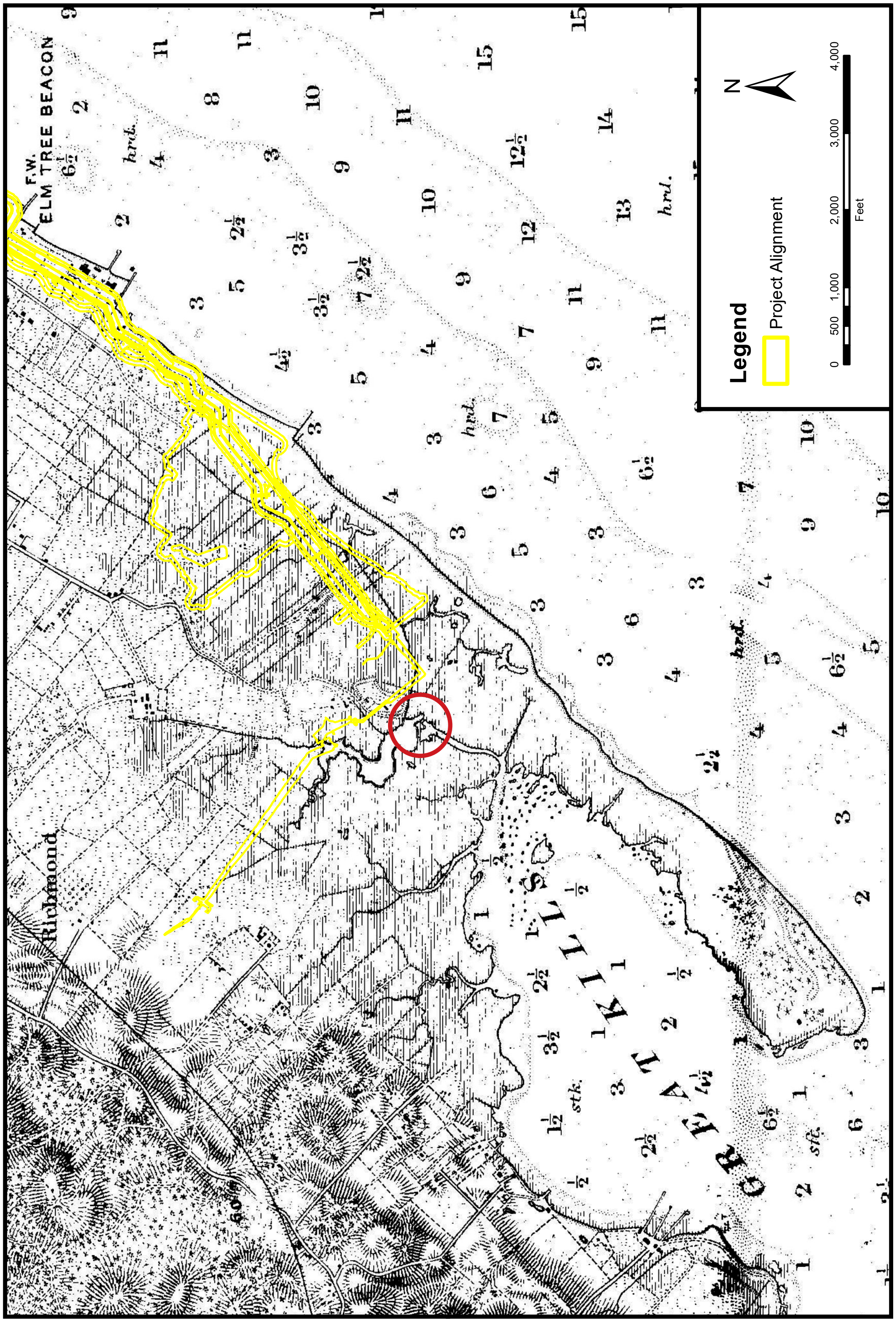


Figure 4.25. U.S. Coast Survey. Detail of *New York Bay and Harbor, New York.* 1889. Location of Lake tide mill site circled.

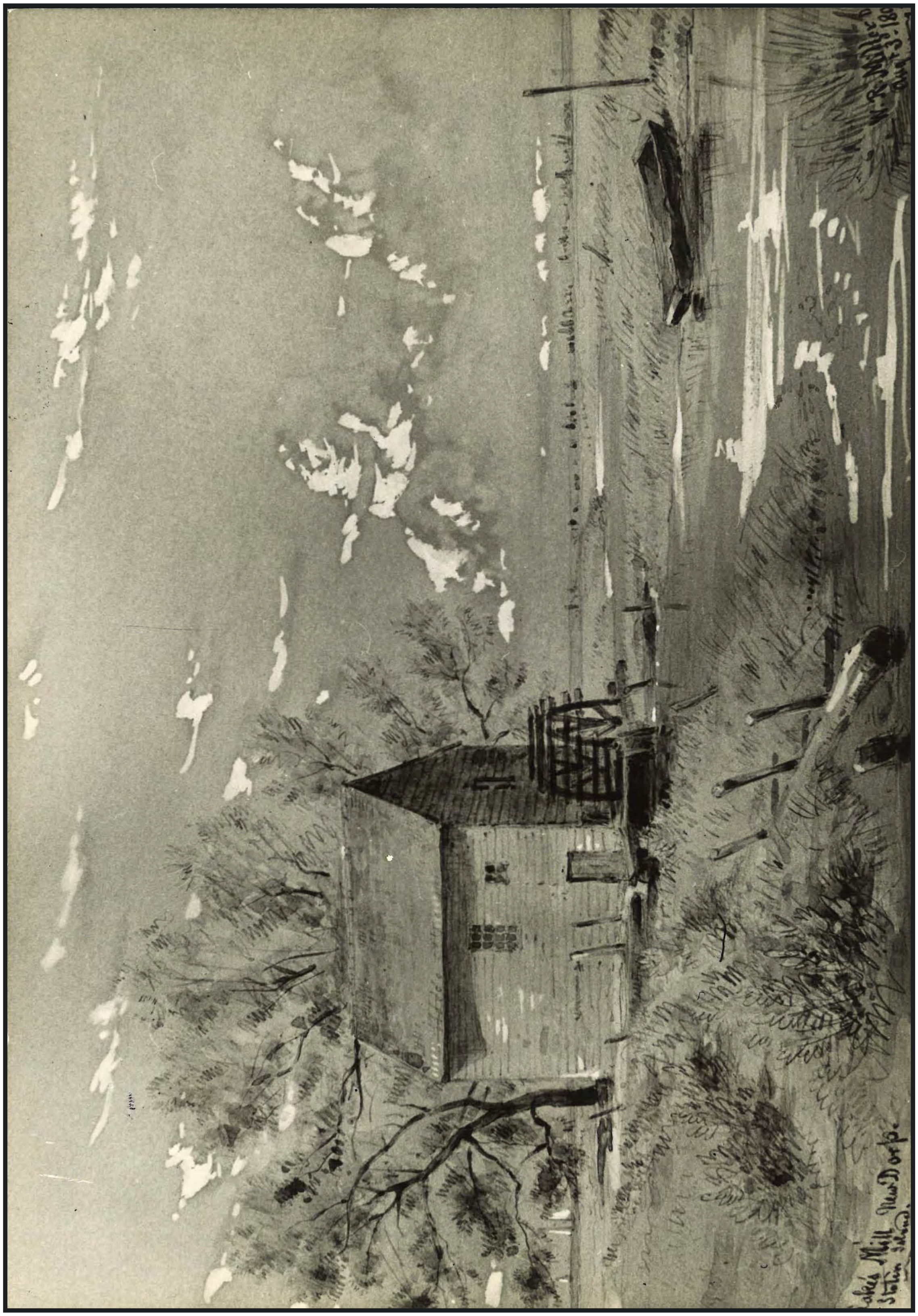


Figure 4.26. Miller, W.R. "Lake's Mill, New Dorp, Staten Island." 1891. Source: Davis 1942:137.

Lake family closed it, although the mill wheel and the dam appear dilapidated. The mill was in a similar condition approximately two years later, as seen in a *circa* 1893 photograph, which gives a clearer sense of the state of deterioration of the waterpower system (Photograph 4.1). The Lake family reportedly demolished the mill "about five or six years" later (Davis, Davis Notebook). However, a map of *New York Bay and Harbor* published by the United States Coast Survey, suggests that the tide mill might already have been demolished by 1895 (Figure 4.27).

Anna Lake continued to occupy the Lake house with her children after her husband's death. The 1900 federal population census reports that the 57-year-old widow headed a household on Mill Road that included her daughter, Mary Lake (36), her daughter, Julia Lake (22), and her son, Arthur G. Lake, Jr. (30) and his family. Arthur G. Lake, Jr. was married to Alberta A. Lake (26), and the couple had three children: Arthur G.W. Lake (5), George R. Lake (3) and Dorothy A. Lake (1) (U.S. Federal Census, Population Schedule, Richmond, New York, New York 1900). The Lake house was a two-story, side-gable, side-hall, clapboarded dwelling with an exterior brick chimney and a one-story, side-gable wing (Photograph 4.2). As noted above, an earthen dyke surrounded the house and property to protect it from inundation at high tide (Photograph 4.3). In addition to the house, the dyke enclosed a barn, several outbuildings, a number of ornamental and fruit trees planted around the house and several acres of land that the Lake family cultivated to meet its needs and, possibly, to supplement its income (Photograph 4.4) (Davis, Davis Notebook; Davis 1942:138; McMillen 1951:4).

During the ensuing decades, the landscape around the Lake house began to change as Staten Island slowly began to develop into a suburban enclave for New York City. In 1900, the house still stood in a relatively desolate landscape surrounded by the Great Kills marshes and salt meadows at the end of Mill Road (Figure 4.28). A *Map of the Richmond Borough Park System* published in 1902, however, shows the suburban landscape of Oakwood beginning to develop to the northwest of the Lake house and Mill Road (Figure 4.29). Although the 1902 map did not depict any buildings, it does indicate the location of the dyke that surrounded the Lake house and property. Within five years, proposed suburban subdivisions occupied much of the agricultural land to the west of the Lake house and the Great Kills (Figure 4.30). Ultimately, the Whitlock subdivision shown on the *Atlas of the Borough of Richmond* published by E. Robinson and R.H. Pidgeon in 1907 between the Great Kills and Hylan Boulevard was never realized. Despite the increasing pressures of suburbanization, salt meadows still surrounded the Lake property, which contained an L-shaped, wood-frame dwelling and two wood-frame stables or barns, in 1907.

Salt meadows continued to dominate the landscape surrounding the Lake house and property into the second and third decades of the 20th century. A topographical map of the Borough of Richmond published in 1910 depicts the Lake house and farm set in a sea of salt meadows characterized by a complex web of ditches (Figure 4.31). The 1910 topographical map details the layout of the Lake farm, showing the dyke that enclosed the property, the stable that stood adjacent to Mill Road, the cultivated fields and the trees that were scattered across the landscape. At the southwestern corner of the dyke, a bridge crossed Bass Creek near the former location of the tide mill. It is unclear if any members of the Lake family occupied the house during this period. By 1910, Anna Lake (67) was living at 303 Guyon Avenue with her daughter, Mary G. Lake (46) and her son, Arthur G. Lake, Jr. (40) and his family (U.S. Federal Census, Population Schedule, Southfield, Richmond, New York 1910). The property remained in the Lake family, however, for George S. Bromley and Walter S. Bromley identify the Lake house as the property of the H.G. Lake estate in the *Atlas of the City of New York* that they

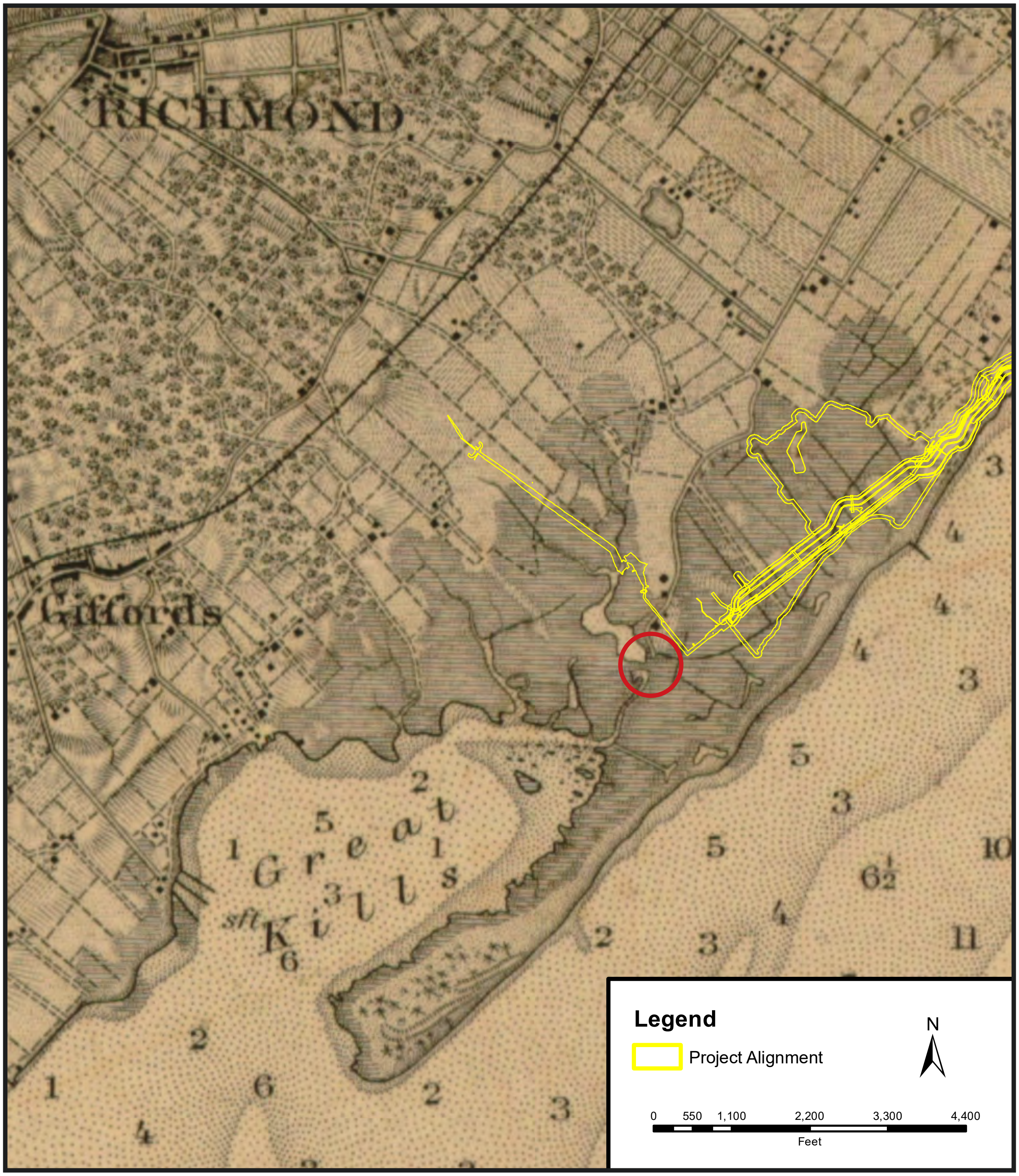


Figure 4.27. U.S. Coast Survey. Detail of *New York Bay and Harbor, New York*. 1895. Location of Lake tide mill site circled.

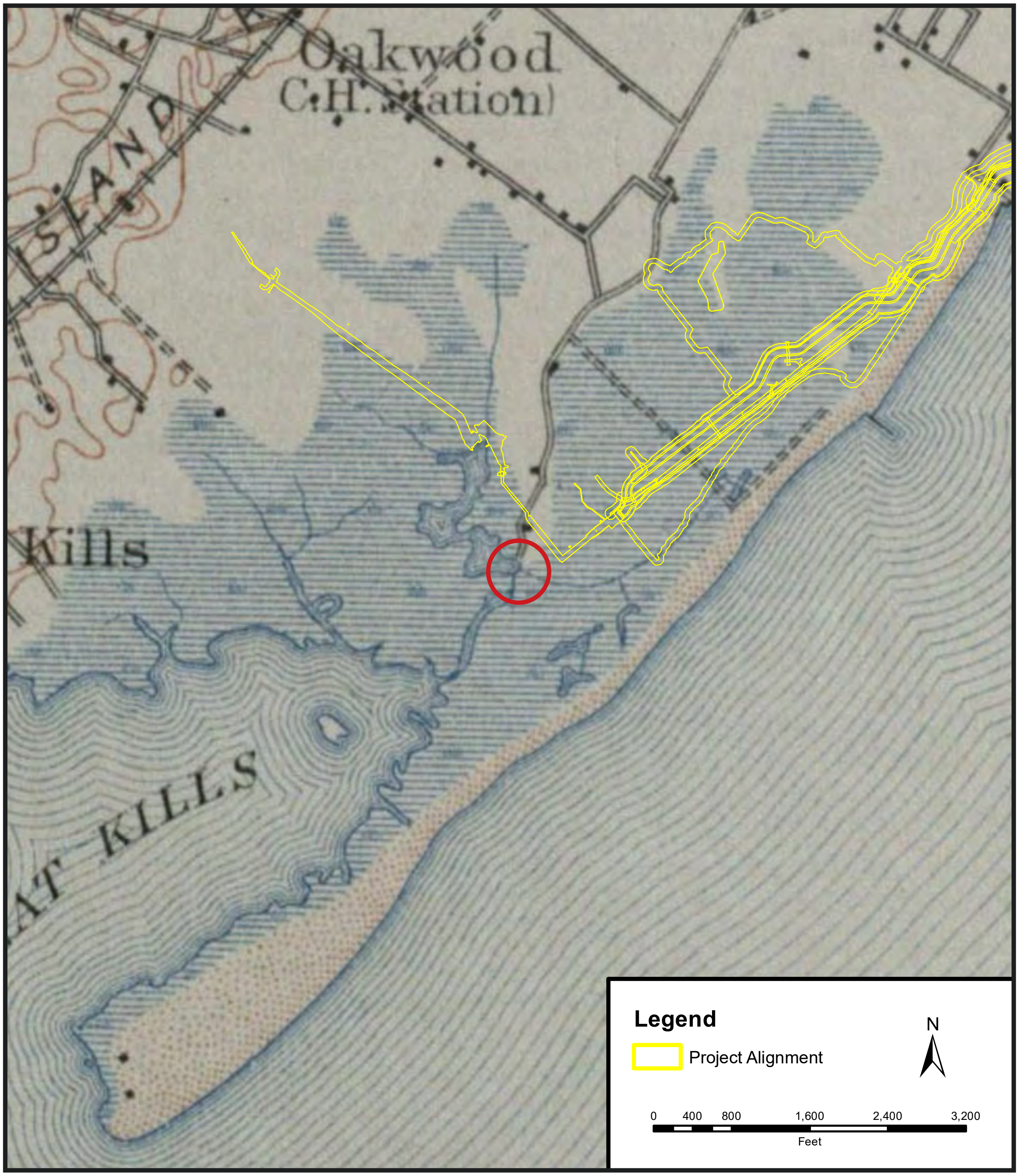


Figure 4.28. U.S. Geological Survey. Detail of *Staten Island Quadrangle*. 1913 [1900]. Location of Lake tide mill site circled.

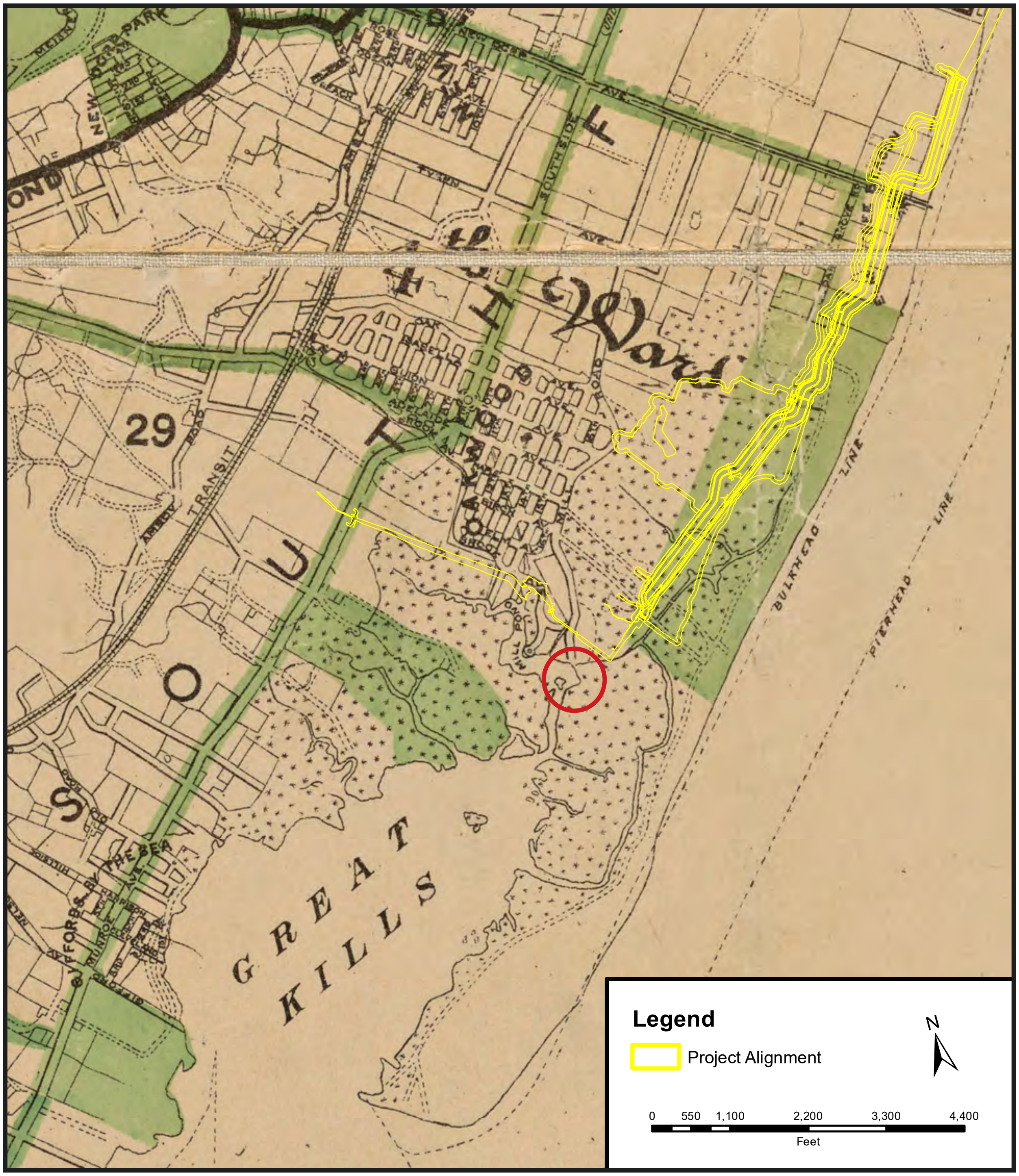


Figure 4.29. Detail of *Map of a Richmond Borough Park System as Recommended by the Committee on Parks of the Staten Island Chamber of Commerce*. 1902. Location of Lake tide mill site circled.

Figure 4.30. Robinson, E. and R.H. Pidgeon. Detail of *Atlas of the Borough of Richmond, City of New York*. 1907. Location of Lake tide mill site circled.

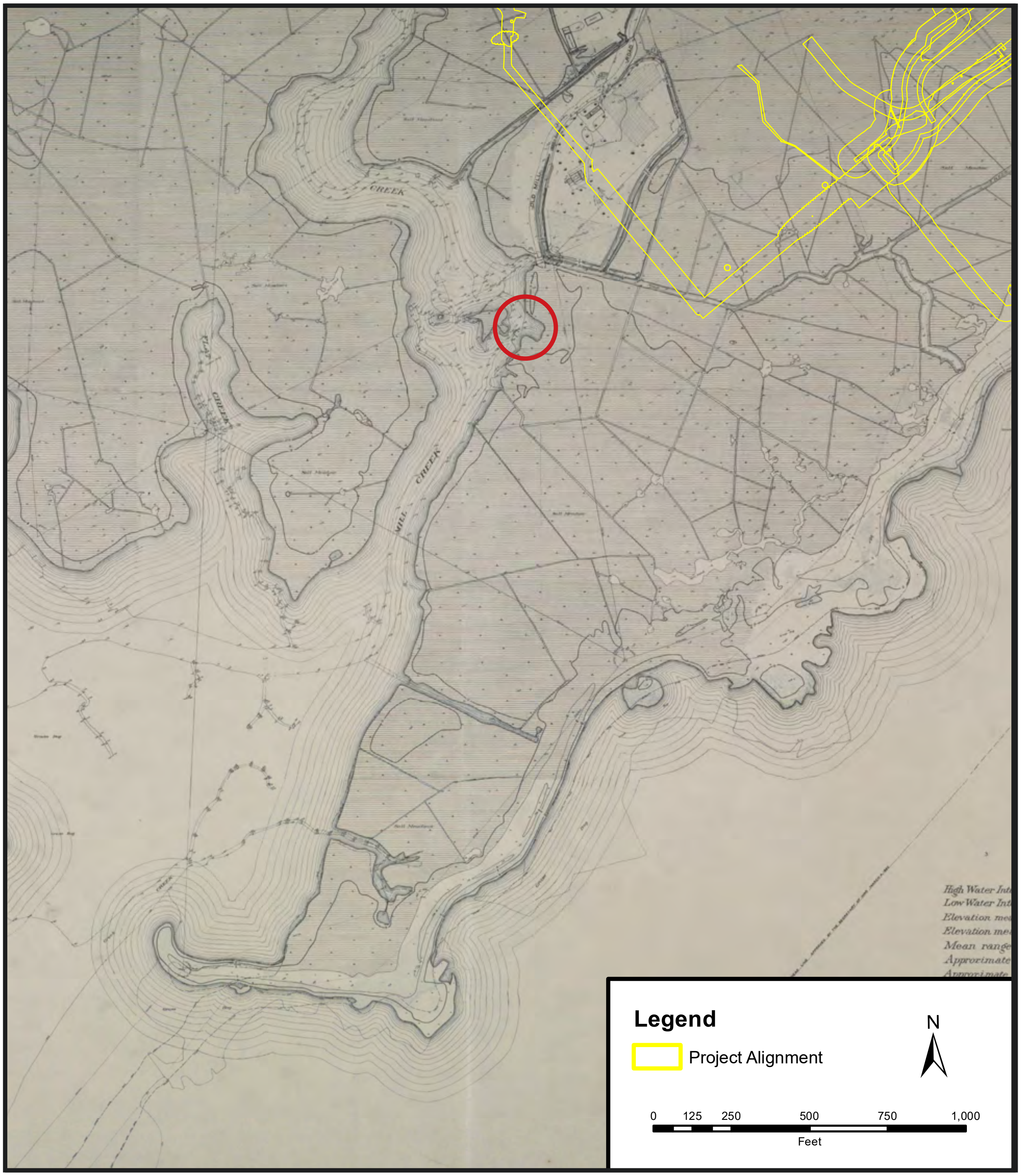
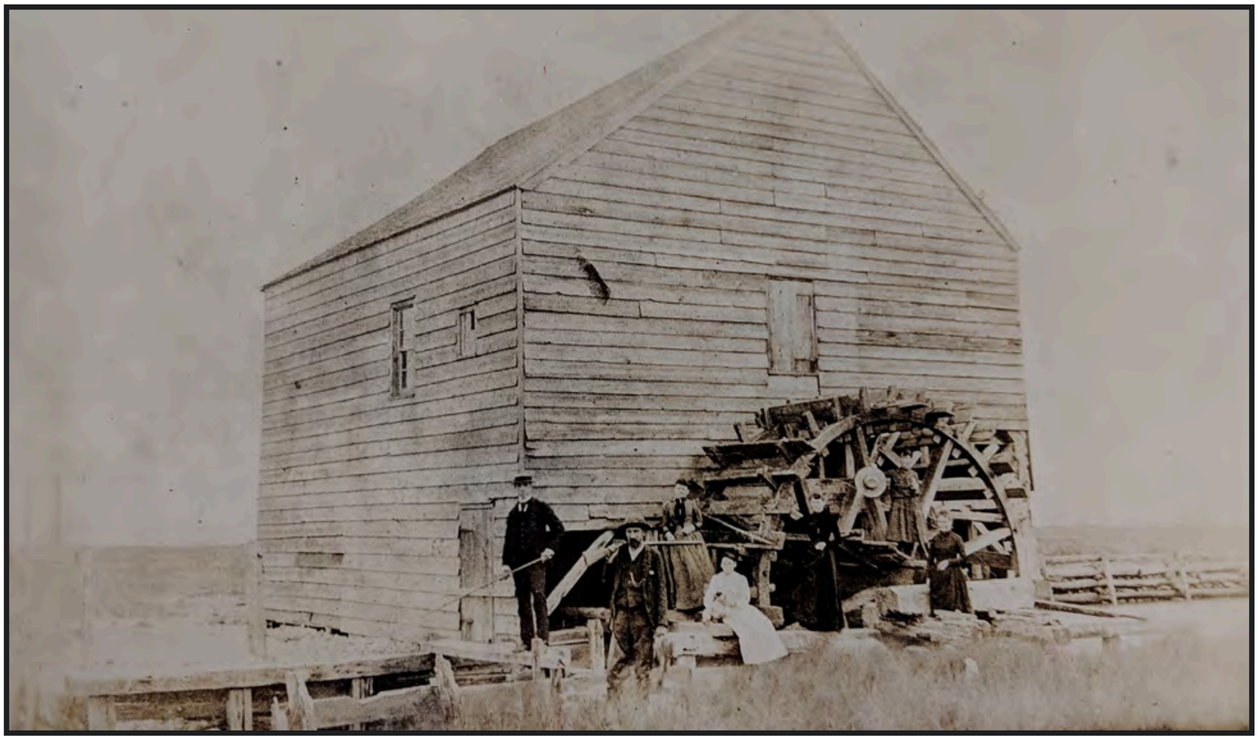


Figure 4.31. Detail of *Borough of Richmond, Topographical Survey*. 1910. Location of Lake tide mill site circled.



Photograph 4.1. Lake's Tide Mill. Circa 1893. Source: Davis. Courtesy of the Staten Island Museum.

Photograph 4.2. Lake House and property. No date. Note the dyke surrounding the property. Courtesy of the Staten Island Museum.

Photograph 4.3. Lake House. 1925. Courtesy of the Staten Island Museum.

Photograph 4.4. Lake House and property. 1926. Note the barn to the right of the Lake House and the outbuildings. Courtesy of the Staten Island Museum.

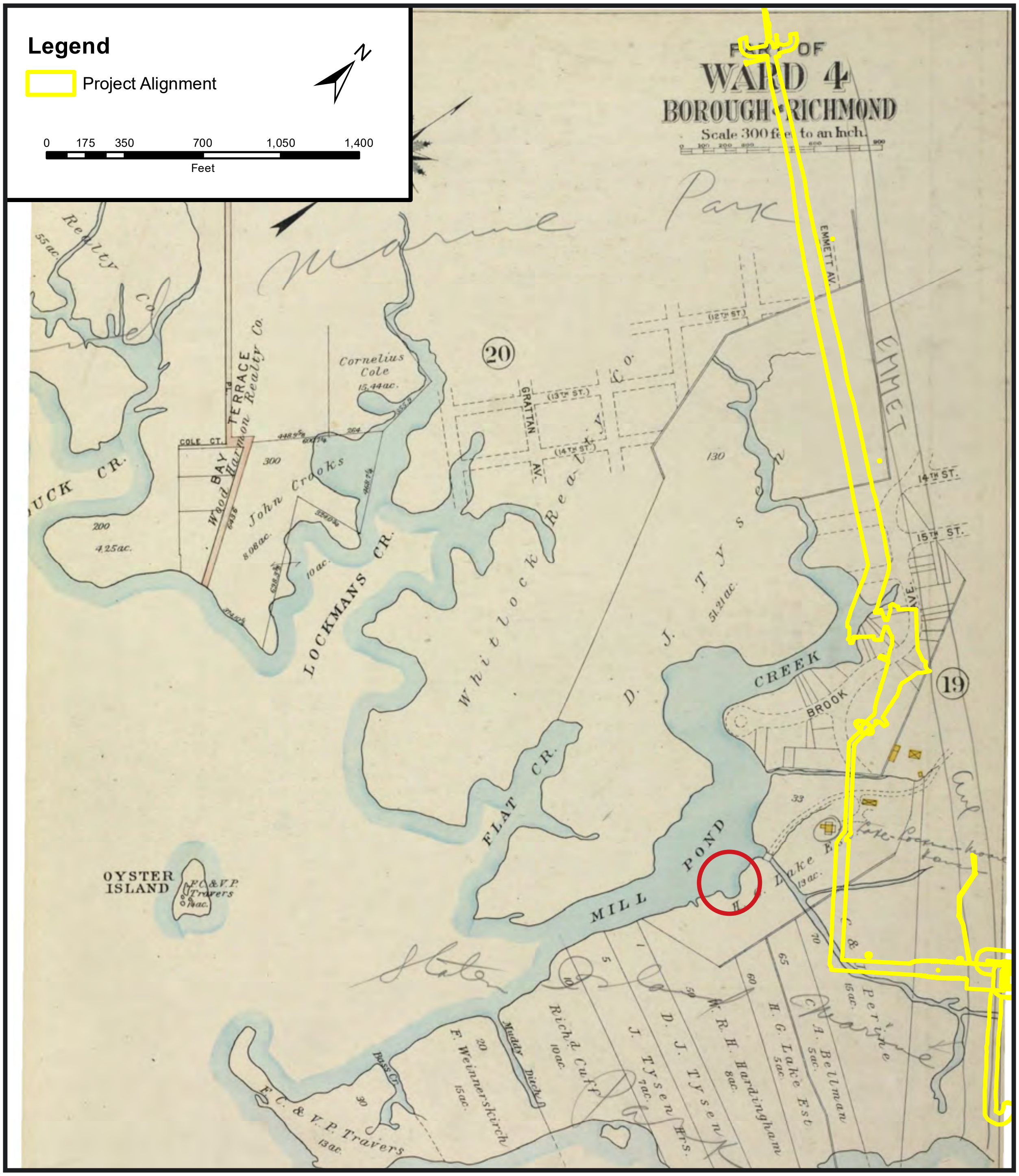


Figure 4.32. Bromley, George W. and Walter S. Bromley. Plate 24. Detail of *Atlas of the City of New York, Borough of Richmond, Staten Island*. 1917. Location of Lake tide mill site circled.

Figure 4.33. Fairchild Aerial Camera Company. Detail of Aerial 34A. Sectional Aerial Map of the City of New York. 1924. Location of Lake tide mill site circled.

published in 1917 (Figure 4.32). The Lake house and barn remained standing through 1924, by which time the Lake family had apparently left the property and a number of cabins had been constructed on the property, including one on the site of the tide mill and at least three within the walls of the dyke (Figure 4.33) (Davis 1942: 138).

All visible traces of the Lake tide mill and the Lake house and property disappeared during the middle decades of the 20th century. The millstone and a portion of the mill wheel from the tide mill survived into the 1920s, but the remains of the wheel were cut up for firewood during the winter of 1933-1934. By 1942, the Lake house had been demolished and the Lake property, including the former site of the tide mill, had been incorporated into Marine Park, now known as Great Kills Park (Davis, Davis Notebook; Davis 1942:137). The dyke and many of the trees that surrounded the Lake house survived until 1942, but the house site and the tide mill site, including the milldam, the millpond and Mill Creek, disappeared prior to 1949 (Davis, Davis Notebook; McMillen 1951:4). Today, the site of the Lake tide mill and the Lake house lie within Great Kills Park.

Chapter 5

GEOMORPHOLOGICAL INVESTIGATIONS AND ANALYSIS

A. FIELD METHODOLOGY

Fieldwork for this study began on August 23, 2018 with the excavation of DH32 at the northern end of the project alignment and continued until November 2018. Following a winter hiatus, work resumed in April 2019. As of December 2019, when field testing was officially considered as concluded, 38 split-spoon borings and 14 Geoprobe borings had been completed along the alignment of the proposed seawall (Appendix B). Forty-one split-spoon borings were initially planned, but three were ultimately eliminated from the work plan. The original scope-of-work agreement called for geomorphological monitoring of 21 of the split-spoon borings. Once fieldwork commenced, however, it became clear that – because of the expeditious manner in which the borings were being carried out – it would be possible monitor a greater number. Ultimately, 29 of the 38 split-spoon borings and all of the 14 Geoprobe borings were observed by the project geomorphologist. Split-spoon borings that were monitored were as follows: DH1, 2, 6, 7, 8, 10, 10A, 11, 12, 13, 14, 15, 16, 19, 19A, 20, 21, 22, 23, 24, 25, 25A, 26, 27, 28, 29, 30, 31 and 32 (Appendix B).

Of the 29 split-spoon borings which were monitored, 20 were carried to a depth of 36.5 feet below surface (bs); the remainder were carried out to depths ranging from 46.5 feet to 136.5 feet below surface (Appendix B). With one exception (DH23, carried out to a depth of 46.5 feet bs), all of the deep borings which were monitored (DH1, 2, 6, 7, 8, 10, 10A, and 11) were located near the southern end of the project alignment. Construction in this area, near Oakwood Beach and the Oakwood Beach Wastewater Treatment Plant, is slated to include deep excavation to accommodate construction of tidal gate structures.

Split-spoon coring was conducted by the Baltimore District U.S. Army Corps of Engineers Field Exploration Unit using the Standard Penetration Test Procedure (SPT) per ASTM D 1586. A truck-mounted rig was employed and 1 3/8 inch ID x 32-inch long split-spoon samplers were advanced by a 140-pound automatic hammer utilizing a 30-inch drop. The spoon was advanced 18 inches, then withdrawn and opened for inspection. Following withdrawal of the spoon after each 18-inch advance, the borehole was advanced 12 inches utilizing a 3.5-inch diameter roller bit. Thus, approximately 60% of the soil profile at each boring location was sampled, with sampling carried out from surface to 1.5 feet; 2.5 to 4 feet; 5 to 6.5 feet; etc. In the deeper borings, this methodology was followed to a depth of 50 feet; below that point, an unsampled auger advance of 3.5 feet was carried out between each 1.5-foot sampling interval.

Following opening of the spoon, the contained core segment was examined and described *in-situ* by the geomorphologist and a geologic inspector. Geomorphological inspection and description were focused on sediment color, texture, gravel content, organic matter content, characteristics of stratigraphic boundaries, etc. Following completion of descriptions by both inspectors, subsamples were taken by the geomorphologist, if warranted, and the remaining sample was bottled and labeled by the geologic inspector. Subsamples taken by the geomorphologist were placed into 1-gallon ziplock storage bags and labeled (date, project name, boring number, depth below surface, and location of subsample within the core segment).

Geoprobe coring was conducted by the Savannah District U.S. Army Corps of Engineers Field Exploration Unit utilizing a tracked Geoprobe Model 7822DT Direct Push machine. All Geoprobe coring was carried out at sites previously cleared and permitted for other subsurface testing. Coring was carried out in 5-foot increments; eight probes were conducted to 15 feet below surface, one to 20 feet below surface, five to 30 feet below surface, and one probe to 40 feet below surface (Appendix B). Following removal of the 2-inch OD, 5-foot long PVC liner from the sheath, the liner was capped at both ends and labeled with the date, boring number, depth of advance, and an arrow indicating the direction of boring. In general, the Geoprobe borings were conducted to gain larger samples and more complete profiles in locations where split-spoon borings had shown facies of interest; not all of the Geoprobe profiles were described in detail.

It should be noted that both split-spoon and Geoprobe sampling, while extremely useful for characterizing the subsurface, are not without their limitations when it comes to analyses such as geoarchaeological and paleoenvironmental studies. The limitations result from the recovery of less-than-complete sediment columns. Results of both of these sorts of studies are optimal when fine-grained details such as the presence of (often thin) buried surfaces and the nature of boundaries between sediment strata or facies (e.g., abrupt, gradual, diffuse, etc.) can be accurately identified. An obvious example would be that an unsampled one-foot auger advance could easily result in the failure to identify a buried formerly stable surface. Similarly, subsurface conditions, including obstructions, frequently result in recovery of partial or no samples. In the current study, prevalence of sandy sediments generally provided good recovery in 18-inch advances of the split-spoon though some advances returned no sample and recoveries ranging from 12 to 16 inches were common. Similarly, for the approximately 60 Geoprobe core advances at 14 locations, average recovery was 2.95 feet per five-foot advance.

Following preliminary review of the field data, selected soil samples were submitted to outside specialists for processing and analysis. Thirty-five samples were submitted to Beta Analytic Laboratory in Miami, Florida, for pretreatment; 28 samples were ultimately chosen for radiocarbon dating (Appendix C). Thirty-two samples were submitted to Dr. John G. Jones, paleoethnobotanist, Chandler, Arizona, for pollen analysis (Appendix D). Eight samples containing gross organic matter were submitted to Ms. Justine Woodard McKnight, archaeobotanical consultant, Severna Park, Maryland for paleobotanical analysis (Appendix E). In most cases there was overlap between these sample submissions, i.e., samples selected for analysis were split and portions submitted for dating, pollen analysis and – where warranted – paleobotanical analysis.

Five samples from a single soil column (DH23) were submitted to PaleoResearch Institute of Golden, Colorado for diatom identification (Appendix F). Fifteen samples, 13 of which came from a single soil column (GP7) were submitted to the Cornell Nutrient Analysis Laboratory (CNAL) at Cornell University, Ithaca, New York, for analysis of total carbon and total nitrogen content. At the request of the project geomorphologist, 45 samples were processed for particle-size analysis by the U.S. Army Corps of Engineers Baltimore District Materials and Instrumentation Unit in Baltimore, Maryland (Appendix G). Particle-size analysis was carried out using both sieve and hydrometer methods.

B. FIELD INVESTIGATIONS

1. Environmental Zones along the Project Alignment (Figure 5.1)

On the basis of both modern surficial conditions and subsurface profiles revealed by borings, the project alignment can be divided into three major zones.

The first zone lies at the southwestern end of the alignment and extends 3,000 feet northwest of the Oakwood Beach Wastewater Treatment Plant (Map Stations 10+00 to 89+00). Sampling in this zone involved DH1 through DH10 and GP1 and GP2. This zone consists mainly of coastal marsh associated with the Great Kills embayment. The marsh, marked by dense phragmites and extensive areas of standing water, surrounds the treatment plant and extends north through the former residential areas of Tarlton Street, Fox Beach Avenue, Fox Lane and Kissam Avenue. Although, overall, the proposed construction corridor is oriented northeast-southwest, an initial northwest-southeast reach is designed to tie the seawall into high ground near the base of the terminal moraine that extends from just west of Hylan Avenue (site of DH1) to the southeast corner of the treatment plant property (site of DH7), at which point the project alignment turns a right angle and heads northeast. The northeast-southwest reach of the project alignment lies at distances of 300 to 600 feet from the shoreline, within the phragmites marsh; the northwest-southeast reach extends into the highly modified hollow of Mill Run, 6,000 feet from the shore. For the purposes of this report, this area is referred to as the ***Oakwood Marsh Zone***.

The second zone consists of a slight topographic high described previously, extending from an area extending from 2,000 feet southwest of Ebbitts Street to 3,000 feet northeast of New Dorp Lane, a distance of around 8,500 feet (Map Stations 90+00 to 175+00). This zone, which includes Cedar Grove Beach, New Dorp Beach, Miller Field and the southwestern end of Midland Beach, was sampled by DH11 through DH19A and GP4 through GP8. From the southwestern end of Midland Beach (DH19A) to the southwestern end of Cedar Grove Beach (DH13) the project alignment is located just landward from the top of the swash zone, along the boundary between the beach and the vegetated shoreline. Southwest of DH13, the alignment angles slightly to the south for a distance of 750 feet before turning southwest again and entering the phragmites marsh. For the purpose of this report, this area is referred to as the ***New Dorp Upland Zone***.

The third zone makes up the northeastern half of the project alignment, from midway between DH19A and DH20 (Map Station 175+00) to the northeastern terminus at DH32 (Map Station 292+45), at the base of the Fort Wadsworth upland. For nearly the entire distance, sampling was carried out on or just landward from the backshore, the highest and most stable part of the former barrier islands. Around DH31, the project alignment route turns inland toward Fort Wadsworth to tie into the base of the upland. This part of the study area is shown on late 18th through early 20th-century maps as lying immediately adjacent to an extensive coastal marsh surrounding New Creek and numerous tributaries and for the purposes of this report is referred to as the ***New Creek Drainage Zone***.

2. Soils along the Project Alignment

USDA-NRCS soil mapping of the project alignment presents as a mosaic in which more than half of the alignment and the area immediately landward reflect disturbance, filling and urban development. Soil series mapped in these areas and denoting filling or disturbance comprise:

- Bigapple (BiA) – sandy dredge spoil; Blown-out land (Bl) – wind-stripped lag marine deposits; Fortress sands (FoA) – sandy dredge spoil;

Greenbelt-Urban land complex (GUA); and Urban land-Greenbelt complex (UGA, UGB, and UGC) – all of which consist of asphalt over human-transported sandy or loamy material;

- Jamaica sands (JaA) – sandy dredge spoil; and Urban land, reclaimed substratum (UrA) and Urban land, sandy substratum (UsA) – both of which consist of asphalt over human-transported material;

- Urban land-Verrazano complex (UVAI) – asphalt over loamy human-transported material over beach sand and/or sandy outwash and/or dredge spoils; and

- Verrazano (VzA) – loamy human-transported material over beach sand and/or sandy outwash and/or dredge spoils

DH1 and DH2, at the extreme southwestern end of the alignment, were situated in an area mapped as the Boonton-Haledon complex, 0-8% slopes. Both the Boonton and Haledon soil series are described as having formed in parent material made up of red coarse-loamy till derived from sedimentary rock. Soils in the area sampled by DH3, DH4 and DH5, along the former (now filled) hollow of Mill Creek, are mapped as the Gravesend-Oldmill complex. Both of these soils consist of sandy human-transported material over human-transported refuse material. DH6 through DH8 and DH9A and DH10A were located on the grounds of the Oakwood Beach Wastewater Treatment Plant and within the large phragmites marsh extending northeast from Great Kills respectively. All were conducted within a large area of Urban land-Verrazano complex, low impermeable surface (UVAI). DH10 was located near DH10A but fell within an area mapped as Jamaica sands, frequently ponded. Jamaica soils are made up of sandy dredge spoil.

The area surrounding DH11 and DH12, at the extreme northeastern end of the large phragmites marsh, is mapped as Ipswich-Pawcatuck complex, very frequently flooded. These soils consist of herbaceous organic material over sandy fluviomarine deposits. Soils in the vicinities of DH13 and DH14, both located along the top of the beach in the Cedar Grove area, are mapped as Hooksan-Verrazano-Urban complex – sandy aeolian deposits, loamy human-transported material over sandy aeolian deposits and/or beach sand and/or sandy dredge spoils and/or sandy glaciofluvial deposits, with paving in some areas. DH15, also in the Cedar Grove area, was located within a small area mapped as Hooksan sand (HkB), which consists of sandy aeolian deposits. DH16, immediately south of Miller Field, was conducted at the seaward edge of a large area mapped as Deerfield loamy fine sand (DfA), formed in sandy outwash derived from granite, gneiss and/or quartzite. Local topography suggests that the Hooksan sand aeolian deposits mapped at DH15 probably overlie soils of the Deerfield series.

The locations of DH17 and DH18, both of which were removed from the testing program, lie at the seaward edge of Miller Field. The soils are mapped as a complex of Hooksan sand (HkB) and Hooksan-Dune land complex (HDB), both consisting of sandy aeolian deposits. Immediately seaward of these mapping polygons lies an area of Blown-out land (Bl) – wind-stripped lag marine deposits. Pertinent to this study is the fact that landward from this, the body of Miller Field is mapped as Branford loam – coarse loamy glaciofluvial deposits over gravelly glaciofluvial deposits. Soils of the Branford series may underlie the aeolian cap mapped along the beach edge.

The locations of DH19 through DH31 all lie along the upper edge of the beach; soils at all of the locations are mapped as “Beaches, sand” (Bs). The entire area landward of this reach is mapped as fill, dredge-derived, and Urban land, including the following soil

Figure 5.1. Key Aerial Photograph of Project Alignment Showing Locations of Borings. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

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series: Bigapple; Urban land, sandy; Urban land, reclaimed; Greenbelt-Urban land complex; Fortress sands; Urban land-Hooksan-Verrazano complex; and Verrazano. The location of DH32, slightly inland and near the base of the Fort Wadsworth upland, is mapped as Verrazano sandy loam – loamy human-transported material over beach sand and/or sandy outwash and/or dredge spoils.

3. Overview of Sedimentary Facies

Split-spoon and Geoprobe core recovery revealed the presence of a minimum of six sedimentary facies along the project alignment. Sedimentary facies are bodies of sediment that are recognizably distinct from adjacent sediments, the differences being attributable to variation in the depositional environments and mechanics.

The uppermost facies, identified throughout the study area, consisted of 3 to 12 feet of marine-derived beach sand of Late Holocene age – coarse to very fine sand containing various amounts of very fine to medium rounded and subrounded gravel (generally zero to 30% by volume). The color of this sand was consistently dark reddish brown to dark brown (generally 2.5YR to 7.5YR 3/2-3/3).

The second major facies was less clearly defined. It is assumed that in some borings, at some as-yet unspecified depth, an interface was encountered between the Late Holocene deposits and Late Pleistocene glacial outwash sand and gravel. This interface was definitively distinguished in only a few borings (DH11 through DH15), where it appears that a thin (one to four feet) deposit of Late Holocene overwash sand overlies soil profiles, some of them truncated, formed in outwash. Even in this area, sediments beneath a relatively thin weathered profile consist of dark reddish brown to dark brown coarse to very fine sand containing varying amounts of very fine to medium rounded and subrounded gravel. Difficulty in distinguishing the marine sand/outwash boundary in most of the project alignment may be in part because much of the sand transported and deposited by wave action has its origin as near-shore outwash sand of relatively local origin. Thus, the material making up the barrier beaches is made up largely of reworked outwash sand and gravel and, as no weathering zone which may have formed at and below the stable outwash plain surface was encountered, the boundary was not identified.

A third major facies consisted of dark gray to black (generally 2.5Y or 2.5YR2.5/1 to 7.5YR4/1) sediment dominated by fine-textured material and containing very fine to gross organic matter. Soil texture was predominantly clay to silty clay but strata of sandy loam, sandy clay loam, loamy sand, very fine sandy clay, and fine and very fine sand were also present. The upper boundary of this facies, which ranged in thickness from 5 to 12 feet, was encountered at depths ranging from 13 to 25 feet below surface (5 to 13 feet below modern sea level). This material is interpreted to be made up of sediment deposited within a coastal lagoon – primarily slackwater deposits along the lagoon edges and within the body of the shallow, brackish lagoon – but may also include tidal delta sediments deposited at tidal inlets and possibly freshwater estuarine deposits marking where terrestrial streams entered the tidal environment of the lagoon.

Sandy strata within the silt- and clay-dominated lagoon facies are interpreted to be the products of overwash of the barrier beach by storm-driven waves powerful enough to carry sediment into the lagoon. In the interest of brevity, in the following descriptions these collective deposits will generally be subsumed under the term “lagoon deposits”; products of the various depositional settings will be specified as appropriate. The organic-rich, fine-textured facies was encountered in eleven of the 29 split-spoon and five of the 14 Geoprobe borings which were monitored for this study; all borings which recovered the dark, organic-bearing lagoon sediments were located within the northeastern half of the project alignment, northeast of Miller Field.

The fourth major facies consisted of very dark gray to black (generally 5YR3/1 to 7.5YR2.5/1) fine to very fine sand containing very fine organic matter and, in many cases, very fine fragments of mollusk or bivalve shell. This facies, ranging in thickness from 2 to 7 feet, was generally encountered at 10 to 12 feet below surface (modern sea level to 4 feet bmsl). This facies was identified in 13 split-spoon borings, all in the northeastern half of the project alignment, and is interpreted to consist of backbarrier sediment. This facies is a product of overwash deposition on the landward side of barrier islands and includes deposition along the lateral fringe of a lagoon or lagoons.

A fifth facies was encountered almost exclusively in the Oakwood Marsh Zone and consisted of dense clay ranging in color from Gley 1 7/N and 2.5Y7/1 to 10R3/6 and 4/8; thin beds and stringers of sandy clay and coarse, highly leached sand were also present. This facies, generally encountered at depths in excess of 40 to 50 feet bs and extending to depths of up to 100 feet bs, was recovered in DH5-9A in the Oakwood Marsh Zone and in DH23 in the New Creek Drainage Zone. These sediments are interpreted as part of the Upper Cretaceous-age Raritan Formation.

A less-widespread facies consisted of associations of silty clay, sandy clay, loam, loamy coarse and medium sand and higher concentrations of gravel than seen in samples throughout most of the project alignment. These sediments, noted in five contiguous split-spoon borings (DH22-DH25A) and GP11, were encountered at general depths between 23 and 30 feet bs (generally between 13 and 20 feet bmsl) and ranged in thickness from one to eight feet. Many of these samples showed evidence of oxidation and reduction (redox), some to the extent of being gleyed. This suite of associated sediments is suggestive of stream channel floor, channel bar and floodplain deposition.

4. Oakwood Marsh Zone (Figure 5.2a; Photographs 5.1-5.3)

The Oakwood Marsh Zone includes an extensive marsh within and extending northeast from Great Kills Park; the grounds of the Oakwood Wastewater Treatment Plant; and the lower reach of the hollow of Mill Creek, north of Great Kills Park.

DH1 was located in the lower reach of the Mill Creek hollow, which extends north from Hylan Boulevard to a head at a watershed divide at around Park Street. The watershed divide, on the terminal moraine 5,000 feet west of Hylan Boulevard, lies at an elevation of around 50 feet amsl; west of the divide, drainage flows west into Richmond Creek. The Mill Creek hollow is a part of the Staten Island Greenbelt, a system of 2,800 acres of contiguous public parkland and natural areas in the central hills of Staten Island. The eastern end of the Greenbelt's White Trail, which allows foot travel from Willowbrook Park near Victory Boulevard to Great Kills Park, lies within the hollow. The hollow is vegetated with trees and thick brush and has been highly modified by the dumping of fill; sequential episodes of filling are visible in cutbanks of a small stream and large vegetated mounds of fill are ubiquitous. The small stream carries flow immediately following rain events but it is likely that most drainage within the hollow is conducted through buried stormwater pipes.

DH1 was located at Map Station 12+66 (NYSP Northing 142357.760/Easting 948641.208), approximately 125 feet northwest of Hylan Boulevard. The opening elevation was 15.49 feet amsl. Visual examination of the setting suggested that approximately six feet of fill might be present and sampling confirmed this. Gravelly coarse sand containing brick and

Figure 5.2a. Aerial Photograph of Project Alignment (Southwest Portion) Showing Detailed Locations of Borings. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

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concrete was recovered to a depth of about six feet. Recovery below this, to a depth of around 30 feet bs, revealed strata of gravelly 2.5YR3/3 to 3/4 sand of various textures (coarse sand to fine sandy loam). At 30.5 feet bs (15 feet bmsl) an abrupt boundary was encountered, with 2.5YR3/3 loamy medium sand with very fine gravel overlying two feet of 7.5YR2.5/3 fine sand containing no gravel. Recovery below this point, to the limit of excavation at 51.5 feet bs, was predominantly coarse and medium sand with varying amounts and sizes of gravel. Soil color was generally 7.5YR2.5/3 to 3/4, with some zones of 5YR and 2.5YR3/3.

DH2 was located just southeast of Hylan Boulevard at Map Station 15+00 (NYSP Northing 142147.722/ Easting 948837.665), 234 feet east of DH1. Opening elevation was 13.25 feet amsl. Although historic and modern landscape alteration mask the true nature of the setting, it differs from that at DH1. Unlike the more confined and moderate-gradient setting at DH1, at the location of DH2 the ancestral Mill Creek had likely entered the head of the outwash plain, undergone a relatively abrupt change in gradient, and become free to move laterally. Today, the Mill Creek hollow has been filled and graded in this area, removing any sign of the underlying topography. The area, bordering the southeastern side of Hylan Boulevard, is maintained as lawn and periodically mowed; phragmites are present immediately to the east of the boring site and dominate the vegetation extending from that point southeastward. Recovery to 4 feet bs consisted of 7.5YR2.5/3 loamy sand fill. Recovery from 5 to 6.5 feet bs was 7.5YR4/4 heavy silt loam exhibiting many medium distinct redoximorphic mottles and containing weakly weathered gravel; the same material was present in the upper four inches of the following advance from 7.5 to 9 feet bs, indicating that the stratum – strongly suggestive of a stable, weathered subsoil – was approximately three feet thick at minimum. Because of an unsampled auger advance from four to 5 feet bs, the precise depth of the upper boundary of this stratum and whether there was an associated overlying A horizon is undetermined. The lower boundary of this material was abrupt, giving way at around 8 feet bs to 2.5YR3/3 sandy loam with fine gravel. Recovery from eight feet to 33 feet bs (approximately 20 feet bmsl) consisted of stratified fine, medium and coarse sand – loamy in some strata, as at the top – containing varying amounts of fine and very fine gravel. Below this, to base of excavation at 51.5 feet bs (38 feet bmsl), recovery consisted of coarse and medium sand – predominantly 7.5YR3/3 to 3/4 – with very fine to medium gravel.

DH3 through DH5 were not monitored for this study, in part because of concerns about soil contamination; following a hiatus, monitoring resumed at DH6 on April 29, 2019. DH6 was located at Map Station 53+21 (NYSP Northing 139693.872/Easting 951567.683), 3,821 feet southeast of DH2, along the southwestern edge of the Oakwood Wastewater Treatment facility. Opening elevation was 11 feet amsl. Excavation of DH6 had been carried out to 34 feet bs (23 feet bmsl) before monitoring for this study commenced. The geologic monitor reported that the upper profile consisted of 10-12 feet of fill (extending more or less to sea level); the rods and spoon dropped from 7.5 to 9 feet bs, suggesting the presence of a void in the fill. Following a one-foot auger advance, monitoring for this study commenced with sampling from 35 to 36.5 feet bs (24-25.5 feet bmsl). Recovery consisted of 5YR3/3 coarse sand with fine and medium gravel. Below this, to 57.5 feet bs (46.5 feet bmsl) recovery was similar, with sand texture generally fining to fine and medium. Following an unsampled 3.5-foot auger advance, recovery from 57.5 to 59 feet bs consisted of Gley1 7/N (light gray) sandy clay and very fine sand. Recovery below this point, to base of excavation at 119 feet bs (108 feet bmsl) was dominated by fine and very fine sand but included thin beds of clay and sandy clay; colors were predominantly light gray to white but included thin oxidized strata of yellowish brown (10YR5/8) to red (10R4/8) (Photograph 5.1). Virtually no gravel was present. Drilling was terminated at 119 feet bs because of collapse.

Photograph 5.1. Core sample from drill hole DH6 (Oakwood Beach Marsh), 117.5 to 119 feet below surface, Cretaceous sand and clay of the Raritan Formation (Photographer: John Stiteler, April 30, 2019).

Photograph 5.2. Core sample from drill hole DH10 (Oakwood Beach Marsh), 82.5 to 84 feet below surface, Cretaceous sands of the Raritan Formation (Photographer: John Stiteler, November 2, 2018).

Photograph 5.3. Core sample from drill hole DH10 (Oakwood Beach Marsh), 115 to 116.5 feet below surface, Cretaceous sand and clay of the Raritan Formation (Photographer: John Stiteler, November 3, 2018).

DH7 was located at the southern corner of the wastewater treatment facility grounds, 550 feet southeast of DH6 (Map Station 58+71; NYSP Northing 139342.095/Easting 951920.437). This point marks a 90° turn to the northeast in the project alignment. Opening elevation was 11.77 feet amsl (rounded here to 12 feet). Recovery to 11.5 feet bs consisted of fill, including gravel and wood. Recovery from 12.5 to 16.5 feet bs (1.5 to 5.5 feet bmsl) was organic material (meadow mat), with an increasing content of mineral soil with depth. Recovery beneath the meadow mat, from 17.5 to 21.5 feet bs (5.5 to 9.5 feet bmsl) was heavily reduced (5Y3/1) very gravelly loam and loamy coarse sand; some gravel was angular to subangular. This material was tentatively identified as early historic fill or roadbed. Recovery from 22.5 to 39 feet bs (10.5-27 feet bmsl) was 2.5YR2.5/2 to 3/3 fine and medium sand with varying (small) amounts of very fine gravel, coarsening in the lower few feet to medium and coarse sand with fine and medium gravel. From 40 to 54 feet bs (28 to 42 feet bmsl) recovery was predominantly 7.5YR3/3-3/4 fine and medium sand with varying (small) amounts of fine and very fine gravel. An abrupt change was encountered in the sample from 57.5 to 59 feet bs, made up of thinly bedded light gray and light yellowish brown (2.5Y7/1 and 6/4) fine and very fine sand free of gravel. The next sample, from 62.5 to 64 feet bs (50.5 to 52 feet bmsl) Gley1 3/N very firm clay. The succeeding sample, from 67.5 to 69 feet bs, was taken within an enclosed Shelby tube and was not available for examination. Recovery of the remainder of the boring – to 134 feet bs (122 feet bmsl) – was dominated by fine and very fine sand, free of gravel, with thin stringers and beds of clay and sandy clay. Thin bedding was common in the sands, frequently with alternating beds being oxidized and reduced. Colors varied widely and ranged from brownish yellow (10YR6/6) to strong brown (7.5YR5/6) to light gray (2.5Y7/1). Some oxidized zones were red to dark red (10R4/8 to 3/6).

DH8 was located at Map Station 63+00 (NYSP Northing 139300.775/Easting 952269.411), 429 feet northeast of DH7. Opening elevation was 11.58 feet amsl (rounded here to 12 feet). Recovery to 9 feet bs consisted of gravelly silt and loam fill. Following a one-foot auger advance, recovery from 10 to 11.5 feet bs consisted of saturated organic matter (meadow mat) over organic-rich clay. Beneath this, to 16.5 feet bs and possibly to 19 feet bs, was loamy coarse sand and coarse sandy loam with much gravel, including angular pebbles. As in DH7, this material was tentatively identified as early historic fill or roadbed. Below this, recovery to 34 feet bs (22 feet bmsl) was 2.5YR2.5/2, grading to 5YR2.5/2, fine and medium sand with minor amounts of very fine gravel. Recovery from 35 feet to 54 feet bs (23 to 44 feet bmsl) was predominantly 7.5YR3/2 to 3/3 sand, coarser and containing medium and coarse gravel in the upper five feet and fining to fine and medium sand with very fine gravel below. Beneath this, to base of excavation at 114 feet bs (102 feet bmsl), recovery was thinly bedded sand with clay stringers and beds as described for DH6 and DH7.

DH10 was located along the southwest side of Kissam Avenue, at Map Station 81+47 (NYSP Northing 140884.783/Easting 953626.704). Kissam Avenue is a northwest-southeast street, bounded at the southeastern end by a constructed sand seawall, and surrounded by phragmites marsh; no houses are currently standing along this former residential street. Opening elevation at DH10 was 3.48 feet amsl. Sampling had proceeded to a depth of 61.5 feet bs (58 feet bmsl) at the time monitoring for this study began. Examination of geologic sample jars indicated that clay was encountered around 48 feet bs (roughly 45 feet bmsl) and was overlain by 12 feet of yellowish brown (10YR6/6) very fine sand transitioning with depth to very fine sandy clay. The clay encountered at 48 feet bs extended to 79 feet bs. The lower boundary was highly weathered gravel which was pulverized by the spoon. Below this point, to base of excavation at 136.5 feet bs (133 feet bmsl) recovery consisted of thinly bedded very fine, fine, and medium sand with thin stringers and beds of clay and sandy clay and reduced and oxidized zones as described for DH6 through 8 (Photographs 5.2 and 5.3).

DH10A was also located along the southwest side of Kissam Avenue, 438 feet northwest of DH10 47 (NYSP Northing 141165.679/Easting 953310.359). Opening elevation was 3.7 feet amsl. A thin (nine inch) layer of fill was present at the surface. Peaty organic matter and organic-rich silt and silty clay were recovered to 8 feet bs (4.3 feet bmsl), overlying very gravelly loam to 11.5 feet bs. Beneath this, recovery to around 30.5 feet bs (around 27 feet bmsl) was fine and medium sand, loamy in some strata, and containing a small amount of very fine to medium gravel; thick to very thin bedding was evident in most samples. Color was predominantly 2.5YR3/2 to 3/3, with zones of 5YR3/2 to 3/4. Color changed to 7.5YR at 30.5 feet bs, as seen at depth in several previous borings. Boring was halted at 36.5 feet bs; no stratified clays and sands, as seen at greater depth in previous borings, were encountered.

5. New Dorp Upland Zone (Figure 5.2a)

The New Dorp Upland Zone is considered to extend from a point immediately southwest of DH11 (Map Station 90+00; NYSP Northing 141742.464/Easting 954425.785) to just northeast of Miller Field, at around Map Station 175+00 (roughly NYSP Northing 147100.000/Easting 959814.000).

DH11 and DH12 were conducted just inside the northern edge of the Great Kills phragmites marsh. The setting was a slight topographic high within the marsh, at elevations of 3.9 feet amsl for DH11 and 3.3 feet amsl for DH12. The area immediately surrounding the boring locations is a roughly circular opening in the phragmites marsh, vegetated in grasses and sedges and including a number of standing trunks of dead trees. DH11 was located on the southwestern edge of the clearing, precisely on the boundary between grasses and phragmites; southwest of this point the surface appears to slowly decline. DH12 was located at the northeastern edge of the opening. The area where DH11 and DH12 were conducted is shown on the 1781 Skinner and Taylor map as the edge of fast land, verging on the marsh (see above, Figure 4.13). On the 1895 U.S. Coast Survey map it correlates with one of several small "islands" of drier ground within the marsh, all more or less circular and appearing to represent the remaining subaerial portions of otherwise submerged knolls or rises (see above, Figure 4.27).

In DH11, the upper mineral soil horizon, beneath 3-5 inches of organic mat, was brown (7.5YR4/3) silt loam to very fine sandy loam containing some rounded and subrounded gravel. The advance from 2.5 to 4 feet bs recovered 5YR3/3 very gravelly coarse sandy loam, high in clay; gravel size ranged from very fine to coarse. This transitioned in the next advance (6 to 7.5 feet bs) to 2.5YR3/3 medium sandy loam containing mainly very fine gravel. This generally describes the following 20 feet of recovery (to 27 feet bs or around 23 feet bmsl), with texture coarsening slightly to medium sand and becoming less loamy. Gravel throughout this thick stratum was consistently very fine. From 27 feet bs to base of excavation at 52.5 feet bs (48.5 feet bmsl), sediments were more varied, with strata of loamy coarse and medium sand and very fine through coarse sand, mostly containing little or no gravel. DH11 was slated to be carried out to 135 feet bs but because of repeated problems with hole collapse was terminated at 52.5 feet bs.

The profile of DH12, 689 feet northeast of DH11 at Map Station 96+89 (NYSP Northing 141774.063/Easting 954710.825), was very similar. The upper mineral soil horizon, beneath 3-5 inches of organic mat, was dark yellowish brown (10YR4/6) heavy silt loam containing a few rounded pebbles; this extended to around 4 feet bs. Below this, as in DH11, texture coarsened to very gravelly medium sandy loam; large zones of Fe-Mn accumulation were noted in the upper two feet. At 8 feet bs the texture coarsened slightly to loamy medium sand containing a small amount of gravel. Recovery below this, to base of excavation at 36.5 feet bs (around 33.2 feet bmsl) was as described for DH11.

Northeast of DH12 the project alignment turns approximately 45° to the east for 750 feet before turning northeast again. No split-spoon borings were conducted along this diagonal dogleg; GP4 was conducted at the southwest end. DH13 was situated near the northeast end of the diagonal, on the landward side of an existing sand berm (Map Station 106+66; NYSP Northing 142172.092/Easting 955558.320). Opening elevation at DH13 was 5.3 feet amsl; the difference in elevation between this and the elevations at DH11 and DH12 appears to be largely the result of the presence of berm sand at DH13. Recovery to 3 feet bs consisted of unconsolidated beach sand. Beneath this, to 4 feet bs, was silt loam, black (7.5YR2.5/1) in the upper three inches and dark brown (7.5YR3/3) with a few rounded pebbles below. Following an auger advance, recovery from 5 to 6.5 feet bs was dark reddish brown (2.5YR3/3) very gravelly loam; the rounded gravel was of all sizes. Following another auger advance (6.5 to 7.5 feet), the same material was found to extend to around 8 feet bs. Underlying the loam was dusky red (2.5YR3/2) loamy fine sand containing a small amount of gravel. Recovery from 10 to 11.5 feet bs (4.7 to 6.2 feet bmsl) was 2.5YR3/2 very gravelly loam to loamy sand; variegations in color suggested weathering. Recovery from 12.5 to 33 feet bs was consistently fine to coarse sand with varying (low) amounts of gravel, generally fine to very fine. Intact bedding was noted throughout much of this recovery. From 33 feet bs to base of excavation at 36.5 feet bs, recovery consisted of 7.5YR3/4 medium and coarse sand containing a small amount of very fine gravel.

DH14 was located at Map Station 117+00 (NYSP Northing 143033.843/Easting 956102.292), 1034 feet northeast of DH13; it was conducted at the base of the seaward side of the sand berm. Opening elevation was 8.8 feet amsl. Recovery to 1.5 feet was unconsolidated berm sand; a faint dark zone at 2.5 to 3 feet bs may represent a short-lived pre-berm surface. Following an auger advance from four to 5 feet bs, a very dark grayish brown silt loam containing brick fragments was recovered from 5 to 5.5 feet bs. Beneath this, to 6.5 feet bs, was dark yellowish brown (10YR3/4) silt loam grading to dark brown (7.5YR3/4) silt loam containing rounded gavel. Recovery from 6.5 to 14 feet bs consisted of 2.5YR3/3 very gravelly sandy loam grading with depth to very gravelly loamy medium sand with less gravel. The remainder of recovery, to 36.5 feet bs, was as described for DH11 through DH13 – 2.5YR3/2 and 3/3 fine to coarse sand showing some bedding and stratification and containing varying amounts of gravel.

DH15 was also located along the seaward side of the berm 1000 feet northeast of DH14 (Map Station 127+00; NYSP Northing 143576.511/Easting 956889.518). The opening elevation was 6.8 feet amsl. The initial advance, to 1.5 feet bs, consisted of unconsolidated berm sand. Following an auger advance to 2.5 feet bs, the next 1.5-foot advance recovered very dark grayish brown (10YR3/2) silt loam containing brick and concrete. The following advances revealed profiles much as described for DH13 and DH14 – silt loam grading with depth to loam, coarse sandy loam, and loamy medium sand to around 16.5 feet bs, much of it very gravelly. The profile underlying this was also as described for the four previous borings – fine to coarse sand showing some bedding and stratification and containing varying amounts of gravel.

DH16 was conducted in a brushy area landward of the sand berm and an adjacent bike and pedestrian path, 980 feet northeast of DH15 (Map Station 136+80; NYSP Northing 144397.302/Easting 957374.593). Opening elevation was 8.4 feet amsl. The initial spoon advance (0-1.5 feet bs) yielded thickly stratified silt and sand interpreted to be either fill or recent deposition. The following advances yielded 2.5YR3/3 gravelly sandy loam and gravelly coarse sandy loam to a depth of 9 feet bs. From 10 to 14 feet bs (1.6 to 5.6 feet bmsl), this transitioned to 2.5YR3/3 loamy medium and fine sand with very fine gravel. Recovery from 14 feet bs to base of excavation at 36.5 feet bs consisted of 2.5YR2.5/2 to 3/3 fine and medium sand with small amounts of very fine gravel, as described for previous borings in this zone.

As noted previously, borings DH17 and DH18 were eliminated from the testing program. These were to have been carried out at the southeastern (seaward) limit of Miller Field, roughly from NYSP Northing 144601/Easting 957849 to Northing 145892/Easting 958672. GP8 was conducted within this reach at a site previously permitted for other subsurface testing (SCPTu10 and DMT-11). Excavation was carried out to a depth of 20 feet bs; recovery from the advances from 0 to 5 feet bs and 5 to 10 feet bs was very poor – approximately one foot of recovery for each five-foot advance.

DH19 was located 3,020 feet northeast of DH16, at Map Station 167+00 (NYSP Northing 146589.578/ Easting 959334.364). Opening elevation was 10.4 feet amsl. Recovery of several pieces of subangular gravel at 4 feet bs suggests that at least that much of the elevation was due to the addition of fill. Recovery from four to 15 feet bs consisted of stratified very fine to coarse 2.5YR3/3 sand, with fine and very fine gravel in some strata. Recovery from 15 to 16.5 feet bs (4.6 to 6.1 feet bmsl) consisted of loamy medium and very fine sand as seen at depth in most of the previous borings in this zone. Recovery from this depth to base of excavation at 36.5 feet bs consisted of stratified 2.5YR2.5/2 to 3/3 fine and medium sand with varying amounts of fine and very fine gravel, as described for the preceding borings.

DH19A was located 500 feet northeast of DH19, at Map Station 172+00 (NYSP Northing 146937.190/ Easting 959644.677). Opening elevation was 9.2 feet amsl. Recovery to 12.5 feet bs consisted of stratified 2.5YR3/3 coarse and medium sand containing varying amounts of fine and very fine gravel. One foot of compact coarse sand with much fine gravel at 12.5 to 13.5 feet bs marked a boundary between the coarser upper sands and a transition to 2.5YR3/3 fine and very fine sand with less gravel to the base of excavation at 36.5 feet bs.

6. New Creek Drainage Zone (Figure 5.2b; Photographs 5.4-5.12)

Sampling in this area consisted of 14 split-spoon borings (DH20 through DH32, plus DH25A) and seven Geoprobe borings (GP9 through GP15). With the exception of DH23, carried out to a depth of 46.5 feet bs, all split-spoon borings in this zone were carried out to 36.5 feet bs. GP9, 13, and 15 were carried out to 15 feet bs; GP10, 12, and 14 to 30 feet bs; GP11 to 40 feet bs.

Late Holocene beach sand, 2.5YR3/3 to 7.5YR4/3 fine to coarse sand with varying amounts of very fine to fine gravel, formed the upper part of the profile in this area. The beach sand ranged in thickness from 6 to 14 feet; in some locations, this facies was thickened by sand used to construct a sand berm as a seawall.

Stratigraphically, the next facies encountered in this zone was the very dark gray to black fine to very fine sand containing very fine organic matter and, in some samples, very fine fragments of mollusk or bivalve shell. This facies, interpreted to be sediments mak-

Figure 5.2b. Aerial Photograph of Project Alignment (Northeast Portion) Showing Detailed Locations of Borings. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

ing up barrier island backbarrier, ranged in thickness from 2 to 7 feet and was generally encountered at 10 to 12 feet below surface (modern sea level to 4 feet bmsl). The backbarrier facies was identified in 13 of the 14 split-spoon borings in the New Creek Drainage Zone; it was not identified in DH20, the southernmost boring, adjacent to the New Dorp Upland, although organic-rich lagoon deposits were recovered there. Four samples of the backbarrier sediments were submitted for radiocarbon dating, three of which returned problematically old dates (Appendix C).

The clay- and organic-rich lagoon facies described previously was identified in 11 of the 14 split-spoon borings and six of the seven Geoprobe borings in the New Creek Drainage Zone. It was consistently overlaid by the backbarrier facies, with four exceptions. At the southwestern end of the zone, lagoon sediments were present in DH20, although no backbarrier sediments were identified; in DH21, backbarrier sediments were present, while lagoon deposits were not. This relationship was not observed in the two northernmost split-spoon borings (DH31 and DH32), where backbarrier sediments but no lagoon sediments were present.

The lagoon facies was distinguished by its color (black, gray-black, brownish-black) and the presence of fine to gross organic material. Texture was predominantly clay to sandy clay or silty clay with little gravel, but the facies included zones of very fine to medium sand containing minor proportions of fine and very fine gravel. Thickness of the sediments ranged from 5 to 12 feet; the upper boundary was encountered at depths ranging from 13 to 25 feet below surface (5 to 13 feet below modern sea level). This material is interpreted to be some combination of lagoon, tidal outlet, and estuarine deposition, with lagoon deposits dominating. The character of these deposits differed somewhat in DH27, DH28, DH29 and GP13, where textures were predominantly fine and very fine sand with small amounts of silt and fine and very fine gravel; some thin horizontal and gently sloping bedding was visible in the core samples. Organic matter, although present in these sediments, was consistently fine to very fine and present in smaller quantities than was the case in the other lagoon sediments.

In DH20, at Map Station 177+00 (NYSP Northing 147327.891/Easting 959984.953), 14 feet of Late Holocene beach sand directly overlaid 11 feet of lagoon deposits, including much peat in the upper three to four feet. Beneath the lagoon deposits, recovery consisted of 11 feet of 2.5YR3/2 and 3/3 fine and medium sand containing small amounts of very fine gravel and showing intact bedding.

DH21 was located at Map Station 187+00 (NYSP Northing 148041.190/Easting 960710.950), 1,000 feet northeast of DH20. There, 11 feet of beach sand overlaid six feet of fine and medium backbarrier sand that also included some silt (Photograph 5.4). The profile of DH21 was distinctive in the New Creek Drainage Zone in that no lagoon sediments were present underlying the backbarrier sand. Instead, recovery consisted of four feet of fine sand overlying 14 feet (to base of excavation) of stratified medium and coarse sand containing varying amounts of fine and very fine gravel, interpreted to be outwash.

The profile of DH22 (Map Station 197+00, NYSP Northing 148713.615/Easting 961415.415), 1000 feet northeast of DH21, consisted of 11 feet of beach sand over four feet of backbarrier sands and eight feet of lagoon sediments, including much organic matter and peat. The lagoon sediments unconformably overlaid eight feet of the stream-related facies that comprised two fining-upward sequences. This was the thickest occurrence of the stream-related sediments seen in any of the five split-spoon borings where it was identified. The sediments, ranging in texture from loamy coarse sand to sandy clay, with some fine gravel throughout, also included some fine organic matter. These stream deposits were underlain by five

Photograph 5.4. Core sample from drill hole DH21 (New Creek Drainage), 15 to 16.5 feet below surface, backbarrier sands (Photographer: John Stiteler, September 5, 2018).

feet of fine and medium sand – including some gravel – that may be related to the overlying stream deposits (Photographs 5.5-5.9).

The profile of DH23, (Map Station 206+88, NYSP Northing 149387.640/Easting 962142.991), 988 feet northeast of DH22, was closely similar. The setting was slightly different, on an area of lawn 100 feet northwest of the constructed sand berm along the top of the beach. The beach sand facies was 12 feet thick, overlying three feet of dark backbarrier sands and seven feet of lagoon sediments (Photograph 5.10). Three feet of the fine-textured (clay to very fine sand) stream-related sediments underlaid the lagoon sediments and were in turn underlain by ten feet of stratified coarse, fine and medium sand with varying amounts of gravel (Photograph 5.11). As in DH22, these sediments may also be a product of stream deposition. At 36 feet bs (26 feet bmsl), the shoe encountered gleyed silty clay. Excavation of the boring, initially scheduled to conclude at 36.5 feet bs, was extended to 46.5 feet bs. Recovery consisted largely of gleyed clay and silty clay but also included sandy clay and coarse sand, equivalent to the Cretaceous clays seen at depth in the Oakwood Marsh Zone.

The profile of DH24, 1023 feet northeast of DH23 at Map Station 217+11 (NYSP Northing 150050.075/ Easting 962903.036), consisted of the same sequence as DH22 and DH23 (less the deep clays seen in DH23, as excavation extended only to 22 feet bmsl). The setting for the probe, located between the beach boardwalk and a constructed sand berm to its seaward side, suggested that as much as six feet of additional berm sand might be present. The upper seven feet of recovery consisted of uniform 5YR3/3 medium and fine sand. At 7 feet bs recovery changed to two feet of 7.5YR3/4 medium sand with very fine gravel and a few fragments of roots, suggesting a former, short-lived stable surface. The remaining six feet of Late Holocene beach sand consisted of 5YR3/3 medium sand; some intact bedding was noted near the base. The boundary between the beach sand and the underlying backbarrier sand lay at one foot bmsl. The backbarrier facies consisted of nine feet of dark (5YR3/1, 10YR2/1, and 7.5YR3/2) sand varying with depth from fine to medium and coarse with varying amounts of fine gravel. The lowest two feet consisted of coarse sand with medium rounded pebbles. An underlying three feet of lagoon sediments consisted of dark (5YR3/1 and 10YR3/1) silty very fine sand. The lagoon sediments were underlain by four feet of stream-related sediments – variegated gravelly loam and gleyed silty clay. The remainder of the probe recovery consisted of 5YR5/2 fine and medium sand containing a small amount of very fine gravel.

DH25 was located at Map Station 227+15 (NYSP Northing 150857.068/Easting 963482.768), 1,004 feet northeast of DH24 and the profile was very similar. The beach sand facies (5YR3/3 medium and coarse sand) extended to 14 feet bs (3 feet bmsl). The underlying backbarrier facies (5YR2.5/1 to 3/2 very fine to coarse sand containing much fine and medium gravel in the lower half, was six feet thick. The lagoon sediments beneath the backbarrier extended from 9 to 17 feet bmsl. These sediments graded downward from very fine sand to very fine sandy clay containing very fine organic matter. Color ranged from black to dark reddish gray (5YR2.5/1 to 2.5YR4/1). The lagoon sediments unconformably overlaid two feet of very gravelly (30-40% fine gravel) sandy loam interpreted to be stream-related sediments. The lowest six feet of the probe, to 25 feet bmsl, recovered 5YR3/3 fine, medium and coarse sand.

DH25A was located at Map Station 232+10.5 (NYSP Northing 151257.744/Easting 963771.637), 494.5 feet northeast of DH25. The beach sand facies was 12 feet thick and consisted of 5YR3/3 medium and coarse sand, as in most of the borings. There was no recovery in the advance from 5 to 6.5 feet because the shoe was plugged by creosote-treated wood similar to timbers used to construct the adjacent boardwalk. The bound-

Photograph 5.5. Core sample from drill hole DH22 (New Creek Drainage), 17.5 to 19 feet below surface, lagoon deposit – silty clay with organics; sand with organics (Photographer: John Stiteler, September 5, 2018).

Photograph 5.6. Core sample from drill hole DH22 (New Creek Drainage), 22.5 to 24 feet below surface, basal lagoon peat over gleyed sandy clay (Photographer: John Stiteler, September 5, 2018).

Photograph 5.7. Core sample from drill hole DH22 (New Creek Drainage), 25 to 26.5 feet below surface, basal organic-rich lagoon deposit over gravelly loam alluvium (Photographer: John Stiteler, September 5, 2018).

Photograph 5.8. Core sample from drill hole DH22 (New Creek Drainage), 27.5 to 29 feet below surface, gravelly loam alluvium over thinly bedded silty clay alluvium (Photographer: John Stiteler, September 5, 2018).

Photograph 5.9. Core sample from drill hole DH22 (New Creek Drainage), 30 to 31.5 feet below surface, slackwater alluvium sediment over alluvial bedload (Photographer: John Stiteler, September 5, 2018).

Photograph 5.10. Core sample from drill hole DH23 (New Creek Drainage), 12.5 to 14 feet below surface, beach sand over backbarrier sands (Photographer: John Stiteler, August 29, 2018).

Photograph 5.11. Core sample from drill hole DH23 (New Creek Drainage), 25 to 26.5 feet below surface, alluvial silty clay over alluvial bedload (Photographer: John Stiteler, August 29, 2018).

ary with the dark, nine-foot thick, fine and very fine sand backbarrier facies was encountered at one foot bmsl. The lagoon sediments were encountered at 10 feet bmsl and extended to 15 feet bmsl. As in DH25, the texture within the lagoon facies slightly coarsened upward, from sandy clay loam at the base to silt and very fine sand in the upper half. Following a one-foot auger advance, a thin (10 inch) stratum of gleyed sandy clay loam showing thin bedding was recovered below the lagoon sediments; it is unknown how much, if any, of this material was removed unsampled by the auger and what the intact thickness of the stratum is. This material was identified as stream-related deposition. DH25A was the northernmost of the five contiguous split-spoon probes where this facies was identified. The remainder of recovery (from 17 to 25 feet bmsl) consisted of 2.5YR to 5YR3/3 medium and coarse sand containing varying amounts of very fine gravel.

DH26 was located at around Map Station 236+00 (NYSP Northing 151638.044/Easting 964081.379) or around 440 feet northeast of DH25A. The location was offset 50-60 feet to the northeast of the originally designated location because that location aligned with utility access covers to the southwest and a stormwater discharge pipe extending offshore. The beach sand facies was 13 feet thick and made up of the standard 5YR3/3 medium and coarse sand (with one zone of 7.5YR3/3) with varying amounts of very fine and fine gravel. The underlying backbarrier facies was encountered at two feet bmsl and extended to 11 feet bmsl. The dark backbarrier sediments were largely fine sand but included a thick zone of coarse sand containing much fine and very fine gravel. A large shell fragment was noted at the upper boundary of the facies. The precise depth of the boundary between the backbarrier and lagoon sediments was unclear; there was no recovery in the spoon advance from 22.5 to 24 feet bs as a result of blockage of the shoe by a rounded quartzite pebble. The seven-foot thick stratum of lagoon sediments, to 20 feet bmsl, varied in texture, including fine sandy clay, sandy loam with gravel, very fine sand and a thick zone of very fine sandy clay containing organic matter (Photograph 5.12). Recovery below this, to base of excavation at 25 feet bmsl, consisted of 5YR3/2 loamy medium sand containing little gravel.

DH27 was located at Map Station 247+04 (NYSP Northing 152431.621/Easting 964740.885), around 1,100 feet northeast of DH26. The beach sand facies (11 feet thick, extending to mean sea level) consisted of the standard medium and coarse sand with varying amounts of gravel and was generally 7.5YR4/3 in color. The underlying backbarrier facies was eight feet thick. The upper three feet of dark reddish brown (5YR3/2) fine and very fine sand contained fine shell fragments. Two feet of very dark gray (10YR3/1) fine and very fine sand from five to seven feet bmsl emitted a noticeable smell of decomposed organic matter. The underlying lagoon-related facies (from eight to 22 feet bmsl) differed from that seen in borings to the south. These sediments contained little or no organic matter. Color was dark reddish brown (5YR3/2 and 3/3). Texture in the upper six feet was loamy medium sand, with some very fine gravel in the lowest foot. Below this was two feet of silt and very fine sand exhibiting sloping bedding. The lowest six feet was fine and medium sand with a small amount of fine gravel overlying fine sand, some of which showed thin bedding, coarsening again to medium sand with some gravel at the base. The lowest three feet of recovery, to 25 feet bmsl, consisted 5YR3/2 fine and medium sand that may have been related to the overlying sediments.

The profile of DH28, 996 feet northeast of DH27, at Map Station 257+00 (NYSP Northing 152431.621/ Easting 964740.885), was closely similar. The beach sand facies was 13 feet thick and as described for other examples. An abrupt boundary separated this from the backbarrier facies, which was somewhat thinner than seen in other borings (four feet, from five

Photograph 5.12. Core sample from drill hole DH26 (New Creek Drainage), 27.5 to 29 feet below surface, basal lagoon deposits – silty clay and peat over reduced sand and gravel (Photographer: John Stiteler, August 25, 2018).

to nine feet bmsl) and consisted of very dark brown (7.5YR2.5/2) fine sand overlying black (2.5Y2.5/1) fine sand containing organic matter and fine shell fragments. The underlying lagoon deposit was 16 feet thick (to 25 feet bmsl) and closely resembled that in DH 27. Textures ranged from very fine to medium sand, with small amounts of silt, clay, and gravel present in some zones; no organic matter was noted. The final three feet of recovery, to base of excavation at 28 feet bmsl, consisted of 5YR3/2 medium sand containing some very fine gravel.

The profile of DH29 at Map Station 267+11 20 (NYSP Northing 153996.052/Easting 965969.952), 1,011 feet northeast of DH28, was closely similar to the previous two. The upper beach sand facies consisted of 7.5YR and 2.5YR3/3 medium sand as previously described. Recovery from 6 to 12 feet bs was not monitored for geoarchaeological purposes because monitoring was being carried out on Geoprobe sampling nearby. Recovery from 12 to 17 feet bs (four to nine feet bmsl) consisted of dark, medium sandy backbarrier deposition containing fine shell fragments and one small piece of twig in the upper three feet. The underlying lagoon sediments were 15 feet thick – extending to 24 feet bmsl – and were as described for the previous two borings. The upper boundary was less than one foot lower than that in DH28. Small amounts of fine organic matter were noted at 19 and 22 feet bmsl; samples were submitted to Beta Analytic for dating, but pretreatment revealed that there was too little carbon present to yield dependable results. The final four feet of recovery, to 28 feet bmsl, consisted of 5YR3/4 medium and coarse sand containing an increasing amount of gravel with depth. As in previous borings, these basal sediments may be related to the overlying lagoon deposition.

DH30 was located at Map Station 277+20 (NYSP Northing 154749.930/Easting 966601.667), 1,009 feet northeast of DH29. The profile differed from the three previous borings in several notable ways. The beach sand deposit was relatively thin, extending only to 6 feet bs. The underlying backbarrier deposit was the thickest seen in any borings, with a thickness of 11 feet (to nine feet bmsl). The texture coarsened slightly with depth, from fine and very fine sand in the upper half to medium sand in the lower half. Fine shell fragments were noted throughout the upper six feet; very fine gravel was present in the lower five feet. The eight feet of underlying lagoon sediments were distinctly different from those in the three borings immediately to the south and were essentially the same as those in DH20 and DH22 through 26 – texturally dominated by black (2.5Y2.5/1) silt and clay and containing organic matter in the upper three feet. Texture coarsened slightly with depth, becoming dark gray (10YR4/1) sandy loam to sandy clay loam, and some gravel – medium to large subrounded pebbles – was present in the lower four feet. Some evidence of fine roots was also noted in the uppermost sample of the gravelly sandy loam to sandy clay loam. At the base of the sandy clay lagoon sediments, an abrupt boundary marked the transition to two feet of well-sorted 5YR4/1-4/2 medium sand with very fine gravel; a second abrupt boundary at the base of the medium sand marked a transition to ten feet of gravel-free very fine sand with some silt. The lowest four inches of recovery, at around 29 feet bmsl, consisted of what appeared to be part of a highly weathered and friable cobble, possibly marking the lower boundary of the fine-textured facies.

DH31 was situated at the top edge of the beach at Map Station 286+90 (NYSP Northing 155455.541/Easting 967250.357), 970 feet northeast of DH30. DH32 was located at Map Station 291+89 (NYSP Northing 155941.568/Easting 967426.509), 499 feet north of DH31. It was the northernmost boring in the project alignment and was situated farther inland than any other borings in the New Creek Drainage Zone, near the base of the upland where Fort Wadsworth is located. The profiles of these two northernmost borings differed from most others in the New Creek Drainage

Zone in that while dark, fine sandy, shell-bearing backbarrier sediments were identified, no fine-textured, organic-rich lagoon sediments were present beneath the backbarrier sands. This was also the case in DH21, near the southern end of the zone. In DH31, the upper boundary of the five-foot thick backbarrier stratum was encountered beneath ten feet of Late Holocene beach sand at two feet bmsl. In DH32, located slightly lower in terms of current topography, the four-foot thick stratum was encountered at modern sea level, beneath five feet of beach sand.

The backbarrier sands in DH32 were unconformably underlain by a thin, three-inch-thick stratum of reduced silty clay overlying two inches of oxidized coarse sand, together suggestive of the boundary between a developed Bw or Bt horizon and underlying BC or C horizon sand. Only three inches of the reduced clay was recovered at the top of a sample; the previous foot of sediment column was not sampled (auger advance), so the overall thickness and a clearer characterization of the silty clay could not be determined. GP15 was conducted adjacent to DH32 in hopes of obtaining a more complete sample. However, recovery was quite poor overall in GP15 and especially in the advance from 5 to 10 feet bs, which recovered only one foot of sample consisting entirely of beach sand and backbarrier sand.

Beneath the silty clay in DH32 and the backbarrier sands in DH31 were ten feet (DH31) and five feet (DH32) of 7.5YR2.5/2 to 3/3 fine to coarse sand and varying amounts of fine gravel, generally similar to the outwash and beach sand which make up the dominant material throughout the project alignment. Below this thick stratum of sand and gravel, recovery in each of these probes consisted of three feet of silt and very fine sand completely free of gravel, similar to that seen at the base of the DH30 boring. Beneath this fine textured material, to the base of excavation, recovery consisted of 5YR to 7.5YR fine to coarse sand and varying amounts of gravel; this material, along with the overlying fine sand and silt, is interpreted to be glacial outwash.

C. SAMPLE ANALYSES

1. Oakwood Marsh Zone

Seven samples from borings within the Oakwood Marsh Zone were submitted for radiocarbon dating (Table 5.1; Appendix C). Six of these were samples recovered at depths ranging from 46 to 77 feet bmsl in hopes of finding a boundary between early post-glacial sediments and underlying Cretaceous deposits. Ten samples from the Oakwood Marsh Zone were also submitted for pollen analysis (Appendix D). All of the six deep samples – from DH7 at 51 feet bmsl; DH8 at 67 and 77 feet bmsl; and DH10 at 46, 53, and 66 feet bmsl – returned "carbon dead" results of ages greater than 43,000 years BP. These samples, along with several undated samples from deep proveniences – DH8 at 60, 81, and 95 feet bmsl – contained only Cretaceous-age palynomorphs, ranging from many, well-preserved spores to a few oxidized and poorly-preserved spores.

A sample of peat (meadow mat) from four feet bmsl (16 feet bs) in DH7 returned a date of 1,605 to 1,744 cal years BP (Beta 532125). The depth below surface includes approximately ten feet of fill. The upper boundary of the organic deposit within the column lies at sea level and the base at six feet bmsl. The upper four feet of the deposit was composed primarily of saturated organic material; the lowest two feet was a mix of organic matter and sandy clay. The submitted sample was taken from the base of the peaty upper zone. Pollen analysis revealed that "[w]hile a few poorly preserved Holocene age grains were noted in [this sample], a count could not be achieved, as only traces of Ambrosia, grass, Acer, Carya, Pinus, Quercus, and indeterminate grains were noted, result-

Table 5.1. Summary of Radiocarbon Dates (Oakwood Marsh).

Drill Hole #	Sample Code	Lab #	Depth (ft bs)	Depth (ft amsl/bmsl)	Sedimentary Facies	Submitted Material	Analyzed Material	Date Range
DH7	SSSI 001	Beta - 532122	62.75-64.0	50.75-52 bmsl	Cretaceous deposits	Peat	Plant material	(> 43500 BP)
DH7	SSSI 004	Beta - 532125	15.5-16.5	3.5-4.5 bmsl	Coastal marsh	Soil containing fine organic matter	Plant material	1744 - 1605 cal BP
DH8	SSSI 003	Beta - 532124	78.5-79.0	66.5-67 bmsl	Cretaceous deposits	Peat	Charred material	(> 43500 BP)
DH8	SSSI 005	Beta - 532126	88.25-89.0	76.25-77.0	Cretaceous deposits	Estuarine clay containing fine organic matter	Organic sediment	(> 43500 BP)
DH10	SSSI 006	Beta - 532127	48.0-48.7	45.0-45.7 bmsl	Cretaceous deposits	Estuarine clay containing fine organic matter	Organic sediment	(> 43500 BP)
DH10	SSSI 007	Beta - 532128	55.0-55.5	52.0-52.5 bmsl	Cretaceous deposits	Estuarine clay containing fine organic matter	Organic sediment	44381 - 42881 cal BP
DH10	SSSI 008	Beta - 532129	67.5-68.25	64.5-65.25 bmsl	Cretaceous deposits	Estuarine clay containing fine organic matter	Organic sediment	47022 - 44836 cal BP

ing in a concentration value of 412 grains per gram of sediment, a value well below the minimal acceptable threshold of around 2000 grains per gram. Oxidizing conditions here led to the loss of nearly all grains from the sample."

2. New Dorp Upland Zone

Two split samples from the New Dorp Upland Zone, both from the upper portion of the GP5 soil column, were submitted for carbon dating and pollen analysis (Table 5.2; Appendices C and D). Particle-size analysis by the U.S. Army Corps of Engineers Soils Laboratory in Baltimore, Maryland was requested on a total of 21 samples from seven sampling locations (Appendix G). Additionally, analysis of total carbon and total nitrogen was conducted by the Cornell Nutrient Analysis Laboratory (CNAL) at Cornell University on 15 samples, including 13 from GP7.

GP5 was located midway between DH13 and DH14, in the central part of the zone. A sample from 2.5 to 2.8 feet bs (6.0 to 6.3 feet amsl) returned a date of 144 to 216 cal years BP (Beta 532138). Analysis revealed that the pollen contained in the sample was in "excellent condition" and included, in the non-arboreal component, predominantly Ambrosia (ragweed), Solidago (goldenrod), sedge, and grass, with smaller amounts of Fabaceae (legume, pea, and bean family), Onagraceae (evening primrose family), Polygonaceae (knotweed and smartweed-buckwheat family), Rosaceae (rose), and Typha latifolia (cattail family), "all types represented by less than a 1.5 percent occurrence." The report states that "[m]ajor arboreal types include Carya (hickory), Castanea (chestnut), Pinus (pine), and Quercus (oak). Additional arboreal types noted in the sample included Alnus (alder), Cornus (dogwood), Juniperus type, and Rhamnaceae (buckthorn) with one Sphagnum and 12 Osmunda grains representing the ferns. The assemblage overall represents a heavily forested environment with some, probably local clearing. Forest composition appears to be essentially identical to that found in the area during early historical times. Re-worked Cretaceous age palynomorphs make up an estimated 25 percent of the grains in the sample."

A sample from 5.0 to 6.0 feet bs (2.8 to 3.8 feet amsl) yielded a date of 937-1,063 cal years BP (Beta 532139). The pollen assemblage was dominated by Ambrosia (ragweed), Solidago (goldenrod), sedge, and grass pollen. Present but less common was pollen of Apiaceae, high spine Asteraceae, Cheno-Ams, Plantago, Polygonaceae, Rosaceae, and Typha latifolia. The pollen analysis report states that "Collectively, these taxa likely composed the marshy plants found along the [upland] margins, as well as in cleared or seasonally exposed areas. Arboreal elements in [this sample] were dominated by grains from Pinus and Quercus, with lesser numbers of Acer, Carya, Castanea, Ilex, Juniperus type, Prunus, Salix, and Tsuga, along with two spores from Sphagnum" and notes that "historically introduced taxa are not present in the samples."

3. New Creek Drainage Zone

A total of 20 samples from the New Creek Drainage Zone were submitted for radiocarbon dating (Table 5.3; Appendix C). Where practicable, several samples from various depths within single borings were submitted in order to establish chronological evolution of the settings. The majority of these samples were also submitted for pollen analysis and – where gross organic material was identified – for paleobotanical analysis (Appendices D and E). Additionally, several undated samples from these sediment columns were submitted for pollen analysis (Appendix D).

Two of the 20 samples, from the lower third of sediments from DH29 – possible tidal delta deposits – were pretreated by Beta Analytic and found to

Table 5.2. Summary of Radiocarbon Dates (New Dorp Upland).

Drill Hole #	Sample Code	Lab #	Depth (ft bs)	Depth (ft amsl/bmsl)	Sedimentary Facies	Submitted Material	Analyzed Material	Date Range
GP5	SSSI 017	Beta - 532138	2.5-2.8	6.0-6.3 amsl	Late Holocene sand	Silty soil with organic content	Plant material	216 - 144 cal BP
GP5	SSSI 018	Beta - 532139	5.0-6.0	2.8-3.8 amsl	Holocene solum	Silty subsoil with small amount organic carbon	Organic sediment	1063 - 937 cal BP

Table 5.3. Summary of Radiocarbon Dates (New Creek Drainage).

Drill Hole #	Sample Code	Lab #	Depth (ft bs)	Depth (ft amsl/bmsl)	Sedimentary Facies	Submitted Material	Analyzed Material	Date Range
DH20	SSSI 009	Beta - 532130	15.75-16.5	5.75-6.75 bmsl	Lagoon	Peat	Organic sediment	728 - 664 cal BP
DH20	SSSI 010	Beta - 532131	18.0-19.0	8.0-9.0 bmsl	Lagoon	Peat	Organic sediment	3060 - 2875 cal BP
GP10	SSSI 019	Beta - 532140	18.0-19.0	7.0-8.0 bmsl	Lagoon	Peat	Plant material	1287 - 1172 cal BP
GP10	SSSI 021	Beta - 532142	20.5-21.0	9.5-10.0 bmsl	Lagoon	Marine estuarine sands with organic matter, capped by beach sands	Plant material	2600 - 2492 cal BP
GP10	SSSI 023	Beta - 532144	24.0-25.0	12.5-13.5 bmsl	Mid-Holocene alluvium	Sandy basal sediments from coastal estuary capped by marine sands	Organic sediment	4085 - 3899 cal BP
GP10	SSSI 024	Beta - 532145	27.0-28.0	15.5-16.5 bmsl	Mid-Holocene alluvium	Sandy clay estuarine sediments possibly containing fine organic	Organic sediment	4830 - 5466 cal BP
GP11	SSSI 025	Beta - 532146	12.0-13.0	2.0-3.0 bmsl	Backbarrier	Sands from coastal lagoon capped by encroaching marine sands	Plant material	967 - 899 cal BP
GP11	SSSI 026	Beta - 532147	16.0-17.0	6.0-7.0 bmsl	Lagoon	Peat	Organic sediment	1714 - 1565 cal BP
GP11	SSSI 027	Beta - 532148	19.0-20.0	9.0-10.0 bmsl	Lagoon	Peat	Organic sediment	2505 - 2351 cal BP
GP11	SSSI 029	Beta - 532150	22.0-22.5	12.0-12.5 bmsl	Mid-Holocene alluvium	Basal estuarine sediments	Organic sediment	3271 - 3140 cal BP
GP12	SSSI 030	Beta - 532151	24.0-25.0	14.5-15.5 bmsl	Lagoon	Sandy estuary sediments with very fine organic	Organic sediment	3511 - 3381 cal BP
DH26	SSSI 011	Beta - 532132	15.5-16.0	5.4-5.9 bmsl	Backbarrier	Marine sand containing fine organic matter	Organic sediment	7759 - 7618 cal BP
DH27	SSSI-005	Beta - 548002	15.5-16.5	5.5-6.5 bmsl	Backbarrier	Marine organic sediment	Organic sediment	5468 - 5314 cal BP
DH28	SSSI-001	Beta - 551303	15.5-16.5	7.5-8.5 bmsl	Backbarrier	Marine organic sediment	Plant material	145 - 15 cal BP
DH28	SSSI-001 charred material	Beta - 552234	15.0-16.0	7.5-8.5 bmsl	Backbarrier	Charred material	Charred material	334 - 281 cal BP
DH30	SSSI 013	Beta - 532134	10.5-11.5	2.5-3.5 bmsl	Backbarrier	Lagoon sands containing some fine organic material	Organic sediment	12686 - 12550 cal BP
DH30	SSSI 014	Beta - 532135	18.5-19.0	10.5-11.0 bmsl	Lagoon	Silty sediment from coastal lagoon, possibly containing organic matter	Plant material	2539 - 2354 cal BP
DH30	SSSI 015	Beta - 532136	20.0-20.5	11.5-12.0 bmsl	Lagoon	Peat	Organic sediment	3259 - 3106 cal BP
DH30	SSSI 016	Beta - 532137	25.0-25.5	16.5-17.0 bmsl	Mid-Holocene alluvium	Sandy clay from lagoon, contains organics	Plant material	3694 - 3560 cal BP

have such low carbon content that there was a possibility that the samples "may yield spurious dates" (Patrick, personal communication 2020). These two samples were not processed further. Following pretreatment, one sample, from backbarrier sediments in DH29, was found to yield datable amounts of organic sediment, charred material and plant material. Dating of the plant material fraction yielded a date that appeared to be anomalous and subsequently the charred material was dated, yielding a result that more or less confirmed that provided by the plant material. Particle-size analysis by the US Army Corps of Engineers Soils Laboratory in Baltimore, Maryland was requested on three to five samples from each of seven split-spoon borings within the New Creek Drainage Zone (Appendix G). Additionally, five samples from three sedimentary facies in DH23 (backbarrier, lagoon, and stream-related facies) were submitted to the PaleoResearch Institute of Golden, Colorado for diatom identification and analysis.

The radiocarbon dates returned from within the lagoon sediments were consistently sequential (younger over older), suggesting continuing aggradation with no noticeable disturbance or overturning of sediments, although in several instances dates from similar depths below mean sea level at different testing locations differed by as much as 1,000 years, suggesting differences in evolutionary histories at those landscape positions.

The descriptions below begin with sediment columns at the southwestern boundary of the New Creek Drainage Zone (DH20) and proceed northeastward.

Two samples of peat from the upper portion of the lagoon sediments in DH20 (Map Station 177+00; NYSP Northing 147327.891/Easting 959984.953) were submitted for dating, pollen analysis and macrobotanical analysis. The lower sample, from 18.0 to 19.0 feet below surface (8.0 to 9.0 feet bmsl) returned a date of 3,060 – 2,875 cal years BP (Beta 532131). Pollen analysis revealed the presence of pollen that was most probably from local vegetation, including common sedges and grasses, cattail, water plantain (potentially including arrow-leaf) and alder. Arboreal pollen from surrounding forests were dominated by hickory and oak. Other taxa were represented by lower numbers of grains, and include hornbeam/hazelnut, beech, willow and elm. A small number of Sphagnum (semi-aquatic or bog-loving moss) spores were identified. Cretaceous age palynomorphs made up approximately 10 percent of the grains in this sample. Paleobotanical analysis revealed the presence of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)," phragmites rhizome fragments, grass (Poaceae) stems, unspecified insect body fragments and egg cases, and monocot (possibly cattail) root material.

A sample from 15.75 to 16.5 feet bs (5.75 to 6.5 feet bmsl) in the DH20 column returned a date of 728 – 664 cal years BP (Beta 532130). The provenance of this sample was approximately 1.75 feet below the upper boundary of the lagoon deposit, which was directly overlain by Late Holocene beach sand in DH20, with no overlying backbarrier sediments. The pollen assemblage was similar to that in the lower sample and included sedges, grasses, hickory, pine and oak, with smaller percentages of birch, hornbeam/hazelnut, chestnut, beech, Juniperus, wax myrtle, hop-hornbeam and elm. Very few reworked Cretaceous spores were present. Paleobotanical analysis of this sample produced the greatest concentrations of seeds of any of the eight samples submitted, with three taxa (knotweed family, rose family, and bulrush) identified, along with phragmites rhizome material, grass (Poaceae) stems and monocot root material (possibly cattail). The general matrix in which this material was "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

Four samples were submitted from the sediment column produced by GP10 (Map Station 202+00; NYSP Northing 149056.455/Easting 961779.884), 500 feet northeast of DH22. Two of these samples came from within the lagoon sediments and two samples from the deeper floodplain/channel bar sediments.

The deepest sample, from 27 to 28 feet bs (15.5 to 16.5 feet bmsl), was equivalent in depth and character (loamy medium sand containing some fine organic matter) to stream deposits identified in DH22. The sample yielded a radiocarbon date of 5,466 to 5,659 cal years BP (Beta 532145). Pollen spores in the sample were heavily oxidized and only a few highly degraded grains were noted. The palynological report attached as Appendix D states that the sediments "had likely been exposed to cyclic wetting and drying, resulting in the loss of most organics from the sediments. No Cretaceous age palynomorphs were present …, having likely suffered the same oxidation as did most Holocene grains and spores."

A sample from 24 to 25 feet bs (12.5 to 13.5 feet bmsl) was also consistent in depth and character with sediments identified as stream deposits in DH22 and in DH23, 500 feet northeast of GP10. The sample yielded a date of 3,899 to 4,085 cal years BP (Beta 532146). Pollen analysis results were identical to those for the previous sample – low count and poor preservation appeared to reflect a history of frequent wetting and drying cycles.

The lower lagoon deposit from GP10, peat recovered at 20.5 to 21.0 feet bs or 9.5-10.0 feet bmsl, returned a date of 2,600 – 2,492 cal years BP (Beta 532142). Grasses, hickory and pine were dominant in the pollen analysis; also present were non-arboreal species such as ragweed, goldenrod, Chenopodium/Amaranth and sedge. Minor woody species included alder, chestnut, beech, ash, Juniperus, Nyssa aquatica, hop-hornbeam and willow. The presence of pollen from ragweed, goldenrod, and members of the Chenopodium-Amaranth family may reflect disturbance on the landscape nearby.

Paleobotanical analysis of a sample of peat immediately overlying this at 19.75 to 20.0 feet bs identified phragmites rhizome material, grass (Poaceae) stems, monocot (possibly cattail) root material and unspecified insect body parts, all contained in a matrix of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

An overlying sample of peat (18.0-19.0 feet bs or 7.0 to 8.0 feet bmsl) was dated at 1,287 – 1,172 cal years BP (Beta 532140). This sample, also peaty in nature, was located 2.5 to 3 feet below the upper boundary of the lagoon deposits in this area; the lagoon sediments were overlain by three feet of backbarrier sands.

Pollen analysis of the sample dated at 1,287 – 1,172 cal years BP revealed that dominant pollen taxa included sedge and grass in the non-arboreal group, and chestnut, pine and oak among the arboreal taxa. The palynological report in Appendix D notes that "[n]on-arboreal types were scarce in this sample, and consisted of Fabaceae, Polygonum, and Rosaceae. Weedy taxa, including Asteraceae types and Cheno-Ams were absent from the assemblage. Arboreal elements present in low numbers includes Abies [fir] likely to have washed in from some distance, Betula [birch], Carya [hickory], Juniperus type, Picea [spruce], Salix [willow], and Tsuga [hemlock]. Overall, the GP 10 core reflects a typical deciduous forest." Paleobotanical analysis of a subsample from within this zone (18.0 to 18.25 feet bs) identified phragmites rhizome material, grass (Poaceae) stems, monocot (possibly cattail) root material and unspecified insect body parts, all contained in a matrix of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

An undated sample from between these dated samples in GP10 (11.0 to 11.5 feet bmsl) revealed much the same suite of arboreal and shrubby species, although the report in Appendix D notes that "[g]rasses in this sample were significantly reduced, from a 23.5 percent in Sample 21 to 6.5 percent occurrence. … Additional non-arboreal taxa noted includes Ambrosia, Cirsium, and sedge. … This sample is generally similar to the deeper samples from this core, though there is a notable decrease in grass pollen, with a corresponding slight increase in weeds and Cheno-Ams, possibly suggesting that human-caused disturbance had taken place in the area."

Five samples from DH23 were submitted to PaleoResearch Institute in Golden, Colorado, for diatom analysis. Diatoms are "unicellular, eukaryotic algae that are distinguished by the presence of a silica cell wall. They live in a wide variety of habitats, including soil, moss, damp rocks, caves, rivers, streams, ponds, lakes, bogs, lagoons, marshes, swamps, mud flats, salt and mud flats, estuaries, bays and oceans. .… Diatoms can be identified to species level and a large and growing body of information exists on the range and ecological tolerances of many of the common forms. They are often good indicators of water chemistry, depth, pH, salinity, habitat, substrate, nutrient concentrations and pollution levels. Because of their silica cell walls they are often preserved in sedimentary deposits, making them well-suited for use in paleoenvironmental reconstruction" (Appendix F). The attached specialist report notes that "[t]he diatoms found in these samples are a mixture of freshwater, brackish and marine species. Because these diatoms do not live in the same habitats, under the same environmental conditions they must be a combination of autochthonous (living at the place of deposition) and allochthonous (transported to the site from elsewhere by water, wind or birds) species. In coastal tide-influenced settings, influx by tidal currents and storm-driven winds can be significant, depending on the energy level of the site" (Appendix F).

The submitted samples were from the backbarrier sands, lagoon sediments and the underlying alluvial sediments. No dating was conducted on samples from DH23 but four dates from these same facies were obtained on samples from GP11, conducted immediately adjacent to DH23. Diatom analysis was pursued as part of this study in the hope that it might add to environmental interpretation of the various facies. The analysis results are somewhat disappointing in that several of the samples yielded few or no complete specimens.

Diatom Sample 1 was obtained within the upper zone of the backbarrier sands at 13.5 to 14.0 feet bs (3.5 to 4.0 feet bmsl). A sample of organic-bearing backbarrier sands from 12.0 to 13.0 feet bs in GP11 yielded a radiocarbon date of 967-899 cal years BP (Beta 532146). The diatom report states that "Sample one contained many small diatom fragments but only three complete or nearly complete valves. These are marine/brackish taxa, but they may very well have been transported to the site. The poor preservation is a result of chemical dissolution and mechanical destruction. Fragmentation may result from transport, but leaching, predation, diagenesis and compaction are also factors (Voss and de Wolf 1988). Reworking of older deposits also cannot be excluded" (Appendix F). Given the mode of deposition of backbarrier sands (overwash or breaching of the island core by waves during storms), the poor state of preservation of the associated diatoms suggests that they were allochthonous (transported to the sampling location from elsewhere via wave action) and/or were contained within sediments reworked within the backbarrier setting.

Diatom Sample 2 was recovered from the uppermost six inches of the lagoon facies at 15.5 to 16.0 feet bs (5.5 to 6.0 feet bmsl). Diatom Sample 3 was recovered from roughly the vertical midpoint of the seven-foot thick lagoon facies at 18.5 to 19.0 feet bs (8.5 to 9.0 feet bmsl). Radiocarbon samples from 16.0 to 17.0 feet bs and 19.0 to 20.0 feet bs in GP11 yielded dates of 1,714 to 1,565 cal years BP (Beta 532147) and 2,505 to 2,351 cal years BP (Beta 532148), respectively. According to the diatom report, "[t]hese two samples contained almost all whole diatom valves. The overwhelming dominant [species] in both of these samples is Diploneis interrupta (Kützing) Cleve, at 68% of the population in sample 2 and 72% in sample 3. Two other species were relatively common. Diploneis smithii (Brébisson) Cleve accounted for 13% of the population in sample 2 and 9% in sample 3. Paralia sulcata (Ehrenberg) Cleve comprised 8.4% of the valves counted in sample 2 and 6% of those counted in sample 3. …. Voss and de Wolf (1988) …. defined the ecological habitat of the "Diploneis interrupta Group" as benthic [related to lake- or sea-bottom environments or sediments], epipelic [growing in mud or at the interface between water and sediment], and aerophilic on supratidal mud that is irregularly flooded ….; and the sedimentary environment as a supratidal salt marsh or periodically dry pool within a back levee marsh."

"Diploneis smithii is a marine/brackish epipelic species that was common in estuarine sediment cores collected in the Pamlico and Neuse River estuaries of North Carolina, increasing in abundance after about 1725, with European land clearance (Cooper et al. 2010). Paralia sulcata is a brackish/marine coastal, littoral, planktonic and benthic diatom with a broad salinity range, found on rocks, sand and macroalgae. It is abundant in tidal mud flats and salt marshes, very common in cool, temperate and tropical estuarine waters, in both littoral and sublittoral zones, prefers well-mixed, nutrient-rich highly saline water, often a bottom dweller, usually associated with sandy habitats, but also thrives in fine-grained sediments, and has fairly wide tolerance ranges for many ecological values. It is a robust diatom that survives transport better than many species and may have been living at the site or washed in with high tides; therefore, it is not useful in identifying a particular paleoenvironment" (Appendix F).

Diatom Sample 4 was obtained from the lowest one foot of the lagoon facies, at 21.0 to 21.5 feet bs (11.0 to 11.5 feet bmsl) and Diatom Sample 5 from the uppermost alluvial sediment facies at 22.5 to 23.0 feet bs (12.5 to 13.0 feet bmsl). Carbon-bearing sediment from 22.0 to 22.5 feet bs in GP11 yielded a radiocarbon date of 3271 to 3140 cal BP (Beta 532150). The PaleoResearch report states that "[o]nly four diatom fragments were observed in Sample 4 and no diatom remains were found in Sample 5. It is interesting to note that the sediments from the freshwater floodplain underlying the coastal lagoon, represented by Sample 5, yielded no diatoms, while the lower coastal lagoon sediments, represented by Sample 4, yielded only a few diatom fragments."

By way of interpretation, the PaleoResearch report concludes that "[e]stuarine and shallow coastal environments are highly dynamic because they change configuration relatively frequently due to variations in winds, tides, and river discharges, and are open systems, actively exchanging materials and energy with adjacent systems (Trobajo and Sullivan 2010). In Samples 2 and 3, the two most abundant diatoms, Diploneis interrupta and Diploneis smithii, are benthic species that were most probably living where they were collected. The environmental characteristics of these two species provide the best interpretation of the paleoenvironmental setting."

"Although sedimentation patterns within estuarine systems are extremely variable in both space and time (Cooper et al. 2010), the similarity in diatom composition of Samples 2 and 3 means that the paleoenvironments represented by these samples, collected from the upper and middle zones of the coastal lagoon sediment, respectively, must have been quite similar in terms of salinity, moisture (frequency and duration of submergence) and substrate composition. The most likely paleoenvironment was probably a very shallow salt marsh or vegetated mud flat that was emergent part of the time. The alkalibiontic preference of the two most abundant diatoms implies that the pH of the water may have been above 7 when these diatoms were growing. The remaining species are usually found in circumneutral or alkaline water."

GP11 was located adjacent to DH23 at Map Station 206+88, 488 feet northeast of GP10. The Geoprobe coring was conducted primarily to obtain suitable samples of target sediments identified in DH23. Four samples from GP11 were submitted for sampling, one from the backbarrier sediments (described above), two from the lagoon sediments and one from the underlying stream channel/floodplain sediments.

The sample of stream-associated sediments was obtained from the upper one foot of that facies at 22.0 to 22.5 feet bs (12.0 to 12.5 feet bmsl) and yielded a date of 3,140 to 3,271 cal years BP (Beta 532150). As with the stream-derived sediments in GP10, pollen analysis revealed that no intact Holocene pollen was present (while "a very few" Cretaceous palynomorphs were present) and that the sediments "were likely to have been exposed to cyclic wetting and drying after their deposition, resulting in the loss of organic materials, including pollen."

A sediment sample overlying this, at 20-21 feet bs (10-11 feet bmsl) was obtained from within the boundary zone between stream-derived sediments and the overlying freshwater wetland/basal lagoon deposits. This sample was undated but is assumed to fall in age between the underlying 3,140 to 3,271 cal years BP date and a date of around 2,505 – 2,351 cal years BP for overlying sediment at 19.0 to 20.0 feet bs (9.0 to10.0 feet bmsl). Pollen preservation was described as "only fair, as reflected by the sample's low concentration value of 700 grains per gram. Ordinarily, a sample with a value this low would not have been counted, and the numbers reflected in the sample assemblage should be viewed with caution. Weedy or disturbance type taxa were particularly common in [the sample] and include Ambrosia, Solidago, sedge, and grasses. Additional non-arboreal types noted in the sample include Fabaceae, Polygonaceae, Rosaceae, and Typha/Sparganium. Common arboreal types include Carya, Pinus, and Quercus, with lesser numbers of Anacardiaceae, Betula, Castanea, Cornus, Ilex, Juniperus type, Liquidambar, and Platanus, with one Osmunda and three Sphagnum spores. The presence of numerous Foramenifera tests in the residue from this sample indicates that the pollen and sediments were likely to have been deposited in a marine setting. The overall environmental picture presented in [the sample] is a marshy area, perhaps with some clearing in the immediate area, surrounded by typical deciduous hardwood forests."

A sample of peat from lagoon sediments at 19.0 to 20.0 feet bs (9.0 to10.0 feet bmsl) was dated with 74.9% certainty to 2,505 – 2,351 cal years BP (Beta 532148), which corresponds closely to a date of 2,600 – 2,492 cal years BP for peat from the same depth below sea level in GP10. Pollen analysis found that the sample "contained reduced numbers of herbaceous taxa [in comparison to a sample from the underlying stream channel/floodplain facies dating to 600-700 years earlier] with six percent grass pollen representing the only taxon present in more than a two percent occurrence." Also represented were ragweed, Chenopodium-Amaranthus and rose. Arboreal pollen types were fairly common, represented by hickory, chestnut, pine and oak. Other arboreal grains identified included sugar maple, Juniperus type, sycamore and hemlock. The palynological report notes that "A large quantity of particulate charcoal in this sample hints at burning in the area, perhaps by native populations, though the generally small size of the charcoal fragments indicates that the carbon may be blowing in from some distance from the region. As sedge pollen is lacking in this sample, it is apparent that the environment of deposition changed since the previous deposits accumulated."

A subsample from within this sample was submitted for paleobotanical analysis, resulting in identification of phragmites rhizome material, grass (Poaceae) stems, monocot (possibly cattail) root material and unspecified insect body parts, all contained in a matrix of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

A sample of peat from lagoon sediments three feet higher in the GP11 column (16.0 to 17.0 feet bs or 6.0 – 7.0 feet bmsl) yielded a date of 1,714 – 1,565 cal years BP (Beta 532147). The pollen suite was dominated by pine, oak, and hemlock, with lesser representation of sugar maple, chestnut, hornbeam/hazelnut, spruce, hop-hornbeam and Juniper type. Non-arboreal species represented in the assemblage included ragweed, goldenrod, Chenopodium-Amaranthus, sedge, Liliaceae, grass, rose and cattail/bur-reed, in all cases represented by an occurrence of 3.5 percent or less. One Sphagnum and two Osmunda spores were also noted in this sample. The palynological report notes that "[i]nterestingly, Carya pollen was absent from this sample. Carya pollen is often considered to be a fairly fragile grain, though other fragile grains were present in the sample, including Liliaceae and Typha/Sparganium, Acer, and Ostrya suggesting that poor pollen preservation is not an issue with this sample. … While small scale differences within the non-arboreal group are present, suggesting that local conditions around the environment of deposition have changed, the forest composition surrounding the area has remained fairly constant."

A subsample from within this sample was submitted for paleobotanical analysis, resulting in identification of phragmites rhizome material, grass (Poaceae) stems, monocot (possibly cattail) root material and unspecified insect body parts, all contained in a matrix of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

The uppermost sample from GP11 was obtained from the upper foot of the three-foot thick backbarrier facies, at 12.0-13.0 feet bs (2.0-3.0 feet bmsl) and yielded a date of 899 to 967 cal years BP (Beta 532146). The pollen analysis report states that "[p]ollen preservation in this sample was good, and the non-arboreal types were dominated by Ambrosia, Cheno-Ams, and grasses, with lesser numbers of Solidago, and high spine Asteraceae, Alismaceae, sedge, and Fabaceae. Arboreal grains in [this sample] were made up largely of Carya, Pinus, and Quercus, along with lower numbers of Acer saccharum, Alnus, Betula, Carpinus, Castanea, Fagus, Juniperus type, Salix, Tilia, and Tsuga. One Osmunda spore was also noted in the sample. This sample fits the pattern established by the other Core GP 11 samples with a pond or lagoon-like environment of deposition, surrounding by a typical eastern deciduous forest. The samples overall represent a sequence covering the period from 3,271-3,140 BP to 967-899 BP and presents a fairly consistent picture of the local and regional environment."

A subsample from within this sample was submitted for paleobotanical analysis, resulting in identification of phragmites rhizome material, grass (Poaceae) stems, monocot (possibly cattail) root material and unspecified insect body parts, all contained in a matrix of "unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter)."

Split samples from a single provenience in GP12 (Map Station 231+95), 2,507 feet northeast of GP11, were submitted for radiocarbon dating and pollen analysis. The sample of loamy fine sand containing very fine organic material, retrieved from the lower zone of lagoon deposits at a depth of 24.0 to 25.0 feet bs (14.5-15.5 feet bmsl) returned a date of

3,511 – 3,381 cal years BP (Beta 532151). Pollen analysis indicated that pollen preservation was excellent. Dominant species represented included grasses, birch, hickory, pine and oak. Non-arboreal species were scarce in the sample, represented by low numbers of ragweed, goldenrod and high spine Asteraceae (aster family), as well as by a few sedges and a single grain of rose pollen. Arboreal pollen types present in lower numbers included hornbeam/hazelnut, chestnut, beech, ash, walnut or butternut, sycamore, willow, hemlock, basswood or yellow poplar and Juniper type. Also noted were two fern spores and one Sphagnum spore. Somewhat atypically in comparison to other samples, Cretaceous-age spores were absent from the sample. The report notes that "the pollen assemblage from [this sample] represents a forested region with little apparent disturbance or clearing near the sampling location."

Two samples of backbarrier sands, one each from DH26 and DH27, yielded what appear to be anomalously old dates. The sample of organic-bearing fine sand from DH26 originated at three feet below the upper boundary of the nine foot-thick backbarrier facies (15.5 to 16.0 feet bs or 5.4 to 5.9 feet bmsl) and yielded a date of 7,618 to 7,759 cal years BP (Beta 532132). The sample of similar material from DH27 came from five feet below the upper boundary of the eight-foot thick facies there (15.5 to 16.5 feet bs or 5.5 to 6.5 feet bmsl) and yielded a date of 5,314 to 5,468 cal years BP (Beta 548002). The age of these samples is discussed further in Chapter 6.

By contrast to these anomalously old dates, a sample of backbarrier sands from DH28, 1,000 feet northeast of DH27, yielded a young, but explicable, date. The sample of fine sand containing organic matter was recovered from 15.5 to 16.5 feet bs (7.5 to 8.5 feet bmsl). Following pretreatment by Beta Analytic, this sample yielded datable fractions of organic sediment, plant material, and charred material. Dating of the plant fraction yielded a result of 145-15 cal years BP. Following this, the charred fraction was processed and returned a date of 334-281, broadly in keeping with the first date in that the charred material may have come from a long-lived tree, in contrast to short-lived grasses or herbaceous plants assumed to have provided the younger date. Three samples from within the lagoon deposits of DH30, 4,525 feet northeast of GP12 were submitted for radiocarbon dating and pollen analysis. This is the northernmost sampling location in which lagoon sediments were identified. All dates are discussed further in Chapter 6.

The deepest sample, sandy clay containing fine organic matter from a depth of 25.0-25.5 feet bs (16.5-17.0 feet bmsl) yielded a date of 3,694 – 3,560 cal years BP (Beta 532137). Like each of the three lagoon samples from this location, the pollen suite in this sample was dominated by sedges and grasses in the non-arboreal component, with hickory, beech, pine oak and willow making up the bulk of the arboreal types. Chestnut, button bush, holly or winterberry, willow, walnut or butternut, sweet gum, sweet gale/wax myrtle, hop-hornbeam, Juniper type and hemlock were also represented. The palynological report notes that "[m] ost of these taxa probably represent local plants; the consistently high presence of Carya [hickory], and relatively high numbers of Fagus [beech] argue that these plants were indeed local to the core environment." Also present were "[n]on-arboreal elements in [the sample] contain few grains that suggest any local disturbance. [The sample] also contained four Typha/ Sparganium and five Typha latifolia [both from the cattail family] grains. These plants would probably not be expected in a high energy environment, suggesting that the environment of deposition might have been a lagoon or pond. These samples represent the highest percentages of Typha spp. in the Staten Island samples, however, Typha counts remain fairly low suggesting that cattails were not common plants in the area. ... Sphagnum was represented by one spore, while 12 Osmunda [fern] spores were noted, likely signaling a nearby shaded forest. … Cretaceous palynomorphs were rare in the sample."

Next highest in the column was a sample of peat obtained at 20.0 to 20.5 feet bs (11.5-12.0 feet bmsl) which yielded a date of 3,259 – 3,106 cal years BP with 79% certainty. The pollen analysis suggested a very similar setting and, as noted for all of these samples, the pollen suite in this sample was dominated by sedges and grasses in the non-arboreal component. The non-arboreal types also included the water-plantain family (possibly arrow-leaf), high spine Asteraceae (possibly including aster and/or sunflower), Fabaceae (pea and bean family, including sweet-peas), Liliaceae, Rosaceae, and both Typha/Sparganium and Typha latifolia. Arboreal taxa included birch, chestnut, button bush, holly or winterberry, Juniperus type and Rhamnaceae. The palynological report notes that "Cretaceous age palynomorphs were very common in the sample and represented perhaps 50 percent of grains present in the sample. … Interestingly, Cephalanthus, an ordinarily rare pollen type, was present in both [this and the previous sample] but was otherwise absent from all other assemblages in this project. Cephalanthus or button bush is known to occur in dense thickets surrounding lakes and ponds. Typha, Alismaceae, Myrica, and Salix all favor a lakeside setting, suggesting that the sediments from Core DH30 may have been deposited in a pond or lake environment."

A fragment of wood recovered from this depth (20.0 to 20.5 feet bs; 11.5-12.0 feet bmsl) was submitted for paleobotanical analysis. The approximately 6.6-gram wood fragment was uncharred but had been compressed and distorted by the weight of overlying sediment. The paleobotanical report states that that "[t]axonomic identification was inconclusive, but the specimen was deciduous, with pores compact and solitary or in radial multiples. The specimen compared favorably in some respects to Diospyros virginiana [persimmon], Carya [hickory], and Juglans [walnut/butternut] species." Hickory and walnut/butternut pollen were not reported for the associated sample, though both were reported for the underlying sample (16.5 to 17.0 feet bmsl; 3,694 – 3,560 cal years BP) and hickory pollen was present in an overlying sample from this boring (10.0-10.5 feet bmsl; 2,539 to 2,354 cal years BP). Pollen of both species was also reported for a sample at 14.5 to 15.5 feet bmsl in GP12, dated at 3,511 to 3,381 cal years BP, and hickory pollen was reported in samples from GP5, GP10 and GP11.

The uppermost lagoon sample from DH30 was silty clay containing fine organic matter, obtained at 18.5 to 19.0 feet bs (10.5-11 feet bmsl). The sample yielded a date of 2,539 – 2,354 cal years BP (Beta 532135). The non-arboreal component of the pollen assemblage was similar to the two underlying samples and included ragweed and goldenrod, polygonum and cattail. The arboreal suite included birch, hornbeam/hazelnut, chestnut, ash, holly or winterberry, sweet gale/wax myrtle and Juniper type. The palynological report states that "[these] sediments were apparently different [from the previous sample]; Cretaceous spores were absent…, and the sample also showed an increase in both Carya [hickory] and Quercus [oak] grains with a simultaneous decrease in both sedge and grass grains. These differences might be minor, though, and a change in sediment deposition or formation might account for these slight variations between samples."

Chapter 6

GEOMORPHOLOGICAL AND PALEOENVIRONMENTAL SYNTHESIS

A. OVERVIEW

Throughout the terminal Pleistocene and early Holocene the setting of the present-day Staten Island shoreline between the Verrazzano Narrows and Great Kills Park – now coastal beach and coastal marsh bordering the Lower Bay – was a low, gently undulating upland at the head of the outwash plain, lying at the base of Todt Hill and many miles from the coast. The distance from the coast steadily decreased over the succeeding millennia as the return of glacial meltwater raised the global sea level. In the period immediately following ice recession, stream systems established themselves on the outwash plain, carrying flow derived from meteoric inputs (rain and snow) and shallow groundwater, including that produced by melting of permafrost on the terminal moraine and the upland above it. Some of the post-glacial surface flow may have exploited hollows already established by waning meltwater discharges.

Initially, these streams, flowing across a landscape of unconsolidated outwash and having a relatively low base level (the channel of the ancestral Hudson River), undoubtedly incised rapidly and probably occupied relatively straight channels and hollows. As noted previously, the presence of Cretaceous-age clay beds or outwash beds of coarse gravel and cobbles may have impeded incision in some areas. Historic maps (e.g., Taylor and Skinner 1781 [see above Figure 4.1]) show at least 12 first-order streams flowing from the terminal moraine in the northeastern end of the project alignment (New Creek Drainage Zone) and at least two second-order streams, Mill Creek and Bass Creek, flowing through the southwestern end (Oakwood Marsh Zone). Some of the northeastern first-order streams undoubtedly combined to form larger second-order streams before passing across the project alignment. The configuration of the upper reaches of these streams suggests that throughout the terminal Pleistocene and the first half of the Holocene four or possibly five active channels would have cut through the project alignment in the northeastern two miles of its length, from around the location of DH20 to the base of the Fort Wadsworth upland. The hollows of these streams, along with those of Bass Creek and Mill Creek and their tributaries, would have been separated by low interfluves of intact outwash, with a higher and wider interfluve between the two drainage basins formed by the New Dorp Upland Zone. These streams would have flowed into the ancestral Hudson and Raritan Rivers. The courses of those flowing to the ancestral Hudson River would been shortened once the breakthrough at the Narrows occurred, establishing a Hudson channel closer to the project alignment.

As the regional climate ameliorated following recession of the ice front, the project vicinity – including the interfluves between the streams – would have become vegetated; initial vegetation would have been grasses and woody herbs and shrubs, including dryas. Pioneer species of trees were probably alder, willow and dwarf birch in stream hollows. Unfortunately, no pollen-bearing samples dating to this period were recovered along the project alignment. With the passage of time, regional forest succession would have been generally as described in Chapter 2C: an open, parkland setting with spruce as the dominant tree on uplands transitioning to denser spruce forests; in-migration of other conifer species such as pine; transition to mixed deciduous-conifer forests; and, ultimately, dominance of deciduous species, with smaller components of conifers.

Streams flowing across the project alignment have been important agents in the evolution of the landscape and have also undergone extensive and dramatic evolution themselves. Nearly all of these streams rise (i.e., have their origin) on the distal, eastern face of or just below the Wisconsinan terminal moraine. In general, they rise within one to one-and-a-half miles west of the present-day coastline. An exception is the main headwater stream of New Creek, which has a length of three miles above the point at which its flow reaches the Lower Bay. The headwater stream has a much larger drainage basin than most of the streams in the immediate area, extending into an embayment in the moraine and draining a large, broad hollow that is the site of Moravian Cemetery. The stream flows almost directly southwest along the base of the moraine for almost half its channel length before turning southeast toward the coast.

The early history of the streams in the project vicinity – as free-flowing streams incising and establishing hollows on the outwash plain – has been discussed above. By the time of European arrival, early maps show all of the streams as relatively short and truncated, flowing for only a brief distance before entering coastal marshes. Toward the northeastern end of the project alignment, drainage was to the impounded marshy area lying west of the barrier beach. From this marsh, the combined flow of all of the streams exited to the Lower Bay via the mouth of New Creek. At the southwestern end of the project alignment, Mill Creek and Bass Creek flowed to and, to some extent, through the Great Kills marsh.

This transition from extended, free-flowing streams to truncated drainages ending in marshes occurred in several phases. As late as the early Middle Holocene, these streams were almost certainly still flowing in relatively straight channels through forested, low-relief landscapes.

As rising sea level produced a rise in base level for the streams in the latter half of the Holocene they would have taken on a more meandering form, broadening their hollows as they incised laterally. This period probably also marked the beginning of aggradation of the floors of the hollows, as sediment stored there by the streams undid some of the earlier vertical incision. Floodplains would have been more expansive in the broadening hollows than was formerly the case, although migration of meander bends may have made the floodplains subject to some reworking.

Continuing sea level rise would have initially resulted in formation of freshwater wetlands in the stream hollows as outflow became impeded by rising base level. These would have transitioned over time to brackish and tidal wetlands and, in the northeastern part of the project alignment, ultimately to full tidal lagoon conditions as the barrier island impinged on the coastal zone and took on its current form as a barrier beach. There appears to be no evidence that a barrier beach formed in the Great Kills area and thus no lagoon emerged. Formation of a long, narrow spit in this area, however, has most likely redirected the course of Bass Creek further to the southwest. In all likelihood, Bass Creek – which now flows southwestward into the marsh, parallel to the landward side of the spit – formerly pursued a course more directly south or southeast.

B. OAKWOOD MARSH ZONE

The Late Wisconsinan outwash plain toward the southwestern end of the project alignment – the area identified here as the Oakwood Marsh Zone – appears to have been downcut over the course of the late Pleistocene and the Holocene by flow from what are now called Mill Creek and Bass Creek, along with several unnamed first-order streams draining the face of the terminal moraine. The resulting embayment appears never to have been completely sealed by encroachment of a barrier island and barrier beach as was the case with the New Creek drainage. Thus, no true lagoon deposits were encountered in testing in this area, where deposits were more in keeping with estuarine and coastal marsh settings.

A prominent Late Holocene spit lies between much of the coastal marsh and the open bay. This is probably the latest iteration of a spit which transgressed landward with rising sea level in much the manner as would occur with a true barrier island. Presence of the spit, produced by longshore currents moving northeast to southwest, may be related to the obstruction formed by the very slight topographic rise of the coastal and nearshore portion of the New Dorp Upland. Presence of the spit has almost certainly resulted in the diversion of the middle and lower reaches of Bass Creek within the Late Holocene from a more southerly or southeasterly flow to the southwesterly flow that is indicated on early historic maps, paralleling the landward side of the spit. Bass Creek is now a tidal creek and lies entirely within the marsh, with a course that is difficult to discern.

Aside from what is almost certainly a weathered subsoil profile seen in DH2, no evidence of intact, stable, developed soil profiles was seen in the Oakwood Marsh Zone. As described above, the subsoil identified in DH2 was initially identified in a spoon advance from 5.0 to 6.5 feet bs, with the preceding interval from 4.0 to 5.0 feet bs (8.25 to 9.25 feet amsl) in an unsampled auger advance. It cannot be ruled out that an intact A horizon, overlain by four feet of sandy fill, was present in the unsampled interval. The subsoil, from 5.0 to around 8.0 feet bs, was heavy silt loam exhibiting many medium distinct redoximorphic mottles and containing a small amount of weakly weathered gravel. The underlying C horizon from eight feet to 33 feet bs (approximately 20 feet bmsl) was to 2.5YR3/3 stratified fine, medium and coarse sand – loamy in some strata – containing varying amounts of fine and very fine gravel. This entire profile – from around four feet to 33 feet bs – is interpreted as being made up of Mill Creek deposition, recording incision into and reworking of outwash plain sediments, followed by aggradation that was, in part, a product of rising Holocene sea level and Mill Creek base level. The only evidence of surface stability was seen in the upper profile; no evidence was seen of buried A horizons within the lower profile. Coarse and medium 7.5YR3/3 to 3/4 sand with very fine to medium gravel underlying the C horizon (and beginning at around 20 feet bmsl) is interpreted as intact outwash forming a 2C2 horizon. The 2C2 horizon extended to the base of excavation at 51.5 feet bs (38 feet bmsl).

Monitoring of DH6 for this study commenced when boring had proceeded to 34 feet bs (23 feet bmsl) and 11-12 feet below the base of fill. Thus, the upper profile cannot be interpreted here. Recovery beginning at 35 feet bs (24 feet bmsl) consisted of largely undifferentiated 5YR3/3 sand with fine and medium gravel, all fining somewhat with depth. Clay, sand and sandy clay interpreted to be of Cretaceous age was encountered at 57.5 feet bs (46.5 feet bmsl), following an unsampled 3.5-foot auger advance. Given the general uniformity of the sandy sediment from 24 to at least 43 feet bmsl, this material is interpreted as intact outwash. The Cretaceous-age sediments extended to the base of excavation at 119 feet bs (108 feet bmsl).

In both DH7 and DH8 fill extended from surface to sea level, below which was organic material (meadow mat), with an increasing content of mineral soil with depth. Recovery beneath the meadow mat, from 5.5 to 9.5 feet bmsl in DH7 and 5 to 7.5 feet bmsl in DH8 was heavily reduced (5Y3/1) very gravelly loam and loamy coarse sand.

Beneath this, recovery to 27 feet bmsl in DH7 and to 22 feet bmsl in DH8 was 2.5YR2.5/2 to 5YR2.5/2 fine and medium sand with varying (small) amounts of very fine gravel, coarsening in the lower few feet to medium and coarse sand with fine and medium gravel. This material is interpreted to be early post-glacial through Holocene alluvium and undoubtedly includes a large element of marine sand in the upper strata. Recovery to 42 feet bmsl in DH7 and to 44 feet bmsl in DH8 was predominantly 7.5YR3/2-3/4 fine and medium sand with varying (small) amounts of fine and very fine gravel. As in DH2 and DH6, this material is interpreted as Late Wisconsinan outwash. Below these depths in both borings, an abrupt change to Cretaceous-age light gray and light yellow-brown thinly bedded sand with clay stringers and beds was encountered. Carbon-bearing samples of this material from around 51-52 feet bmsl (DH7) and 67-67.5 and 77-77.5 feet bmsl (DH8) all returned carbon-dead results of greater than 43,500 years. Pollen analysis of several of these samples revealed a lack of Quaternary pollen.

In DH10, sampling had proceeded to a depth of 61.5 feet bs (58 feet bmsl) at the time monitoring for this study began. Examination of geologic sample jars from the overlying profile suggested that Cretaceous sediments were encountered at around 32.5 feet bmsl. Cretaceous clays and sands extended to the base of excavation at 136.5 feet bs (133 feet bmsl).

Three sediment samples were submitted for both radiocarbon dating and pollen analysis. These analyses were conducted in hopes of finding a boundary between Cretaceous clays and sands and any overlying late Pleistocene clays and sands of similar character that might be present, related to downcutting of the Cretaceous sediments by meltwater or post-glacial streamflow. The uppermost sample, from 48.0 to 48.7 feet bs, returned a carbon date of greater than 43,000 BP (Beta 532127). Samples from 55.0 to 55.5 feet bs and 67.5 to 68.25 feet bs returned dates of 44,381 to 42,881 cal years BP (Beta 532129) and 47,022 to 44,836 cal years BP (Beta 532128), respectively (Appendix C).
Given the radiocarbon-dead result of the sample at 48.0 to 48.7 feet bs, Mr. Ron Hatfield, president of Beta Analytic, stated "[g]iven the geological setting and that you have the dead date so far above the one finite and one near dead / dead, I'd say that…, lacking any evidence to the contrary regarding any dislocation of organics or movements of humic acids horizontally through the profile that they [Beta 532128 and Beta 532129] should both be considered as Radiocarbon dead."
Pollen analysis of the three samples revealed that, "though near perfectly preserved Cretaceous palynomorphs were abundant in all samples," Quaternary-age pollen was absent from all samples (Appendix D).

In DH10A, a thin (< 1 foot) layer of fill overlaid peaty organic matter and organic-rich silt and silty clay to 8 feet bs (4.3 feet bmsl), overlying very gravelly loam to 11.5 feet bs (around 8 feet bmsl). Beneath this, recovery to around 30.5 feet bs (around 27 feet bmsl) was fine and medium 2.5YR3/2 to 3/3 sand, loamy in some strata, and containing a small amount of very fine to medium gravel; thick to very thin bedding was evident in most samples. Color changed to 7.5YR at 30.5 feet bs (around 27 feet bmsl), as seen at depth in several previous borings. Boring was halted at 36.5 feet bs; no stratified clays and sands, as seen at greater depth in previous borings, were encountered.

As stated previously, only one example of a preserved developed soil profile (in DH2) was identified within the Oakwood Marsh Zone, which encompassed DH1 through 10A. Sediments recovered landward of there in DH1, within the hollow of Mill Creek, suggest that this setting was generally too dynamic to allow formation of stable floodplains; at a minimum, this is true at the sampling location itself. The three to four feet of weathered heavy silt loam encountered beneath fill in DH2 is interpreted to be Mill Creek floodplain of Holocene (probably Middle or early Middle through Late Holocene) age. The heavy silt loam texture indicates deposition by low energy floods, though the presence of a small amount of gravel suggests that the area was occasionally swept by higher-energy floods. Seaward from DH2, no monitoring of the upper profile was carried out between DH2 and DH7, a span of 4,370 feet. Thus, the extent of the developed profile east of DH2 cannot be clearly defined except to say that no such stable profile was present in the DH7 or DH8 profiles.

The profiles of borings DH7, DH8, and the upper profile of DH10A (excavated only to 36.5 feet bs) were very similar, as were the monitored lower profiles of DH10 and DH6. The general pattern included the presence of sands and clays interpreted to be of Cretaceous age beginning at 42 to 46 feet bmsl in DH6, DH7, and DH8 and at 32.5 bmsl in DH10. The shallower depth to the Cretaceous sediments in DH10, coupled with the fact that similar material was encountered at around 25 feet bmsl in DH23, suggests the possibility that greater scouring by glacial meltwater and outwash took place at the extreme southwestern end of the project alignment (Great Kills area) where the meltwater flows may have been confined on the west by the base of the terminal moraine.

Sand and gravel overlying the Cretaceous sediments, varying in thickness from 15 to at least 18 feet, is interpreted to be Late Wisconsinan outwash. This material, identified in borings DH2, DH7, DH8 and DH10A is almost certainly a remnant of a much thicker deposit; truncation of the outwash in this area is a result of post-glacial incision by Mill Creek, Bass Creek, and several smaller streams. Stratified fine and medium sand and gravel overlying the outwash – ranging in thickness from 15 to around 29 feet – is interpreted here to be post-glacial through Late Holocene stream alluvium. In the borings closer to the modern coastline, this almost certainly includes marine sands in the upper few feet. No evidence was seen in these alluvial sediments suggesting the presence of any stable, weathered profiles or stable former surfaces.

In DH7, DH8 and DH10A, a stratum of very gravelly loam and loamy coarse sand was present in the upper profile, overlying the well-sorted stream alluvium and directly beneath several feet of organic meadow mat. When this stratum was first encountered in DH7, where it was four feet thick and extended to 9.5 feet bmsl, the presence of a small amount of angular and subangular gravel led to a tentative identification as early historic fill, possibly an eroded remnant of roadbed. Presence of a similar stratum in DH8, 2.5 feet thick and extending to 7.5 feet bmsl, did not seem to entirely rule this out. However, the stratum was also identified in DH10A, roughly 3.5 feet thick and extending to 8 feet bmsl. Fine plant material from within the stratum (3.5 to 4 feet bmsl) in DH7 returned a date range of 1,744 to 1,605 cal years BP (85.6%) to 1,812 to 1,750 cal years BP (9.8%). Both the poorly-sorted, loamy texture and the high gravel content are somewhat remarkable when compared to the vast majority of samples from throughout the overall project alignment. This material is now interpreted as a product of Bass Creek and/or one of its tributaries – poorly-sorted bedload material deposited as channels aggraded and became prone to migration as a result of sea level rise and loss of gradient.

C. NEW DORP UPLAND ZONE

The New Dorp Upland Zone comprises the testing locations of DH11 through DH19A. In DH11 through DH15, silt loam to very fine sandy loam horizons were present within the upper profile. In DH13, DH14 and DH15 the silt loam horizon was overlain by several feet of fine and medium sand, a product of Late Holocene wind- and wave-borne deposition along with modern beach maintenance and sand berm construction. In DH11 and DH12, at a greater distance from the modern shoreline, no discrete cap of sand was observed, although a 2 to 3-inch-thick organic mat overlying the surface contained some fine sand.

In borings DH11 through DH15, the upper three to five feet of subsurface below the silt loam horizon was gravelly to very gravelly loam to heavy silt loam. Gravel content was as high as 30 to 40%, particularly in the upper portion of this zone, which overall was three to five feet thick. This constituted some of the highest gravel content seen throughout the entire project alignment. Concentration of gravel in this zone is interpreted to be a result of early post-glacial deflation of the unvegetated surface by wind, possibly including katabatic winds draining from the persistent ice sheet to the north. Thickness of the deflated gravelly zone may be attributable to ongoing cryoturbation as deflation was occurring. The silty to very fine sandy horizon overlying the gravelly sand is interpreted to be a product of later (terminal Pleistocene and Younger Dryas to very Early Holocene) aeolian deposition, probably including silt lifted from exposed glacial lakebeds to the west and northwest. Biomantle formation (upward transport of individual soil particles from lower in the profile by invertebrates) may also have contributed.

The relatively small size and some deformation of the samples retrieved by the split-spoon make extensive description of soil characteristics problematic. However, the clay content of the gravelly subsoil, along with evidence of clay accumulation in soil pores and on ped faces led to a field identification of this as a Bt horizon, indicating long-term stability. Some redoximorphic mottles and variegation were also noted, evidence of weathering and biotic activity. In all of the probes, the weathered Bt horizon extended to around three to four feet bmsl. The general thickness of the Bt horizon, along with around one foot of silty to very fine sandy A horizon, suggests an overall thickness of four to six feet for the weathered profile, in keeping with developed profiles on other Late Wisconsinan outwash plains in the Northeast. The weathered subsoil extended to a general depth of three to five feet bmsl. The gravelly Bt horizon gave way with depth to faintly weathered (potentially a BC or CB horizon) and then to unweathered 2.5YR and 5YR fine and medium sand with fine and medium gravel (C horizon). Some bedding was evident. Colors at the greatest depths tended to fall into the 7.5YR class.

The area sampled by DH11 and DH12 lies just within the northeastern edge of the Great Kills phragmites marsh at elevations of 3.9 feet amsl for DH11 and 3.3 feet amsl for DH12. The area is vegetated in grasses and sedges in contrast to the surrounding phragmites monoculture. Within the phragmites, standing water was present at the time of testing; within the grassy opening, the surface was spongy underfoot and water was encountered within a few inches of the surface. This area is shown on the 1781 Taylor and Skinner map as the edge of fast land, verging on the marsh (see above, Figure 4.1). On the 1895 U.S. Coast Survey map it is depicted as one of several small "islands" of drier ground within the marsh, all more or less circular and appearing to represent the remaining subaerial portions of otherwise submerged knolls or rises (see above, Figure 4.27). In the case of DH11 and DH12, the landform appears, based on the historic maps and the modern configuration of phragmites growth, to constitute a sort of peninsula lying between the headwater drainage of Bass Creek to the east and the drainage of a first- or second-order Bass Creek tributary extending a short distance north.

The Late Holocene through modern sand cap in DH13, DH14 and DH15 varied in thickness from three to six feet. Beneath this, brick and concrete were recovered within the silt loam horizon at 6 feet bs (2.8 feet amsl) in DH14 and at 3 to 4 feet bs (2.8-3.8 feet amsl) in DH15. GP5 was conducted midway between DH14 and DH13 (Map Station 111+95) at an opening elevation of 8.8 feet amsl, equivalent to that at DH14. Radiocarbon dating of the upper profile yielded dates of 144 to 216 cal years BP (Beta 532138) at 2.3-2.5 feet bs (6.0 to 6.3 feet amsl and roughly at the base of overlying berm sand) and 937-1,063 cal years BP (Beta 532139) for a dark organic zone at 5.0-6.0 feet bs (2.8-3.8 feet amsl). Results of pollen analyses of these samples have been discussed elsewhere in this report (see above, Chapter 5).

A shallow bucket-auger probe was conducted adjacent to DH13 and recovered organic-rich silt at 34 to 40 inches bs. Shallow groundwater was encountered at 24 inches bs and recovery below 40 inches was made impossible by slumping of the walls in the saturated material. Particle-size analysis by the Corps of Engineers Baltimore District Materials and Instrumentation Unit characterized the sediment as sandy elastic silt; silt and clay content by weight was slightly over 50% of the total.

No intact silt to very fine sandy loam surface horizon or overlying cap of sand comparable to that seen in DH11-DH15 was present at the DH16 testing location. Instead, the upper 1.5 feet of recovery consisted of thinly stratified 2.5YR3/3 sand and dark silt loam. This is interpreted to be a product of frequent flooding and ponding on a truncated surface. Beneath this was a very gravelly sandy loam closely resembling the Bt horizon described for the previous borings. The underlying sediments were faintly weathered and unweathered 2.5YR to 7.5YR sand and gravel, exhibiting some bedding, also as described for the previous borings.

DH17 and DH18, scoped to be conducted at the southeasternmost edge of Miller Field, were removed from the testing schedule, resulting in a 3,000-foot gap in the data for the area between DH16 and DH19. GP8 was conducted at the point cleared for SCPTu-10 and DMT-11, midway between DH16 and DH19, but recovery of useful data was disappointing. Recovery in the advance from surface to 5 feet bs (11.5 to 6.5 feet amsl) consisted of three feet of berm sand. Recovery in the advance from 5 to 10 feet bs (6.5 to 1.5 feet amsl) consisted of one foot of mixed sandy and silty material. Recovery in the advance from 10 to 15 feet bs (1.5 feet amsl to 3.5 feet bmsl) consisted of 2.9 feet of sandy material showing no evidence of being part of a developed profile. Three 8 to 10-inch increments of this material were submitted to the Corps of Engineers Baltimore District Materials and Instrumentation Unit for particle-size analysis. All of the samples were dominated by fine and medium sand and contained 10 to 14% silt and clay by weight. Silt and clay content was highest in the uppermost increment and decreased with depth, suggesting that these samples may represent the lowest zone of a developed but severely truncated profile. Recovery in the advance from 15 to 20 feet bs (3.5 to 8.5 feet bmsl) consisted of 3.7 feet of sand. Particle-size analysis of the uppermost and lowest foot of recovery yielded similar results to the overlying sediments, with fine and medium sand dominating and silt content at around 8-9% in each sample.

No evidence of profile development was detected in the profiles of DH19 or DH19A. Opening elevations at these boring locations was 10.4 and 9.2 feet amsl, respectively. Recovery in the upper 12 to 15 feet of the profile consisted almost exclusively of 2.5YR and 5YR3/3-4/3 fine and medium sand with small amounts of gravel. In DH19, loamy very fine sand and very gravelly loamy medium sand at around 4.5 to 6 feet bmsl may mark a small remnant of the very lowest zone of the developed subsoil. No trace at all of a former stable profile was seen in DH19A, 500 feet to the north.

Overall, the New Dorp Upland Zone shows evidence of having been the most stable setting within the project alignment over the course of the terminal Pleistocene and the Holocene. At the height of stream incision in the New Creek drainage to the northeast and the Mill Creek/Bass Creek drainage to the southwest (probably the Early to Middle Holocene before sea level rise triggered the beginning of aggradation in the stream hollows), relief between the highest point of the upland within the project alignment and the floors of the adjacent hollows appears to have been in the range of 20 feet. The path of landscape evolution postulated here for the upland surface begins with deflation and cryoturbation of the outwash plain in the early post-glacial period, followed by accumulation of a cap of windblown clay, silt and very fine sand over the course of the terminal Pleistocene, including the Younger Dryas. Weathering processes resulted in development of a soil profile four to six feet thick, forming largely in outwash. It appears that within the project alignment the highest and most stable portion of the upland was the southwestern half, adjacent to the Mill Creek and Bass Creek drainages. Developed soil profiles there are largely intact, although those closest to the modern shoreline are in danger of erosion. Absence of anything more than remnants of a developed profile in the northern half of the Zone suggests that this area may have sloped very gently toward the New Creek drainage, with slightly lower surface elevation making the developed profiles susceptible to erosion by the encroaching ocean in the Late Holocene. Presence of a low-order stream hollow paralleling the coastline, as shown on the Taylor and Skinner map of 1781 (see above, Figure 4.1), may have increased the efficiency of erosion in this area, allowing overwashing waves to sweep down the hollow and erode the narrow neck of land between from both sides. The maps suggest that the head of the hollow was in the vicinity of DH18.

D. NEW CREEK DRAINAGE ZONE

As noted above, the stream channels flowing across the project alignment within the New Creek Drainage Zone were presumably separated by low interfluves – up to several hundred meters wide – during much of the post-glacial through Middle Holocene evolution of the landscape. Scant evidence was seen in the borings in this area for the presence of the interfluves, as lagoon deposits (in some cases directly overlying stream deposits) were seen in 13 consecutive borings over a span of 8,000 feet. This may be, in part, a result of wide spacing of the sampling locations – generally 1,000 feet in the case of the split-spoon borings. It may also reflect some erosion of the interfluves as the streams took on meandering, laterally-migrating forms in the late Holocene, along with erosion by coastal waves before the point at which the barrier island accreted to the coast and formed a protective barrier beach.

The single instance in which deposits interpreted to be part of an interfluve were noted was in DH21, near the southwestern end of the New Creek Drainage Zone. There, the stratigraphy consisted of backbarrier sands directly overlying sand interpreted here to be intact outwash deposits, while lagoon deposits were present to the southwest and northeast in DH20 and DH22. The stream configuration in this area may have been somewhat different than that in the broader drainage. Nearly all streams shown flowing into the coastal marsh on the Taylor and Skinner map of 1781 originated on the terminal moraine and the base of Todt Hill (see above, Figure 4.1). The southwestern end of the drainage provides one exception to this, however, in the form of a first-order stream originating on the New Dorp Upland near the coastline and flowing northeast into the marsh. This stream does not appear on later maps, although the 1872 Dripps map (see above, Figure 4.5) records the presence of "Cedar Creek Road" in this general location. While depicted on the late 18th-century map as flowing northeast into the marsh, this stream (for the purposes of this report referred to as "Cedar Creek") almost certainly flowed more directly east upon reaching the base of the upland before being blocked by the barrier beach in the late Holocene. If that is the case, the lagoon deposits seen in DH20 may have formed in its former stream hollow and the sandy sediments seen beneath backbarrier sands in DH21 may be part of a sizeable interfluve between the southwesternmost stream and the main body of the drainage basin. This interfluve would actually have been the northeasternmost toe slope of the New Dorp Upland, cut off from the main body of the upland by the incision of the small local stream (Cedar Creek) and thus may have been higher and more substantial than other interfluves in the drainage zone.

It should be noted that, as was the case along most of the project alignment, no developed soil profile was identified in DH21. This suggests that, if these sediments do represent an interfluve remnant, sufficient surface erosion – probably wave erosion with marine encroachment – took place to remove stable surface soils that might have had the potential to contain cultural material. As the interfluve surfaces were non-depositional settings, all cultural material would have been confined to the surface and near-surface. Once a fairly thin upper profile, consolidated to some extent by accumulated silt and clay, was eroded from these low rises, the sandy underlying C horizon would have been easily eroded and reworked, obliterating evidence of the presence of the former rise.

Sediments interpreted to be a product of Holocene stream activity were encountered in adjacent split-spoon and Geoprobe borings DH22, GP10, GP11, DH23, DH24, DH25, DH25A, and DH30, spanning a distance of over 8,000 feet and encompassing much of the New Creek Drainage Zone. In DH22 through DH24 (including GP10 and 11), these sediments were encountered at 12 to 13 feet bmsl and ranged in thickness from three feet (DH23) to eight feet (DH22). In DH25, these sediments were recovered from 17 to 19 feet bmsl and in DH25A from 15 to 16 feet bmsl. In contrast to the dominantly sandy basal sediments seen in most borings, these sediments included sandy clay, silty clay, sandy clay loam, silt with some clay, loam and gravelly sandy loam. Fine organic material was present in some samples and evidence of redox, including gleyed sediments, was common. These sediments are interpreted to be remnants of various aspects of stream activity, including floodplain construction, deposition within abandoned channel segments, and channel floor and bar deposition. Radiocarbon dates of organic material within the stream-related sediments ranged from 5,659 to 5,466 cal years BP to 3,271 to 3,140 cal years BP.

In each instance where stream-related sediments were encountered, they were directly overlain by dark, fine-textured, generally organic-rich lagoon sediments. In some borings, the boundary between the organic-rich, silty clay lagoon deposits and the underlying stream deposits was abrupt and easily discernible. In other cases, the boundary was less clear and the sediments appear to record a gradual transition from alluvial setting to freshwater wetland to brackish lagoon environment. In these instances, the vertical boundary as described has been somewhat arbitrarily defined.

The nature of the sediments underlying the stream deposits is also not entirely clear. Generally, these consist of fine and medium sand with varying but low amounts of very fine to medium gravel, much as seen in intact outwash to the southwest on the New Dorp Upland. It is possible that in some areas the stream was, in fact, running on intact outwash. It is more likely that in most areas a period of stream-bed aggradation took place took place as base level rose and that the bedload of the streams – eroded outwash and moraine material from up-system – is indistinguishable from the water-laid outwash itself. Because neither the *in-situ* outwash nor the reworked material has undergone appreciable weathering, it is difficult or impossible to distinguish the two. Thus, it is not entirely clear if the testing to a general depth of 36.5 feet bs in the New Creek Drainage Zone (which includes 10-15 feet of Late Holocene marine sand) reached the maximum depth of stream incision throughout the zone and extended into *in-situ* outwash. From an archaeological perspective this is something of a non-issue, in that there is little to no chance that any intact former alluvial surfaces are present below the testing depth.

The thickest packet of sediments interpreted to be stream-related was encountered in DH22, from 13 to 21 feet bmsl. The sediments consisted of gravelly loamy coarse sand at the base, overlain by reddish black (2.5YR2.5/1) bedded silty clay, weak red (2.5YR4/2) loamy medium sand with gravel, dark reddish gray (2.5YR3/1) sandy clay loam with very fine organic matter, and gleyed sandy clay with much fine gravel. The upper boundary was an abrupt transition to organic-rich reddish black (2.5YR2.5/1) sandy clay loam and peat lagoon deposits. This was the southwesternmost occurrence of the stream-related deposits and was located 1,000 feet northeast of DH21, where sediments at an equivalent depth are tentatively identified as an interfluve remnant. This suggests that the depth to which stream sediments are present in DH22 may be a result of a channel segment becoming entrenched as it flowed along the base of the interfluve.

Stream-related deposits (loamy medium sand with gravel and fine organic material; sandy clay with fine organic material) were identified from 12 to 16 feet bmsl in GP10, 500 feet northeast of DH22. A sample from the base of these deposits (15 to 16 feet bmsl) was dated to 5,659 to 5,466 cal years BP. Pollen from this sample was found to be too degraded by oxidation to be analyzed and was interpreted to have been subjected to frequent wetting and drying cycles. A sample from the upper portion of the deposit, at 12 to 13 feet bmsl, yielded a date of 4,085 to 3,899 cal years BP; pollen from this sample had been similarly degraded by frequent wetting and drying cycles. The inferred evidence of frequent wetting and drying, along with the texture of the deposits, is interpreted to reflect deposition on a rapidly accreting Middle Holocene floodplain, with accumulation of three to four feet of sediment taking place over a period of 1,500 to 1,700 years.

GP11 was conducted immediately adjacent to DH23, 500 feet northeast of GP10. Stream-related deposits in both were recovered from a similar depth to that in GP10 – 12 to 15 feet bmsl. These samples were predominantly compact silt with lesser amounts of clay and very fine sand. A sample from the upper zone (12-12.5 feet bmsl) yielded a radiocarbon date of 3,271 to 3,140 cal years BP, approximately 700-800 years younger than that from a similar depth in GP10. Here, too, pollen was found to have been degraded by frequent wetting and drying cycles and was virtually absent; a few Cretaceous palynomorphs, presumably carried from sources higher in the drainage basin, were present. Evidence of frequent wetting and drying cycles is once again interpreted to indicate that deposition took place on a subaerial, relatively well-drained floodplain. The younger age of the uppermost floodplain sediments may reflect channel migration to the northeast in this period or simply channel avulsion and reworking of a portion of the rapidly-accreting floodplain.

Stream-related deposits consisting of variegated gravelly loam with gravel and redoximorphic mottles along with a zone of gleyed silty clay was identified in DH24 at a depth of 14 to 18 feet bmsl. DH24 was located 1000 feet northeast of GP11 and DH23. These sediments appear to be a product of deposition in a dynamic setting, with all particle sizes included and evidence of frequent saturation in the form of the redoximorphic mottles. Examples of such settings might be an in-channel low area between a bar and bank or a swale or flood chute on a low floodplain.

In DH25, 1,000 feet northeast of DH24, sediment identified as stream-related was confined to very gravelly (30-40% fine rounded gravel) sandy loam from 17 to 19 feet bmsl. These sediments are interpreted to be channel floor deposition. The sediments associated with stream activity which were recovered in DH25A, 500 feet northeast of DH25, consisted of a thin deposit of gleyed sandy clay loam recovered at 15-16 feet bmsl, interpreted to be floodplain deposition.

Stream-related sediments recovered from DH30, near the northeastern end of the project alignment, are interpreted to be the product of a small second-order stream, shown on the Taylor and Skinner map of 1781 draining the northeastern end of the terminal moraine on Staten Island (later the site of Fort Wadsworth). The sediments, recovered from 13 to 17 feet bmsl, consisted of dark gray (10YR4/1) sandy loam to sandy clay loam containing coarse pebbles, fine organic material, and some evidence of fine, preserved roots. A sample of the basal sediments yielded a date of 3,694 to 3,560 cal years BP.

As previously described, the pollen assemblage from this sample was dominated by sedges and grasses in the non-arboreal component; arboreal species included hickory, beech, pine, oak, willow, birch, chestnut, walnut or butternut, buttonbush, holly or winterberry, walnut, Juniperus type, sweet gum, sweet gale or wax myrtle, hop-hornbeam and hemlock. The pollen report notes that "[n]on-arboreal elements in [the sample] contain few grains that suggest any local disturbance. … [The sample] also contained four Typha/Sparganium, and five Typha latifolia grains. These plants would probably not be expected in a high energy environment, suggesting that the environment of deposition might have been a lagoon or pond. These samples represent the highest percentages of Typha spp. in the Staten Island samples, however, Typha counts remain fairly low suggesting that cattails were not common plants in the area. … Sphagnum was represented by one spore, while 12 Osmunda spores were noted, likely signaling a nearby shaded forest. … Cretaceous palynomorphs were rare in the sample." Taken together, the pollen assemblage and soil texture – including deposition of gravel – suggests that this sample may record the early stage of freshwater wetland formation in this part of the project alignment, focused around the small second-order stream draining the northeastern extreme of the terminal moraine as it entered the low-gradient setting of the outwash plain and its flow was impeded by rising base level.

Lagoon sediments were recovered in 14 adjacent split-spoon and Geoprobe borings in the New Creek Drainage Zone (DH22 through DH30 and GP10-12 and 14) and in non-adjacent DH20. A total of nine radiocarbon dates were obtained from the lagoon sediments, encompassing the 10,000-foot lateral expanse of the facies as well as nearly the entire vertical span of the sediments, ranging from 6-7 feet to 16-17 feet bmsl. The dates in successive samples from individual columns showed an intact chronological sequence, indicating no major overturning or disturbance of the sediments. Ages at equivalent depths below mean sea level varied somewhat laterally (i.e., samples from a similar depth bmsl from borings 1,000-2,000 feet apart varied by as much as 500-1,000 years), but this is attributable to the dynamism of a tidal lagoon, with highly mobile tidal channels cutting voids in older sediments that subsequently filled with younger material.

Radiocarbon dates on the organic-rich lagoon deposits ranged from 3,511 to 3,381 cal years BP on basal deposits (15-16 feet bmsl) in GP12, near the horizontal center of the lagoon facies, to 728 to 664 cal years BP near the upper boundary (6-7 feet bmsl) in DH20, the southernmost occurrence of the facies. Variations in dating of the upper zone of the lagoon deposit will be discussed below.

Pollen analysis of the basal lagoon deposits in GP12 (3,511 to 3,381 cal years BP) indicate the nearby presence of a primarily deciduous forest that also included some pine, hemlock and juniper. Deciduous species included birch, hickory, oak, hornbeam/hazelnut, chestnut, beech, ash, walnut or butternut, sycamore, willow and basswood or yellow poplar.

Three samples from near the vertical midpoint of the lagoon sediments, all from similar depths below mean sea level, were retrieved over a span of 8,500 feet. The samples yielded closely aligned radiocarbon dates, as follows: GP10, 9.5 to 10 feet bmsl – 2,600 to 2,492 cal years BP; GP11, 9.0 to 10 feet bmsl – 2,505 to 2,351 cal years BP; DH30, 10.5 to 11 feet bmsl – 2,539 to 2,354 cal years BP. The most closely aligned dates, from GP11 and DH30, were separated by a distance of 8,000 feet. Pollen analysis indicated the nearby presence of a mature mixed conifer and deciduous forest. The samples all included pollen from oak, pine, chestnut, Juniper type and hickory; also present, though not in each of the samples, were alder, ash, beech, birch, hemlock, holly or winterberry, hornbeam and hop hornbeam, sugar maple and sycamore.

The upper zone of the lagoon deposits, as noted, yielded relatively varied Late Holocene dates over a relatively short lateral span in DH20, GP10 and GP11. All of these samples were retrieved from between 1.75 and three feet below the upper boundary of the lagoon facies, which was at a roughly equivalent depth of five feet bmsl in each of the probes. All three samples consisted of peat.

A sample from 1.75 to 2.5 feet below the upper boundary (5.75 to 6.5 feet bmsl) in DH20 yielded a date of 728 to 664 cal years BP. A peat sample retrieved from between two and three feet below the upper boundary (7.0 to 8.0 feet bmsl) in GP10 dated to 1,287 to 1,172 cal years BP and peat from between one and two feet below the upper boundary (6.0 to 7.0 feet bmsl) dated to 1,714 to 1,565 cal years BP, roughly 1,000 years older than the sample from DH20, 3,000 feet to the southwest. The younger date at DH20 may reflect ongoing activity by Cedar Creek, cutting channels in the lagoon sediments there and creating space for younger sediments. This is supported to some extent by the fact that organic material in backbarrier sands at 2-3 feet bmsl in GP11 also yielded a date older than the upper lagoon deposits in DH20 (899 to 967 cal years BP). The variations in the dates may also have been influenced by penetration of successively younger roots from overlying growth into underlying peat. Pollen analysis indicated little change from the earlier Late Holocene landscape, with arboreal species dominated by hickory, pine, oak, and chestnut and smaller numbers of birch, hornbeam/hazelnut, wax myrtle, hop-hornbeam, elm, hemlock and Juniper type.

Sediments in three successive borings at depths corresponding to those of the lagoon facies differed from the typical organic-rich, fine-textured sediments, but are interpreted to be lagoon deposition nonetheless. These sediments, recovered in DH27-29 (and possibly GP14), contained only trace amounts of very fine organic matter; textures generally tended to be well-sorted and included silt, very fine, fine and medium sand, and a very small amount of clay. A few beds contained a small amount of fine or very fine gravel and both horizontal and sloping bedding were present in some fine and very fine sand beds. These sediments, which extended laterally over 2,000 feet, ranged in thickness from 14 to 16 feet. The upper boundary was located at nine feet bmsl in DH28 and 29 and eight feet bmsl in DH27 and in each location was directly overlain by the backbarrier sand facies. The sediments are interpreted to be those of a tidal delta formed on the landward margin of a broad or – more likely – laterally migrating lagoon inlet. Tidal delta formation has been described above in Chapter 2C on barrier island and lagoon formation. The inlet associated with the delta is interpreted to have been open and active until late into the process of the barrier island's accretion to the coast, forming the barrier beach/lagoon complex. No tidal opening is indicated on the 1781 Taylor and Skinner map (see above, Figure 4.1) and this inlet is assumed to have closed by that point, leaving the debouchure of New Creek as the only tidal connection between the lagoon and the Lower Harbor. If the inlet was migrating over the course of the very late Holocene, it would have migrated northeast to southwest, as prevailing longshore currents deposited sand on the northeast side of the inlet opening and forced erosive tidal flow to the southwest (Kumar and Sanders 1974). Two samples from the lower zone of the tidal delta sediments in DH29 (18.9-19.0 and 22.0-22.5 feet bmsl) were submitted for radiocarbon dating, but after pretreatment both were found to have too little carbon to provide a reliable result.

The backbarrier sands facies was identified in 13 split-spoon borings and six Geoprobe cores. In ten of the split-spoon borings and five of the Geoprobe cores, the backbarrier sands directly overlaid the lagoon facies, recording transgression of the barrier island/barrier beach over the seaward edge of the lagoon. In some cases, the boundary between the two deposits was abrupt, with fine to medium dark sand directly overlying peaty, fine-grained (silt to clay) lagoon material. In other cases, the boundary was more transitional but was discernible over a core segment of five to six inches. Five carbon-bearing sediment samples from the backbarrier facies were submitted for radiocarbon dating, three of which yielded problematically old results.

The oldest date, obtained on sand containing fine organic matter from 2.5 to 3.5 feet bmsl (10.5 to 11.5 feet bs) in DH30, was 12,686 to 12,550 cal years BP (Beta 532134). This sample was taken at seven feet above fine plant material dated to 2,539 to 2,354 cal years BP (Beta 532137), nine feet above peat dated to 3,259 to 3,106 cal years BP (Beta 532136), and 13 feet above fine plant material dated to 3,694 to 3,560 cal years BP. The lowest date was obtained from material interpreted to be associated with alluvial deposition produced by the second-order stream draining the adjacent Fort Wadsworth upland. The upper boundary of the backbarrier sands in DH30 was several feet higher than at any other location (three feet amsl), suggesting that – once the lagoon and associated backbarrier had formed – inputs of sediment from the same stream may have produced a small delta or alluvial fan there. The anomalously old date is interpreted to be a result of headward erosion by the stream, tapping into a source of older carbon that was then transported to the lagoon area and incorporated into the backbarrier sands. The source of the older carbon may have been the stable topsoil of the upland or a reservoir of older carbon such as a glacial kettle or other closed depression.

Pollen analysis of this sample revealed that "[v]ery few poorly preserved pollen grains were noted in [the sample], where sedge, grass, Quercus, and indeterminate grains were noted; the sample had an exceedingly low concentration value of 153 grains per gram of sample, well below the acceptable minimal threshold of around 2000 grains per gram. These sediments, at one time, may have been raised above water level allowing for oxidation of organic materials. Cretaceous age organic remains, representing maybe 65 percent of the pollen in the sample, were also poorly preserved. [This sample] may represent rapidly deposited eroded materials accounting for the oxidized sediments and inverted radiocarbon date."

Dates of 7,759 to 7,618 cal years BP and 5,468 to 5,314 cal years BP were obtained on organic-bearing backbarrier sands obtained at 4.0 to 5.0 feet bmsl (15.0-16.0 feet bs) in DH26 and DH27, respectively. In each case the backbarrier sand deposit was eight to nine feet in thickness and the dated samples were obtained from the middle portion of the deposit. The backbarrier sands overlaid undated lagoon deposits similar in character and depth bmsl to those in borings to the north and south. In the case of DH27, the underlying lagoon deposit was interpreted to be Late Holocene tidal delta deposition, as described above. No pollen analysis was conducted on the samples which provided these anomalously old dates. These dates are interpreted to be a result of older carbon (possibly older lagoon deposits) exhumed by wave action seaward from the barrier island/barrier beach being deposited on the backbarrier as washover during storm events.

Two other dates on backbarrier sands appear to be much more in keeping with the postulated evolutionary track of the landscape. In GP11, adjacent to DH23, a sample of fine plant material recovered from sands at 2.0 to 3.0 feet bmsl (12-13 feet bs) primarily dated to 967 to 899 cal years BP (70.7%), with smaller fractions yielding later dates of 868 to 822 cal years BP (19.4%) and 815 to 798 cal years BP (5.3%) (Beta 532146). The sample came from within the uppermost foot of the three-foot thick backbarrier facies, unconformably overlain by the beach sand facies. The variation in dates of the fractions may reflect penetration of roots of increasingly more recent plant growth. This is the uppermost in a sequence of four radiocarbon dates from the GP11 core. The underlying dates, previously described, were: 3,271 to 3,140 cal years BP (stream-related deposition) at 9.5 to 10 feet lower in the column (12.0-12.5 feet bmsl); 2,505 to 2,351 cal years BP and 1,714 to 1,565 cal years BP from 7 and 4 feet, respectively, lower in the column (lagoon sediments).

Pollen analysis revealed that "preservation in this sample was good, and the non-arboreal types were dominated by Ambrosia, Cheno-Ams, and grasses, with lesser numbers of Solidago, and high spine Asteraceae, Alismaceae, sedge, and Fabaceae. Arboreal grains in [the sample] were made up largely of Carya, Pinus, and Quercus, along with lower numbers of Acer saccharum, Alnus, Betula, Carpinus, Castanea, Fagus, Juniperus type, Salix, Tilia, and Tsuga. One Osmunda spore was also noted in the sample. This sample fits the pattern established by the other Core GP 11 samples with a pond or lagoon-like environment of deposition, surrounding by a typical eastern deciduous forest."

Following pretreatment at Beta Analytic Testing Laboratory, a sample of backbarrier sand from 7.5 to 8.5 feet bmsl (15.5-16.5 feet bs) in DH28 was found to contain both 3.3 mg of plant matter and 0.81 mg of charred material (wood). The sample provenience was located at two to three feet below the upper boundary of the backbarrier facies, which was four feet thick at this location; the sample contained fine shell fragments in addition to the plant and charred material. The plant matter was dated and yielded results of 145 to 15 cal years BP (68.3%) and 268 to 214 cal years BP (27.1%) (Beta 551303). Subsequently, the charred material was dated and yielded results of 334 to 281 cal years BP (46.7%), 435 to 353 cal years BP (42.4%), and 169 to 152 cal years BP (6.3%) (Beta 552234). These recent dates suggest that the backbarrier in this area formed and remained exposed quite late in the evolution of the study area, exposure that possibly continued into the early Historic period before burial of the area by encroaching beach sands. The lagoon deposits present within two feet below the dated depth are part of the sandy, carbon-poor deposit identified here as tidal delta deposits associated with a tidal inlet. The date of the backbarrier sands appears to offer support for the assertion that the tidal inlet was open and active until shortly before Europeans arrived in the area. No pollen analysis was conducted on this sample, which was a late addition to the sample analysis program.

The dates on organic matter from the upper zone of backbarrier sands at two to three feet bmsl in GP11, falling within a range from 967 to 798 cal years BP, suggests that the beach sand facies began to encroach over the backbarrier roughly between 800 and 1,000 years BP, as sea level was approaching its modern level. As noted, burial of the backbarrier sands at DH28 appears to have taken place at or after the protohistoric/historic boundary. This late date for encroachment of the beach sands there, along with the relatively thin accumulation of backbarrier sand facies and the anomalous depth of its upper surface bmsl all appear to support the late closing of the tidal inlet there, with beach sand moving over the topographic low left after the closing.

Within the New Creek Drainage Zone, the beach sand facies varied in thickness from five feet (on the base of the Fort Wadsworth upland) to 15 feet, with the majority measuring between 11 and 14 feet in thickness, with the surface at 10 to 11 feet amsl. No datable material was encountered within the beach sand facies anywhere within the project alignment. Given what was considered a poor environment for pollen preservation, no samples were submitted for pollen analysis.

Chapter 7

CULTURAL RESOURCE SENSITIVITY ASSESSMENT

A. PREHISTORIC ARCHAEOLOGICAL POTENTIAL

Marine transgression over existing land surface is inherently a dynamic, destructive and erosive process. Encroachment of waves – including large storm-driven events, along with processes associated with tides and longshore currents – have the potential to incrementally rework miles of coastline. The exact dynamics of the coastal erosion are controlled by numerous factors, including coastal emergence or subsidence, coastal relief and geology, and rate and persistence of sea level rise. The latter is of prime importance and can result in transgression taking one of two forms. A slow rate of sea level rise generally allows for prolonged periods of erosion of the former terrestrial sediments, along with reworking of recently-deposited sediments associated with the ongoing transgression. A rapid rate of sea level rise may result in a step-like or "leapfrogging" advance as the transgressing ocean moves quickly landward, perhaps with less thorough erosion of the sea floor. This may especially be the case in settings where barrier islands create a temporary impediment to the sea's advance, leading to a pause which results in a rapid transgression as ongoing sea level rise overtops the barriers.

In addressing the potential for intact sites to be present in submerged offshore settings, Kraft *et al.* (1983) have proposed that in some cases former stable surfaces and associated cultural remains might be preserved beneath a protective cap of fine-textured or peaty cohesive sediment accumulated in a low-energy setting such as a lagoon protected by a barrier island. In the case of now-submerged offshore settings, the potential for the preservation of the sites is dependent on the depth to which erosion occurs as ongoing sea level rise drives the transgressing ocean over the former barrier island/lagoon system. Depth and extent of erosion is controlled to some extent, as noted, by rate of sea level rise with slow rate of rise resulting in more thorough erosion and reworking.

Prehistoric archaeological potential within the 5.3-mile-long project alignment is considered as limited to a few relatively small areas, mostly towards the southwestern end of the study area, where intact or nearly intact soil profiles were encountered. Some potential may also exist at the extreme northern end of the project alignment, although the results of sampling merely hinted at this and no intact profile was identified there. Elsewhere, few indications of the persistence of such intact, weathered soil profiles were seen in any of the borings that were subject to monitoring. In some locations, remnants of weathered subsoil – the lower zones of profiles truncated by wave action – were identified, although for the most part these had formed in stable deposits of glacial outwash. In these non-depositional settings, the gravelly lower subsoil is considered to have no potential for containing cultural materials.

A developed subsoil was identified in alluvial soils in DH2, adjacent to the former course of Mill Creek (Figure 7.1). This is just north of the intersection of Buffalo Street and Hylan Boulevard, on the downstream side of the bridge that carries Hylan Boulevard over the culverted Mill Creek next to the entrance to Great Kills Park. Because the split-spoon testing methodology produced unsampled gaps in the profiles, it is unclear whether an intact A horizon associated with this profile is present. A Geoprobe boring (GP1) conducted at the same site yielded incomplete recovery and failed to resolve the ques-

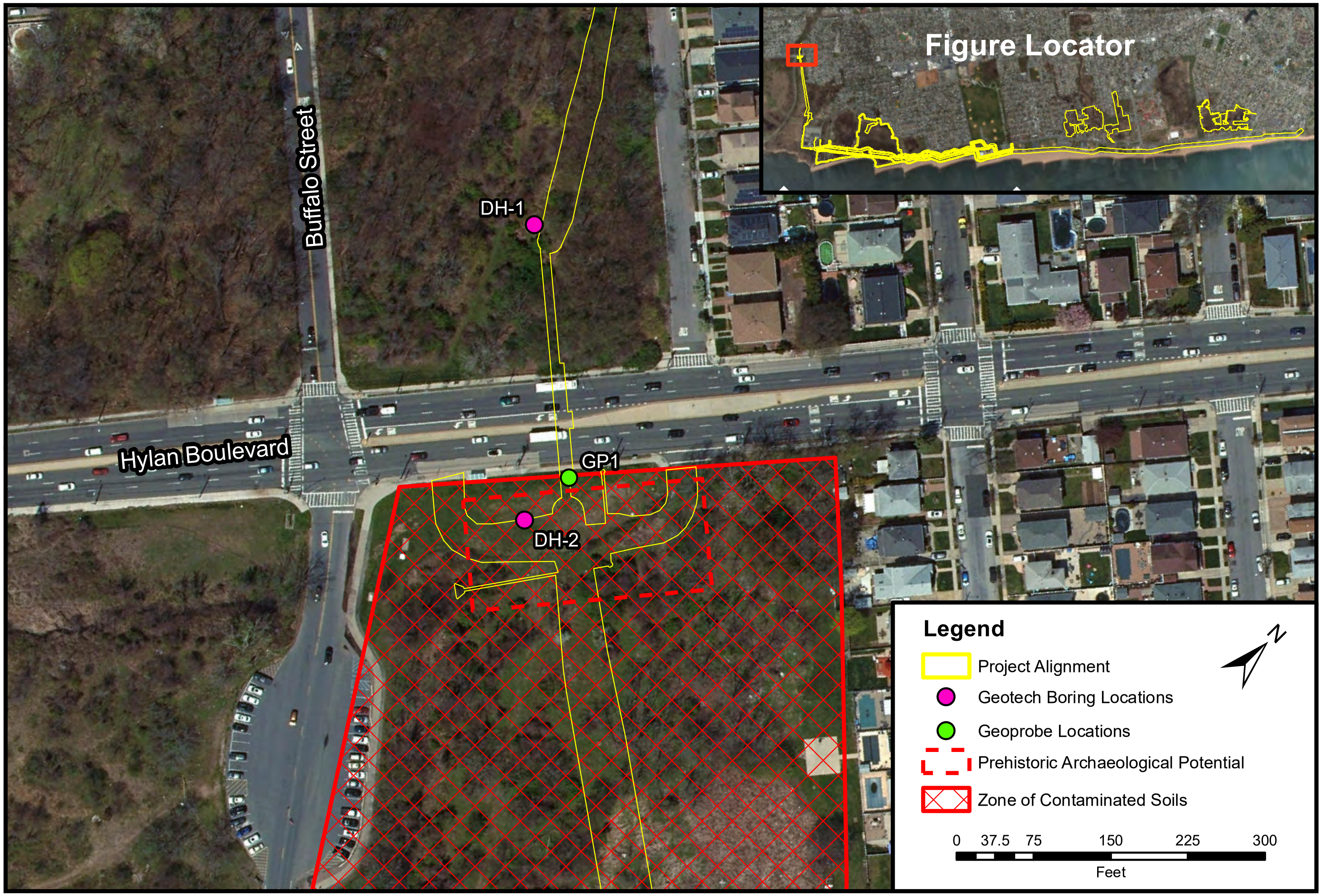

Figure 7.1. Area of Prehistoric Archaeological Sensitivity, DH2, Hylan Boulevard and Mill Creek. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

tion. If an intact A horizon is present, it would most likely be encountered between four and five feet bs, beneath four or more feet of fill. The subsoil identified from five to eight feet bs is interpreted to have formed in Middle through Late Holocene Mill Creek alluvium and is also interpreted to hold archaeological potential. These sediments appear to be a product of frequent low-energy flooding, although there is some evidence that the area was occasionally swept by higher energy floods.

The area of potential prehistoric archaeological sensitivity surrounding DH2 is somewhat circumscribed and further investigation will be constrained by the presence of contaminated soils in this area (Figure 7.1). Hylan Boulevard, a flanking sidewalk, and buried utilities lie 50-60 feet to the northwest. Mill Creek streamflow to the southwest is apparently contained within a buried culvert as it passes beneath Hylan Boulevard and through the filled area where DH2 was located. The stream daylights again 75 to 100 feet south southeast of the DH2 location. At some undetermined point south of DH2 (toward Buffalo Street), subsurface excavation would encounter the Late Holocene and Historic Mill Creek channel and, almost certainly, soil disturbance related to culvert installation. This area would have no archaeological potential. The Mill Creek channel area immediately downstream (southeast) from Hylan Boulevard has been identified as being contaminated by illegal dumping of chemical and radioactive medical and other hazardous waste. This will, in all likelihood, hamper attempts at any archaeological work there. Additionally, at some point within this area to the northeast a boundary would be encountered, marking a transition from preserved profiles developed in Mill Creek alluvium to estuarine, marsh and marine sand deposits overlying incised outwash, as seen in DH6, DH7 and DH8.

The greatest extent of soils containing archaeological potential in the vicinity of DH2 appears to lie immediately northeast of the boring location (Figure 7.1). Although addition of fill has leveled the surface and obscured the landscape, at some point in this area would lie the boundary between the Mill Creek hollow and the more stable upland of the head of the outwash plain. The presence of cedars and oaks opposite the intersection of Currie Avenue and Hylan Boulevard suggests that this area may lie on the boundary. It is also to be expected that fill within the hollow would thin out in this direction, making the underlying profile more accessible. Conjecturally, the potential for the presence of an older, slightly higher terrace within the area between DH2 and the northern edge of the hollow cannot be ruled out. Such a terrace would be a product of the early incision of the hollow and thus would have the potential to have been occupied during the terminal Pleistocene and Early Holocene, before accumulation of the alluvium identified in DH2.

The segment of the project alignment between DH6 and DH10 and 10A is interpreted as having no potential to contain intact prehistoric archaeological resources. Soil profiles there suggest that the area was extensively reworked by migrating channels of terrestrial streams and later by wave action.

A second broader area judged to have prehistoric archaeological potential spans the distance from DH11 roughly to New Dorp Lane and the southeast corner of Miller Field. The setting of DH11 and DH12, approximately 700 feet northwest of the modern shoreline, is the former surface of a small knoll projecting southwest from the main body of the New Dorp Upland (Figure 7.2). A similar knoll-like landform with a clump of trees exists some 1,200 feet to the northeast, roughly 400 feet northwest of the project alignment. Because of their distance from the shoreline, very little accumulation of wave-borne or wind-borne sand is apparent in these two locations. The knoll tested with DH11 and DH12 displayed a

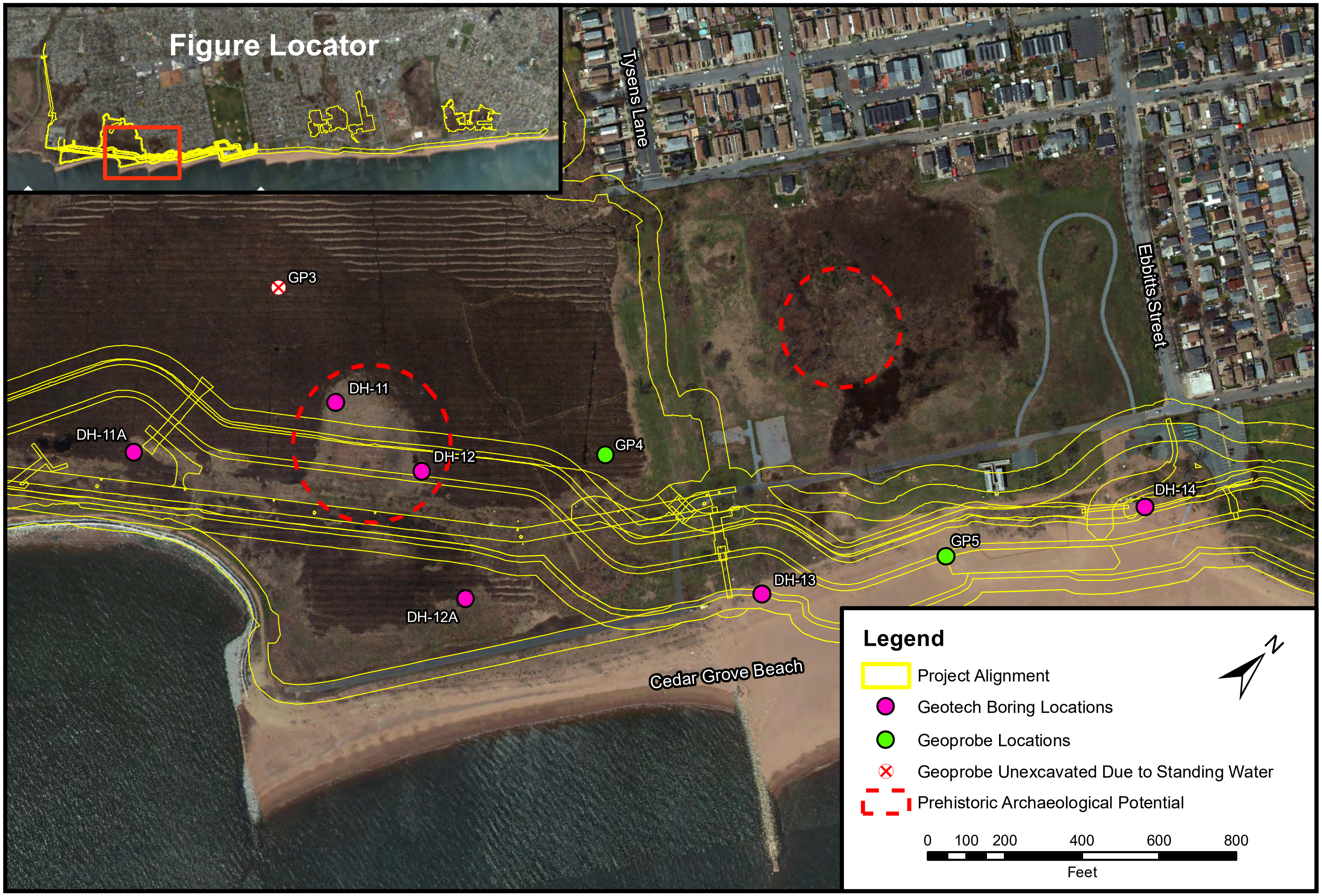

Figure 7.2. Area of Prehistoric Archaeological Sensitivity, DH11 and DH12, Oakwood Marsh. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

very fine sandy to silt loam A horizon that was present just below a thin organic mat and which appears to have been relatively stable for the entire Holocene and perhaps slightly longer. The underlying gravelly loam Bt horizon is interpreted to have formed in outwash that was exposed in the early post-glacial period and, although the potential for Native American occupation of this exposed, wind-swept surface would seem to be very low, it cannot be said to be nil. Given this and the potential for bioturbation, testing in this area would need to extend only six to 12 inches into the subsoil. This setting, a low knoll between two low-order streams and overlooking an expanding coastal marsh in the latter half of the Holocene, would seem to have a high potential for the presence of cultural material. It should be noted that traditional archaeological excavation would be complicated here by the fact that the shallow groundwater table extends more or less to the ground surface (see below, Chapter 8, for further discussion of the practicality of archaeological testing).

The portion of the project alignment between DH12 and DH13, near the modern shoreline, lies within a low area where one to three feet of standing water was present throughout the period when fieldwork was being conducted. Additionally, there is extensive disturbance in this reach as a result of installation of a large sewer or stormwater main. This area has a reduced potential for yielding intact prehistoric archaeological resources.

In DH13, DH14, and DH15, a cap of three to six feet of Late Holocene to modern sandy deposition overlies the A horizon and in each case the water table was encountered at least one foot above the A horizon. In DH14, a brick fragment was recovered in the silt loam A horizon between 5.0 and 5.5 feet bs and the gravelly subsoil was encountered between 6.0 and 6.5 feet bs. In DH15, concrete and brick were recovered within a silt loam horizon at between 2.5 and 4.0 feet bs; the next spoon advance, from 5.0 to 6.5 feet bs recovered silt loam free of modern debris and also recovered gravelly subsoil beginning at around 6.0 feet bs. At DH16, 1,000 feet north of DH15, the A horizon had been removed, though it appeared that much of the underlying subsoil was intact. In place of the A horizon was a thinly stratified silt and sand suggestive of deposition by ponded floodwater; no cap of Late Holocene to modern sand was present. Taken together, this suggests grading of the surface in the relatively recent past, possibly related either to development or demolition of structures in the early/mid-20th century or construction of the extant bicycle and pedestrian path. The lateral extent of this grading is unknown; hence, the entire area between DH15 and New Dorp Lane, just northwest of DH16, is included in the area judged to have archaeological potential (both prehistoric and historic), with the exception of the area immediately surrounding DH16 (Figure 7.3).

As noted elsewhere in this report, very little subsurface information is available for the southeastern edge of Miller Field. However, limited recovery from the single Geoprobe core retrieved there (GP8), combined with information from DH19 and DH19A to the northeast, appears to indicate that the archaeologically sensitive upper profile has been eroded by the encroaching ocean in this area. This area is judged to hold no potential to contain prehistoric cultural material, although historic resources may be present beneath the sand berm at the eastern end of the field and elsewhere near the southeastern end of New Dorp Lane (see below).

The New Creek Drainage Zone, while rich in paleoenvironmental data, is judged to have virtually no potential to contain prehistoric cultural material. The single exception to this is the area around DH32, at the extreme north end of the study corridor, which may also hold some historic archaeological sensitivity (Figure 7.4). For much of the post-glacial period and the Holocene this setting was part of the lower slope of the Fort Wadsworth upland and marks the northern boundary of the New Creek drainage. Silty

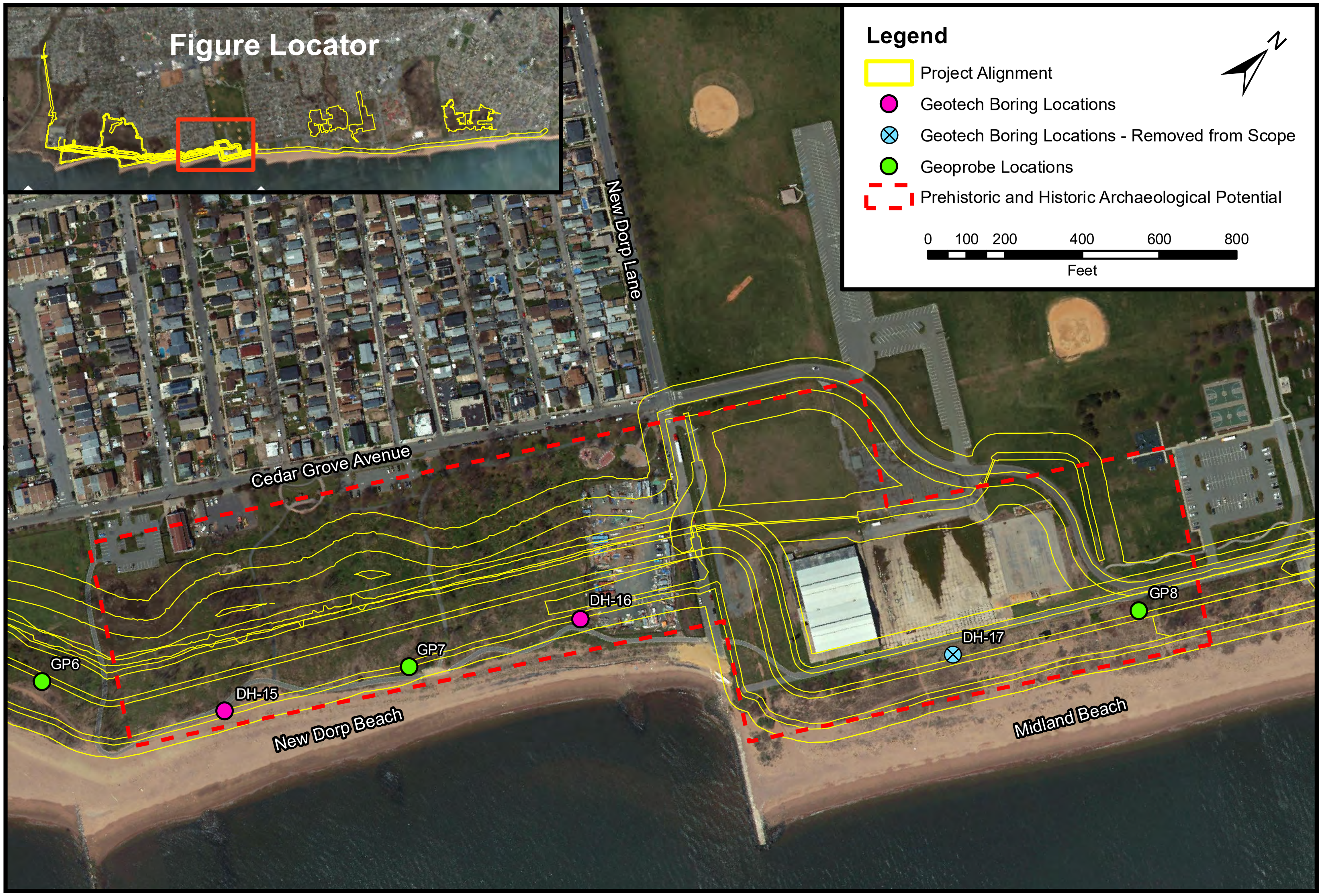

Figure 7.3. Area of Prehistoric and Historic Archaeological Sensitivity, DH15 to GP8, Cedar Grove Avenue, New Dorp Lane and Miller Field.
Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

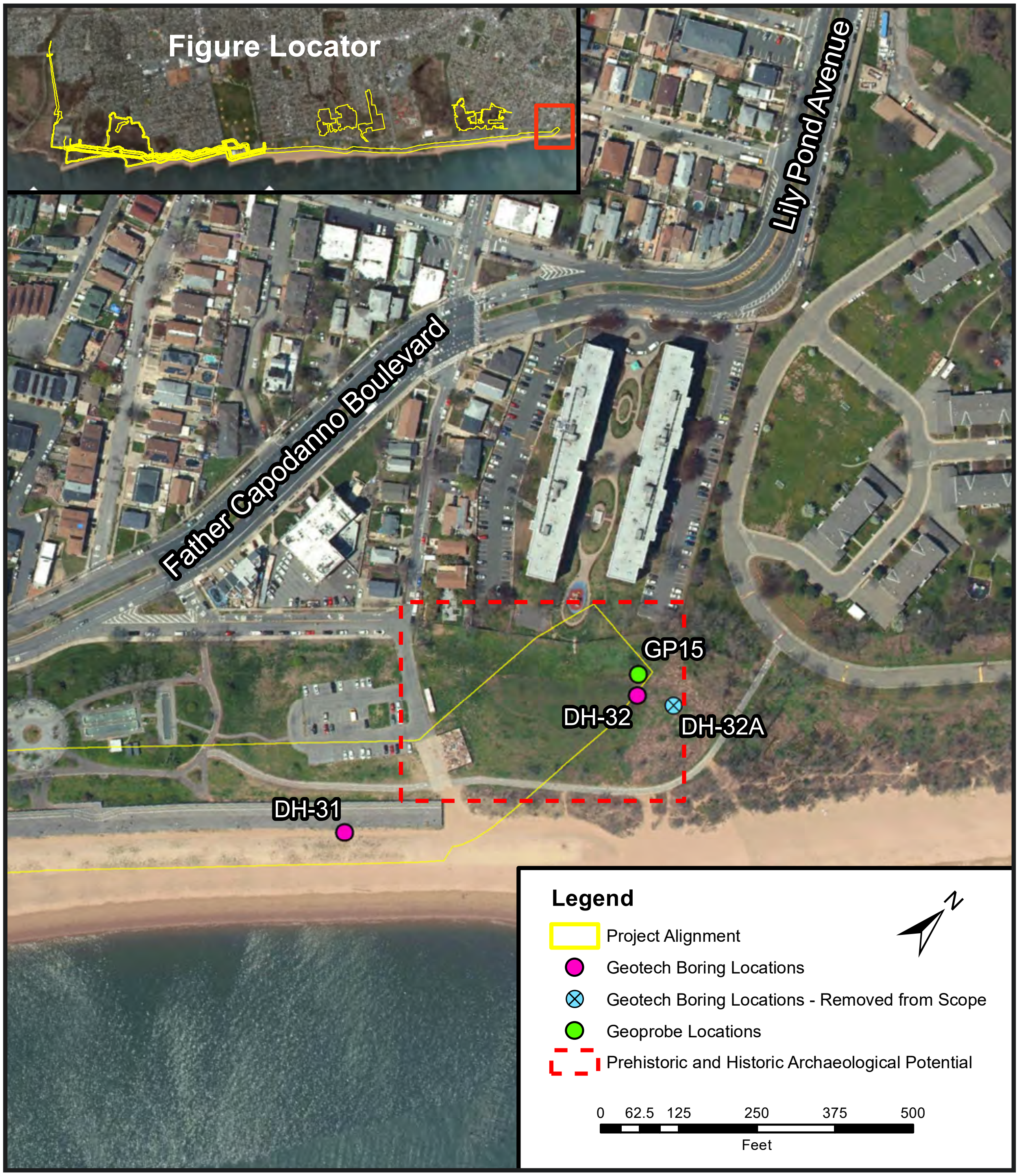

Figure 7.4. Area of Prehistoric and Historic Archaeological Sensitivity, DH32, Ocean Avenue. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

clay recovered at 9 to 10 feet bs (4 to 5 feet bmsl) in DH32 may be a remnant of a stable subsoil developed either in in-situ glacial outwash or outwash-derived slopewash from higher on the Fort Wadsworth upland. If this is the case, the upper portions of this developed profile were apparently eroded by the overwashing waves that deposited the backbarrier sands that now directly overlie the silty clay. If this is, in fact, a remnant of a stable toe-slope profile, then intact examples of this profile may be present west and north of the location of DH32, where slight gains in elevation and distance from the shoreline may have resulted in less erosion during marine transgression. Assuming a developed profile thickness of three to four feet and assuming slightly less Late Holocene deposition with greater elevation and distance from the shoreline, the upper boundary of such a profile might be encountered at three to four feet below the modern surface.

In the rest of the New Creek Drainage Zone, between DH32 and DH20, no evidence was seen of stable profiles formed before the Late Holocene marine transgression. The most stable settings within the drainage would have been the surfaces of the low interfluves lying between the separate stream and floodplain environments. Only a single instance of a possible interfluve remnant – with no evidence of soil profile development – was detected in the borings (DH21). Some erosion of the sides of the interfluves may have begun during the period of stream hollow aggradation, which would have been accompanied by increased lateral migration of channels. Even allowing for the relatively wide spacing of samples within the New Creek Drainage Zone (500 to 1,000 feet), the lack of evidence of interfluves suggests that the topographic low formed by the drainage area underwent heavy reworking by wave and tidal processes in the period before the barrier island had encroached enough to impede wave erosion. Following removal of weathered, relatively cohesive surficial soils by these processes, the unconsolidated outwash of the interfluve cores would have been easily dispersed, with the eroded sediment removed by longshore currents. As noted previously, it cannot be categorically ruled out that in some places a thin mid-Holocene stream floodplain A horizon may have been subsumed and incorporated into the lowest silty lagoon sediments. If this is the case, the floodplain surface would have been short-lived, as by the time of marine incursion the streams of the New Creek drainage would have been aggrading their beds and floodplains. It is notable that the majority of the sediments recovered in the probes which are interpreted to be of alluvial origin fall into the loamy to silty clay textural classes and are therefore more cohesive and resistant to erosion than the sand and fine gravel that makes up most of the study area, including the former interfluves.

B. HISTORIC ARCHAEOLOGICAL POTENTIAL

The main focus of historical and historic archaeological interest in the current study has been the site of the Lake tide mill, a gristmill that was in operation from the early 18th through into the late 19th century. Analysis of historic maps and aerial photographs, coupled with field inspection, has allowed the location of the mill to be established with reasonable precision as lying some 400 feet southwest of the alignment of the proposed floodwall that will be constructed along the southwestern edge of the Oakwood Beach Wastewater Treatment Plant (Figure 7.5). This location today lies within the marshland at the northeastern end of Great Kills Park and is largely inaccessible. No obvious surface traces of the mill building, milldam, millpond or other hydropower elements survive. While subsurface remains of the mill and its hydropower system may survive within the marsh, the archaeological integrity of the mill site (and of the associated site of the Lake family homestead) is marginal, having been compromised by the creation of Great Kills Park and the construction of the wastewater treatment plant, both of which entailed a radical transformation of the

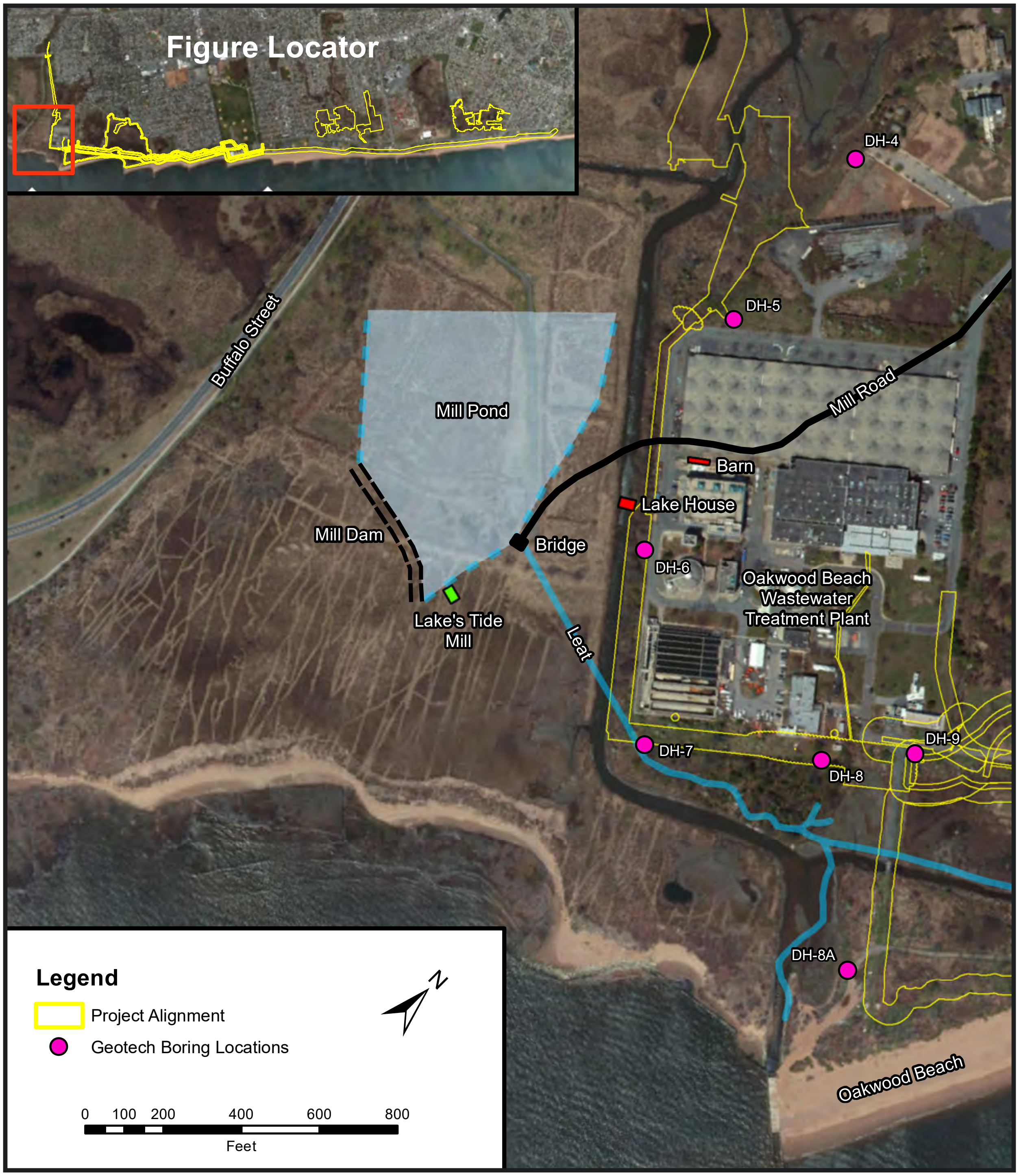

Figure 7.5. Location of Lake's Tide Mill in Great Kills Park. Source: New York Division of Homeland Security and Emergency 2018 and U.S. Army Corps of Engineers, New York District.

landscape which can be traced in aerial photographs of 1954, 1966 and 1980 (Nationwide Environmental Title Research 2020).

Two other locations of potential historic archaeological concern are identified, which may be affected by the coastal storm reduction project. Both locations overlap with areas of potential prehistoric archaeological interest as identified above.

One area lies at the southeastern end of New Dorp Lane, specifically in the southeastern corner of Miller Field and within the strip of land between New Dorp Beach and Cedar Grove Avenue (Figure 7.3). New Dorp Lane likely came into being in the early historic period, perhaps as early as the second half of the 17th century, connecting a landing place on the shore with farms and villages in the interior of the island. The landing may also have been a focus of fishing activity in the bay. The earliest detailed map of the area, dating from 1781 (see above, Figure 4.1), shows the lane in existence and a building nearby on the shoreline. In the early 19th century, a prominent elm tree on the shoreline at the end of the lane served as a navigational aid for shipping approaching the Narrows. By the late 1850s, a lighthouse and lighthouse keeper's station had replaced the elm on the southwest side of the lane. The first lighthouse was replaced in the late 1880s by a second lighthouse, the Elm Tree Beacon, on the opposite side of the lane on the Vanderbilt estate, now a part of Miller Field. Also, beginning in the 1880s and continuing into the early/mid-20th century, the east side of Cedar Grove Avenue, was developed with a number of sizeable resort facilities (hotels and bath houses) and the Seaside Hospital of St. John's Guild (see above, Figures 4.2, 4.4b, 4.6b, 4.8c, 4.8d, 4.9d and 4.9e). While the creation of the Miller Field air station, redevelopment and storm damage have all taken their toll on these earlier historic features of the landscape, the shoreline at the seaward end of New Dorp Lane has remained relatively stable and there remains some potential for substantial archaeological survival of the larger structures (e.g., lighthouses and hotels) and associated cultural deposits in this area.

The second location with some historic archaeological sensitivity is at the extreme northeastern end of the project alignment in the vicinity of DH32 and GP15 (Figure 7.4). This location, at the base of the upland terrace and extending upslope to the north and west, lies on the periphery of Oude Dorp, or Old Town, the first permanent settlement on Staten Island. Excavations immediately adjacent to the project alignment on the site of the Walton-Stillwell house site, today occupied by the Seaside Plaza apartment complex, produced Contact period and 17th-century features and artifacts (Anderson and Sainz 1965). Historic homes continued to occupy this blufftop setting through into the early 20th century until redevelopment resulted in the construction of bungalows in much of this area (see above, Figures 4.3, 4.4a, 4.5, 4.6a, 4.8a and 4.9a). Despite the subsequent construction of the apartment complex, based on current site conditions, there still exists some potential for early historic archaeological resources surviving on undeveloped land both on the upland rim and at the base of the slope northeast of Ocean Avenue and southeast of Drury Avenue.

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

Geomorphological/archaeological assessment of the South Shore of Staten Island Coastal Storm Reduction Project indicates that there are substantial portions of the project alignment that hold little to no potential for yielding intact buried land surfaces and significant archaeological remains.

At the southwestern end of the project, most of the Mill Creek drainage from just downstream of Hylan Boulevard to the Oakwood Beach Wastewater Treatment Plant was largely unavailable for testing owing to contaminated soils. Land along this segment of the alignment has been modified as a result of the creation of Great Kills Park in the mid-20th century and prior to this was subject to erosion by the frequently changing course of the creek. Although unsupported by in-field testing data, it is thought unlikely that this area will contain significant, intact prehistoric or historic archaeological data.

Soil profiles around the periphery of the Oakwood Beach Wastewater Treatment Plant and extending northeast to Kissam Avenue (DH6-DH10) show that this area was extensively reworked by migrating channels of terrestrial streams and later by wave action. There is little prospect of prehistoric archaeological deposits or cultural materials being found along this section of the alignment, while construction of the treatment plant has largely destroyed evidence of the early historic mill site and related settlement at the southwestern end of Mill Road (see below, Section D).

The long segment of the project alignment extending from the northeast corner of Miller Field almost to Ocean Avenue (DH19-DH31), while rich in paleoenvironmental data, is judged to have virtually no potential to contain intact prehistoric archaeological deposits or cultural materials. In this dynamic coastal marsh in the New Creek drainage zone, no evidence was seen of stable soil profiles forming before the Late Holocene marine transgression in DH20-DH31 or GP9-GP14. Similarly, there is no documentary or cartographic evidence to indicate the possible existence of historic period archaeological resources.

Three locations have been identified, however, where there exists some prospect of prehistoric and/or historic archaeological resources surviving within the project's Area of Potential Effect (APE). These are summarized below along with recommendations for further evaluation at the Phase I level of study. All three of these locations lie within the limits of the Gateway National Recreation Area and further study involving archaeological excavation will require issuance of Archaeological Resources Protection Act (ARPA) permits by the National Park Service.

A. **HYLAN BOULEVARD AND MILL CREEK**

An area measuring roughly 225 feet southwest/northeast by 100 feet southeast/northwest is defined on the southeast side of Hylan Boulevard, northeast of Mill Creek, where a developed subsoil was identified in alluvial soils in DH2 (Figure 7.1). Although an intact A horizon was not observed owing to the split-spoon testing methodology adopted, such a horizon may survive at a depth of around four to five feet below the present ground surface with the possibility that the underlying Middle through Late Holocene deposits could yield prehistoric cultural materials.

Ideally, Phase I archaeological testing at this location would involve pre-construction backhoe-assisted and manual excavation overseen by a qualified geoarchaeologist with expertise in Middle Atlantic coastal prehistory. However, radiological contamination of the soils precludes effective archaeological investigation of what at best is a limited area of moderate archaeological potential. The most practical and safest approach to further archaeological testing at this location is considered to involve monitoring of the early stages of ground preparation for construction with a clear provision that a geoarchaeologist, suitably protected, be given the opportunity to examine any buried A and upper B horizons, if these indeed survive. In the event, monitoring should encounter cultural deposits worthy of further archaeological assessment, these could then be subject to a more formal combined Phase I and II (identification and evaluation) archaeological survey in advance of further construction activity.

B. CEDAR GROVE BEACH TO MILLER FIELD

Tests along the section of the project alignment from the southwestern end of Cedar Grove Beach to the southeastern corner of Miller Field (DH11-GP8) encountered intermittent evidence of a buried A horizon and a thin but relatively stable soil profile at depths ranging from one to 6.5 feet below the surface (Figures 7.2 and 7.3). This stretch of shoreline forms part of a setting that includes the former headwaters of Bass Creek and the upland zone traversed by New Dorp Lane. The soil conditions offer some prospect that prehistoric archaeological resources could survive, although their examination would be hampered considerably by the high water table, which typically is above the level of the A horizon.

Of particular note is a knoll-like landform examined through DH11 and DH12, where the A horizon was observed close to the surface, yet barely above the water table (Figure 7.2). Rather than attempt archaeological testing within the limits of the project alignment at this location, it is recommended instead that a comparable landform be sampled, in this instance a knoll, further inland and at a slightly higher elevationin the adjacent marsh between Ebbitts Street and Tysens Lane, where the water table will be deeper below the present ground surface. This particular knoll is capped with a clump of trees and appears to have lain adjacent to a relict headwater tributary of Bass Creek (circled in Figure 7.2). Archaeological testing can be conducted manually and potential cultural deposits of interest are anticipated to survive above the water table. Between 40 and 50 shovel tests and one to three one-meter-square excavation units are recommended.

Northeast of Ebbitts Street to Miller Field, a zone of combined prehistoric and historic archaeological potential is identified (Figure 7.3). The prehistoric component comprises the buried A horizon observed in DH15 and tests further to the southwest, while the historic archaeological remains may include foundations of two 19th-century lighthouses and a lighthouse keeper’s station, at least two turn-of-the-20th-century hotels, bathhouses and a hospital, as well as possible earlier features from the late 17th and 18th centuries. Although later cabins, a storage yard, landscaping and the Miller Field air station have been erected in this area, the likelihood is strong that earlier, potentially significant historic features and cultural deposits may survive beneath fill, demolition debris and beach sediment.

To address both the prehistoric and historic archaeological potential of this area, site-specific background research and mechanically-assisted excavation is recommended in the form of a series of four 100-foot-long trenches, or their linear equivalent, positioned perpendicular to the shoreline. Three trenches are suggested for the area southwest of New Dorp Lane and a single trench to the northeast. The excavation team should include both a qualified geoarchaeologist with expertise in Middle Atlantic coastal prehistory and an historical archaeologist with knowledge of Staten Island history.

C. SOUTHEAST END OF OCEAN AVENUE

At the far northeastern end of the project alignment, on the northeast side of Ocean Avenue, toward the base of the slope of the upland at the southwestern end of Fort Wadsworth, an area measuring roughly 400 feet southwest/northeast by 300 feet southeast/northwest is defined as having both prehistoric and historic archaeological potential. Even though there has been extensive land modification and redevelopment in this location over the years, there remains the possibility that archaeological deposits may survive intact beneath fill and landscaping. DH32 indicated a possible stable Holocene soil profile at depths of nine to ten feet below the present ground surface, while archaeological excavations in the mid-1960s found Contact period and early historic artifacts, possibly reflecting the original Oude Dorp settlement immediately adjacent to the project alignment to the northwest.

To address both the prehistoric and historic archaeological potential of this area, site-specidic background research followed by mechanically-assisted excavation is recommended in the form of two 100-foot-long trenches, or their linear equivalent, oriented on a northwest/southeast axis. The excavation team should include both a qualified geoarchaeologist with expertise in Middle Atlantic coastal prehistory and an historical archaeologist with knowledge of Staten Island history.

D. LAKE TIDE MILL

The Lake tide mill formed a particular focus of research in the current study and its history has been laid out in considerable detail in Chapter 4B. In addition, careful georeferencing and rubbersheeting of historic maps has enabled the sites of the mill and its various component parts to be located within the present-day cultural landscape with reasonable confidence. Although no formal archaeological evaluation of the mill site is offered, it is very likely that any below-ground remains have been compromised by the creation of Great Kills Park and the construction of the Oakwood Beach Wastewater Treatment Plant.

The core of the mill site lies approximately 400 feet southwest of the proposed floodwall alignment along the southwest side of the wastewater treatment plant. The coastal storm reduction project will have no effect on the mill site. No further historical or archaeological evaluation of the mill site is considered necessary.

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Appendix A

SCOPE-OF-WORK

Scope of Work
and
Request for Proposal
For a
Geomorphological/Archaeological Study
In Connection with the
South Shore of Staten Island
Coastal Storm Damage Reduction Project
Richmond County, New York

I. Introduction

The U.S. Army Corps of Engineers, New York District (Corps), has been authorized by the Disaster Relief Appropriations Act of 2013 (Public Law 113-2), to undertake Preconstruction Engineering and Design (PED), and construction of a flood risk management project along the South Shore of Staten Island in Richmond County, New York.

The Corps, as a federal agency is required to identify cultural resources within its project areas and evaluate their eligibility for listing on the National Register of Historic Places (NRHP). The Federal statutes and regulations authorizing the Corps to undertake these responsibilities include Section 106 of the National Historic Preservation Act, as amended through 1992 and the Advisory Council on Historic Preservation Guidelines for the Protection of Cultural and Historic Properties (36 CFR Part 800). The New York District (District) is applying the National Register of Historic Places (NRHP) Criteria to properties identified within the Area of Potential Effect (APE) on a phased basis, and to date has completed substantial surveys within the APE with the recognition that additional identifications and evaluations are required. Work that the District will undertake in the PED phase has been stipulated in a Programmatic Agreement signed in 2016 by the District, National Park Service, and the New York State Historic Preservation Office (NYSHPO).

The District in consultation with the NYSHPO has determined that there is the potential to encounter deeply buried landforms and Native American sites in the APE along the project Line of Protection (LOP); the continuous alignment of levee, seawall, and floodwalls along the shore. The locations of interior drainage features are also considered sensitive. It is very probable that any prehistoric resources identified would be found to be eligible for listing in the NRHP under Criterion D of 36 CFR Part 60, due to their contribution in the study of the life and culture of indigenous peoples before the advent of written records. The documentation of the presence or absence of such sites and spatial distribution relative to landforms and resources would be important to the interpretation of prehistoric regional settlement patterns, demography and ecology.

The LOP shall be investigated by the District through the excavation of borings along the project alignment. Interior drainage areas will also be studied. In accordance with the PA the excavation of borings is to be overseen by a geoarchaeologist. The purpose of the investigations outlined in this scope is to assess the potential for prehistoric resources within the project area by evaluating pertinent geophysical and paleoenvironmental data with respect to deglaciation, relative sea level rise, paleogeography, and the effects of marine erosion. The overall goal of this cultural resource work will be to determine those locations within the project area that are potentially sensitive for prehistoric resources. The resulting report will include recommendations for mitigation of any potentially significant resources encountered. Avoidance of resource is preferred and should be recommended although may prove not feasible.

The assessment will be based on, though not limited to, previous geological and cultural resource studies, both published and in the "gray literature," and the borings excavated for geotechnical purposes as part of the South Shore of Staten Island Project. The excavation of the proposed borings will be conducted under a separate contract but their collection will be monitored under this contract by an individual qualified in both fields of geomorphology and archaeology. Approximately 40 borings (or Drill Holes [DH]) are scheduled be taken for geomorphological and HTRW testing purposes along the LOP and a further six in the location of interior drainage features (Locations labeled DH-# in Attachment 1). The borings along the LOP will be excavated by split spoon using a drill rig but the interior drainage areas sampling will done by hand auger. The locations of these excavations were determined by engineering needs. Part of the scope of this work is to identify additional boring locations (up to 10 additional) if necessary along the LOP and/or interior drainage areas.

The LOP in the Oakwood Beach area is in the vicinity of an historic mill site. Research on the mill will be undertaken under this scope. An examination of borings in the vicinity of the mill and pond may be precluded due to the presence of radioactive waste in the vicinity of the site.

Palynological analysis (ID and count) will be undertaken on all pertinent strata and radiocarbon dating of selected samples will be undertaken as deemed necessary by the Principal Investigator. Grain size analysis will be conducted as part of the geotechnical study and the results will be made available for the work to be conducted under this scope. The Principal Investigator will determine which of these sediments should be tested.

II. Project Background

A. Project Location

The study area consists of approximately 5.5 miles of coastline in the Borough of Staten Island, New York City, New York, extending along the Lower New York Bay and Raritan Bay. The approximate west and east limits (i.e. along the south shoreline) of the study area are Oakwood Beach and the easternmost point of land within Fort Wadsworth at the Narrows. The principal neighborhoods along the study reach from east to west are South Beach, Midland Beach, New Dorp Beach, and Oakwood Beach. The study limit is bound inland by natural high ground approximately one mile from the shoreline.

B. Project Description (Enclosure 2)

The recommended plan includes:

- Construction of flood risk management features consisting of buried seawall and armored levee along a majority of the Fort Wadsworth – Oakwood Beach reach of Staten Island, approximately 5.3 miles at an elevation of 19.4 feet NAVD88, that will serve as the first line of defense against coastal surge flooding and wave forces. The flood risk management features are comprised of four sections:
    - Reaches A-1 and A-2 : Construction of an earthen levee 3,400 feet in length with a crest elevation of 16.9 feet NAVD88.
    - Reach A-3: Construction of a vertical floodwall 1,800 feet in length with a crest elevation of 19.4 feet NAVD88.
    - Reach A-4: Construction of a buried seawall 22,700 feet in length with a crest elevation of 19.4 feet NAVD88
- Implementation of an interior drainage plan that includes:
    - Acquisition and preservation of 301 acres of open space;
    - Excavation of a pond approximately 188 acres in size including removal of existing Phragmites monoculture and seeding/re-planting of ponds with native vegetation, creating 46 acres of emergent wetland habitat;
    - Construction of tide gates and gate chambers along the project alignment;
    - Raising of three roads: Seaview Avenue (at Father Capodanno Boulevard), Kissam Avenue, and Mill Road, and;
    - Other minor interior drainage measures necessary to meet the Minimum Facility Plan as defined in the Final FR/EIS.

III. Previous Research

Most of the project's APE has been subject to cultural resource surveys by USACE or by others. A reconnaissance report was prepared for this study in 1995 which was a summary of cultural resources work conducted to date in the project vicinity, a brief overview of historic map research and recommendations for further work (Rakos 1995). This work summarized and updated a previous study undertaken for the project (Lipson, et al. 1978.). In 1996, USACE conducted archaeological investigations at Oakwood Beach and identified a Native American site (Rakos 1996). This site was later destroyed by a private development project. A Phase I survey of the entire south shore of Staten Island project area was completed for USACE in 2005 (Panamerican Consultants. Inc., 2005). This work included archaeological testing and an historic architectural survey. The resulting report recommended further archaeological investigations in selected locations along the proposed project alignment and interior drainage features. The only historic structures noted in the APE are at Miller Field. All District cultural resources studies were coordinated with the New York State Historic Preservation Office (SHPO).

No Native American resources were identified along the proposed alignment as a result of cultural resources surveys. However, the shoreline was determined sensitive for deeply buried sites (Panamerican 2005). The potential for deeply buried sites was corroborated by a geomorphological study conducted for the USACE's New York and New Jersey Harbor Navigation Project (Geoarchaeological Research Associates 2014). While this study's APE was offshore, it suggested that the south shore of Staten Island is moderately sensitive for now inundated or deeply buried shoreline sites. Work recommended in the 2005 survey along the LOP included the excavation of deep borings in selected locations to test for the presence of early landforms buried under marsh or organic soils. Borings will serve to determine if any significant resources or sensitive landforms are present. If such resources are identified then construction impacts will be determined and mitigation measures developed. There is a moderate potential to encounter significant archaeological deposits.

USACE has prepared a Programmatic Agreement (PA) which stipulates the actions will be undertaken as the project proceeds with regard to cultural resources. The PA will be used to ensure that USACE satisfies its responsibilities under Section 106 of the NHPA and other applicable laws and regulations. Under the PA, deep testing/borings are required to determine the potential for deeply buried prehistoric sites.

Prehistoric archaeological sites previously recorded in the vicinity of the project area were largely documented in the late 19th and early 20th centuries although a few have come to light through more recent cultural resource management studies. The "Arrochar" site, near the northern end of the APE, yielded both Native American and early European materials. The Walton-Stillwell house site (northwest of the present intersection of Drury Lane and Ocean Avenue) also indicated occupation by Native American populations as well as evidence of the 17-th century European habitation. At Oakwood Beach the Oakwood/Lake's Mill site a shell midden and lithic finds were reported. Testing by the USACE at Oakwood Beach identified a Native American site (Rakos 1996). This site was later destroyed by a private development project. A number of finds were documented in the vicinity of Great Kills including *Sites #A-085-01-0162* through *0165*, described respectively as a campsite at Crooke's Point, isolated fluted point northwest of Great Kills Harbor, a camp and shell midden and what was possibly Contact Period site (John Milner Associates 1978). These sites are south of the APE.

The presence of prehistoric sites along the south shore of Staten Island is affected by the topography and physiography of the area. As revealed by various historic maps extensive areas of salt marsh formerly extended along the shoreline adjacent to much of the project area. During the latter portion of the prehistoric period, areas of salt marsh would not have provided favorable environments for prehistoric settlement. Similarly, beach areas, although undoubtedly visited and utilized by Native Americans would not have represented likely areas for settlement or long-term occupation. Marsh areas could however contain deeply buried evidence of early prehistoric utilization.

IV. Contractor Services and Required Investigations

A. The general services to be provided under this contract are those required to conduct research and prepare a report on the prehistoric environment along the South Shore of Staten Island.

B. The Contractor shall be responsible for conducting, in the manner prescribed, the work detailed below. Failure to fully meet the requirements of this scope of work may be cause for termination of work for default of the contract, or for an evaluation of unsatisfactory upon completion of the project.

C. This scope of work requires the completion of the following tasks:

Task 1 - Review Previous Research and Background Research

a. The Contractor shall review the documents cited in Section III, "Previous Research" above, as well as other applicable texts. Many of the cultural resource reports cited are available at the New York District.

b. The Contractor shall also conduct additional research to:

1. determine the prehistory of the project area and vicinity.

2. identify previously known cultural resources within the project area and vicinity.

3. outline pertinent research issues associated with this study.

4. research the geology, hydrology, sea level rise, depositional history etc. of the project area.

5. consult the New York State Historic Preservation Offices (NYSHPO). This office should be contacted again for more recent material. The New York State Museum may be consulted.

6. Conduct historic research on the mill site at Oakwood Beach

<u>Task 2 – Prepare Health and Safety Plan</u>

a. A Health and Safety Plan (HASP) and a Hazard Analysis Plan shall be prepared. The HASP will serve as a safety plan and research strategy for all work. The HASP and all work will comply with Engineering Manual EM 385-1-1, "Safety and Health Requirements Manual" dated 3 November 2003 and all other applicable regulations and guidelines. Appendix A of this manual provides a minimum basic outline for the plans. The Corps can provide samples of plans. The manual is available on-line at http://www.hq.usace.army.mil/soh/hqusace_soh.htm.

b. District acceptance of the HASP must be obtained before any fieldwork is undertaken.

c. The HASP will also indicate the location of proposed tests and provide an overall strategy for conducting the work.

d. It must be noted that an area near the Oakwood Beach Waste Water Treatment plant has been determined to contain radioactive material in the soils. No work will be conducted there under this contract. The area of concern will be delimited by the Corps' Baltimore District, who will be conducting the borings.

Task 2 - <u>Monitor Excavation of Borings</u>

Borings will be excavated for the Corps by the Corps' Baltimore District. The geomorphologist retained under this task order will monitor the borings excavated in those areas they determine to be potentially sensitive for cultural resource data. As currently proposed 40 cores (Drill Holes [DH]) will be excavated by machine along the LOP and six will be excavated by hand in the interior drainage areas (**Locations labeled DH-# in Attachment 1).** The locations of the borings were determined by geotechnical and environmental needs. There will be up to 10 additional borings for which the locations will be determined by the geomorphologist. These probes will be solely for archaeological purposes and it is possible that geoprobes instead of splits-poon sampling may be undertaken. If possible, a continuous profile should be obtained through Holocene deposits and into the terminal Pleistocene deposits. The schedule will be determined in consultation with the Corps project archaeologist, Corps Engineering Division and the boring contractor but will not be more than 60 days. The area between stations 15+00 and 40+00 will not be accessible under this contract due to contaminations. Presently proposed borings DH-3 and DH-4 will not be monitored but data from those cores will be made available.

<u>Task 3 - Sediment Testing</u>

Samples will be taken from the cores and examined for evidence of cultural resources and paleoenvironmental data. All samples selected for further analysis will undergo palynological testing (not to exceed 50 samples). Grain size and Carbon-14 analyses will be undertaken for only those sediments determined by the geomorphologist as likely to yield significant information. The number of samples to be tested for grain size by the geomorphologist will not exceed 25. Carbon-14 testing will not exceed 20 samples.

Task 4 - Data Analysis

The Contractor will assemble and interpret all data collected for this study with the purpose of collating it in the preparation of the draft and final reports. The report requirements are outlined in Section V, below.

Task 5 - Report Preparation

The Contractor shall prepare interim, draft and final reports. The final report will incorporate all comments received from the Corps and other reviewing agencies.

The reports produced by a cultural resource investigation is of potential value not only for its specific recommendations but also as a reference document. To this end, the report must be a scholarly statement that can be used as a basis for any future cultural resources work. It must meet both the requirements for cultural resource protection and scientific standards of current research as defined in 36 CFR Part 800 and the Councils Handbook.

1. One copy of each interim report will be submitted to the Corps, according to the time schedule established in Section VI "Project Schedule", below. Each interim report will provide a brief summary of the work conducted to date and the work yet to be completed. It shall present any preliminary results of the research and field effort.

2. One hard copy and a digital version of the draft report will be prepared and submitted to the Contracting Office according to the schedule established in Section VI "Project Schedule", below. The draft report will be reviewed by the Corps, the NYSHPO and possibly other agencies. All comments of the reviewing agencies will be transmitted to the Contractor prior to the submission of the final report.

3. Two bound paper copies of the final report shall be submitted to the Contracting Office according to the schedule established below in Section VI "Project Schedule". Each paper copy shall have a labeled CD containing a copy of the report in .pdf format. Three (3) additional labeled CDs with the final report shall also be submitted. The final report shall address all comments made on the draft report.

Task 6 - Project Management

The Contractor will be responsible for ensuring that all deliverables are provided on schedule and that all terms of this scope of work are satisfied.

V. Report Format and Content

A. The draft and final reports shall have the following characteristics:

1. The draft and final copies of the cultural resources report shall reflect and report on the work outlined in Section IV (Contractor Services and Required Investigations) above. They shall be suitable for publication and be prepared in a format reflecting contemporary organizational and illustrative standards of professional archaeological journals. The draft report will be revised to address all review comments.

2. The report produced by a cultural resources investigation is of potential value not only for its specific recommendations, but also as a reference document. To this end, the report must be a scholarly statement that can be used as a basis for any future cultural resources evaluation. It must meet both job requirements for cultural resources protection and scientific standards as defined in 36 CFR Part 800 and in the "The Treatment of Archeological Properties: A Handbook" (1980) published by the Advisory Council on Historic Preservation.

3. All interim, draft and final copies of the report shall reflect and report on the work required by this scope.

B. **PAGE SIZE AND FORMAT.** Each report shall be produced on 8 1/2" x 11" archivally stable paper, single spaced with double spacing between paragraphs. The printing of the text should be letter quality. All text pages, including figures, tables, plates and appendices must be consecutively numbered.

C. Three final copies of the report, with original photographs, shall be submitted in a hard-covered binder suitable for shelving.

D. The **TITLE PAGE** of the report shall include the municipalities and counties incorporated by the project area, the author(s) including any contributor(s). The Principal Investigator should be identified and is required to sign the original copies of the report. If the report has been written by someone other than the contract Principal Investigator, then the cover of the publishable report must bear the inscription "*Prepared Under the Supervision of (NAME), Principal Investigator*". The Principal Investigator in this case must also sign the original copies of the report.

E. A **MANAGEMENT SUMMARY** or **ABSTRACT** shall appear before the **TABLE OF CONTENTS** and **LIST OF FIGURES**. It should include a brief project description including the location and size of the project area, the methods of data collection, the results of the study, evaluations and identification of impacts and recommendations. It should also include the location of where copies of the report are on file.

F. The **TABLE OF CONTENTS** will include a list of all figures, plates and tables presented in the report.

G. The **INTRODUCTION** will state the project's purpose and goals as defined by the scope of work and will include the applicable regulations for conducting this work and will contain a general statement of the work conducted and the recommendations proposed.

H. The **BACKGROUND RESEARCH** must be sufficient to provide a detailed description and evaluation of the prehistoric research of the project area. This section should include a summary of the existence of sites and a description of previous work conducted in the area. The following information should be presented and discussed:

1. The **ENVIRONMENTAL SETTING**, including bathymetry, soils, and geology.

2. An **ANALYSIS** of paleoenvironment, present climate and current vegetation.

3. **PAST AND PRESENT LAND USES** and current conditions.

4. A **DISCUSSION** of prehistoric and historic cultural history of project locale. This section should provide contexts for research questions, survey methods, etc.

5. A **REVIEW** of known sites, previous investigations and research in the project area and vicinity.

I. A **RESEARCH DESIGN** will outline the purpose of the investigation, basic assumptions about the location and type of cultural resources within the project area. The following shall also be included:

1. **RESEARCH OBJECTIVES** and **THEORETICAL CONTEXT**

2. Specific **RESEARCH PROBLEMS** or questions.

3. **METHODS** to be employed to address the research objectives and questions.

4. A **DISCUSSION** of the expected results, including hypotheses to be tested.

J. A **METHODS** section, if applicable, shall include:

1. A **DESCRIPTION OF FIELD METHODS** employed, including rationale, discussion of biases and problems or obstacles encountered.

2. A **DEFINITION** of site used in the survey.

K. **RESULTS, INTERPRETATIONS AND RECOMMENDATIONS.** A discussion of the results in terms of the background cultural context, research design, goals, research problems, and potential research questions.

L. A **REFERENCES CITED** section will list all references and citations located within the text, including all figures, plates or maps, and within any appendices. All sources (persons consulted, maps, archival documentation, etc.) maybe listed together. This list must be in a format used by professional archaeological journals, such as *American Antiquity*.

M. **APPENDICES** shall include, but not be limited to:

1. A copy of relevant boring/subsurface exploration data used in the report.

2. The **QUALIFICATIONS** of the Principal Investigator and any other key personnel used.

3. The final **SCOPE OF WORK**.

O. **PHOTOGRAPHS** Digital images may be used in the report and should appear on the facing page of the subject they illustrate. The images should be counted as "Figures" in a single running series of illustrations. All images used should be a clear representation of the features. Photograph captions for site overviews must include direction or orientation. Photographs of features should include a scale, title board and orientation. At a minimum, captions should identify feature or location, direction, photographer and date taken.

P. **GRAPHIC PRESENTATION OF THE RESULTS.**

1. All pages, including graphic presentations, will be numbered sequentially.

2. All graphic presentations, including maps, charts and diagrams, shall be referred to as "Figures". All figures must be sequentially numbered and cited by number within the body of the text.

3. All figures, plates and tables should be incorporated into the text on the page following their citation. They should not be appended.

4. All tables shall have a number, title, appropriate explanatory notes and a source note.

5. All figures shall have a title block containing the name of the project, county

and state.

6. All maps, including reproductions of historic maps, must include a north arrow, accurate bar scale, delineation of the project area, legend, map title and year of publication.

7. The report must include the project area(s) accurately delineated on a U.S.G.S. 7.5' topographic map and a county soils survey map, if available for that area.

VI. Project Schedule

A. All reports should be submitted in a timely manner as stipulated below:

1. A brief interim report summarizing work conducted during a billing period will be submitted to the Corps monthly with each invoice. The interim report shall discuss what work has been accomplished and what work has yet to be completed. It shall also state any problems the Contractor has encountered in conducting the work or contain requests for information.

2. the draft report will be submitted to the Corps not later than four (4) months after completion of fieldwork. The draft report will be reviewed by the Corps, the NYSHPO and possibly other agencies. The final report will address all comments provided with the draft report.

3. The final report will be submitted to the Corps four (4) weeks after the Contractor receives the draft report with comments.

B. The number of copies for the interim, draft, and final reports will be submitted, according to the above schedule, as follows:

1. One (1) copy of each interim report.

2. One (1) hard copy and a digital version of the draft report

3. Two (2) bound paper copies of the final report, each shall have, in a pocket attached to the report, a labeled CD containing a copy of the report in .pdf format. Three (3) additional labeled CDs of the final report shall also be submitted.

C. Scheduled completion date for the work specified in this scope is 30 September 2019.

VII. Additional Contract Requirements

A. Agencies, institutions, corporations, associations or individuals will be considered qualified when they meet the minimum criteria given below. As part of the supplemental documentation, a contract proposal and appendices to the draft and final report must include vitae for the **PRINCIPAL INVESTIGATOR** and **MAIN SUPERVISORY PERSONNEL** in support of their academic and experiential qualifications for the research, if these individuals were not included in the original contract proposal. The Principal Investigator must also be a qualified geomorphologist. Additional personnel should consist of an archaeologist that meets the qualifications presented below. Personnel must meet the minimum professional standards stated below:

1. Archaeological Project Director or Principal Investigator (PI). Persons in charge of an archaeological project or research investigation contract, in addition to meeting the appropriate standards for archaeologist, must have a doctorate or equivalent level of professional experience as evidenced by a publication record that demonstrates experience in project formulation, execution, and technical monograph reporting. Suitable professional references may also be made available to obtain estimates regarding the adequacy of prior work. If prior projects were of a sort not ordinarily resulting in a publishable report, a narrative should be included detailing the proposed project director's previous experience along with references suitable for to obtain opinions regarding the adequacy of this earlier work.

2. Geomorphologist. Personnel hired for their special knowledge and expertise in geomorphology should have a Master's degree or better and experience and a publication record demonstrating a substantial contribution to the field through research. For this project, the individual must have experience in the interpretation of sediments on the coastal plain, particularly with regard to the potential for archaeological resources. The individual should also ideally be able to interpret seismic data.

3. Archaeologist. The minimum formal qualifications or individuals practicing archaeology as a profession area a B.A. or B.S. degree from an accredited college or university, followed by two years of graduate study with concentration in anthropology and specialization in archaeology during one of these programs, and at least two summer field schools or their equivalent under the supervision of an archaeologist of recognized competence. A Master's thesis or its equivalent in research and publications is highly recommended, as is the PhD degree. Individuals lacking such formal qualifications may present evidence of a publication record and references from archaeologists who do meet these references. In addition, the archaeologist should also have experience in the prehistoric archaeology of the southern New York - northern New Jersey area.

4. Standards for Consultants. Personnel hired or subcontracted for their special

knowledge and expertise must carry academic and experiential qualifications in their own fields of competence. Such qualifications are to be documented by means of vitae attachments to the proposal or at a later time if the consultant has not been retained at the time of proposal.

B. Principal Investigators shall be responsible for the validity of the material presented in their reports. In the event of a controversy or court challenge, Principal Investigators shall be required to testify on behalf of the government in support of findings presented in their reports.

C. Neither the Contractor nor his representatives shall release any sketch, photograph, report or other data, or material of any nature obtained or prepared under this contract without the specific written approval of the Contracting Officer prior to the time of final acceptance by the government.

D. The Contractor shall furnish all labor, transportation, instruments, survey equipment, boats and other associated materials to perform the work required by this Scope of Work.

E. The Contractor shall return all copies of reports provided by the Corps when the final report is submitted.

VIII. Fiscal Arrangements

A. Partial payments of the total amount allocated will be dispersed upon the receipt of invoices. Invoices will be submitted with the interim reports and with the draft report and will reflect the amount expended. The total amount of all monthly invoices shall not total more than 90% of the agreed work order amount. The remaining 10% of the agreed work order amount shall be paid upon the receipt and acceptance of the final report, all reports provided by the Corps, etc. and receipt of the final invoice. **No invoice payments will be made if it is does not include an accompanying interim or draft report.**

B. Invoice payments will be made pursuant to the "Prompt Payment" clause of the contract.

References:

Geoarchaeological Research Associates
2014 Geomorphology/Archaeological Borings and GIS Model of Submerged Paleoenvironment in the New York and New Jersey Harbor and Bight in Connection with the New York and New Jersey Harbor Navigation Project, Port of New York and New Jersey.

John Milner & Associates
1978 A Cultural Resources Inventory of the Gateway National Recreation Area. National Park Service, Denver Service Center. On file, New York State Office of Parks, Recreation and Historic Preservation, Peebles Island, Waterford, New York.

Lipson, Clara, John Piet, Michael Alterman and Kris Egelhof
1978 Phase I Cultural Resources Reconnaissance Beach Erosion Control and Hurricane Protection Project at Staten Island. On file, U.S. Army Corps of Engineers, New York District.

Panamerican Consultants. Inc
2005 Phase I Combined Erosion Control and Storm Damage Protection Feasibility Study, South Shore of Staten Island, Richmond County, New York. On file, U.S. Army Corps of Engineers, New York District.

Rakos, Lynn
1995 A Cultural Resource Reconnaissance Study of the South Shore of Staten Island, Richmond County, New York. On file, U.S. Army Corps of Engineers, New York District.

ATTACHMENT 1

Drill Hole (DH) Locations

South Shore of Staten Island
Coastal Storm Risk Managment Project
Subsurface Investigation Sites

Owner	Site Name	Block	Lot	Longitude	Latitude	Vicinity Location
NPS	DMT-11	3930	90	-74.093121	40.565829	Miller Field
NPS	SCPTu-10	3930	90	-74.093000	40.565760	Miller Field
NPS	DH-17	3930	90	-74.094046	40.564667	Miller Field
NPS	DH-18	3930	90	-74.092030	40.567070	Miller Field
NPS	DMT-10	3930	90	-74.095155	40.563674	Miller Field
NPS	A	3930	90	-74.104504	40.573131	Miller Field
NPS	D	3930	90	-74.102906	40.572688	Miller Field
NPS	F	3930	90	-74.103162	40.571480	Miller Field
NPS	DH-32A	3128	1	-74.060388	40.594768	Fort Wadsworth
NYC DEP	DH-6	5067	1	-74.117610	40.550070	3650 Hylan Boulevard
NYC DEP	SCPTu-3	5067	1	-74.116860	40.549360	3650 Hylan Boulevard
NYC DEP	DH-7	5067	1	-74.116512	40.549040	3650 Hylan Boulevard
NYC DEP	DH-5	5067	500	-74.118730	40.551210	751 Mill Road
NYC DEP	DH-8	5067	500	-74.115163	40.549925	751 Mill Road
NYC DEP	SCPTu-2	5067	500	-74.118120	40.550610	751 Mill Road
NYC DEP	SCPTu-4	5067	500	-74.115723	40.549580	751 Mill Road
NYC DEP	DH-10	4782	40	-74.110289	40.553226	Kissam Avenue
NYC DEP	AB-2	3748	43	-74.083959	40.579853	Patterson Avenue
NYC DEP	AB-5	3545	1	-74.100130	40.583677	Cletus Street
NYC DOE	B	3930	10	-74.105081	40.572336	2151 New Dorp Lane
NYC DOE	C	3930	10	-74.103931	40.572250	2151 New Dorp Lane
NYC DOE	E	3930	10	-74.104387	40.571647	2151 New Dorp Lane
NYC DOT	DH-9	-	-	-74.114430	40.550500	Cedar Grover Ave Exd
NYC DOT	SCPTu-5	-	-	-74.114218	40.550713	Cedar Grover Ave Exd
NYC DOT	DH-10B	-	-	-74.110210	40.552810	ROW near Block 4785 Lot 1
NYC DOT	DMT-4	-	-	-74.110060	40.553370	Kissam Ave, near Block 4782 Lot 39
NYC DOT	DMT-6	-	-	-74.105220	40.556771	Row near Block 4108 Lot 45
NYC DOT	DMT-4A	-	-	-74.110950	40.554120	Kissam Ave, near Block 4768 Lot 75
NYC DOT	AB-3	-	-	-74.071182	40.588224	McLaughlin Street, near Block 3414 Lot 1
NYC DOT	DH-12	-	-	-74.106260	40.555883	ROW near Block 4130 Lot 1
NYC DOT	DH-12B	-	-	-74.106220	40.555924	ROW near Block 4130 Lot 1
NYC DOT	AB-1	-	-	-74.087467	40.575328	Patterson Ave ROW, near Block 3769 Lot 1
NYC Parks	DMT-1	4994	200	-74.123060	40.554460	Emmet Avenue
NYC Parks	SCPTu-1	4994	200	-74.123031	40.554444	Emmet Avenue
NYC Parks	DH-4	4994	200	-74.120183	40.552888	Emmet Avenue

South Shore of Staten Island
Coastal Storm Risk Managment Project
Subsurface Investigation Sites

Owner	Site Name	Block	Lot	Longitude	Latitude	Vicinity Location
NYC Parks	DMT-2	4994	200	-74.121631	40.553830	Emmet Avenue
NYC Parks	DH-2	4994	1	-74.127451	40.556932	Marine Park
NYC Parks	DH-3	4994	1	-74.124520	40.555342	Marine Park
NYC Parks	DMT-3	4788	11	-74.112750	40.551833	Cedar Grove Avenue
NYC Parks	SCPTu-6	4788	11	-74.112721	40.551850	Cedar Grove Avenue
NYC Parks	DH-8A	4787	1	-74.113507	40.549233	Cedar Grove Avenue
NYC Parks	DMT-5A	4160	70	-74.109805	40.554871	Mill Road
NYC Parks	SCPTu-7A	4160	70	-74.109788	40.554895	Mill Road
NYC Parks	DMT-5	4160	70	-74.109020	40.554351	Mill Road
NYC Parks	SCPTu-7	4160	70	-74.109004	40.554376	Mill Road
NYC Parks	DH-11	4160	70	-74.108194	40.554768	Mill Road
NYC Parks	DH-11A	4160	100	-74.108488	40.555963	Mill Road
NYC Parks	DMT-7	4105	50	-74.102301	40.557974	126 Cedar Grove Avenue
NYC Parks	SCPTu-8	4105	50	-74.102286	40.557998	126 Cedar Grove Avenue
NYC Parks	DMT-9	4105	50	-74.097559	40.561870	126 Cedar Grove Avenue
NYC Parks	SCPTu-9	4105	50	-74.097541	40.561894	126 Cedar Grove Avenue
NYC Parks	DH-13	4105	50	-74.103370	40.556900	126 Cedar Grove Avenue
NYC Parks	DH-14	4105	50	-74.101296	40.559126	126 Cedar Grove Avenue
NYC Parks	DH-15	4105	50	-74.098452	40.560695	126 Cedar Grove Avenue
NYC Parks	DH-16	4105	50	-74.096790	40.563070	126 Cedar Grove Avenue
NYC Parks	DH-12A	4105	50	-74.105386	40.555359	126 Cedar Grove Avenue
NYC Parks	DMT-8	4105	50	-74.099881	40.559947	126 Cedar Grove Avenue
NYC Parks	DMT-6A	4105	50	-74.104150	40.555297	126 Cedar Grove Avenue
NYC Parks	DH-19	3893	1	-74.089708	40.569018	660 Lincoln Avenue
NYC Parks	DMT-12	3893	1	-74.090899	40.567990	660 Lincoln Avenue
NYC Parks	DMT-14	3879	2	-74.086118	40.572093	Father Capodanno Blvd
NYC Parks	DMT-13	3879	1	-74.088544	40.570047	2231 Father Capodanno Blvd
NYC Parks	SCPTu-11	3879	1	-74.088521	40.570068	2231 Father Capodanno Blvd
NYC Parks	DH-20	3879	1	-74.087339	40.571085	2231 Father Capodanno Blvd
NYC Parks	DH-21	3868	60	-74.084722	40.572958	Father Capodanno Blvd
NYC Parks	DMT-15	3851	50	-74.083230	40.573750	Father Capodanno Blvd
NYC Parks	SCPTu-12	3851	50	-74.083202	40.573767	Father Capodanno Blvd
NYC Parks	DH-22	3851	50	-74.082184	40.574835	Father Capodanno Blvd
NYC Parks	DMT-17	3833	500	-74.077980	40.577550	Father Capodanno Blvd
NYC Parks	SCPTu-13	3833	500	-74.077954	40.577569	Father Capodanno Blvd

South Shore of Staten Island
Coastal Storm Risk Managment Project
Subsurface Investigation Sites

Owner	Site Name	Block	Lot	Longitude	Latitude	Vicinity Location
NYC Parks	DH-23	3833	3	-74.079580	40.576630	Father Capodanno Blvd
NYC Parks	DMT-16	3833	3	-74.080930	40.575800	Father Capodanno Blvd
NYC Parks	AB-4	3715	Lot 1	-74.092826	40.579768	Off of Mason Ave ROW
NYC Parks	AB-6	3696	1	-74.099739	40.575715	Lincoln Avenue
NYC Parks	DMT-18	3525	200	-74.075740	40.579490	300 Father Capodanno Blvd
NYC Parks	DMT-19	3525	200	-74.073750	40.581880	300 Father Capodanno Blvd
NYC Parks	SCPTu-14	3525	200	-74.073729	40.581902	300 Father Capodanno Blvd
NYC Parks	DMT-21	3525	200	-74.069216	40.586103	300 Father Capodanno Blvd
NYC Parks	SCPTu-15	3525	200	-74.069194	40.586125	300 Father Capodanno Blvd
NYC Parks	DH-24	3525	200	-74.076870	40.578540	300 Father Capodanno Blvd
NYC Parks	DH-25	3525	200	-74.074720	40.580760	300 Father Capodanno Blvd
NYC Parks	DH-26	3525	200	-74.072880	40.582700	300 Father Capodanno Blvd
NYC Parks	DH-27	3525	200	-74.070290	40.585030	300 Father Capodanno Blvd
NYC Parks	DH-28	3525	200	-74.068096	40.587195	300 Father Capodanno Blvd
NYC Parks	DH-29	3525	200	-74.065820	40.589360	300 Father Capodanno Blvd
NYC Parks	DMT-20	3525	200	-74.071430	40.583970	300 Father Capodanno Blvd
NYC Parks	DMT-22	3525	200	-74.067020	40.588330	300 Father Capodanno Blvd
NYC Parks	DMT-23	3125	2	-74.064700	40.590450	Father Capodanno Blvd
NYC Parks	SCPTu-16	3125	2	-74.064677	40.590471	Father Capodanno Blvd
NYC Parks	DH-30	3125	2	-74.063580	40.591460	Father Capodanno Blvd
NYC Parks	DH-31	3125	2	-74.061210	40.593410	Father Capodanno Blvd
NYC Parks	DMT-24	3125	2	-74.062460	40.592430	Father Capodanno Blvd
NYC Parks	DH-32	3125	3	-74.060677	40.594754	Father Capodanno Blvd
NYC Parks	DH-1	-	-	-74.127980	40.557420	Green Belt White Trail
NYS	DH-10A	4768	72	-74.111350	40.554122	Kissam Avenue
NYS	DH-10C	4768	72	-74.111306	40.554143	Kissam Avenue

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0 100 200 300 400 500 Feet

N E S W

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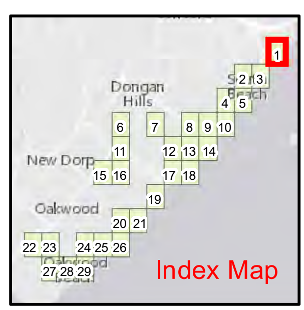

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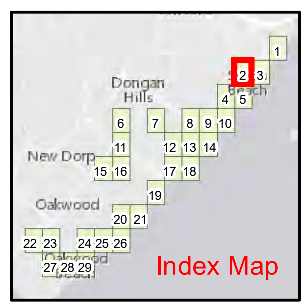

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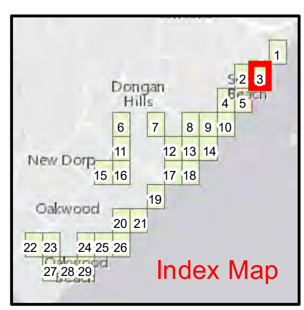

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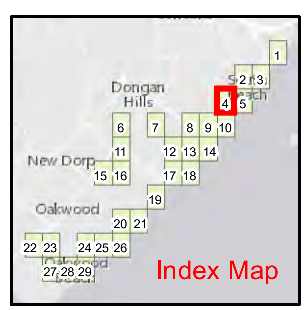

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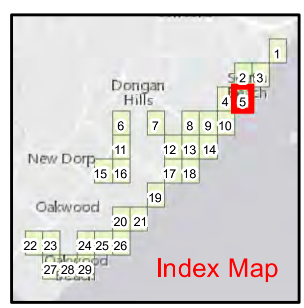

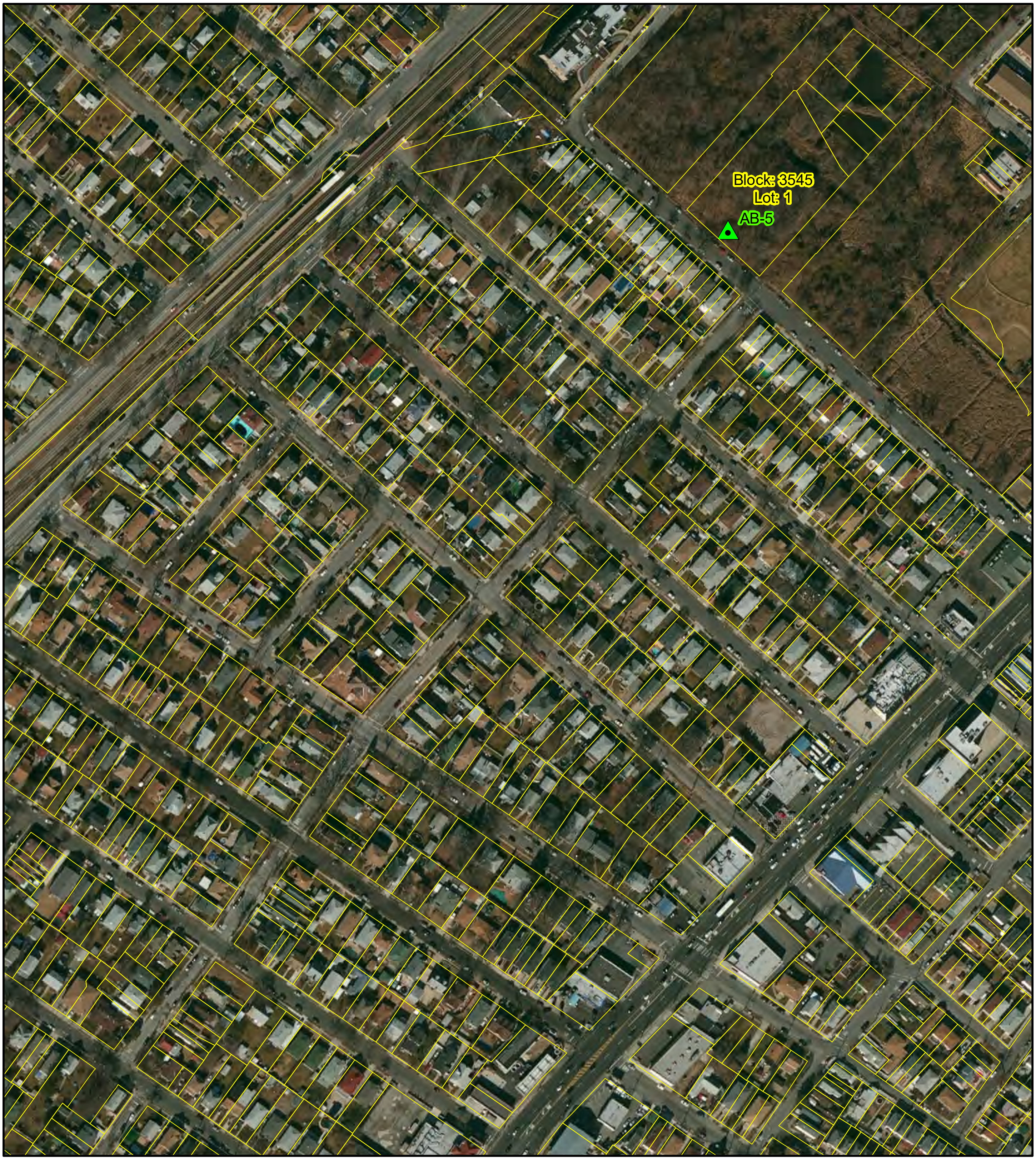

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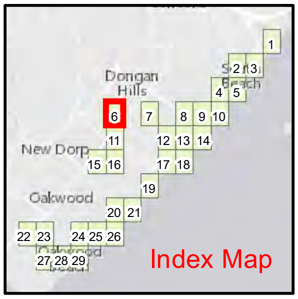

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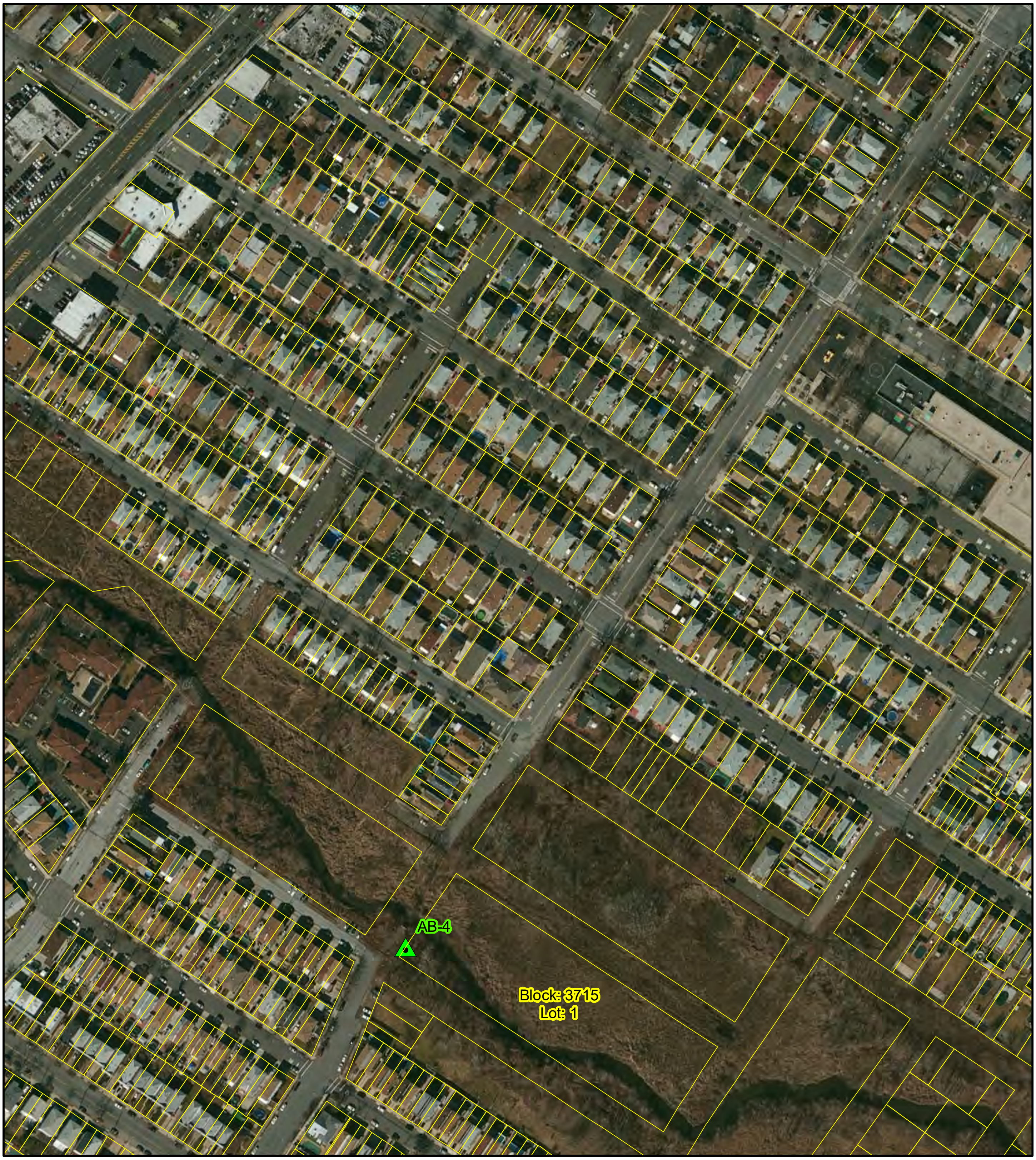

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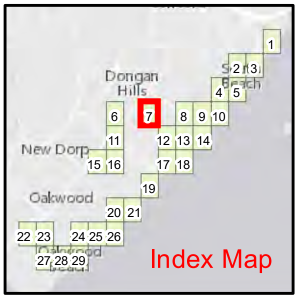

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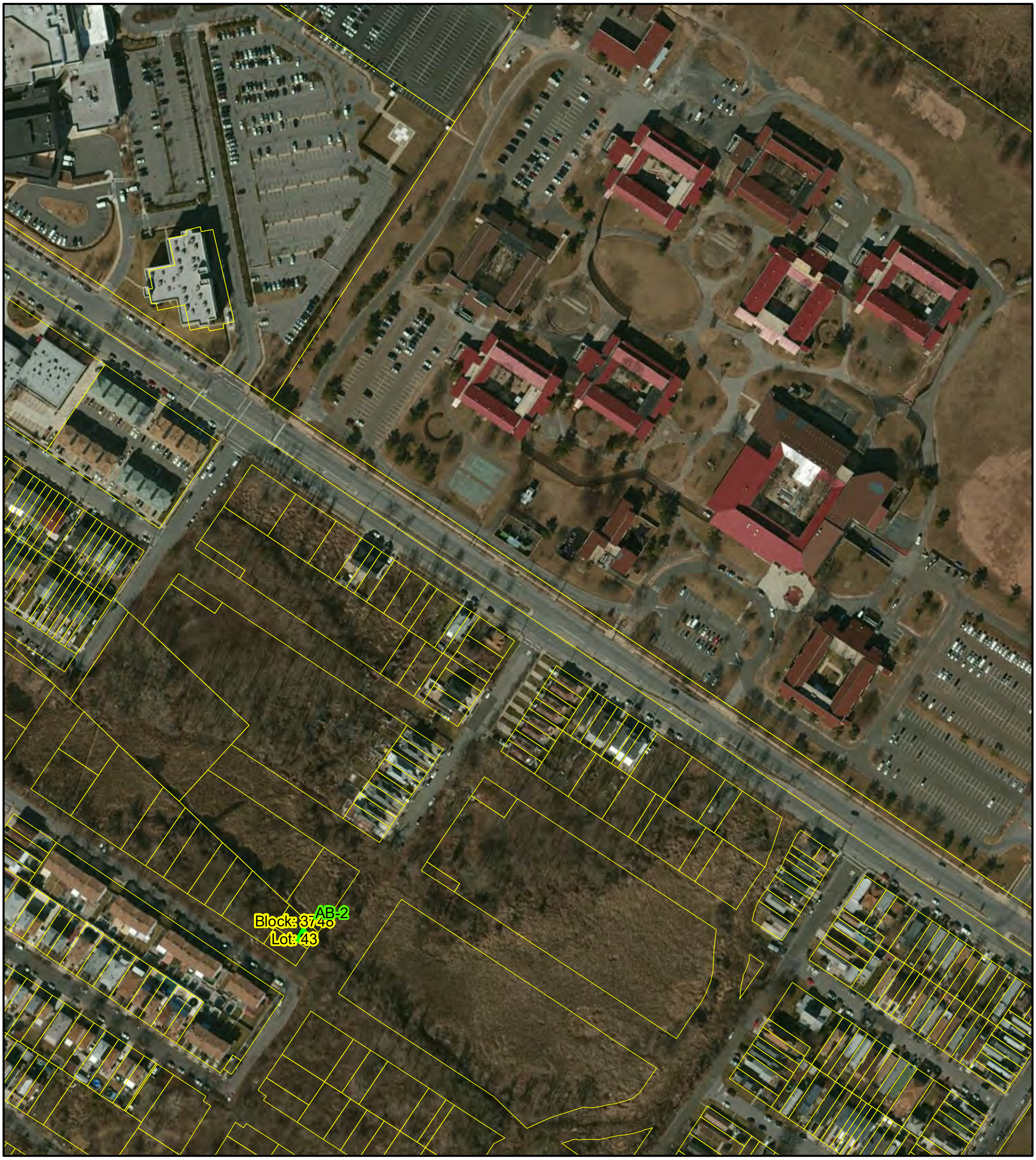

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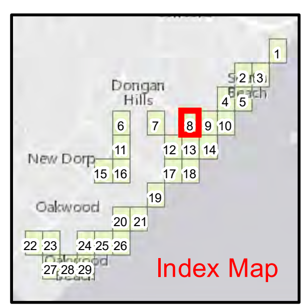

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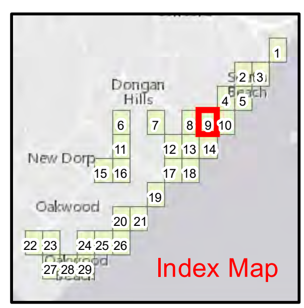

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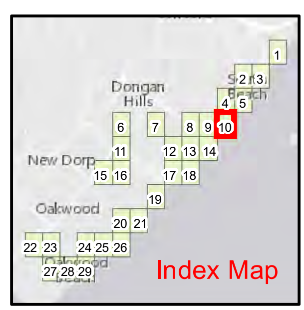

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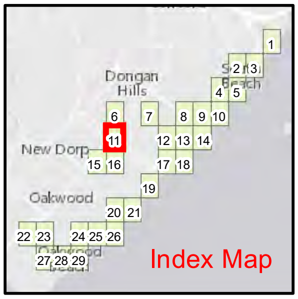

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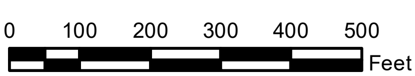

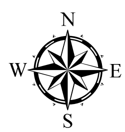

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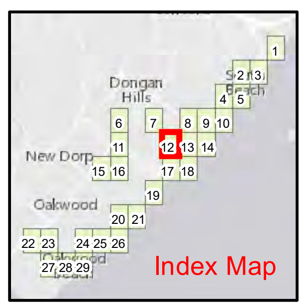

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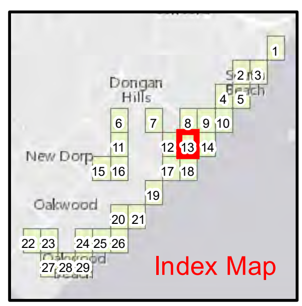

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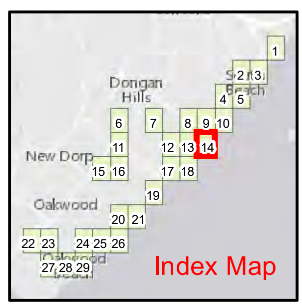

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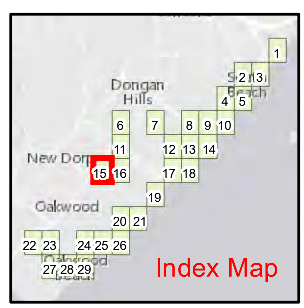

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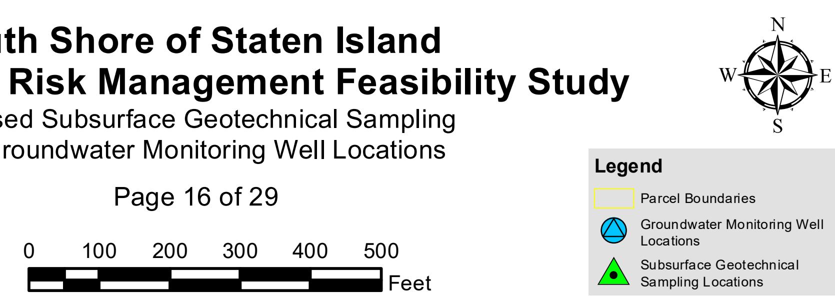

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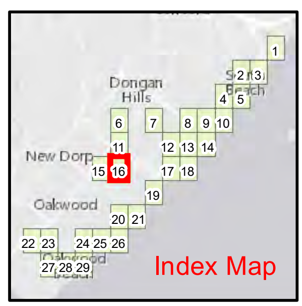

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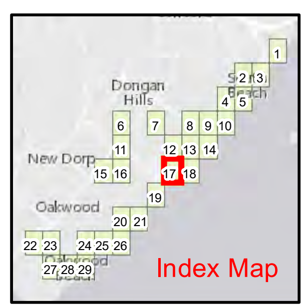

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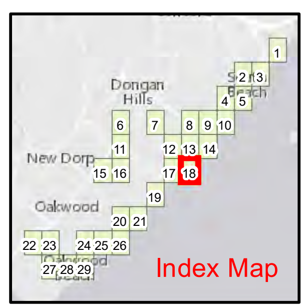

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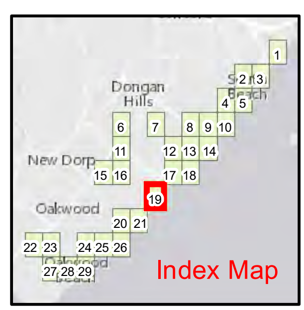

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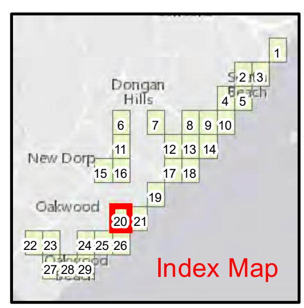

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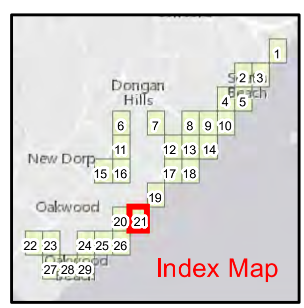

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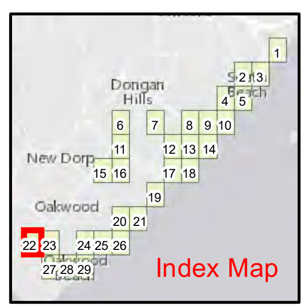

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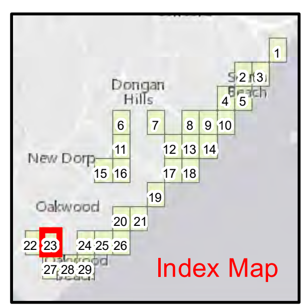

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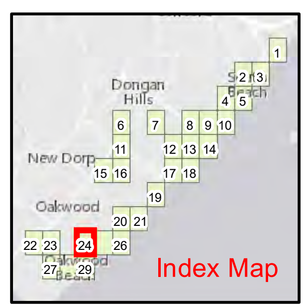

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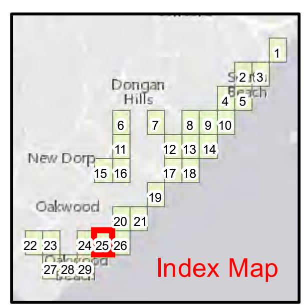

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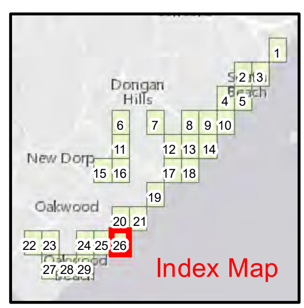

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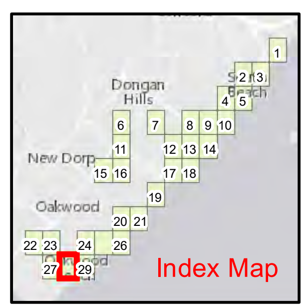

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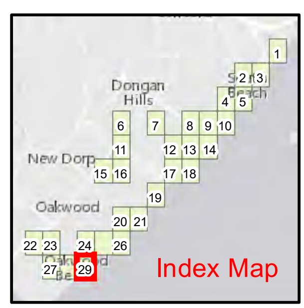

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Appendix B

CROSS-SECTIONAL SUMMARY OF BORINGS

Appendix B.1. Cross-Sectional Summary of Boring Data (Oakwood Marsh)

BORING LOCATION

ELEVATION	DH1	DH2	DH6	DH7	DH8	DH10A	DH10
16							
15	5YR2.5/2 co sl (fill)						
14	2.5YR3/3 sl, brick (fill)						
13	2.5YR3/3 sl, brick (fill)	7.5YR2.5/3 ls (fill)					
12	2.5YR3/3 sl, brick (fill)	7.5YR2.5/3 ls (fill)					
11	2.5YR3/3 (fill)	7.5YR2.5/3 ls (fill)		10YR3/2 sil, gravel, wood (fill)	7.5YR2.5/2 l w/ grav (fill)		
10	2.5YR3/3 (fill)	auger advance - unknown	not monitored	10YR3/2 sil, gravel, wood (fill)	7.5YR2.5/2 l w/ grav (fill)		
9	2.5YR3/4 sl, f and m grav	7.5YR4/4 heavy sil, redox mottles	not monitored	10YR3/2 sil, gravel, wood (fill)	2.5YR3/3 sil w/ grav (fill)		
8	2.5YR3/4 sl, f and m grav	7.5YR4/4 heavy sil, redox mottles	not monitored	2.5YR3/3 v. grav sil, compact (fill)	2.5YR3/3 sil w/ grav (fill)		
7	2.5YR3/3 sl, f and m grav	7.5YR4/4 heavy sil, redox mottles	not monitored	2.5YR3/3 v. grav sil, compact (fill)	2.5YR3/3 sil w/ grav (fill)		
6	2.5YR3/3 sl, f and m grav	7.5YR4/4 heavy sil, redox mottles	not monitored	7.5YR3/2 lms, grav (fill)	2.5YR3/3 sil w/ grav (fill)		
5	2.5YR3/3 sl, f and m grav	2.5YR3/3 sl, f and m grav	not monitored	7.5YR3/2 lms, grav (fill)	2.5YR3/3 sil w/ grav (fill)		
4	2.5YR3/3 sl, f and m grav	2.5YR3/3 sl, f and m grav	not monitored	7.5YR3/2 lms, grav (fill)	2.5YR3/3 sil w/ grav (fill)		
3	2.5YR3/3 fsl, f and m grav	2.5YR3/3 sl, f and m grav	not monitored	7.5YR3/2 lms, grav (fill)	2.5YR3/3 sil w/ grav (fill)	10YR3/2 grav si c fill; 10YR2/2 sic w/OM	
2	2.5YR3/3 fsl, f and m grav	2.5YR3/3 sl, f and m grav	not monitored	7.5YR3/2 lms, grav (fill)	OM (meadow mat)	2.5Y2.5/1 si and OM	Not monitored
1	2.5YR3/3 fsl, f and m grav	2.5YR3/4 sil and ls, some grav, bedded	not monitored	sandstone in shoe - no recovery	OM (meadow mat)	2.5Y2.5/1 si and OM	Not monitored
0	2.5YR3/3 fsl, f and m grav	2.5YR3/4 sil and ls, some grav, bedded	not monitored	sandstone in shoe - no recovery	OM-rich c	2.5Y2.5/1 si and OM	Not monitored
-1	2.5YR2.5/4 grav, some co s	2.5YR3/2-3/3 lco and ms, much grav	not monitored	OM - meadow mat	variegated grav c	10YR2/1 sic w/ OM	Not monitored
-2	2.5YR2.5/3 lms, f and m grav	2.5YR3/2-3/3 lco and ms, much grav	not monitored	OM - meadow mat	variegated grav c	OM; 2.5YR4/1 lms	Not monitored
-3	2.5YR2.5/3 lms, f and m grav	2.5YR3/2-3/3 lco and ms, much grav	not monitored	OM - meadow mat	7.5YR2.5/2 l co s, rd grav	2.5YR4/1 lms	5YR3/3 vf sc, brick frags?
-4	2.5YR2.5/3 lcos, f and m grav	2.5YR3/3 co s	not monitored	OM - meadow mat **1744-1605 bp**	7.5YR2.5/2 l co s, rd grav	OM	5YR3/3 vf sc, brick frags?
-5	2.5YR2.5/3 lcos, f and m grav	2.5YR3/4 lms, much grav	not monitored	meadow mat w/ much sc	7.5YR2.5/2 l co s, rd grav	2.5YR3/2 v grav l	5YR3/3 ls, f grav
-6	2.5YR2.5/3 lcos, f and m grav	2.5YR3/3 lco and ms, vf grav	not monitored	meadow mat w/ much sc	2.5YR2.5/2 co s, much vf and f grav	2.5YR3/2 v grav l	5YR3/3 ls, f grav
-7	2.5YR2.5/3 lcos, f and m grav	2.5YR3/3 lco and ms, vf grav	not monitored	5Y3/1 v grav l	2.5YR2.5/2 co s, much vf and f grav	2.5YR3/2 v grav l	2.5YR4/1 lcos, f and m grav
-8	2.5YR2.5/3 lcos, f and m grav	2.5YR3/3 lco and ms, vf grav	not monitored	5Y3/1 v grav l	2.5YR3/2 f and m s, vf grav	2.5YR3/2 v grav l	2.5YR4/1 lcos, f and m grav
-9	2.5YR2.5/3 lcos, f and m grav	2.5YR2.5/3 f, m, co ls, bedded	not monitored	7.5YR3/2 lcos, much grav	2.5YR3/2 f and m s, vf grav	thickly bedded 2.5YR3/3 and 4/2 lms	2.5YR4/1 lcos, f and m grav
-10	2.5YR2.5/3 lcos, f and m grav	2.5YR2.5/3 f, m, co ls, bedded	not monitored	7.5YR3/2 lcos, much grav	2.5YR3/2 f and m s, vf grav	thickly bedded 2.5YR3/3 and 4/2 lms	2.5YR4/3 lcos, much vf grav
-11	2.5YR2.5/3 lcos, f and m grav	2.5YR3/3 ms	not monitored	2.5YR3/3 lms	2.5YR3/2 f and m s, vf grav	thickly bedded 2.5YR3/3 and 4/2 lms	2.5YR4/3 lcos, much vf grav
-12	2.5YR3/3 lms, vf grav	5YR3/2 vf and f s	not monitored	2.5YR3/3 lms	2.5YR3/2 f and m s, vf grav	thickly bedded 2.5YR3/3 and 4/2 lms	2.5YR4/3 lcos, much vf grav
-13	2.5YR3/3 lms, vf grav	5YR3/2 vf and f s	not monitored	2.5YR3/3 lms	5YR2.5/2 f and m s, some vf grav	2.5YR3/3 lf and m s, thinly bedded	2.5YR4/3 lcos, much vf grav
-14	2.5YR3/3 lms, vf grav	5YR3/2 vf and f s	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	2.5YR3/3 lf and m s, thinly bedded	2.5YR4/3 lcos, much vf grav
-15	2.5YR3/3 lms, vf grav	5YR3/2 vf and f s	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	2.5YR3/3 lf and m s, thinly bedded	2.5YR4/3 lcos, much vf grav
-16	7.5YR2.5/3 fs	2.5YR2.5/2 m and co s, f and vf grav	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	5YR3/3 and 5/4 fs, thinly bedded	2.5YR4/3 lcos, much vf grav
-17	7.5YR2.5/3 fs	2.5YR3/3 l m s	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	5YR3/3 and 5/4 fs, thinly bedded	2.5YR3/4 lcos, much vf grav
-18	7.5YR2.5/3 m and cos, f grav	2.5YR2.5/2 l m and co s, vf grav	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	5YR3/3 and 5/4 fs, thinly bedded	2.5YR3/4 lcos, much vf grav
-19	7.5YR2.5/3 m and cos, f grav	2.5YR2.5/2 l m and co s, vf grav	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, some vf grav	5YR3/3 and 5/4 fs, thinly bedded	2.5YR3/4 lcos, much vf grav
-20	7.5YR2.5/3 m and cos, f grav	2.5YR2.5/2 l m and co s, vf grav	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 co s, f and vf grav	2.5YR3/2 f and vfs	2.5YR3/3 fs, no grav
-21	7.5YR2.5/3 m and cos, f grav	7.5YR3/4 m and co s, f and vf grav	not monitored	2.5YR2.5/2 f and m s, vf grav	5YR2.5/2 f and m s, f and vf grav	2.5YR3/2 f and ms	2.5YR3/3 fs, no grav
-22	2.5YR3/3 ms, f and vf grav	7.5YR3/4 m and co s, f and vf grav	not monitored	2.5YR3/2 f and ms, vf grav	5YR2.5/2 f and m s	2.5YR3/2 f and ms	2.5YR3/3 fs, no grav
-23	2.5YR3/3 ms, f and vf grav	7.5YR3/4 m and co s, f and vf grav	not monitored	2.5YR3/2 f and ms, vf grav	7.5YR3/3 lcos, m and co grav	2.5YR3/2 f and ms, m grav	2.5YR3/3 lfs, f grav
-24	5YR3/3 cos, f and m grav	7.5YR3/4 co s, f and m grav	not monitored	2.5YR3/3 m and co s, f and m grav	7.5YR3/3 lcos, m and co grav	2.5YR3/2 f and ms	2.5YR3/3 lfs, f grav
-25	5YR3/3 cos, f and m grav	7.5YR3/4 co s, f and m grav	5YR3/3 co s, f and m grav	2.5YR3/3 m and co s, f and m grav	7.5YR3/3 lcos, m and co grav	2.5YR3/2 f and ms, f and m grav	2.5YR3/3 lfs, f grav
-26	5YR3/3 cos, f and m grav	7.5YR3/4 co s, f and m grav	5YR3/3 co s, f and m grav	2.5YR3/3 m and co s, f and m grav	7.5YR3/3 lcos, m and co grav	2.5YR3/2 f and ms, m grav	2.5YR3/3 lfs, f grav
-27	5YR3/3 cos, f and m grav	7.5YR3/4 co s, f and m grav	5YR3/3 co s, f and m grav	2.5YR3/3 m and co s, f and m grav	7.5YR3/3 lcos, m and co grav	2.5YR3/2 ms, m grav	2.5YR3/3 lfs, f grav
-28	7.5YR4/4 ms	7.5YR3/4 co s, f and m grav	5YR3/3 co s, f and m grav	2.5YR3/3 m and co s, f and m grav	7.5YR3/3 lcos, m and co grav	7.5YR3/3 ms, m grav	2.5YR3/3 lfs, f grav
-29	7.5YR3/4 ms	7.5YR3/4 co s, f and m grav	5YR3/2 f and m s, f and m grav	2.5YR3/3 f and m s, vf and f grav	7.5YR3/3 m s, some vf grav	7.5YR3/3 ms, m grav	2.5YR3/3 m and co s, f grav
-30	7.5YR3/4 ms, some f grav	7.5YR3/4 co s, f and m grav	5YR3/2 f and m s, f and m grav	2.5YR3/3 f and m s, vf and f grav	7.5YR3/3 m s, some vf grav	7.5YR3/3 ms, f and m grav	2.5YR3/3 m and co s, f grav
-31	7.5YR3/4 ms, some f grav	5YR3/2 m s, f grav	5YR3/2 f and m s, f and m grav	7.5YR3/3 ms, vf grav	7.5YR3/3 m and co s, f and vf grav	7.5YR2.5/2 lfs	f grav
-32	7.5YR3/4 m and cos, f grav	5YR3/2 m s, f grav	pebble in shoe - no recovery	7.5YR3/3 ms, vf grav	7.5YR3/3 m and co s, f and vf grav	5YR2.5/2 f and vfs	f grav
-33	7.5YR3/4 m and cos, f grav	5YR3/2 m s, f grav	pebble in shoe - no recovery	7.5YR3/3 ms, vf grav	7.5YR3/2 lcos, f and m grav	5YR2.5/2 f and vfs	5YR3/3 ms, m grav
-34	7.5YR3/4 m and cos, f grav	5YR3/2 m s, f grav	5YR3/2 f and m s, f and m grav	7.5YR3/3 ms, vf grav	5YR3/2 fs		5YR3/3 ms, m grav
-35	7.5YR3/4 m and cos, f grav	5YR3/2 m s, f grav	5YR3/2 f and m s, f and m grav	7.5YR3/4 m and fs, vf grav	5YR2.5/2 m s, vf grav		10YR6/6 fs
-36	7.5YR2.5/3ms, f grav	5YR3/2 f s	5YR3/2 f and m s, f and m grav	7.5YR3/4 m and fs, vf grav	5YR2.5/2 m s, vf grav		10YR6/6 fs
-37		5YR3/2 f and m s, grit	5YR3/2 f and m s, f and m grav	5YR3/2 m and co s, vf grav	5YR2.5/2 m s, vf grav		10YR6/6 fs
-38		5YR3/2 f and m s, grit	5YR3/2 f and m s, f and m grav	augered - no sampling	5YR2.5/2 m s, vf grav		10YR6/6 fs
-39			augered - no sampling	augered - no sampling	5YR2.5/2 m s, vf grav		10YR6/6 fs
-40			augered - no sampling	augered - no sampling	5YR2.5/2 m s, vf grav		10YR6/6 fs, thin beds of 7/2
-41			augered - no sampling	5YR3/2 f and m s, vf grav	5YR2.5/2 m s, vf grav		10YR6/6 fs, thin beds of 7/2
-42			5YR3/2 f and m s, f and m grav	5YR3/2 f and m s, vf grav	5YR2.5/2 m s, vf grav		7.5YR5/8 fs
-43			5YR3/2 f and m s, f and m grav	augered - no sampling	5YR2.5/2 m s, vf grav		7.5YR5/8 fs
-44			augered - no sampling	augered - no sampling	5YR2.5/2 m s, vf grav		7.5YR5/8 fs
-45			augered - no sampling	augered - no sampling	Gley1 7/N m s, no grav		7.5-10YR5/8 sic
-46			augered - no sampling	2.5Y7/1 and 6/3 f and vfs	Gley1 7/N f s, no grav		7.5-10YR5/8 sic **>43,500 bp**
-47			Gley1 7/N vfs	2.5Y7/1 and 6/3 f and vfs	augered - no sampling		10YR3/1 c, some si
-48			Gley1 7/N vfs	augered - no sampling	augered - no sampling		10YR3/1 c, some si
-49			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, some vfs
-50			augered - no sampling	augered - no sampling	Gley1 7/N f s, no grav		10YR3/1 c, some vfs
-51			augered - no sampling	Gley1 3/N c, v firm **>43,500 bp**	Gley1 7/N f s, no grav		10YR3/1 c
-52			Gley1 7/N vfs	Gley1 3/N c, v firm	augered - no sampling		10YR3/1 c
-53			Gley1 7/N vfs, some oxidation	augered - no sampling	augered - no sampling		10YR3/1 c **44,381-42,881 bp**
-54			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs
-55			augered - no sampling	augered - no sampling	Gley1 7/N and 2.5Y6/1 f and m s, bedded		10YR3/1 c, thin lenses vfs
-56			augered - no sampling	Shelby tube - no sample	Gley1 7/N and 2.5Y6/1 f and m s, bedded		10YR3/1 c, thin lenses vfs
-57			Gley1 7/N f and vfs	Shelby tube - no sample	Gley1 7/N and 2.5Y6/1 f and m s, bedded		10YR3/1 c, thin lenses vfs
-58			Gley1 7/N f and vfs	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-59			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-60			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-61			augered - no sampling	7.5YR5/8, 6/6 vf, f, ms	7.5YR5/3 c, some sandy zones		10YR3/1 c, thin lenses vfs, vfsc
-62			10YR6/4 and 7/3 f s, some beddding	7.5YR5/8, 6/6 vf, f, ms	7.5YR5/3 c, some sandy zones		10YR3/1 c, thin lenses vfs
-63			10YR6/4 and 7/3 f s, some beddding	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs
-64			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfsc
-65			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-66			augered - no sampling	7.5YR6/4 vf and fs	Gley1 3/N c, v thin sand stringers		10YR3/1 c, thin lenses vfs, vfsc **47,022-44,836 bp**
-67			10YR6/4 and 2.5YR4/6 f, vf s, bedded	7.5YR6/4 vf and fs	Gley1 3/N c, v thin sand stringers **>43,500**		10YR3/1 c, thin lenses vfs, vfsc
-68			10YR6/4 and 2.5YR4/6 f, vf s, bedded	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-69			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-70			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c, thin lenses vfs, vfsc
-71			augered - no sampling	7.5YR5/6 f and vf s	Shelby tube - no sample		10YR3/1 c, thin lenses vfs, vfsc
-72			2.5YR and 5YR4/6 f and vf s	7.5YR5/6 f and vf s	Shelby tube - no sample		10YR3/1 c
-73			2.5YR and 5YR4/6 f and vf s	augered - no sampling	augered - no sampling		10YR3/1 c
-74			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c
-75			augered - no sampling	augered - no sampling	augered - no sampling		10YR3/1 c
-76			augered - no sampling	5YR5/4 vf and fs, v thin c stringers	Gley1 3/N c		stratified 10YR7/2 vf, f, m s
-77			10YR5/8-6/8 f, vf s	5YR5/4 vf and fs, v thin c stringers	Gley1 3/N c **>43,500 bp**		stratified 10YR7/2 vf, f, m s
-78			10YR5/8-6/8 f, vf s	augered - no sampling	augered - no sampling		stratified 10YR7/2 vf, f, m s
-79			augered - no sampling	augered - no sampling	augered - no sampling		stratified 10YR7/2 vf, f, m s
-80			augered - no sampling	augered - no sampling	augered - no sampling		stratified 10YR7/2 vf, f, m s
-81			augered - no sampling	10YR6/6 f and ms	10YR6/1-6/2 c		stratified 10YR7/2 vf, f, m s
-82			vfs to m s, bedded, ox and red	10YR6/6 f and ms	10YR6/1-6/2 c		Gley1/7N vfs and lvfs, bedded
-83			vfs to m s, bedded, ox and red	augered - no sampling	augered - no sampling		Gley1/7N vfs and lvfs, bedded
-84			augered - no sampling	augered - no sampling	augered - no sampling		Gley1/7N vfs and lvfs, bedded
-85			augered - no sampling	augered - no sampling	augered - no sampling		Gley1/7N vfs and lvfs, bedded
-86			augered - no sampling	7.5YR5/6 fs	Gley1 7/N f and m s		Gley1/7N vfs and lvfs, bedded
-87			10YR to 2.5R f, vfs, some si, c	10YR5/6 co s	10YR6/1-6/2 c, some v thin sand stringers		Gley1/7N vfs and lvfs, bedded
-88			10YR to 2.5R f, vfs, some si, c	augered - no sampling	augered - no sampling		Gley1/7N vfs and lvfs, bedded
-89			augered - no sampling	augered - no sampling	augered - no sampling		Gley1/7N vfs and lvfs, bedded
-90			augered - no sampling	augered - no sampling	augered - no sampling		Gley1/7N m and f s
-91			augered - no sampling	thin beds f and vf s, ox and red	7.5YR5/6 m and co ls, much oxidized Fe		Gley1/7N m and f s
-92			10R4/6 and 5R4/6 m and f s	thin beds f and vf s, ox and red	7.5YR5/6 m and co ls, much oxidized Fe		lfs and lvfs, much Fe
-93			10R4/6 and 5R4/6 m and f s	augered - no sampling	augered - no sampling		lfs and lvfs, much Fe
-94			augered - no sampling	augered - no sampling	augered - no sampling		lfs and lvfs, much Fe
-95			augered - no sampling	augered - no sampling	augered - no sampling		bedded f to co s, reduced and oxidized zones
-96			augered - no sampling	thin beds f and vf s, ox and red	vfs, vfsc, bedded much oxidized Fe		bedded f to co s, reduced and oxidized zones
-97			10R4/6 m and f s	thin beds f and vf s, ox and red	vfs, vfsc, bedded much oxidized Fe		bedded f to co s, reduced and oxidized zones
-98			10R4/6 m and f s	augered - no sampling	augered - no sampling		bedded f to co s, reduced and oxidized zones
-99			augered - no sampling	augered - no sampling	augered - no sampling		bedded f to co s, reduced and oxidized zones
-100			augered - no sampling	augered - no sampling	augered - no sampling		l f to lco s, much FeO
-101			augered - no sampling	thin beds f and vf s, ox and red	5YR5/8 f and m s, thick beds, much oxidized Fe		l f to lco s, much FeO
-102			laminated ms, vfs, c	thin beds f and vf s, ox and red	5YR5/8 f and m s, thick beds, much oxidized Fe		5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-103			laminated ms, vfs, c	augered - no sampling			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-104			augered - no sampling	augered - no sampling			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-105			augered - no sampling	augered - no sampling			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-106			augered - no sampling	2.5Y7/3 co s, vf grav			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-107			v thinly laminated c and vfs, ox and red	2.5YR4/4 fs			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-108			v thinly laminated c and vfs, ox and red	augered - no sampling			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-109			hole collapse	augered - no sampling			5YR5/8 ms, thin beds 2.5YR3/6 lvfs
-110				augered - no sampling			10 YR and 7.5YR4/6 lf and lms
-111				2.5Y7/1 lfs, redox throughout			
-112				2.5Y7/1 lfs, redox throughout			
-113				augered - no sampling			
-114				augered - no sampling			
-115				augered - no sampling			
-116				7.5YR3/2 c, thinly laminated			
-117				7.5YR3/2 c, thinly laminated			
-118				augered - no sampling			
-119				augered - no sampling			
-120				augered - no sampling			
-121				2.5YR7/2 sc, redox throughout			
-122				2.5YR7/2 sc, redox throughout			
-123							
-124							
-125							
-126							
-127							
-128							
-129							
-130							

KEY

- Late 20th-/early 21st-century fill
- Late Holocene-modern beach sand
- Late Holocene-modern coastal marsh
- Holocene solum
- Backbarrier
- Late Holocene lagoon
- Lagoon tidal delta?
- Stream alluvium?
- Stream hollow aggradation?
- Late Pleistocene glacial outwash
- Cretaceous sediments
- **radiocarbon date**

v - very
f - fine
m - medium
co - coarse
s - sand, sandy
si - silt, silty
c - clay, clayey
l - loam, loamy
grav - gravel, gravelly
OM - organic matter
redox - redoximorphic
abt bound - abrupt boundary

Appendix B.2. Cross-Sectional Summary of Boring Data (New Dorp Upland)

BORING LOCATION

ELEVATION	DH11	DH12	DH13	GP5	DH14	GP6	DH15	GP7	DH16	GP8	DH19	DH19A
16												
15												
14												
13												
12												
11												
10												
9										surface ^		
8				surface	5YR3/4 ms - berm						7.5YR4/3 ms	
7					5YR3/4 ms - berm						7.5YR4/3 ms, few peb	2.5YR3/3 fs
6				216-144 bp	2.5YR3/3 ms		5YR3/3 fs		si and s fill		2.5YR3/3 fs	2.5YR3/3 ms, vf grav
5					2.5YR3/3 ms		5YR3/3 fs	surface ^	s and s fill		2.5YR3/3 fs, few sa grav	2.5YR3/3 ms, vf grav
4			2.5YR3/3 ms - base of berm		2.5YR3/3 ms		10YR3/2 sil w/ brick, conc		2.5YR3/3 sl-ls, grav		5YR4/3 f and m s, bedded	2.5YR3/3 ms, vf grav
3	7.5YR4/3 sil-vfsl, few rd, sr peb		2.5YR3/3 ms - base of berm	1063-937 bp	10YR3/2 sil, brick		10YR3/2 sil w/ brick, conc		2.5YR3/3 sl-ls, grav		5YR4/3 f and m s, bedded	2.5YR3/3 ms, vf grav
2	7.5YR4/3 sil-vfsl, few rd, sr peb	OM	2.5YR3/3 ms - base of berm		10YR4/4 sil; 7.5YR sl, grav		10YR4/3 sil, redox		2.5YR3/3 sl-ls, grav		5YR4/3 f and m s	2.5YR3/3 co s, grit, grav
1	5YR3/3 v grav co sl, f to co grav	10YR4/6 heavy si l, grav, redox	7.5YR2.5/1 si l;7.5YR3/3 sil, rd peb		2.5YR3/3 sl, 25-30% grav		10YR4/3 sil, redox		2.5YR3/3 co sl, very grav		5YR4/3 f and m s	2.5YR3/3 ms
0	5YR3/3 v grav co sl, f to co grav	10YR4/6 heavy si l, grav, redox	7.5YR3/3 sil, rd peb		2.5YR3/3 sl, 25-30% grav		10YR4/3 loam, much rd grav		2.5YR3/3 co sl, very grav		5YR4/3 f and m s, grit	2.5YR3/3 co s
-1	5YR3/3 v grav co sl, f to co grav	2.5YR3/3 lms, v grav, Mn accum	2.5YR3/3 loam v. gritty, gravelly		2.5YR3/3 sl, 25-30% grav		10YR4/3 loam, much rd grav		2.5YR3/3 co sl, very grav		5YR4/3 f and m s	2.5YR3/3 co s fining
-2	2.5YR3/3 lms, grit, vf grav	2.5YR3/3 lms, v grav, Mn accum	2.5YR3/3 loam v. gritty, gravelly		2.5YR3/3 lms, 25-30% grav		2.5YR3/3 co sl, 30-40% grav		2.5YR3/3 co sl, very grav		2.5YR3/3 co s, much f, vf grav	2.5YR3/3 ms
-3	2.5YR3/3 lms, grit, vf grav	2.5YR3/3 lms, v grav, Mn accum	2.5YR3/3 loam v. gritty, gravelly		2.5YR3/3 lms, 25-30% grav		2.5YR3/3 co sl, 30-40% grav		2.5YR3/3 l m and fs, vf grav		2.5YR3/3 co s, much f, vf grav	2.5YR3/2 ms
-4	2.5YR3/3 lms, grit, vf grav	2.5YR3/3 lms, v grav, Mn accum	2.5YR3/2 fs, some grav in lowest		2.5YR3/3 lms, less grav		As above, some zones less grav		2.5YR3/3 l m and fs, vf grav		2.5YR3/3 f, m s, vf grav lenses	2.5YR3/3 co s, grit, grav
-5	2.5YR3/3 lms, grit, vf grav	2.5YR3/3 lms, v grav, Mn accum	2.5YR3/3 lms-l, v grav and gritty		2.5YR3/3 lms, grav		As above, some zones less grav		2.5YR3/3 l m and fs, vf grav		Abt bound, 2.5YR3/3 vf s, no grav	2.5YR3/3 compact co s, much f grav
-6	2.5YR3/3 lms, grit, vf grav	2.5YR3/2 lms, some grit, vf grav	2.5YR3/3 lms-l, v grav and gritty		2.5YR3/3 lms, grav		2.5YR3/3 f and m ls, much vf grav		2.5YR3/3 l m and fs, vf grav		2.5YR3/3 vf s, no grav	2.5YR3/3 fs, no grav
-7	2.5YR3/3 lms, grit, vf grav	2.5YR3/2 lms, some grit, vf grav	2.5YR3/3 lms-l, v grav and gritty		2.5YR3/3 lms, grav		2.5YR3/3 f and m ls, much vf grav		2.5YR3/3 l m and fs, vf grav		2.5YR3/1 lvfs, no grav	2.5YR3/3 fs, no grav
-8	2.5YR3/3 lms, grit, vf grav	2.5YR3/2 lms, some grit, vf grav	2.5YR2/3 ms, vf grav, grit		2.5YR3/3 lms, grav		2.5YR3/3 f and m ls, much vf grav		2.5YR3/3 l m and fs, vf grav		2.5YR3/1 v grav lms	2.5YR3/3 fs, no grav
-9	5YR3/3 lfs, little grit	2.5YR3/2 lms, some grit, vf grav	2.5YR2/3 fs		2.5YR3/2 fs, some grit		2.5YR3/3 f and m ls, much vf grav		2.5YR3/3 f and vfs, no grav		2.5YR3/3 f , m s, much vf grav	2.5YR3/3 fs, no grav
-10	5YR3/3 lfs, little grit	2.5YR3/2 lms, some grit, vf grav	2.5YR2/3 fs		2.5YR3/2 fs, some grit		2.5YR3/3 f and m ls, much vf grav		2.5YR3/3 f and vfs, no grav		2.5YR3/3 f , m s, much vf grav	2.5YR3/3 fs, no grav, some co zones
-11	5YR3/3 lms	2.5YR3/2 lms, some grit, vf grav	2.5YR3/3 ms, some grav, bedded		2.5YR3/2 fs, some grit		2.5YR3/3 fs, no grav		2.5YR3/3 m and f s, grit		2.5YR3/3 f , m s, much vf grav	2.5YR3/3 fs, no grav, some co zones
-12	5YR3/3 lms	2.5YR3/2 fs, some grit	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/2 fs, some grit		2.5YR3/2 f and m s, grit, vf grav		2.5YR3/3 m and f s, grit		2.5YR3/3 f s, no grav (wood fibre?)	2.5YR3/3 fs, no grav
-13	5YR3/3 lfs, little grit	2.5YR3/2 fs, some grit	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/2 fs, some grit		2.5YR3/3 fs, no grav		2.5YR3/3 m and f s, grit		2.5YR3/3 lms, v gravelly	2.5YR3/3 fs, no grav
-14	5YR3/3 lfs, little grit	2.5YR3/2 fs, some grit	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/3 f and vf s, bedded		2.5YR3/3 f and lf s, no grav		2.5YR2.5/2 f and m s, bedded		2.5YR3/3 f and m s, vf grav	2.5YR3/3 fs, no grav
-15	2.5YR3/2 ms, much grit	2.5YR3/2 fs, some grit	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/2 f and m s, grit		2.5YR3/2 lfs, grit		2.5YR2.5/2 f and m s, bedded		2.5YR3/3 f and m s, vf grav	2.5YR3/3 fs, no grav
-16	2.5YR3/2 ms, much grit	2.5YR3/2 fs, some grit, 1 sr peb	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/2 f and m s, grit		2.5YR3/2 lf and ms, grit		2.5YR2.5/2 f and m s, bedded		2.5YR3/3 f and m s, vf grav	2.5YR3/3 fs, no grav
-17	2.5YR3/2 ms, much grit	2.5YR3/2 fs, some grit	2.5YR3/2 fs, 7.5YR3/4 fs, vfs, bedded		2.5YR3/2 f, m s, 40-50% vf grav		2.5YR3/2 lfs w/ grit		2.5YR3/2 vfs, no grav or grit		2.5YR3/3 f and m s, vf grav	2.5YR3/3 fs, no grav
-18	2.5YR3/2 ms, much grit	2.5YR3/2 fs, some grit	5YR2.5/2 m and co s, grit, bedded		2.5YR3/2 f, m s, 40-50% vf grav		2.5YR3/2 lfs w/ grit		2.5YR3/2 f and m s, vf grav		2.5YR3/3 f and m s, no grav	2.5YR3/3 fs, no grav
-19	2.5YR3/2 ms, much grit	2.5YR3/2 m and co s, grit, grav	2.5YR3/2 ms, grit, some vf grav beds		7.5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 f and m s, grit		2.5YR3/2 f and m s, vf grav		2.5YR2.5/2 lfs, some vf grav	2.5YR3/3 fs, no grav
-20	2.5YR3/2 ms, much grit	2.5YR3/2 m and co s, grit, grav	2.5YR3/2 ms, grit, some vf grav beds		7.5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 f and m s, grit		2.5YR3/2 f and m s, vf grav		2.5YR2.5/2 lfs, some vf grav	2 5YR3/3 fs, vf grav
-21	2.5YR3/2 ms, much grit	2.5YR3/2 fs, grit, bedding	2.5YR3/2 ms, grit, some vf grav beds		7.5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 f and m s, grit		2.5YR3/2 f and m s, vf grav		2.5YR2.5/2 lfs, some vf grav	2 5YR3/3 fs, med grav
-22	2.5YR3/2 ms, much grit	2.5YR3/2 ms, grit	2.5YR3/2 ms, grit, some vf grav beds		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/3 m s, grit, vf grav		Abt bound to 7.5YR3/4 lms		2.5YR2.5/2 lfs, some vf grav	2 5YR3/3 fs, med grav
-23	2.5YR3/2 ms, much grit	2.5YR3/2 ms, grit	2.5YR3/2 f and m s, grit		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/3 m s, grit, vf grav		7.5YR3/4 lms		2.5YR2.5/2 lfs, some vf grav	2 5YR3/3 f and vf s
-24	2.5YR3/2 lcos, f and m grav	2.5YR3/2 m and co s, grit, reduced	2.5YR3/2 f , vfs		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 f and m s, grit, bedded		7.5YR3/4 ms, grit, some vf grav		2.5YR2.5/2 f and m s, much grit, vf grav	2 5YR3/3 f and vf s
-25	2.5YR3/3 lms, much grit	2.5YR3/2 m and co s, grit, reduced	2.5YR3/2 f , vfs		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 f and m s, grit, bedded		7.5YR3/4 ms, grit, some vf grav		2.5YR2.5/2 f and m s, much grit, vf grav	2 5YR3/3 f and vf s
-26	2.5YR3/3 lms, much grit	7.5YR4/3 fs	2.5YR3/2 f , vfs		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/2 ms, grit		7.5YR3/4 ms, grit, some vf grav		2.5YR2.5/2 f and co s, stratified	2 5YR3/3 f and vf s
-27	2.5YR3/3 lcos, much grit	7.5YR4/6 ms, Fe-rich, oxidized	2.5YR3/2 lms, med grav		5YR3/2 f, m s, grit, vf grv, some bed		2.5YR3/3 f, vf, m s, grit, bedded		7.5YR3/4 ms, grit, some vf grav		2.5YR2.5/2 f and co s, stratified	2 5YR3/3 f and vf s
-28	2.5YR3/3 lcos, much grit	7.5YR4/6 ms, Fe-rich, oxidized	2.5YR3/2 lms, med grav		5YR3/2 m, co s, grit, vf grv, some bed		2.5YR3/3 f, vf, m s, grit, bedded		7.5YR3/4 ms, grit, some vf grav		2.5YR2.5/2 f and co s, stratified	2 5YR3/3 f and m s, vf grav
-29	2.5YR3/3 lcos, much grit	5YR3/2 ms	7.5YR3/4 med, co s, some vf grav				2.5YR3/3 f, vf, m s, grit, bedded		7.5YR3/4 ms, grit, some vf grav			2 5YR3/3 f and m s, vf grav
-30	2.5YR3/3 lcos, much grit	5YR3/2 ms	7.5YR3/4 med, co s, some vf grav				2.5YR3/3 f, vf, m s, grit, bedded					
-31	2.5YR3/3 lcos, much grit	5YR3/2 ms	7.5YR3/4 med, co s, some vf grav									
-32	2.5YR3/3 lcos, much grit	5YR3/2 ms	7.5YR3/4 med, co s, some vf grav									
-33	2.5YR2.5/2 m s, grit	2.5YR3/2 f and m s										
-34	2.5YR2.5/2 co s, grit	2.5YR3/2 f and m s										
-35	2.5YR2.5/2 m and co s											
-36	2.5YR2.5/2 f, vf, m s, bedded											
-37	2.5YR2.5/2 f, vf, m s, bedded											
-38	7.5YR3/2 m s, sm amt vf grav											
-39	7.5YR3/2 m s, sm amt vf grav											
-40	7.5YR3/2 m s, 2-3 lg pebbles											
-41	7.5YR3/2 m s, 2-3 lg pebbles											
-42	7.5YR3/2 m s, 2-3 m pebbles											
-43	7.5YR3/2 m s, 1 lg pebble											
-44	7.5YR3/2 m s, 1 lg pebble											
-45	7.5YR3/2 m s, vf grav											
-46	7.5YR3/2 m s, vf grav											
-47	7.5YR3/2 m s, vf grav											
-48	7.5YR3/2 m s, vf grav											
-49												
-50												
-51												
-52												
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-59												
-60												

KEY

- Late 20th-/early 21st-century fill
- Late Holocene-modern beach sand
- Late Holocene-modern coastal marsh
- Holocene solum
- Backbarrier
- Late Holocene lagoon
- Lagoon tidal delta?
- Stream alluvium?
- Stream hollow aggradation?
- Late Pleistocene glacial outwash
- Cretaceous sediments
- radiocarbon date

v - very
f - fine
m - medium
co - coarse
s - sand, sandy
si - silt, silty
c - clay, clayey
l - loam, loamy
grav - gravel, gravelly
OM - organic matter
redox - redoximorphic
abt bound - abrupt boundary

Appendix B.3. Cross-Sectional Summary of Boring Data (New Creek Drainage [Southwest Portion])

	BORING LOCATION										
ELEVATION	DH20	GP9	DH21	DH22	GP10	GP11	DH23	DH24	DH25	GP12	DH25A
16											
15											
14											
13								5YR3/3 m and fs			
12								5YR3/3 m and fs			
11								5YR3/3 m and fs			
10					surface ^			5YR3/3 m and fs	5YR3/3 m and co s		5YR3/3 ms
9			5YR4/3 ms	7.5YR2.5/2 si s		surface ^	5YR3/3 m s, some vf grav	5YR3/3 m and fs	5YR3/3 m and co s	surface	5YR3/3 ms
8	2.5YR3/3 ms		5YR4/3 ms	2.5YR3/3 f, m s			5YR3/3 m and co s, vf grav	5YR3/3 m and fs	5YR3/3 m and co s		5YR3/3 ms
7	2.5YR3/3 ms, vf grav		2.5YR3/3 ms, some vf grav	2.5YR3/3 m s, some vf grav			5YR3/3 m and co s, vf grav	5YR3/3 m and fs	5YR3/3 m and co s		5YR3/3 ms
6	2.5YR3/3 ms, vf grav		2.5YR3/3 ms, some vf grav	2.5YR3/3 m s, some vf grav			5YR3/3 m and co s, vf grav	7.5YR3/4 ms, vf grav	5YR3/3 m and co s		no recov
5	2.5YR3/3 ms, vf grav		2.5YR3/3 fs	2.5YR3/3 m s, more vf grav			5YR3/3 m s	7.5YR3/4 ms, vf grav	5YR3/3 m and co s		no recov
4	2.5YR3/3 ms, vf grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, more vf grav			5YR3/3 m s	5YR3/3 ms	5YR3/3 m and co s		no recov
3	2.5YR3/3 ms, vf grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, more vf grav			5YR3/3 m s	5YR3/3 ms	5YR3/3 m and co s		5YR3/3 m and co s
2	2.5YR3/3 ms, vf grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, less grav			5YR3/3 co s, vf grav	5YR3/3 ms	5YR3/3 m and co s		5YR3/3 m and co s
1	2.5YR3/3 ms, vf grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, vf grav			5YR3/2 m s, some vf grav	5YR3/3 ms	5YR3/3 m and co s		5YR3/3 ms
0	2.5YR2/2 ms, vf grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, vf grav			5YR3/2 m s, some vf grav	5YR3/3 ms	5YR3/3 m and co s		5YR3/3 ms
-1	2.5YR3/3 co s, 30% grav		2.5YR3/3 co s, grav	2.5YR3/3 m s, vf grav			5YR3/2 m s, some vf grav	5YR3/3 ms, bedding	5YR3/3 m and co s		5YR3/3 ms
-2	2.5YR3/3 ms		5YR3/2 ms, some si	2.5YR3/2 ms, some m grav			5YR3/2 m s, some vf grav	5YR4/2 fs	5YR3/3 m and co s		5YR3/1 f and vfs
-3	2.5YR3/3 ms, vf grav		5YR3/2 ms, some si	2.5YR3/2 ms, some m grav		967-899 bp	5YR3/2 m s, some vf grav, some shell	5YR3/1 fs	5YR3/3 m and co s		5YR3/1 f and vfs
-4	2.5YR3/3 m and co s, f, m grav		5YR3/2 ms, some si	2.5YR3/2 ms, some m grav			5YR2.5/1 vfs w/ vf OM, OM smell	5YR3/1 fs, some vf grav	5YR2.5/2 fs, some vf grav		5YR3/2 fs
-5	2.5YR3/3 m and co s, f, m grav		5YR3/2 ms, some si	2.5YR3/2 ms, some m grav			5YR2.5/1 vfs w/ vf OM, OM smell	5YR3/1 fs, some vf grav	5YR2.5/1 vfs		5YR3/2 fs
-6	10YR3/1 si w/ OM		Abt bound to 5YR3/1 fs	7.5YR3/1 sic, si s, sic w/ OM			7.5YR2.5/1 sic w/ vf OM	10YR2/1 m and co s, vf grav	5YR3/2 ms		5YR3/3 co s, much grav
-7	OM 728-664 bp		5YR3/1 fs	7.5YR3/1 sic, si s, sic w/ OM		1714-1565 bp	5YR3/1 co s w/ OM	10YR2/1 m and co s, vf grav	5YR3/2 m and co s, much f, m grav		5YR3/3 f and vfs, no grav
-8	OM		5YR3/3 fs	7.5YR3/1 sic, si s, sic w/ OM	1287-1172 bp		5YR2.5/1 si, sic	10YR2/1 m and co s, vf grav	5YR3/2 m and co s, much f, m grav		5YR3/2 f, vfs, no grav
-9	OM 3060-2875 bp		5YR3/3 fs	7.5YR3/1 sic, si s, sic w/ OM			5YR2.5/1 ms over sic w/ much OM	7.5YR3/2 co s, rd pebbles	5YR3/2 m and co s, much f, m grav		5YR3/2 f, vfs, no grav
-10	10YR3/1 ms		5YR3/3 fs	2.5YR2.5/1 scl w/ OM, MM	2600-2492 bp	2505-2351 bp	5YR2.5/1 sc, f OM	7.5YR3/2 co s, rd pebbles	5YR2.5/1 vfs		5YR3/2 f, vfs, no grav
-11	10YR3/1 lfs, vf grav		5YR3/3 fs	2.5YR2.5/1 scl w/ OM,			5YR2.5/1 sc, f OM	5YR3/1 vfs, si	5YR3/2 vfs		5YR3/1 vfs and si
-12	10YR3/1 lms, f grav		5YR3/3 m and co s,vf grav	2.5YR2.5/1 scl w/ OM,			5YR2.5/1 sc, f OM	5YR3/2 vfs, si	5YR3/2 vfs		5YR3/1 vfs and si
-13	10YR3/1 lms, f grav		5YR3/2 si s	2.5YR2.5/1 scl w/ OM, MM	4085-3899 bp	3271-3140 bp	5YR3/3 compact si, some clay, vfs	10YR3/1 fs, little vf grav	5YR3/1 vfs, some silt		7.5YR4/1 scl, no grav
-14	10YR3/1 lms, f grav		2.5YR3/3 co s, vf grav	Abt bound to Gley sc, much f grav			7.5 YR 4/4 compact si, some clay, vfs	varieg loam, grav	10YR3/1 vfs, some OM		7.5YR4/1 scl, no grav
-15	10YR3/1 lms, f grav		2.5YR3/3 co s, vf grav	2.5Y3/1 scl, OM			5YR3/3 si, much clay	varieg loam, grav	2.5Y4/1 vfscl, vf OM		7.5YR4/1 scl, no grav
-16	2.5YR3/1 ms, vf grav, OM?		2.5YR3/3 co s, vf grav	Abt bound to 2.5YR4/2 lms, grav	5659-5466 bp		5YR3/3 co s, f and m grav, abt upper bound	gley silty clay	2.5Y4/1 vfscl, vf OM	3511-3381 bp	Gley1 4/N scl, some bedding
-17	2.5YR3/3 ms, vf grav		2.5YR3/3 co s, grav	2.5YR4/2 lms, grav			5YR3/3 co s, f and m grav	varieg loam, grav	2.5Y4/1 vfscl, vf OM		2.5YR3/2 m-co s, vf grav
-18	2.5YR3/3 ms, vf grav		2.5YR3/3 med and co s, grav	2.5YR4/2 lms, grav			5YR3/3 co s, f and m grav	5YR2.5/2 ms, little vf grav	5YR3/3 sl, 30-40% f grav		5YR3/3 ms, some vf grav
-19	2.5YR3/2 bedded f and m s		2.5YR3/2 med and co s, grav	Abt bound to 2.5Y2.5/1 sic, bedded			5YR3/3 fs	5YR2.5/2 ms, little vf grav	5YR3/3 sl, 30-40% f grav		5YR3/3 ms, some vf grav
-20	2.5YR3/2 bedded f and m s		2.5YR3/2 co s, grav	2.5Y2.5/1 sic, bedded			5YR3/2 fs	5YR2.5/2 ms, little vf grav	5YR3/3 f and m s, little grav		5YR3/3 m and co s, much vf grav
-21	2.5YR3/2 bedded f, m s, vf grav		2.5YR3/3 ms	2.5Y2.5/2 l cos, much vf grav			5YR3/2 fs	5YR2.5/2 fs, no grav	5YR3/3 f, m, co s, little grav		5YR3/3 m and co s, much vf grav
-22	2.5YR3/2 bedded f, m s, vf grav		2.5YR3/3 m and co s, f, vf grav	10YR3/4 fs no grav			5YR3/2 fs	5YR2.5/2 fs, no grav	5YR3/3 f, m, co s, little grav		5YR3/3 ms
-23	2.5YR3/2 bedded f, m s, vf grav		2.5YR3/3 m and co s, f, vf grav	10YR3/4 fs no grav			5YR3/2 ms w/ grit, vf grav		5YR3/3 f, m, co s, little grav		5YR 3/3 ms
-24	2.5YR3/2 bedded f, m s, vf grav		2.5YR3/3 m and co s, f, vf grav	7.5YR3/3 fs, no grav			5YR3/2 ms w/ grit, vf grav		5YR3/3 f, m, co s, little grav		7.5YR3/2 ms
-25	2.5YR3/2 bedded f, m s, vf grav		2.5YR3/3 m and co s, f, vf grav	5YR3/2 ms, vf grav			5YR3/2 ms w/ grit, vf grav		5YR3/3 f, m, co s, little grav		
-26	2.5YR3/3 ms, some vf grav			5YR3/2 ms, vf grav			Gley1 4/1 compact sic, some stringers sand				
-27	2.5YR3/3 ms, some vf grav						Augered - no sample				
-28							Augered - no sample				
-29							Augered - no sample				
-30							Gley1 3/1 c, sandy stringers				
-31							Gley1 3/1 c, sandy stringers				
-32							Augered - no sample				
-33	**KEY**						Augered - no sample				
-34	Late 20th-/early 21st-century fill						Augered - no sample				
-35	Late Holocene-modern beach sand						Gley1 3/1 c, sandy zones				
-36	Late Holocene-modern coastal marsh						Gley1 3/1 c, sandy zones				
-37	Holocene solum										
-38	Backbarrier										
-39	Late Holocene lagoon										
-40	Lagoon tidal delta?										
-41	Stream alluvium?										
-42	Stream hollow aggradation?										
-43	Late Pleistocene glacial outwash										
-44	Cretaceous sediments										
-45	radiocarbon date										
-46											
-47	v - very										
-48	f - fine										
-49	m - medium										
-50	co - coarse										
-51	s - sand, sandy										
-52	si - silt, silty										
-53	c - clay, clayey										
-54	l - loam, loamy										
-55	grav - gravel, gravelly										
-56	OM - organic matter										
-57	redox - redoximorphic										
-58	abt bound - abrupt boundary										
-59											
-60											

Appendix B.4. Cross-Sectional Summary of Boring Data (New Creek Drainage [Northeast Portion])

BORING LOCATION

ELEVATION	DH26	DH27	DH28	GP13	DH29	GP14	DH30	DH31	GP15	DH32
16										
15										
14										
13										
12										
11										
10	5YR3/3 ms	7.5YR4/3 ms								
9	5YR3/3 m and co s, vf grav	7.5YR4/3 ms								
8	5YR3/3 co s, little vf grav	7.5YR4/3 ms, few rd peb								
7	5YR3/3 co s, little vf grav	7.5YR4/3 m and co s, some grav	7.5YR3/4 ms		7.5YR3/3 ms		7.5YR4/4 f and m s	7.5YR3/4-4/4 fs		
6	5YR3/3 co s, more grav	7.5YR4/3 m and co s, some grav	7.5YR3/4 ms		7.5YR3/3 ms		7.5YR4/4 f and m s	7.5YR3/4-4/4 fs		
5	5YR3/3 co s, more grav	7.5YR4/3 m and co s, more grav	7.5YR3/4 ms, oyster sh		2.5YR3/3 ms		7.5YR4/4 f, m, co s, some grav	7.5YR3/4-4/4 fs, thin lenses grav		
4	5YR3/3 co s, more grav	7.5YR4/3 m and co s, more grav	7.5YR3/4 ms, vf grav		2.5YR3/3 ms, much f grav		7.5YR4/4 f, m, co s, some grav	7.5YR3/4-4/4 fs, thin lenses grav		si l over 7.5YR4/3 ms
3	7.5YR3/3 ms	7.5YR4/3 m and co s, less grav	7.5YR3/4 ms		2.5YR3/3 ms		7.5YR4/4 f and m s, no grav	7.5YR3/4 m, co s, vf grav		7.5YR4/3 ms
2	7.5YR3/3 ms, , med grav	7.5YR4/3 m and co s, grav	7.5YR3/4 ms		2.5YR3/3 ms		7.5YR4/4 f and m s, no grav	7.5YR3/4 m, co s, vf grav		7.5YR4/3 ms
1	5YR3/3 m and co s, some vf grav	7.5YR4/3 m and co s, grav	7.5YR3/4 ms		not monitored		7.5YR3/2 fs, vf shell frags	7.5YR3/4 m, co s, vf grav		7.5YR4/3 ms
0	5YR3/3 m and co s, some vf grav	7.5YR3/3 ms, much f grav	7.5YR3/4 ms		not monitored		7.5YR3/2 fs, vf shell frags	7.5YR3/4 m, co s, vf grav		7.5YR4/3 ms
-1	5YR3/3 m s, some f grav	5YR3/2 f and vf s, shell frags	7.5YR3/4 ms		not monitored		7.5YR3/3 fs, vf shell frags	7.5YR3/4 m, co s, vf grav		7.5YR3/1 si and fs
-2	5YR3/3 m s, some f grav	5YR3/2 f and vf s, shell frags	7.5YR3/4 ms		not monitored		7.5YR3/3 fs, vf shell frags	7.5YR3/4 m, co s, vf grav		7.5YR3/1 si and fs
-3	5YR3/2 fs, lg shell frag, no grav	5YR3/2 f and vf s, shell frags	7.5YR3/2 ms, some co s		not monitored		2.5/1 fs, vf shell frags 12,686-12,550 bp	7.5YR3/1 fs, shell frags fs		7.5YR2.5/1 si and fs
-4	5YR3/2 fs, some bedding	7.5YR2.5/2 f and vfs	7.5YR3/2 ms, some co s		not monitored		7.5YR2.5/1 fs, vf shell frags, wood	7.5YR3/1 fs, shell frags fs		7.5YR2.5/1 si and fs
-5	5YR3/1 fs, 7759-7618 bp	7.5YR2.5/2 f and vfs 5468-5314 bp	7.5YR3/2 m and co s		2.5YR2.5/2 ms, shell frags		5YR4/1 ms, vf grav	7.5YR3/1 fs, few shell frags		reduced si c/ox co s
-6	5YR3/2 fs, no grav	10YR3/1 f and vfs, organic smell	7.5YR2.5/2 fs, no grav		2.5YR2.5/2 ms, shell frags		7.5YR2.5/1 ms, vf grav	7.5YR3/1 fs, no shell frags, few grav		7.5YR3/2 co s , f grav
-7	5YR3/2 co s, much f and vf grav	10YR3/1 f and vfs, organic smell	7.5YR2.5/2 fs, no grav		2.5YR2.5/2 ms, shell frags, twig		5YR2.5/1 ms, vf grav	7.5YR3/1 fs, no shell frags, few grav		7.5YR3/2 co s , f grav
-8	5YR3/2 co s, much f and vf grav	Abt to 5YR4/1 fs, no OM;10YR3/1 ms, grav	Abt to 2.5Y2.5/1 fs, shells, OM 334-281/145-15 bp		2.5YR3/3 ms, f grav		5YR4/1 ms, vf grav	7.5YR3/3 fs, more grav		7.5YR3/2 co s , f grav
-9	5YR3/2 co s, much f and vf grav	5YR3/2 l m s	2.5Y2.5/1 fs, shells, OM		2.5YR3/3 ms, f grav		5YR4/1 ms, vf grav	7.5YR3/3 fs, more grav		7.5YR3/3 f and m s, no grav
-10	5YR3/2 co s, much f and vf grav	5YR3/2 l m s	2.5Y3/1 ms		2.5YR3/3 co s, f grav; 5YR2.5/1 lfs, m, vfs		2.5Y2.5/1 si c, f OM	7.5YR3/2 m and co s, vf grav		7.5YR3/3 f and m s, no grav
-11	5YR 4/1 fs	5YR3/2 l m s	2.5Y3/1 ms		2.5YR3/2 vf and f s, bedded		2.5Y2.5/1 si c, f OM 2539-2354 bp	7.5YR3/2 m and co s, vf grav		7.5YR3/4-4/4 si and vfs
-12	no recov - pebble in shoe	5YR3/2 l m s	2.5Y3/1 ms		2.5YR3/2 bedded f and vfs		2.5Y2.5/1 si c, f OM	7.5YR3/2 m and co s, vf grav		7.5YR3/4-4/4 si and vfs
-13	no recov - pebble in shoe	5YR3/2 l m s	2.5Y3/1 ms		2.5YR3/3 si		2.5Y2.5/1 scl, little vf grav 3259-3106 bp	7.5YR3/4 fs, 2 co pebbles		7.5YR3/4-4/4 si and vfs
-14	5YR3/1 vfs	5YR3/2 l ms, f and m grav	5YR3/3 fs, si		2.5YR3/4 si and vfs, abt lwr bound		10YR4/1 sl to scl, co pebbles, roots?	7.5YR2.5/2 ms, some vf grav		7.5YR3/4-4/4 f and m s
-15	2.5Y3/1 vfsc w/ OM	5YR3/3 si, vfs - sloping bedding	5YR3/2 ms, vf grav		5YR3/3 ms, no grav		10YR4/1 sl to scl, co pebbles	7.5YR2.5/2 ms, some vf grav		7.5YR3/4-4/4 f and m s
-16	2.5Y5/1 vfsc, OM	5YR3/3 si, vfs - sloping bedding	5YR3/2 ms, vf grav		5YR3/3 ms, no grav		10YR4/1 sl to scl, co pebbles, some OM	7.5YR2.5/2 ms, some vf grav		7.5YR3/4-4/4 f and m s
-17	5Y2.5/1 vfsc, OM	5YR3/3 ms, f grav	5YR3/2 ms, vf grav		5YR3/3 fs, no grav		as above, 3694-3560 bp	7.5YR2.5/2 ms, some vf grav		7.5YR3/4-4/4 f and m s
-18	5YR4/1 sl, f and m grav	5YR3/3 ms, f grav	5YR3/2 f, vf s		2.5YR3/4 silt		abt bound to 5YR4/1-4/2 ms w/ vf grav	5YR3/4 si and vfs, no grav		7.5YR3/4-4/4 f and m s, some co
-19	5YR4/1 sl, f and m grav	5YR3/2 fs, thin bedding	5YR3/2 f, vf s		2.5YR3/3 fs, si, some OM		5YR4/1-4/2 ms, vf grav	5YR3/4 si and vfs, no grav		7.5YR3/4-4/4 f and m s, some co
-20	Gley2 5/1 fsc; 3/2 lms, less grav	5YR3/2 fs	5YR3/2 f, vf s		5YR3/3 ms, no grav		5YR3/3 vfs and si, no grav	5YR3/4 si and vfs, no grav		7.5YR3/4-4/4 f and m s, some f grav
-21	5YR3/2 lms, f and m grav	5YR3/2 ms	5YR3/2 f, vfs, si, some c		5YR3/3 ms, no grav		5YR3/3 vfs and si, no grav	5YR3/3 f and m s, some vf grav		7.5YR4/4 bedded f, m, co s, no grav
-22	5YR3/2 lms, no grav	5YR3/2 ms, f grav	5YR3/2 f, vfs, si, some c		2.5YR3/3 ms, some OM		5YR3/3 vfs and si, no grav	5YR3/3 f and m s, some vf grav		7.5YR4/4 bedded f, m, co s, no grav
-23	5YR3/2 lms, no grav	5YR3/2 m and f s	5YR3/2 f, vfs		5YR2.5/2 ms, no grav		5YR3/1 ms, no grav	5YR3/3 m s, more grav		7.5YR4/4 bedded f, m, co s, some f, vf grav
-24	5YR3/2 lms, no grav	5YR3/2 m and f s	5YR3/2 f, vfs		5YR3/3 ms, no grav		5YR3/1 ms, no grav	5YR3/3ms, more f and vf grav		7.5YR4/4 bedded f, m, co s, some f, vf grav
-25	5YR3/2 lms, no grav	5YR3/2 m and f s	5YR3/2 f, vfs		5YR3/4 m and co s, vf grav		5YR3/2 vfs, some si	5YR3/3 ms, f and vf grav		7.5YR4/4 bedded f, m, co s, some f, vf grav
-26			5YR3/2 ms, vf grav		5YR3/4 m and co s, vf grav		5YR3/2 vfs, some si	5YR3/3 ms, f and vf grav		7.5YR4/4 bedded f, m, co s, some f, vf grav
-27			5YR3/2 ms, vf grav		5YR3/4 m and co s, more grav		5YR3/2 vfs, some si	5YR3/3 ms, more grav		7.5YR4/4 bedded f, m, co s, much vf grav
-28			5YR3/2 ms, vf grav		5YR3/4 m and co s, more grav		5YR3/2 vfs, some si	5YR3/3 ms, more grav		7.5YR4/4 bedded f, m, co s, some m grav
-29	KEY						5YR3/2 vfs, some si, poss weathered cobble			7.5YR4/4 vfs
-30	Late 20th-/early 21st-century fill									7.5YR4/4 vfs
-31	Late Holocene-modern beach sand									7.5YR4/4 vfs
-32	Late Holocene-modern coastal marsh									7.5YR4/4 vfs
-33	Holocene solum									7.5YR4/4 vfs
-34	Backbarrier									
-35	Late Holocene lagoon									
-36	Lagoon tidal delta?									
-37	Stream alluvium?									
-38	Stream hollow aggradation?									
-39	Late Pleistocene glacial outwash									
-40	Cretaceous sediments									
-41	**radiocarbon date**									
-42										
-43	v - very									
-44	f - fine									
-45	m - medium									
-46	co - coarse									
-47	s - sand, sandy									
-48	si - silt, silty									
-49	c - clay, clayey									
-50	l - loam, loamy									
-51	grav - gravel, gravelly									
-52	OM - organic matter									
-53	redox - redoximorphic									
-54	abt bound - abrupt boundary									
-55										
-56										
-57										
-58										
-59										
-60										

Appendix C

RADIOCARBON DATES

Beta Analytic, Inc.

Beta Analytic
TESTING LABORATORY

Beta Analytic Inc
4985 SW 74 Court
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Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2005-Accredited Testing Laboratory

August 12, 2019

Mr. John Stiteler
Hunter Research, Inc
201 Connecticut Hill Road
Newfield, NY 14867
United States

RE: Radiocarbon Dating Results

Dear Mr. Stiteler,

Enclosed are the radiocarbon dating results for 25 samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

Our invoice will be emailed separately. Please forward it to the appropriate officer or send a credit card authorization. Thank you. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

Beta Analytic
TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler	Report Date: August 12, 2019
Hunter Research, Inc	Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532122	**SSSI 001**	**> 43500 BP**	IRMS δ13C: -23.1 o/oo

Submitter Material:	Peat
Pretreatment:	(plant material) acid/alkali/acid
Analyzed Material:	Plant material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	< 0.44 pMC
Fraction Modern Carbon:	< 0.0044
D14C:	< -995.5 o/oo
∆14C:	< -995.6 o/oo(1950:2,019.00)
Measured Radiocarbon Age:	(without d13C correction): NA
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler
Hunter Research, Inc

Report Date: August 12, 2019
Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532124	**SSSI 003**	**> 43500 BP**	IRMS δ13C: -24.3 o/oo

Submitter Material: Peat
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: < 0.44 pMC
Fraction Modern Carbon: < 0.0044
D14C: < -995.5 o/oo
Δ14C: < -995.6 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): NA
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler | Report Date: August 12, 2019

Hunter Research, Inc | Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532125	**SSSI 004**	**1770 +/- 30 BP**	IRMS δ13C: -24.8 o/oo

(85.6%)	**206 - 345 cal AD**	**(1744 - 1605 cal BP)**
(9.8%)	**138 - 200 cal AD**	**(1812 - 1750 cal BP)**

Submitter Material: SOIL CONTAINING FINE ORGANIC MATTER
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 80.22 +/- 0.30 pMC
Fraction Modern Carbon: 0.8022 +/- 0.0030
D14C: -197.76 +/- 3.00 o/oo
Δ14C: -204.42 +/- 3.00 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 1770 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Beta Analytic TESTING LABORATORY

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REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler	Report Date: August 12, 2019
Hunter Research, Inc	Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532126	**SSSI 005**	**> 43500 BP**	IRMS δ13C: -24.5 o/oo

Submitter Material:	ESTUARINE CLAY CONTAINING FINE ORGANIC MATTER
Pretreatment:	(organic sediment) acid washes
Analyzed Material:	Organic sediment
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	< 0.44 pMC
Fraction Modern Carbon:	< 0.0044
D14C:	< -995.5 o/oo
Δ14C:	< -995.6 o/oo(1950:2,019.00)
Measured Radiocarbon Age:	(without d13C correction): NA
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler — Report Date: August 12, 2019

Hunter Research, Inc — Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532127	**SSSI 006**	**> 43500 BP**	IRMS δ13C: -23.7 o/oo

Submitter Material: ESTUARINE SANDY CLAY CONTAINING FINE ORGANIC MATTER
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: < 0.44 pMC
Fraction Modern Carbon: < 0.0044
D14C: < -995.5 o/oo
Δ14C: < -995.6 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): NA
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler

Hunter Research, Inc

Report Date: August 12, 2019

Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532128	**SSSI 007**	**39940 +/- 420 BP**	IRMS δ13C: -23.9 o/oo

(95.4%) **42432 - 40932 cal BC** **(44381 - 42881 cal BP)**

Submitter Material: ESTUARINE CLAY CONTAINING FINE ORGANIC MATTER
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 0.69 +/- 0.04 pMC
Fraction Modern Carbon: 0.0069 +/- 0.0004
D14C: -993.07 +/- 0.36 o/oo
Δ14C: -993.13 +/- 0.36 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 39920 +/- 420 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 532129	**SSSI 008**	**42620 +/- 570 BP**	IRMS δ13C: -23.6 o/oo

(95.4%) **45073 - 42887 cal BC** **(47022 - 44836 cal BP)**

Submitter Material: ESTUARINE CLAY CONTAINING FINE ORGANIC MATTER
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 0.50 +/- 0.04 pMC
Fraction Modern Carbon: 0.0050 +/- 0.0004
D14C: -995.04 +/- 0.35 o/oo
Δ14C: -995.08 +/- 0.35 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 42600 +/- 570 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532130	**SSSI 009**	**750 +/- 30 BP**	IRMS δ13C: -25.4 o/oo

(95.4%) **1222 - 1286 cal AD** **(728 - 664 cal BP)**

Submitter Material: Peat
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 91.09 +/- 0.34 pMC
Fraction Modern Carbon: 0.9109 +/- 0.0034
D14C: -89.14 +/- 3.40 o/oo
Δ14C: -96.71 +/- 3.40 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 760 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532131	**SSSI 010**	**2850 +/- 30 BP**	IRMS δ13C: -27.5 o/oo

(95.4%) **1111 - 926 cal BC** **(3060 - 2875 cal BP)**

Submitter Material: Peat
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 70.13 +/- 0.26 pMC
Fraction Modern Carbon: 0.7013 +/- 0.0026
D14C: -298.68 +/- 2.62 o/oo
Δ14C: -304.51 +/- 2.62 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 2890 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532132	**SSSI 011**	**6860 +/- 30 BP**	IRMS δ13C: -24.1 o/oo

(95.4%) **5810 - 5669 cal BC** **(7759 - 7618 cal BP)**

Submitter Material: MARINE SAND CONTAING FINE ORGANIC MATTER
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 42.57 +/- 0.16 pMC
Fraction Modern Carbon: 0.4257 +/- 0.0016
D14C: -574.29 +/- 1.59 o/oo
Δ14C: -577.82 +/- 1.59 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 6840 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532134	**SSSI 013**	**10620 +/- 30 BP**	IRMS δ13C: -24.4 o/oo

(95.4%) **10737 - 10601 cal BC** **(12686 - 12550 cal BP)**

Submitter Material: LAGOON SANDS CONTAINING SOME FINE ORGANIC MATERIAL (?)
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 26.66 +/- 0.10 pMC
Fraction Modern Carbon: 0.2666 +/- 0.0010
D14C: -733.41 +/- 1.00 o/oo
Δ14C: -735.63 +/- 1.00 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 10610 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532135	**SSSI 014**	**2430 +/- 30 BP**	IRMS δ13C: -11.2 o/oo

(69.3%)	**590 - 405 cal BC**	**(2539 - 2354 cal BP)**
(19.5%)	**750 - 683 cal BC**	**(2699 - 2632 cal BP)**
(6.6%)	**668 - 639 cal BC**	**(2617 - 2588 cal BP)**

Submitter Material: SILTY SEDIMENT FROM COASTAL LAGOON, POSSIBLY CONTAINING ORGANIC MATTER
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 73.90 +/- 0.28 pMC
Fraction Modern Carbon: 0.7390 +/- 0.0028
D14C: -261.04 +/- 2.76 o/oo
Δ14C: -267.18 +/- 2.76 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 2200 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532136	**SSSI 015**	**3010 +/- 30 BP**	IRMS δ13C: -27.9 o/oo

(79.0%)	**1310 - 1157 cal BC**	**(3259 - 3106 cal BP)**
(12.0%)	**1386 - 1340 cal BC**	**(3335 - 3289 cal BP)**
(4.4%)	**1147 - 1128 cal BC**	**(3096 - 3077 cal BP)**

Submitter Material: Peat
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 68.75 +/- 0.26 pMC
Fraction Modern Carbon: 0.6875 +/- 0.0026
D14C: -312.51 +/- 2.57 o/oo
∆14C: -318.22 +/- 2.57 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 3060 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532137	**SSSI 016**	**3370 +/- 30 BP**	IRMS δ13C: -27.9 o/oo

(94.7%)	**1745 - 1611 cal BC**	**(3694 - 3560 cal BP)**
(0.7%)	**1572 - 1566 cal BC**	**(3521 - 3515 cal BP)**

Submitter Material: SANDY CLAY FROM LAGOON, CONTAINS ORGANICS
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 65.74 +/- 0.25 pMC
Fraction Modern Carbon: 0.6574 +/- 0.0025
D14C: -342.64 +/- 2.46 o/oo
Δ14C: -348.10 +/- 2.46 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 3420 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 532138	**SSSI 017**	**210 +/- 30 BP**	IRMS δ13C: -13.3 o/oo

(50.5%)	**1734 - 1806 cal AD**	**(216 - 144 cal BP)**
(30.8%)	**1646 - 1684 cal AD**	**(304 - 266 cal BP)**
(14.1%)	**1929 - Post AD 1950**	**(21 - Post BP 0)**

Submitter Material: SILTY SOIL WITH ORGANIC CONTENT
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 97.42 +/- 0.36 pMC
Fraction Modern Carbon: 0.9742 +/- 0.0036
D14C: -25.80 +/- 3.64 o/oo
Δ14C: -33.90 +/- 3.64 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 20 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532139	**SSSI 018**	**1100 +/- 30 BP**	IRMS δ13C: -19.7 o/oo

(95.4%) **887 - 1013 cal AD** **(1063 - 937 cal BP)**

Submitter Material: SILTY SUBSOIL WITH SMALL AMOUNT ORGANIC CARBON
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 87.20 +/- 0.33 pMC
Fraction Modern Carbon: 0.8720 +/- 0.0033
D14C: -127.97 +/- 3.26 o/oo
Δ14C: -135.22 +/- 3.26 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 1010 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 532140	**SSSI 019**	**1270 +/- 30 BP**	IRMS δ13C: -12.5 o/oo

(92.1%)	**663 - 778 cal AD**	**(1287 - 1172 cal BP)**
(1.7%)	**842 - 860 cal AD**	**(1108 - 1090 cal BP)**
(1.3%)	**792 - 804 cal AD**	**(1158 - 1146 cal BP)**
(0.3%)	**818 - 822 cal AD**	**(1132 - 1128 cal BP)**

Submitter Material:	Peat
Pretreatment:	(plant material) acid/alkali/acid
Analyzed Material:	Plant material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	85.38 +/- 0.32 pMC
Fraction Modern Carbon:	0.8538 +/- 0.0032
D14C:	-146.24 +/- 3.19 o/oo
Δ14C:	-153.33 +/- 3.19 o/oo(1950:2,019.00)
Measured Radiocarbon Age:	(without d13C correction): 1060 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler | Report Date: August 12, 2019

Hunter Research, Inc | Material Received: July 25, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532142	**SSSI 021**	**2530 +/- 30 BP**	IRMS δ13C: -14.5 o/oo

(45.7%)	**651 - 543 cal BC**	**(2600 - 2492 cal BP)**
(35.8%)	**797 - 731 cal BC**	**(2746 - 2680 cal BP)**
(13.9%)	**691 - 660 cal BC**	**(2640 - 2609 cal BP)**

Submitter Material: MARINE ESTUARINE SANDS WITH ORGANIC MATTER, CAPPED BY BEACH SANDS
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 72.98 +/- 0.27 pMC
Fraction Modern Carbon: 0.7298 +/- 0.0027
D14C: -270.18 +/- 2.73 o/oo
Δ14C: -276.24 +/- 2.73 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 2360 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532144	**SSSI 023**	**3660 +/- 30 BP**	IRMS δ13C: -18.4 o/oo

(95.4%) **2136 - 1950 cal BC** **(4085 - 3899 cal BP)**

Submitter Material: SANDY BASAL SEDIMENTS FROM COASTAL ESTUARY CAPPED BY MARINE SANDS
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 63.41 +/- 0.24 pMC
Fraction Modern Carbon: 0.6341 +/- 0.0024
D14C: -365.95 +/- 2.37 o/oo
Δ14C: -371.22 +/- 2.37 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 3550 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532145	**SSSI 024**	**4830 +/- 50 BP**	IRMS δ13C: -19.3 o/oo

(94.5%)	**3710 - 3517 cal BC**	**(5659 - 5466 cal BP)**
(0.9%)	**3397 - 3385 cal BC**	**(5346 - 5334 cal BP)**

Submitter Material: SANDY CLAY ESTUARINE SEDIMENTS POSSIBLY CONTAINING FINE ORGANIC MATTER
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 54.81 +/- 0.34 pMC
Fraction Modern Carbon: 0.5481 +/- 0.0034
D14C: -451.89 +/- 3.41 o/oo
Δ14C: -456.44 +/- 3.41 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 4740 +/- 50 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532146	**SSSI 025**	**1000 +/- 30 BP**	IRMS δ13C: -27.3 o/oo

(70.7%)	**983 - 1051 cal AD**	**(967 - 899 cal BP)**
(19.4%)	**1082 - 1128 cal AD**	**(868 - 822 cal BP)**
(5.3%)	**1135 - 1152 cal AD**	**(815 - 798 cal BP)**

Submitter Material: SANDS FROM COASTAL LAGOON CAPPED BY ENCROACHING MARINE SANDS
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 88.29 +/- 0.33 pMC
Fraction Modern Carbon: 0.8829 +/- 0.0033
D14C: -117.05 +/- 3.30 o/oo
Δ14C: -124.39 +/- 3.30 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 1040 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532147	**SSSI 026**	**1740 +/- 30 BP**	IRMS δ13C: -17.1 o/oo

(95.4%) **236 - 385 cal AD** **(1714 - 1565 cal BP)**

Submitter Material: Peat
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 80.52 +/- 0.30 pMC
Fraction Modern Carbon: 0.8052 +/- 0.0030
D14C: -194.75 +/- 3.01 o/oo
Δ14C: -201.45 +/- 3.01 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 1610 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532148	**SSSI 027**	**2420 +/- 30 BP**	IRMS δ13C: -15.3 o/oo

(74.9%)	**556 - 402 cal BC**	**(2505 - 2351 cal BP)**
(15.5%)	**748 - 685 cal BC**	**(2697 - 2634 cal BP)**
(4.6%)	**666 - 642 cal BC**	**(2615 - 2591 cal BP)**
(0.4%)	**587 - 581 cal BC**	**(2536 - 2530 cal BP)**

Submitter Material: Peat
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 73.99 +/- 0.28 pMC
Fraction Modern Carbon: 0.7399 +/- 0.0028
D14C: -260.11 +/- 2.76 o/oo
Δ14C: -266.26 +/- 2.76 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 2260 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532150	**SSSI 029**	**3020 +/- 30 BP**	IRMS δ13C: -17.8 o/oo

(73.0%)	**1322 - 1191 cal BC**	**(3271 - 3140 cal BP)**
(18.8%)	**1391 - 1337 cal BC**	**(3340 - 3286 cal BP)**
(2.0%)	**1144 - 1131 cal BC**	**(3093 - 3080 cal BP)**
(1.5%)	**1177 - 1163 cal BC**	**(3126 - 3112 cal BP)**

Submitter Material: BASAL ESTUARINE SEDIMENTS
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 68.66 +/- 0.26 pMC
Fraction Modern Carbon: 0.6866 +/- 0.0026
D14C: -313.37 +/- 2.56 o/oo
Δ14C: -319.07 +/- 2.56 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 2900 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 532151	**SSSI 030**	**3230 +/- 30 BP**	IRMS δ13C: -17.9 o/oo

(87.3%)	**1562 - 1432 cal BC**	**(3511 - 3381 cal BP)**
(8.1%)	**1608 - 1582 cal BC**	**(3557 - 3531 cal BP)**

Submitter Material: SANDY ESTUARY SEDIMENTS WITH VERY FINE ORGANIC MATERIAL
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 66.89 +/- 0.25 pMC
Fraction Modern Carbon: 0.6689 +/- 0.0025
D14C: -331.08 +/- 2.50 o/oo
Δ14C: -336.64 +/- 2.50 o/oo(1950:2,019.00)
Measured Radiocarbon Age: (without d13C correction): 3110 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.8 o/oo)

Laboratory number **Beta-532125**

Conventional radiocarbon age **1770 ± 30 BP**

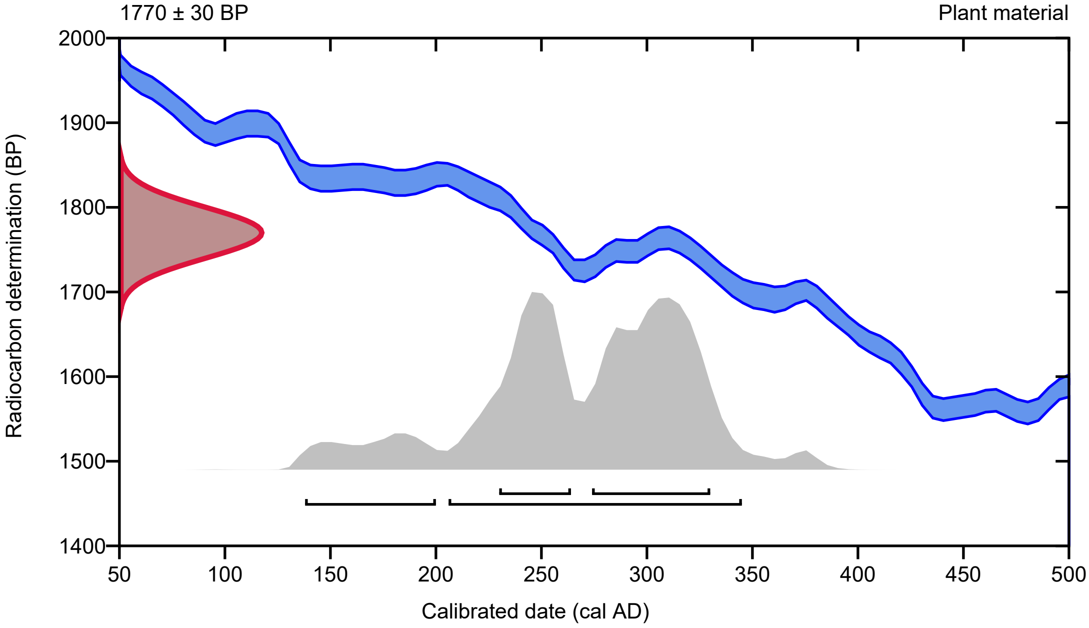
95.4% probability

(85.6%)	206 - 345 cal AD	(1744 - 1605 cal BP)
(9.8%)	138 - 200 cal AD	(1812 - 1750 cal BP)

68.2% probability

(42.5%)	274 - 330 cal AD	(1676 - 1620 cal BP)
(25.7%)	230 - 264 cal AD	(1720 - 1686 cal BP)

SSSI 004



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -23.9 o/oo)

Laboratory number **Beta-532128**

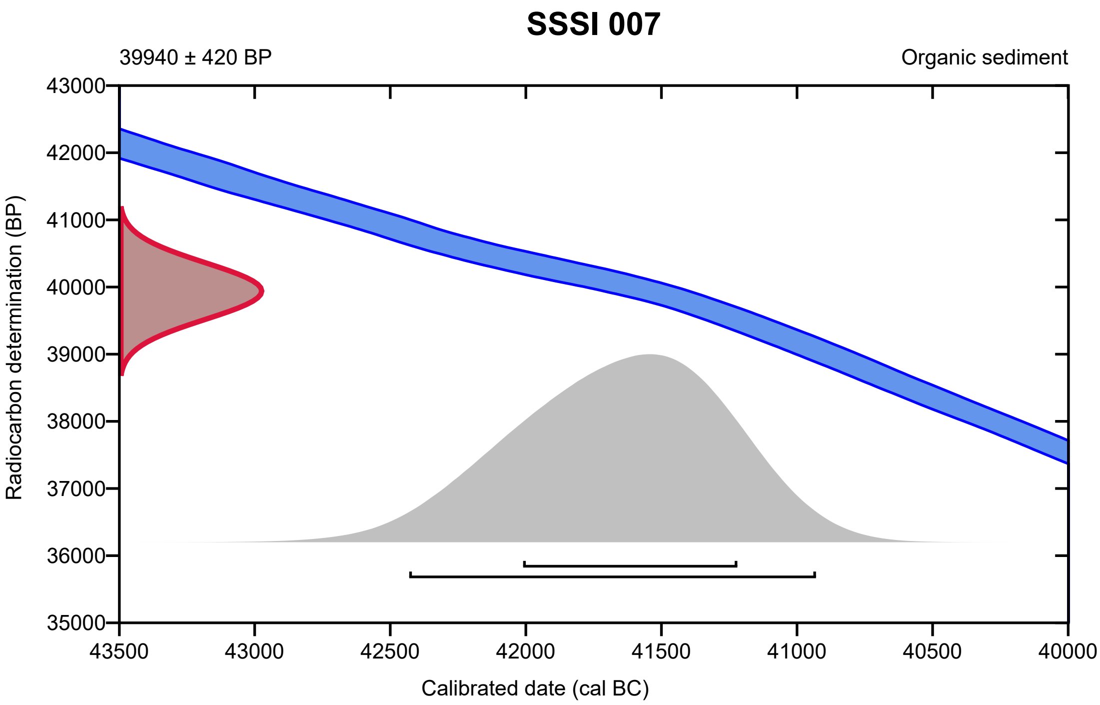
Conventional radiocarbon age **39940 ± 420 BP**

95.4% probability

(95.4%) 42432 - 40932 cal BC (44381 - 42881 cal BP)

68.2% probability

(68.2%) 42012 - 41222 cal BC (43961 - 43171 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -23.6 o/oo)

Laboratory number **Beta-532129**

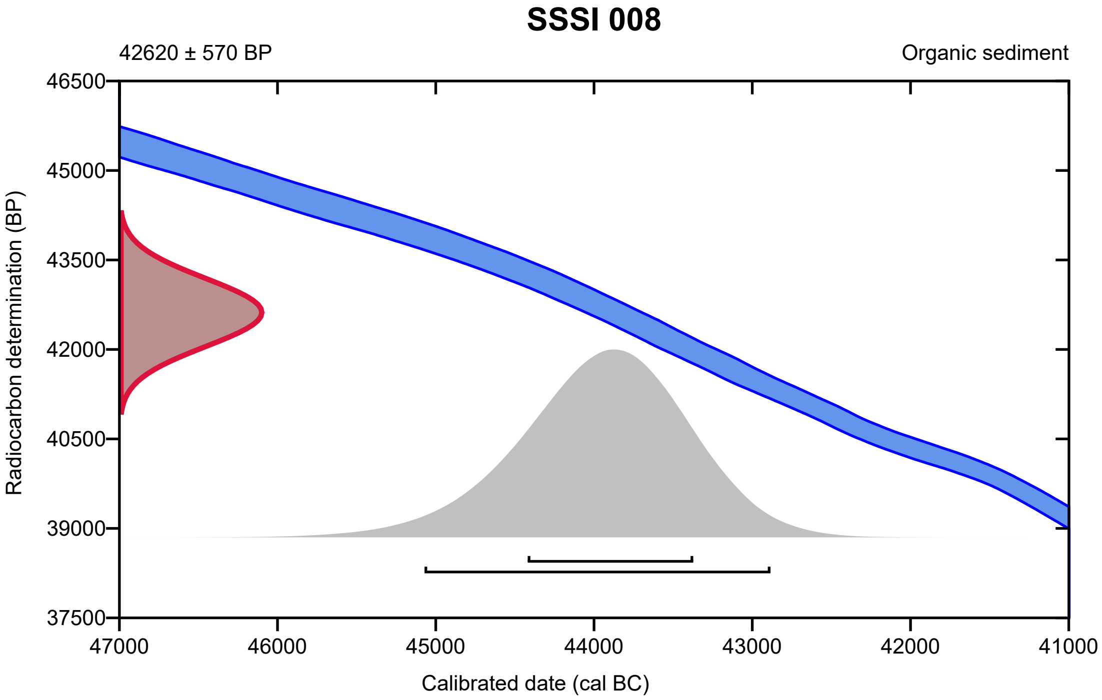
Conventional radiocarbon age **42620 ± 570 BP**

95.4% probability

(95.4%) 45073 - 42887 cal BC (47022 - 44836 cal BP)

68.2% probability

(68.2%) 44421 - 43375 cal BC (46370 - 45324 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -25.4 o/oo)

Laboratory number **Beta-532130**

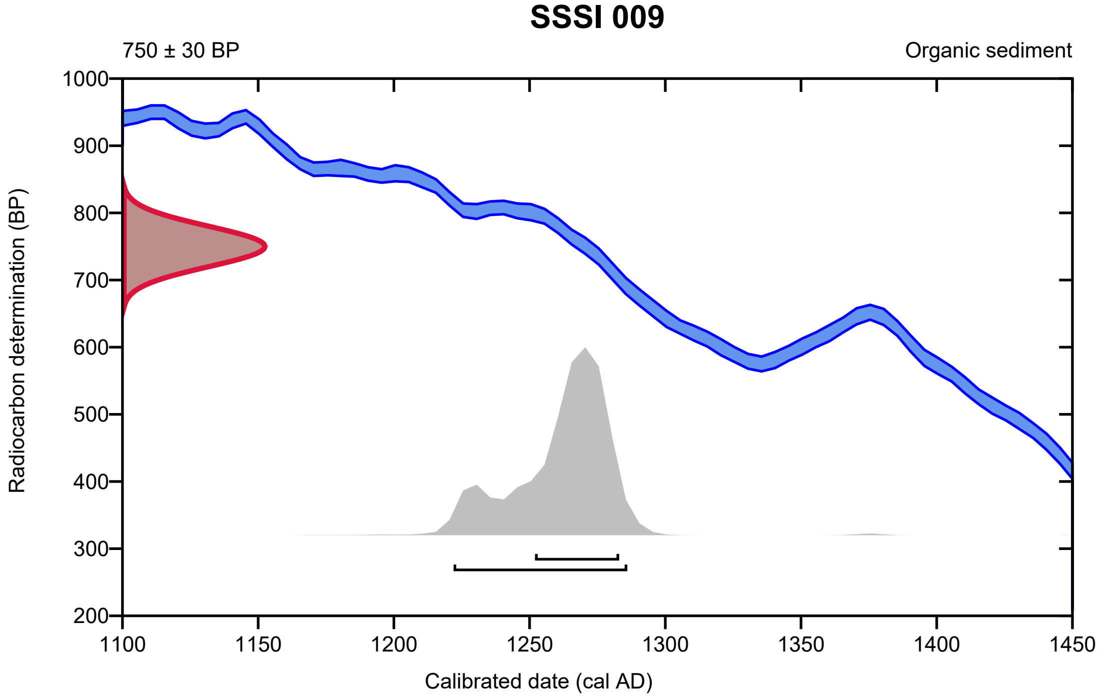
Conventional radiocarbon age **750 ± 30 BP**

95.4% probability

(95.4%) 1222 - 1286 cal AD (728 - 664 cal BP)

68.2% probability

(68.2%) 1252 - 1283 cal AD (698 - 667 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -27.5 o/oo)

Laboratory number **Beta-532131**

Conventional radiocarbon age **2850 ± 30 BP**

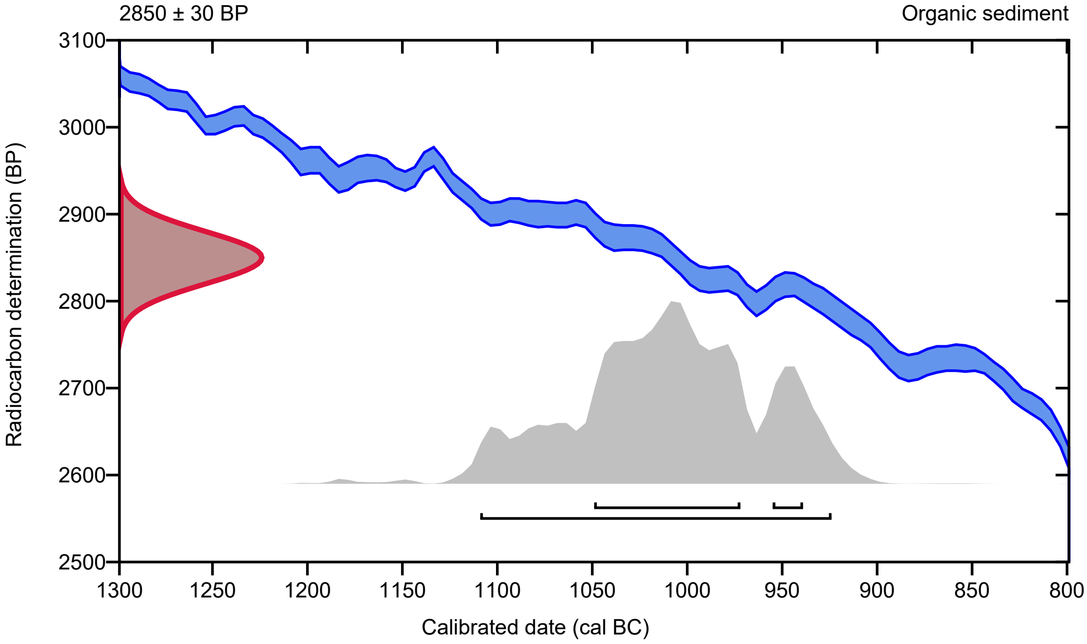
95.4% probability

(95.4%)	1111 - 926 cal BC	(3060 - 2875 cal BP)

68.2% probability

(59.2%)	1051 - 974 cal BC	(3000 - 2923 cal BP)
(9%)	957 - 941 cal BC	(2906 - 2890 cal BP)

SSSI 010



Database used

INTCAL13

References

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.1 o/oo)

Laboratory number **Beta-532132**

Conventional radiocarbon age **6860 ± 30 BP**

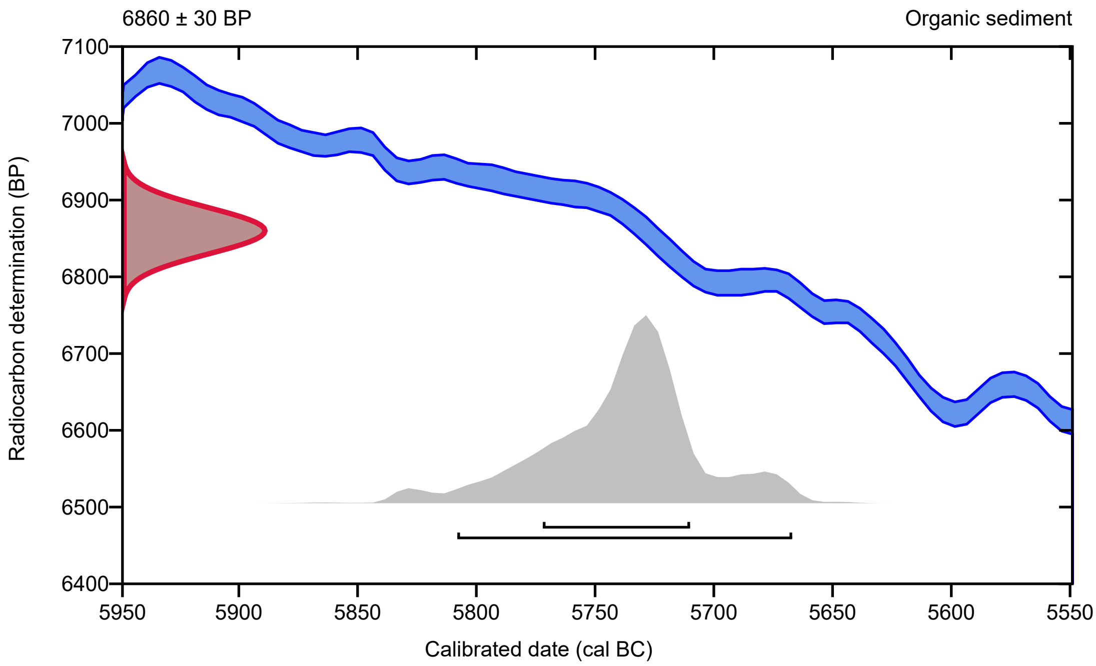
95.4% probability

(95.4%) 5810 - 5669 cal BC (7759 - 7618 cal BP)

68.2% probability

(68.2%) 5774 - 5712 cal BC (7723 - 7661 cal BP)

SSSI 011



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.4 o/oo)

Laboratory number **Beta-532134**

Conventional radiocarbon age **10620 ± 30 BP**

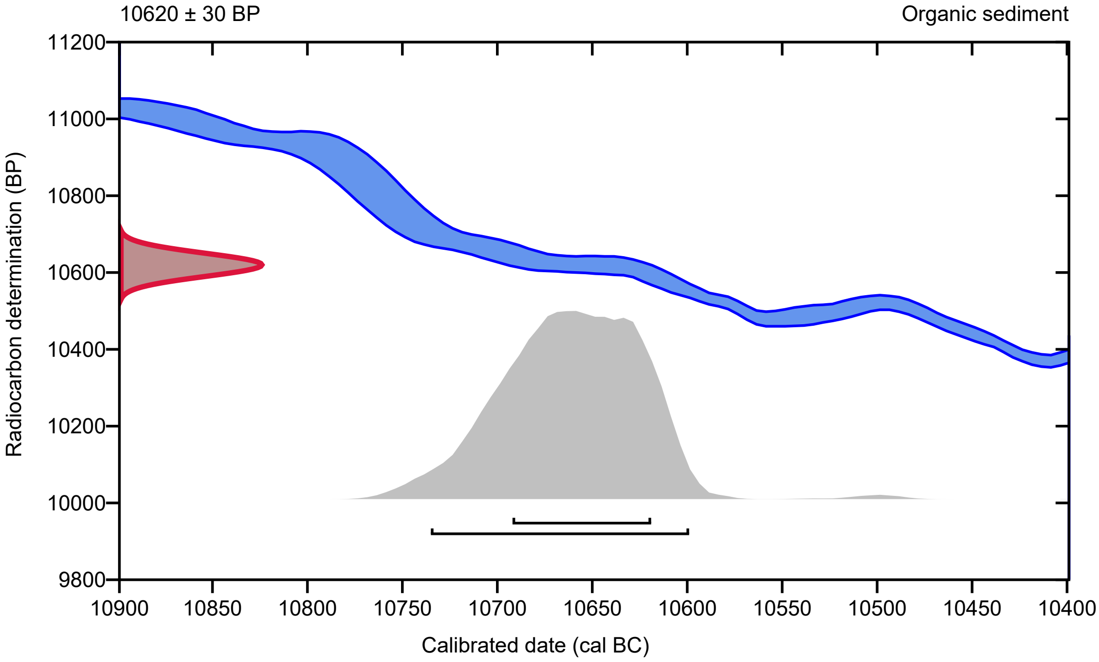
95.4% probability

(95.4%) 10737 - 10601 cal BC (12686 - 12550 cal BP)

68.2% probability

(68.2%) 10694 - 10621 cal BC (12643 - 12570 cal BP)

SSSI 013



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -11.2 o/oo)

Laboratory number **Beta-532135**

Conventional radiocarbon age **2430 ± 30 BP**

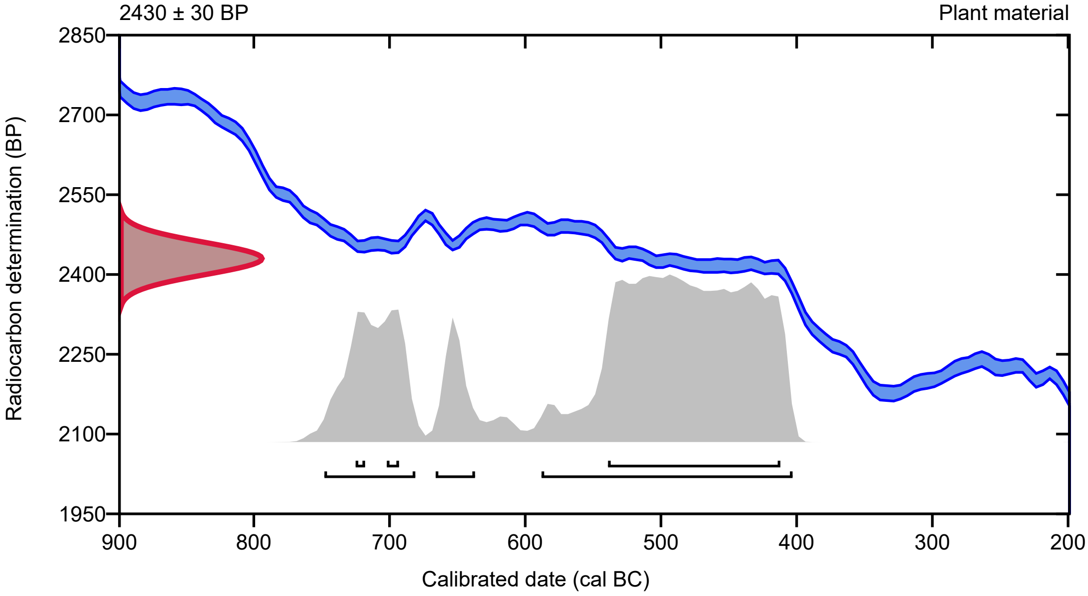
95.4% probability

(69.3%)	590 - 405 cal BC	(2539 - 2354 cal BP)
(19.5%)	750 - 683 cal BC	(2699 - 2632 cal BP)
(6.6%)	668 - 639 cal BC	(2617 - 2588 cal BP)

68.2% probability

(61.7%)	541 - 414 cal BC	(2490 - 2363 cal BP)
(3.7%)	704 - 695 cal BC	(2653 - 2644 cal BP)
(2.8%)	727 - 720 cal BC	(2676 - 2669 cal BP)

SSSI 014



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -27.9 o/oo)

Laboratory number **Beta-532136**

Conventional radiocarbon age **3010 ± 30 BP**

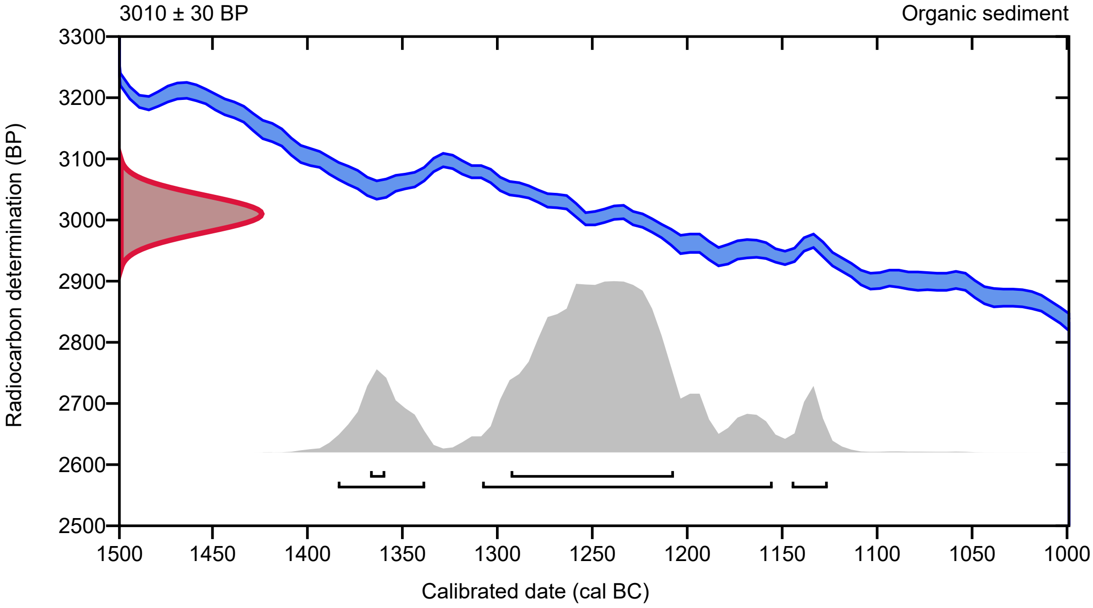
95.4% probability

(79%)	1310 - 1157 cal BC	(3259 - 3106 cal BP)
(12%)	1386 - 1340 cal BC	(3335 - 3289 cal BP)
(4.4%)	1147 - 1128 cal BC	(3096 - 3077 cal BP)

68.2% probability

(64.6%)	1295 - 1209 cal BC	(3244 - 3158 cal BP)
(3.6%)	1369 - 1361 cal BC	(3318 - 3310 cal BP)

SSSI 015



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -27.9 o/oo)

Laboratory number **Beta-532137**

Conventional radiocarbon age **3370 ± 30 BP**

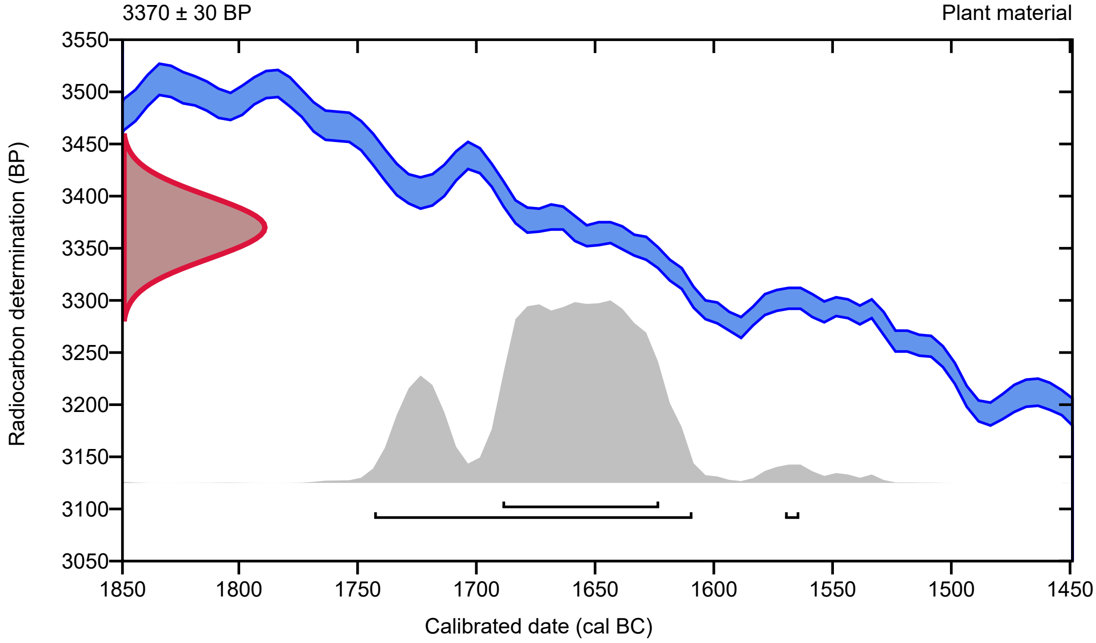
95.4% probability

(94.7%)	1745 - 1611 cal BC	(3694 - 3560 cal BP)
(0.7%)	1572 - 1566 cal BC	(3521 - 3515 cal BP)

68.2% probability

(68.2%)	1691 - 1625 cal BC	(3640 - 3574 cal BP)

SSSI 016



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -13.3 o/oo)

Laboratory number **Beta-532138**

Conventional radiocarbon age **210 ± 30 BP**

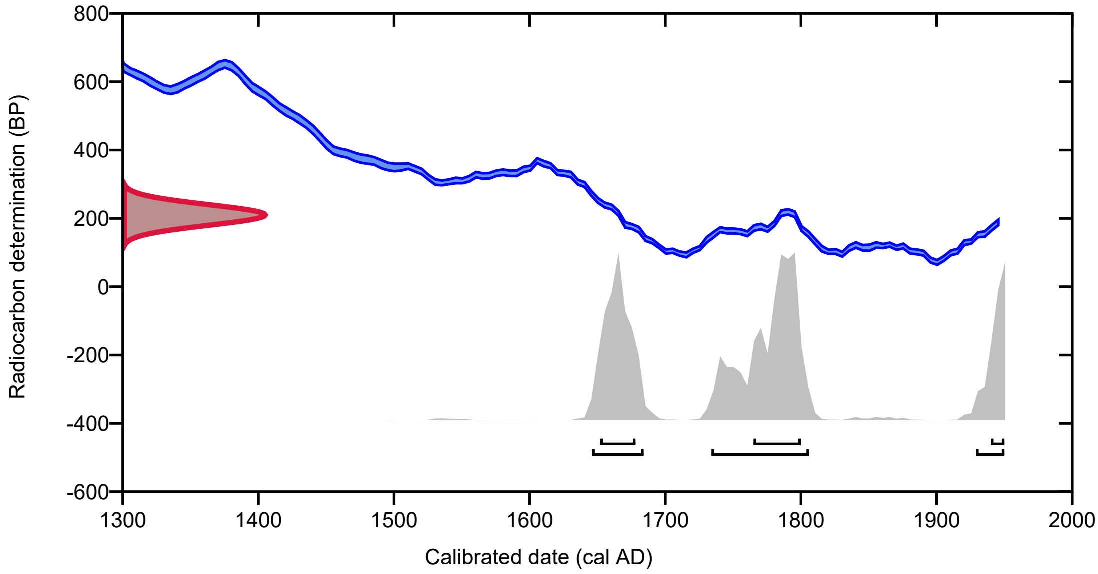
95.4% probability

(50.5%)	1734 - 1806 cal AD	(216 - 144 cal BP)
(30.8%)	1646 - 1684 cal AD	(304 - 266 cal BP)
(14.1%)	1929 - Post cal AD 1950	(21 - Post cal BP 0)

68.2% probability

(33%)	1765 - 1800 cal AD	(185 - 150 cal BP)
(25%)	1652 - 1678 cal AD	(298 - 272 cal BP)
(10.2%)	1940 - Post cal AD 1950	(10 - Post cal BP 0)

SSSI 017



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -19.7 o/oo)

Laboratory number **Beta-532139**

Conventional radiocarbon age **1100 ± 30 BP**

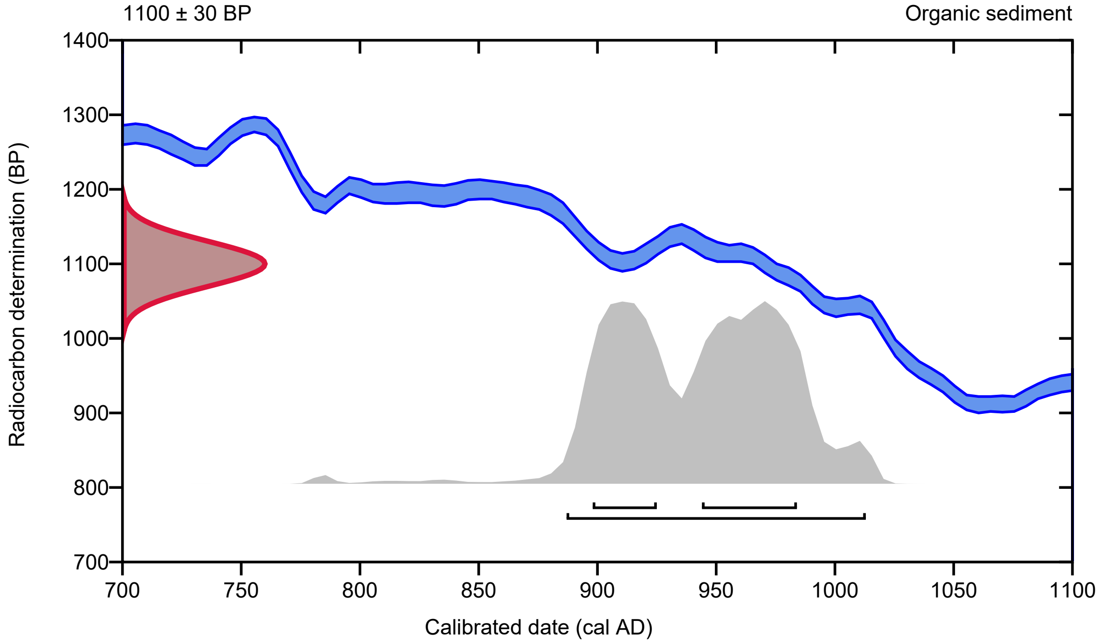
95.4% probability

(95.4%)	887 - 1013 cal AD	(1063 - 937 cal BP)

68.2% probability

(40.4%)	944 - 984 cal AD	(1006 - 966 cal BP)
(27.8%)	898 - 925 cal AD	(1052 - 1025 cal BP)

SSSI 018



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -12.5 o/oo)

Laboratory number **Beta-532140**

Conventional radiocarbon age **1270 ± 30 BP**

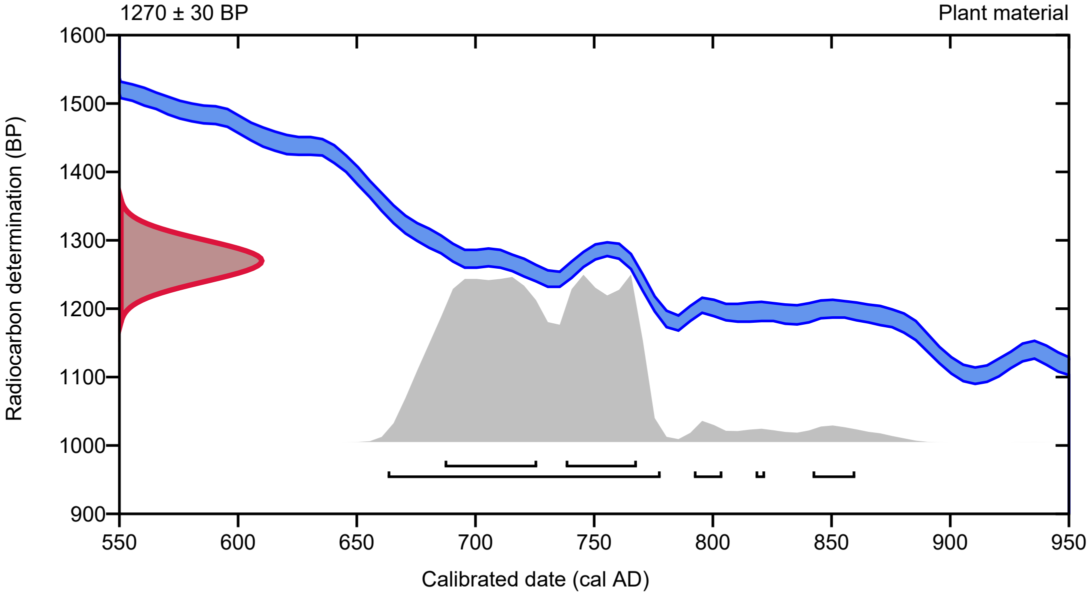
95.4% probability

(92.1%)	663 - 778 cal AD	(1287 - 1172 cal BP)
(1.7%)	842 - 860 cal AD	(1108 - 1090 cal BP)
(1.3%)	792 - 804 cal AD	(1158 - 1146 cal BP)
(0.3%)	818 - 822 cal AD	(1132 - 1128 cal BP)

68.2% probability

(39.1%)	687 - 726 cal AD	(1263 - 1224 cal BP)
(29.1%)	738 - 768 cal AD	(1212 - 1182 cal BP)

SSSI 019



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -14.5 o/oo)

Laboratory number **Beta-532142**

Conventional radiocarbon age **2530 ± 30 BP**

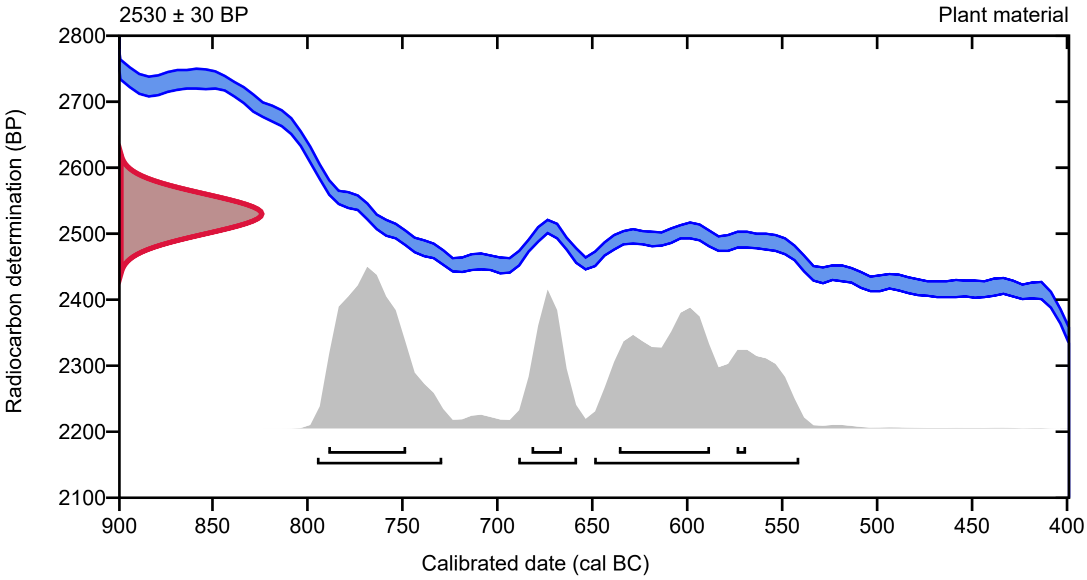
95.4% probability

(45.7%)	651 - 543 cal BC	(2600 - 2492 cal BP)
(35.8%)	797 - 731 cal BC	(2746 - 2680 cal BP)
(13.9%)	691 - 660 cal BC	(2640 - 2609 cal BP)

68.2% probability

(29.7%)	791 - 750 cal BC	(2740 - 2699 cal BP)
(26.1%)	638 - 590 cal BC	(2587 - 2539 cal BP)
(10.2%)	684 - 668 cal BC	(2633 - 2617 cal BP)
(2.2%)	576 - 571 cal BC	(2525 - 2520 cal BP)

SSSI 021



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -18.4 o/oo)

Laboratory number **Beta-532144**

Conventional radiocarbon age **3660 ± 30 BP**

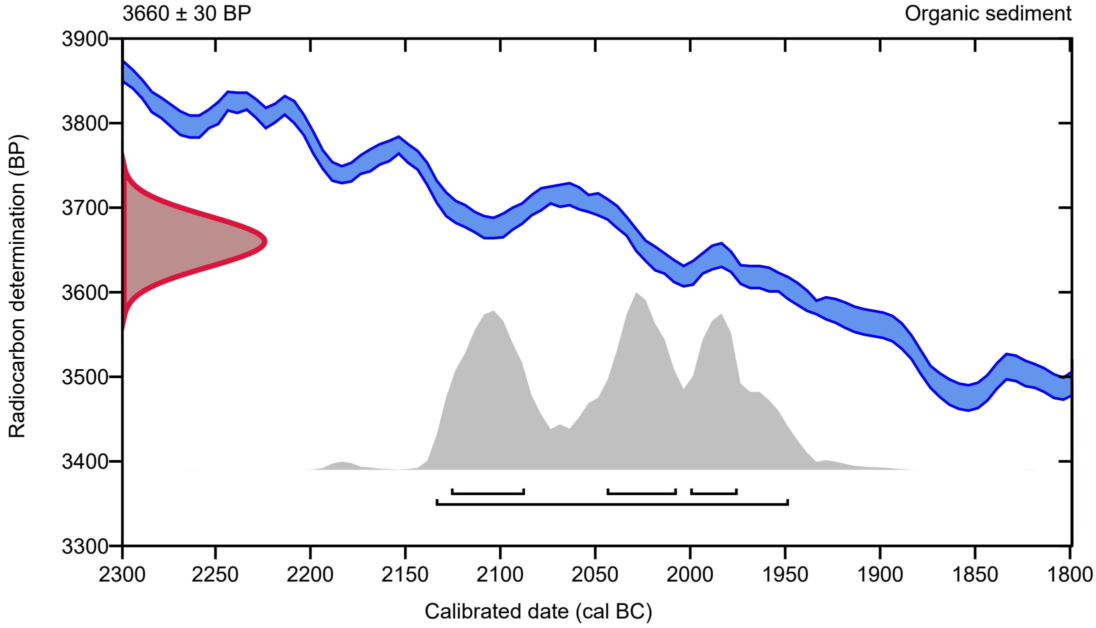
95.4% probability

(95.4%)	2136 - 1950 cal BC	(4085 - 3899 cal BP)

68.2% probability

(25.9%)	2046 - 2009 cal BC	(3995 - 3958 cal BP)
(25.6%)	2128 - 2089 cal BC	(4077 - 4038 cal BP)
(16.7%)	2002 - 1977 cal BC	(3951 - 3926 cal BP)

SSSI 023



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -19.3 o/oo)

Laboratory number **Beta-532145**

Conventional radiocarbon age **4830 ± 50 BP**

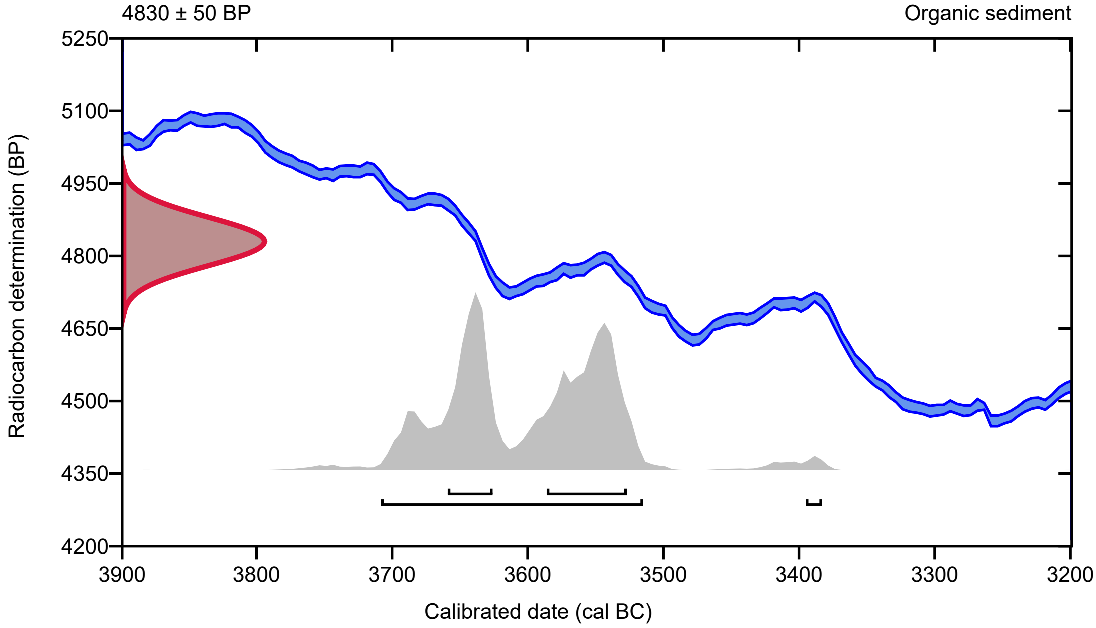
95.4% probability

(94.5%)	3710 - 3517 cal BC	(5659 - 5466 cal BP)
(0.9%)	3397 - 3385 cal BC	(5346 - 5334 cal BP)

68.2% probability

(40.3%)	3588 - 3529 cal BC	(5537 - 5478 cal BP)
(27.9%)	3661 - 3628 cal BC	(5610 - 5577 cal BP)

SSSI 024



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -27.3 o/oo)

Laboratory number **Beta-532146**

Conventional radiocarbon age **1000 ± 30 BP**

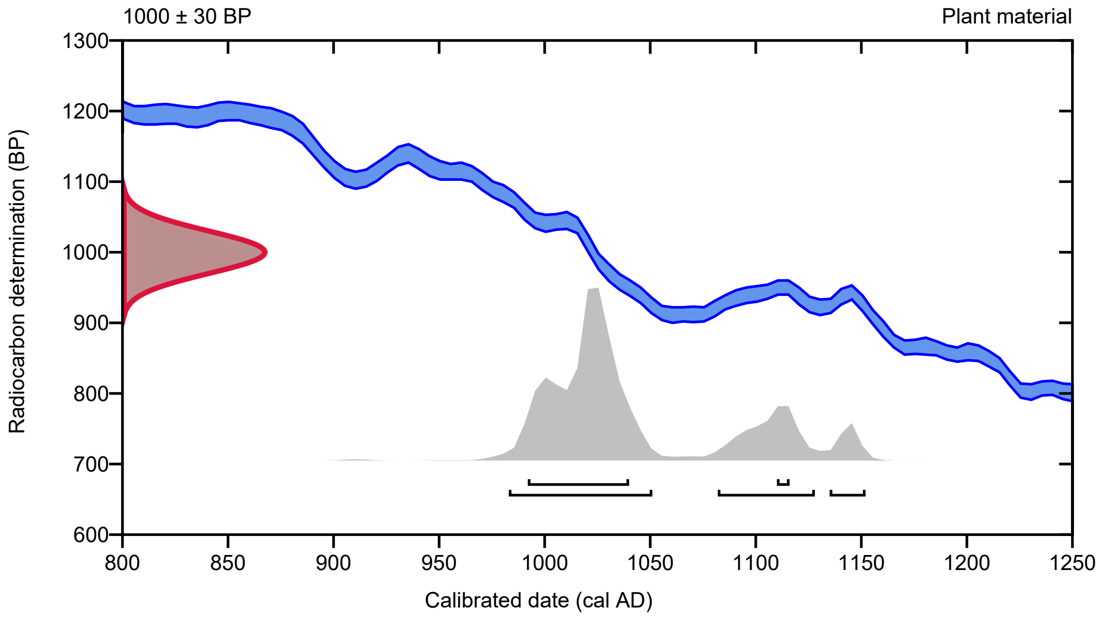
95.4% probability

(70.7%)	983 - 1051 cal AD	(967 - 899 cal BP)
(19.4%)	1082 - 1128 cal AD	(868 - 822 cal BP)
(5.3%)	1135 - 1152 cal AD	(815 - 798 cal BP)

68.2% probability

(63.9%)	992 - 1040 cal AD	(958 - 910 cal BP)
(4.3%)	1110 - 1116 cal AD	(840 - 834 cal BP)

SSSI 025



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -17.1 o/oo)

Laboratory number **Beta-532147**

Conventional radiocarbon age **1740 ± 30 BP**

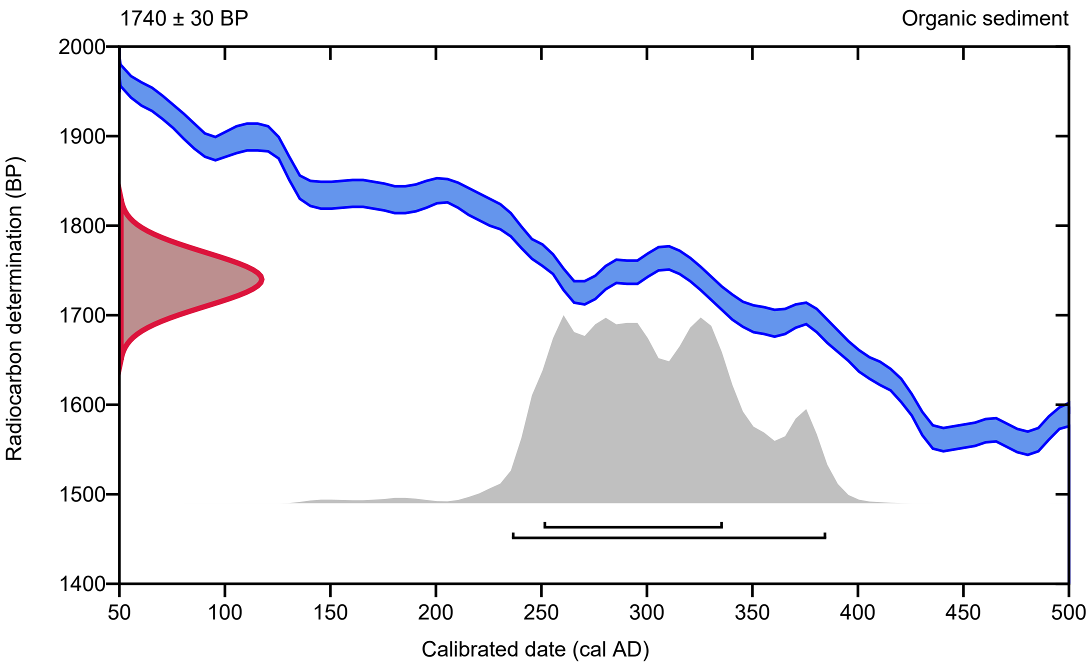
95.4% probability

(95.4%) 236 - 385 cal AD (1714 - 1565 cal BP)

68.2% probability

(68.2%) 251 - 336 cal AD (1699 - 1614 cal BP)

SSSI 026



Database used
INTCAL13

References

References to Probability Method
Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.
References to Database INTCAL13
Reimer, et.al., 2013, Radiocarbon55(4).

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -15.3 o/oo)

Laboratory number **Beta-532148**

Conventional radiocarbon age **2420 ± 30 BP**

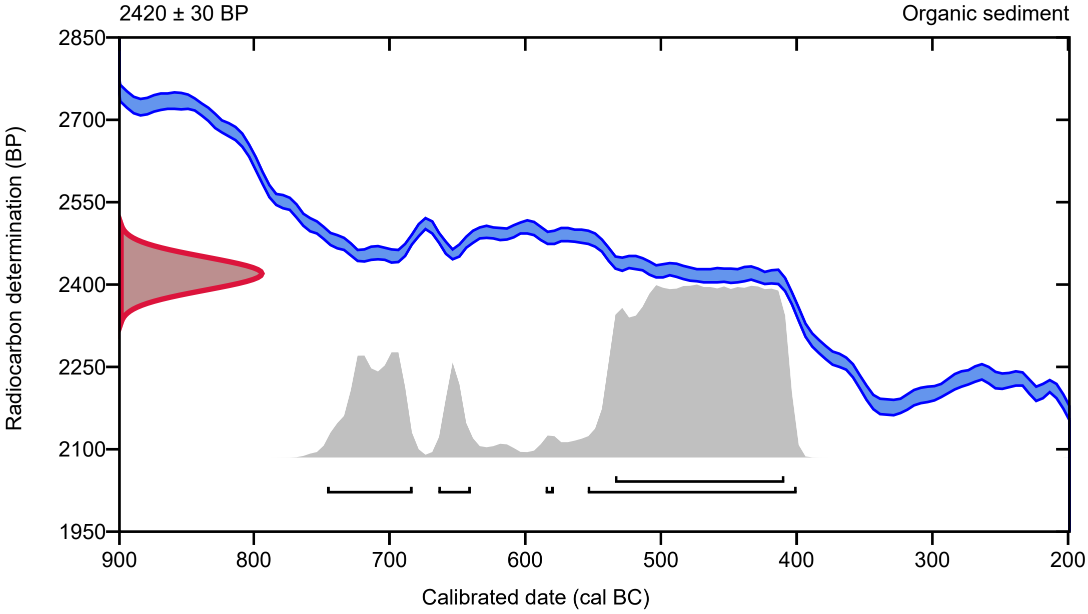
95.4% probability

(74.9%)	556 - 402 cal BC	(2505 - 2351 cal BP)
(15.5%)	748 - 685 cal BC	(2697 - 2634 cal BP)
(4.6%)	666 - 642 cal BC	(2615 - 2591 cal BP)
(0.4%)	587 - 581 cal BC	(2536 - 2530 cal BP)

68.2% probability

(68.2%)	536 - 411 cal BC	(2485 - 2360 cal BP)

SSSI 027



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -17.8 o/oo)

Laboratory number **Beta-532150**

Conventional radiocarbon age **3020 ± 30 BP**

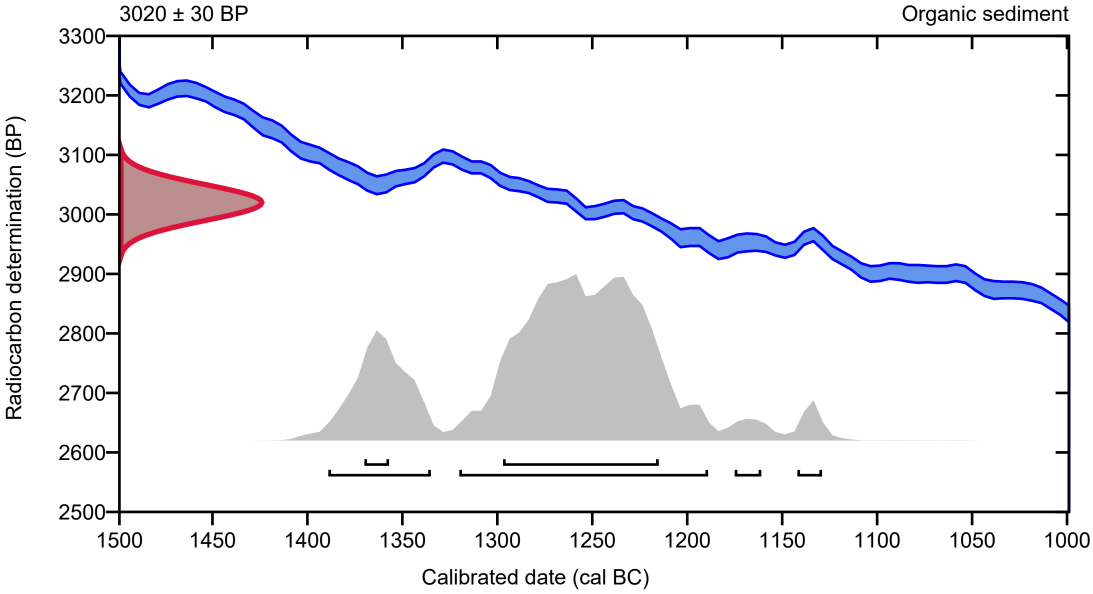
95.4% probability

(73%)	1322 - 1191 cal BC	(3271 - 3140 cal BP)
(18.8%)	1391 - 1337 cal BC	(3340 - 3286 cal BP)
(2%)	1144 - 1131 cal BC	(3093 - 3080 cal BP)
(1.5%)	1177 - 1163 cal BC	(3126 - 3112 cal BP)

68.2% probability

(61.2%)	1299 - 1217 cal BC	(3248 - 3166 cal BP)
(7%)	1372 - 1359 cal BC	(3321 - 3308 cal BP)

SSSI 029



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -17.9 o/oo)

Laboratory number **Beta-532151**

Conventional radiocarbon age **3230 ± 30 BP**

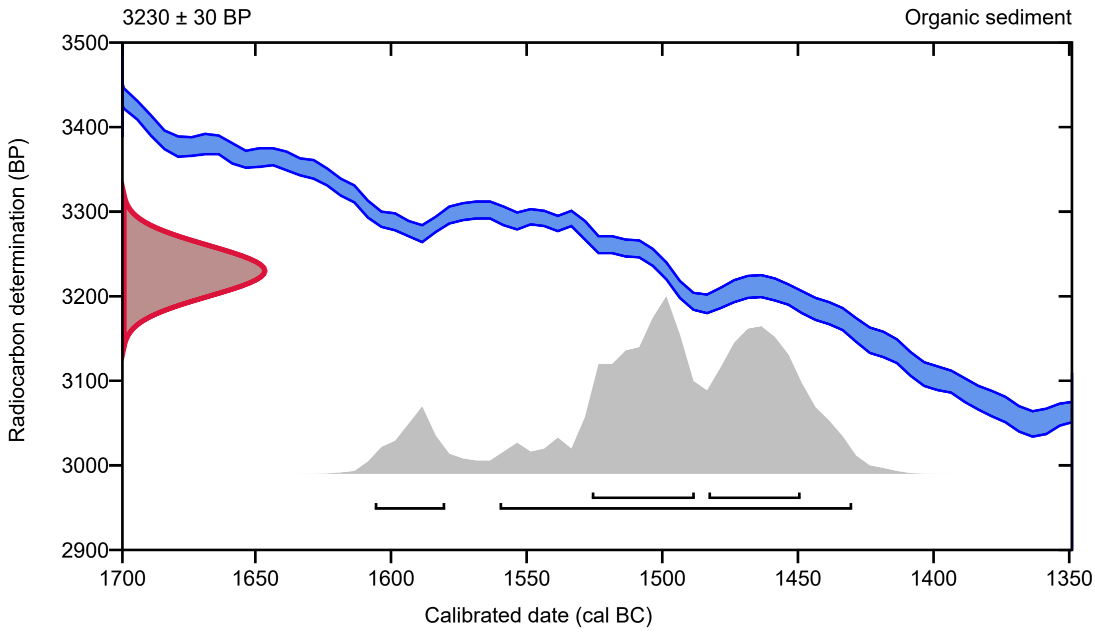
95.4% probability

(87.3%)	1562 - 1432 cal BC	(3511 - 3381 cal BP)
(8.1%)	1608 - 1582 cal BC	(3557 - 3531 cal BP)

68.2% probability

(36.8%)	1528 - 1490 cal BC	(3477 - 3439 cal BP)
(31.4%)	1485 - 1451 cal BC	(3434 - 3400 cal BP)

SSSI 030



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Beta Analytic
TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: August 12, 2019
Submitter: Mr. John Stiteler

QA MEASUREMENTS

Reference 1

Expected Value: 96.69 +/- 0.50 pMC

Measured Value: 97.16 +/- 0.28 pMC

Agreement: Accepted

Reference 2

Expected Value: 129.41 +/- 0.06 pMC

Measured Value: 129.42 +/- 0.35 pMC

Agreement: Accepted

Reference 3

Expected Value: 0.42 +/- 0.04

Measured Value: 0.42 +/- 0.03 pMC

Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Chris Patrick
Digital signature on file

Date: August 12, 2019

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Beta Analytic
TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

January 08, 2020

Mr. John Stiteler
Hunter Research, Inc
201 Connecticut Hill Road
Newfield, NY 14867
United States

RE: Radiocarbon Dating Results

Dear Mr. Stiteler,

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

R.E. Hatfield

Digital signature on file

Ronald E. Hatfield President

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info@betalabservices.com

BETA Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler	Report Date: January 08, 2020
Hunter Research, Inc	Material Received: December 17, 2019

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 548002	**SSSI-005**	**4660 +/- 30 BP**	IRMS δ13C: -22.8 o/oo

(95.4%) **3519 - 3365 cal BC** **(5468 - 5314 cal BP)**

Submitter Material: Marine Organic Sediment
Pretreatment: (organic sediment) acid washes
Analyzed Material: Organic sediment
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 55.98 +/- 0.21 pMC
Fraction Modern Carbon: 0.5598 +/- 0.0021
D14C: -440.16 +/- 2.09 o/oo
Δ14C: -444.88 +/- 2.09 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 4620 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.8 o/oo)

Laboratory number **Beta-548002**

Conventional radiocarbon age **4660 ± 30 BP**

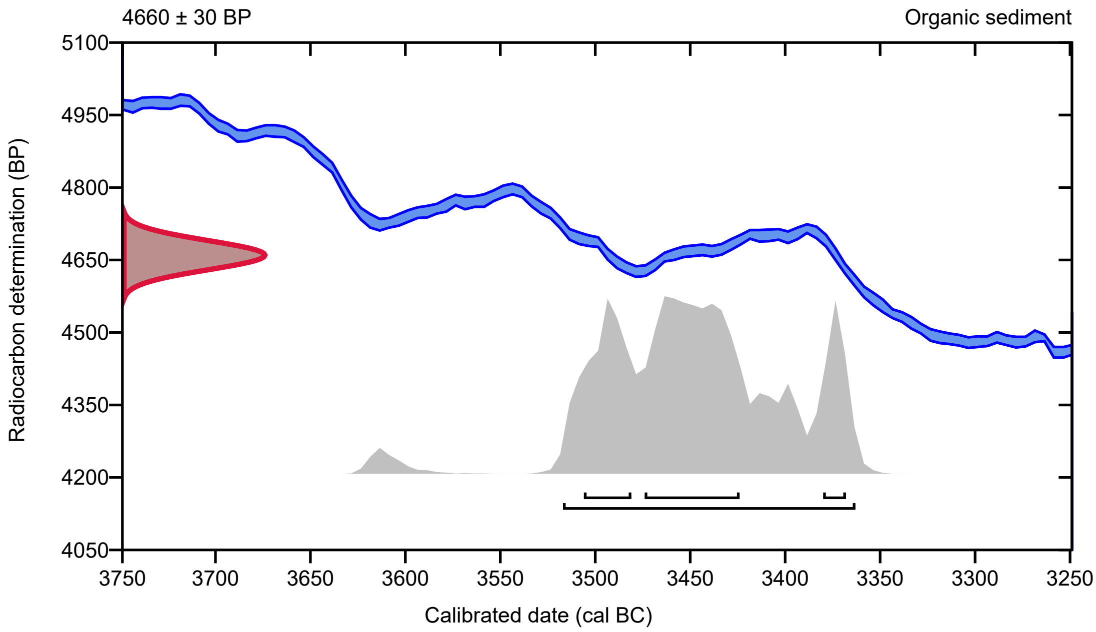
95.4% probability

(95.4%)	3519 - 3365 cal BC	(5468 - 5314 cal BP)

68.2% probability

(41.4%)	3476 - 3426 cal BC	(5425 - 5375 cal BP)
(18.3%)	3508 - 3483 cal BC	(5457 - 5432 cal BP)
(8.5%)	3382 - 3370 cal BC	(5331 - 5319 cal BP)

SSSI-005



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: January 08, 2020
Submitter: Mr. John Stiteler

QA MEASUREMENTS

Reference 1

Expected Value: 129.41 +/- 0.06 pMC

Measured Value: 129.43 +/- 0.37 pMC

Agreement: Accepted

Reference 2

Expected Value: 0.40 +/- 0.04 pMC

Measured Value: 0.40 +/- 0.04 pMC

Agreement: Accepted

Reference 3

Expected Value: 96.69 +/- 0.50 pMC

Measured Value: 96.75 +/- 0.30 pMC

Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Digital signature on file

Date: January 08, 2020

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February 03, 2020

Mr. John Stiteler
Hunter Research, Inc
201 Connecticut Hill Road
Newfield, NY 14867
United States

RE: Radiocarbon Dating Results

Dear Mr. Stiteler,

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

Thank you for prepaying the analysis. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Vice President Laboratory Operations

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler	Report Date: February 03, 2020
Hunter Research, Inc	Material Received: January 24, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 551303	**SSSI-001**	**100 +/- 30 BP**	IRMS δ13C: -23.7 o/oo

(68.3%)	**1805 - 1935 cal AD**	**(145 - 15 cal BP)**
(27.1%)	**1682 - 1736 cal AD**	**(268 - 214 cal BP)**

Submitter Material: Marine Organic Sediment
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 98.76 +/- 0.37 pMC
Fraction Modern Carbon: 0.9876 +/- 0.0037
D14C: -12.37 +/- 3.69 o/oo
Δ14C: -20.70 +/- 3.69 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 80 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -23.7 o/oo)

Laboratory number **Beta-551303**

Conventional radiocarbon age **100 ± 30 BP**

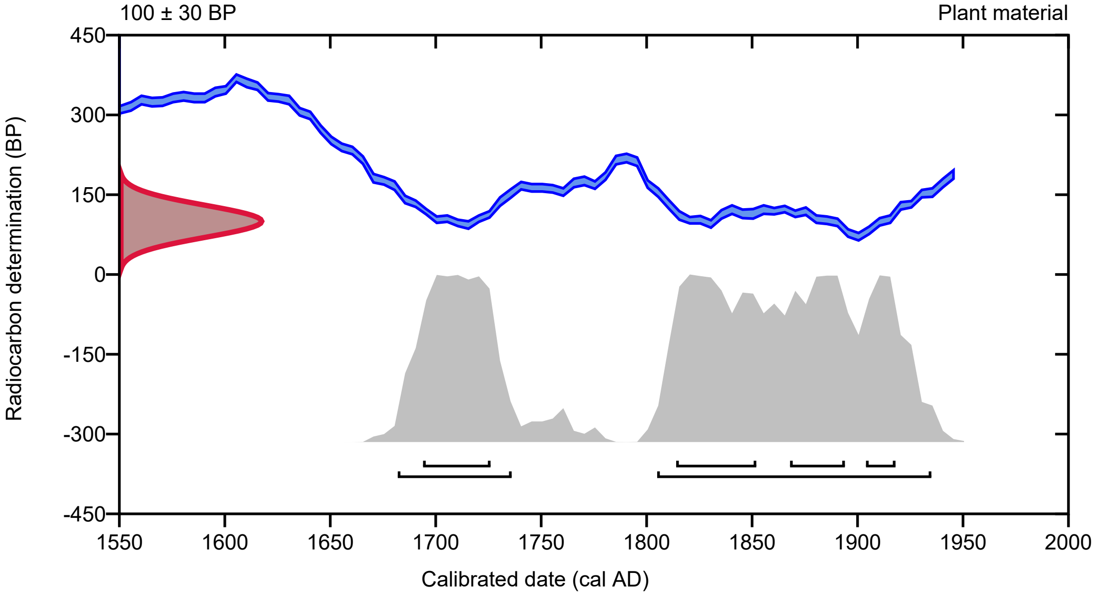
95.4% probability

(68.3%)	1805 - 1935 cal AD	(145 - 15 cal BP)
(27.1%)	1682 - 1736 cal AD	(268 - 214 cal BP)

68.2% probability

(22.2%)	1814 - 1852 cal AD	(136 - 98 cal BP)
(20.8%)	1694 - 1726 cal AD	(256 - 224 cal BP)
(16.8%)	1868 - 1894 cal AD	(82 - 56 cal BP)
(8.4%)	1904 - 1918 cal AD	(46 - 32 cal BP)

SSSI-001



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 03, 2020
Submitter: Mr. John Stiteler

QA MEASUREMENTS

Reference 1

Expected Value: 0.447 +/- 0.04 pMC
Measured Value: 0.45 +/- 0.03 pMC
Agreement: Accepted

Reference 2

Expected Value: 129.41 +/- 0.06 pMC
Measured Value: 129.22 +/- 0.35 pMC
Agreement: Accepted

Reference 3

Expected Value: 96.69 +/- 0.50 pMC
Measured Value: 97.35 +/- 0.28 pMC
Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Chris Patrick
Digital signature on file

Date: February 03, 2020

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Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

February 10, 2020

Mr. John Stiteler
Hunter Research, Inc
201 Connecticut Hill Road
Newfield, NY 14867
United States

RE: Radiocarbon Dating Results

Dear Mr. Stiteler,

Enclosed is the radiocarbon dating result for one sample recently sent to us. As usual, specifics of the analysis are listed on the report with the result and calibration data is provided where applicable. The Conventional Radiocarbon Age has been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

The reported result is accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all pretreatments and chemistry were performed here in our laboratories and counted in our own accelerators here in Miami. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 program participated in the analysis.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result. The reported d13C was measured separately in an IRMS (isotope ratio mass spectrometer). It is NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the result, please consider any communications you may have had with us regarding the sample. As always, your inquiries are most welcome. If you have any questions or would like further details of the analysis, please do not hesitate to contact us.

The cost of analysis was previously invoiced. As always, if you have any questions or would like to discuss the results, don't hesitate to contact us.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

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REPORT OF RADIOCARBON DATING ANALYSES

John Stiteler

Hunter Research, Inc

Report Date: February 10, 2020

Material Received: February 05, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 552234	**SSSI-001 charred material**	**270 +/- 30 BP**	IRMS δ13C: -24.4 o/oo

(46.7%)	**1616 - 1669 cal AD**	**(334 - 281 cal BP)**
(42.4%)	**1515 - 1597 cal AD**	**(435 - 353 cal BP)**
(6.3%)	**1781 - 1798 cal AD**	**(169 - 152 cal BP)**

Submitter Material: Charred material
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 96.69 +/- 0.36 pMC
Fraction Modern Carbon: 0.9669 +/- 0.0036
D14C: -33.05 +/- 3.61 o/oo
Δ14C: -41.21 +/- 3.61 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 260 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), “present” = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.4 o/oo)

Laboratory number **Beta-552234**

Conventional radiocarbon age **270 ± 30 BP**

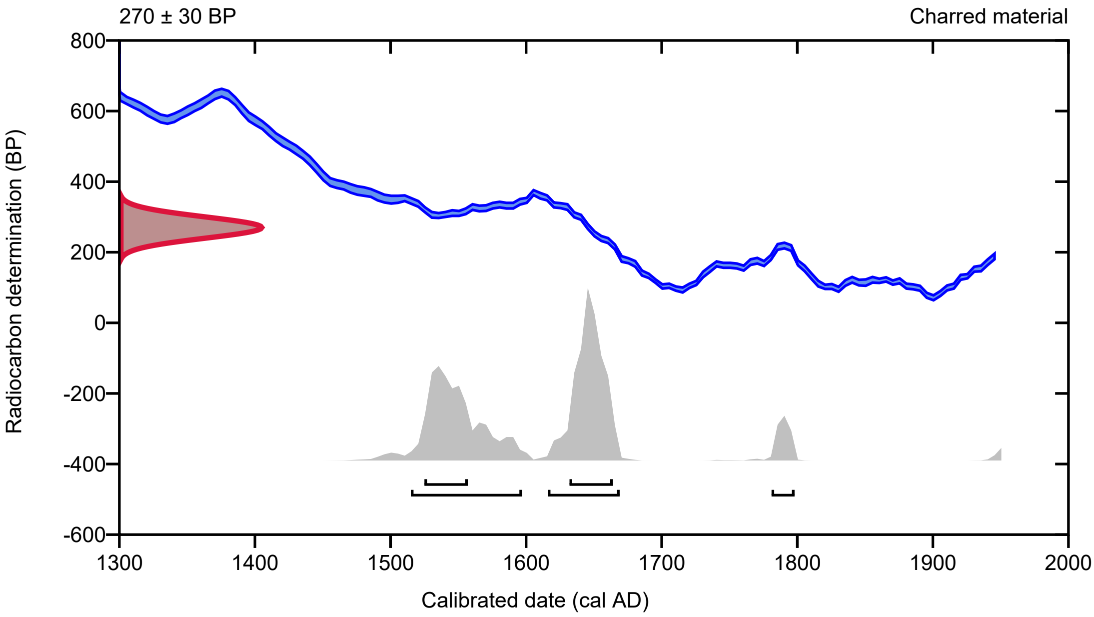
95.4% probability

(46.7%)	1616 - 1669 cal AD	(334 - 281 cal BP)
(42.4%)	1515 - 1597 cal AD	(435 - 353 cal BP)
(6.3%)	1781 - 1798 cal AD	(169 - 152 cal BP)

68.2% probability

(40.7%)	1632 - 1664 cal AD	(318 - 286 cal BP)
(27.5%)	1525 - 1557 cal AD	(425 - 393 cal BP)

SSSI-001 charred material



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NIST SRM-4990B and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 10, 2020
Submitter: Mr. John Stiteler

QA MEASUREMENTS

Reference 1

Expected Value: 0.447 +/- 0.04 pMC

Measured Value: 0.46 +/- 0.03 pMC

Agreement: Accepted

Reference 2

Expected Value: 129.41 +/- 0.06 pMC

Measured Value: 129.40 +/- 0.39 pMC

Agreement: Accepted

Reference 3

Expected Value: 96.69 +/- 0.50 pMC

Measured Value: 97.54 +/- 0.30 pMC

Agreement: Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Chris Patrick
Digital signature on file

Date: February 10, 2020

Appendix D

POLLEN ANALYSIS

John Jones

APPENDIX D

ANALYSIS OF POLLEN FROM A SERIES OF CORES FROM STATEN ISLAND, NEW YORK

John G. Jones, Ph.D.

Pollen and phytolith samples were collected from a series of sediment cores from the Staten Island area. These cores, frequently lengthy, contained both Holocene and Cretaceous age sediments, and it was anticipated that an environmental and depositional history could be obtained from a detailed study of these materials. A total of 32 samples were examined, and Pleistocene/Holocene materials were counted. Proveniences for these samples are provided in Table 1.

Pollen Analysis

Theoretical Background

The foundation of palynological analysis lies in the observation that proportions of various pollen types contained within a sediment sample vary proportionally with the increasing or decreasing abundance of the source plants in the surrounding area, and with the relative proximity of those plants to the sampling locus. However, the relationship between plant and pollen is not straightforward. While there is not a direct one-to-one relationship between pollen in a sediment sample and past vegetation, through an understanding of pollen production, dispersion, and preservation, patterns can be established. Anemophilous (wind-pollinated) plants produce the most pollen, typically between 10,000 and 70,000 pollen grains per anther (Bryant and Holloway 1983), while zoophilous plants generally produce far fewer pollen grains, and rely on some animal (bats, birds) or insect (e.g., bees, moths, butterflies, flies) to transport the pollen from the anther of one flower to the stigma of another. An evolutionary outcome of this more efficient pollination method is decreased pollen production of approximately 1,000 or fewer grains per anther (Bryant and Holloway 1983). Furthermore, pollinators rapidly deplete the pollen content of a zoophilous flower (Harder and Thomson 1989; Young and Stanton 1990), leaving little potential for such pollen to become incorporated into the pollen record. On the other hand, some ostensibly zoophilous plants, such as willow and knotweed, are facultatively anemophilous, producing more pollen than is typical and therefore standing a far greater chance of being observed in the pollen record of a sediment sample.

Pollen of anemophilous and facultatively anemophilous taxa also can be transported and deposited hundreds of meters, and, particularly in the case of the anemophilous taxa, sometimes even hundreds of kilometers from their source (Faegri and Iversen 1989). Therefore, anemophilous pollen is both much more abundant and much more widely dispersed than zoophilous pollen. The result is that anemophilous plants are much better represented in the pollen record of archaeological sediment samples. If those plants are also common members of the vegetation community, their pollen will tend to dominate the palynological findings. Several pollen taxa tend to be overrepresented throughout their North American range, namely low-spine Asteraceae, Cheno-Am, and Poaceae, with the consequence that insect-pollinated plants are underrepresented in these same samples.

In cultural settings, pollen samples are also affected by human activity. Often this activity directly affects the local source vegetation, enhancing and expanding suitable habitats for some plants, while degrading and reducing suitable habitats for others. Impacts on the vegetation associated with clearing the land for cultivation or construction, the introduction and use of irrigation or other forms of disturbance, and the cultivation or encouragement of selected native taxa are prime examples. Furthermore, amounts of local pollen can be augmented and nonlocal pollen introduced through collection of comestibles, fuel wood, or

Table 1. Pollen Sample Proveniences from the Staten Island Cores.

Core	Lab Sample	Depth BS	Age
DH 7	4	*15.5-16.0*	Cretaceous
DH 7	1	62.5-64.0	Cretaceous
DH 7	31	128.0-128.5	Cretaceous little pollen
DH 8	2	*73.0-73.75*	Cretaceous
DH 8	3	78.5-79.0	Cretaceous
DH 8	5	88.25-89.0	Cretaceous
DH 8	11	*93.5-94.0*	Cretaceous little pollen
DH 8	12	108.0-108.5	Cretaceous little pollen
DH 10	6	48.0-48.7	Cretaceous
DH 10	7	*55.0-55.5*	Cretaceous
DH 10	8	67.5-68.25	Cretaceous
DH 20	9	15.75-16.5	Holocene
DH 20	10	*18.0-19.0*	Holocene
DH 25A	32	15.0-15.5	Holocene
DH 30	13	10.5-11.5	Holocene Oxidized
DH 30	14	*18.5-19.0*	Holocene
DH 30	15	20.0-20.5	Holocene
DH 30	16	25.0-25.5	Holocene
GP 5	17	*2.5-2.8*	Holocene
GP 5	18	5.0-6.0	Holocene
GP 10	19	18.0-19.0	Holocene
GP 10	20	*19.0-20.0*	Holocene
GP 10	21	20.5-21.0	Holocene
GP 10	22	22.0-22.5	Holocene
GP 10	23	*24.0-25.0*	Holocene Oxidized
GP 10	24	27.0-28.0	Holocene Oxidized
GP 11	25	12.0-13.0	Holocene
GP 11	26	*16.0-17.0*	Holocene
GP 11	27	19.0-20.0	Holocene
GP 11	28	20.0-21.0	Holocene
GP 11	29	*22.0-22.5*	Holocene Oxidized
GP 12	30	24.0-25.0	Holocene

construction materials; and, during historic and recent times, by the planting of nonlocal taxa for aesthetic reasons. Thus, components of the pollen record can be interpreted culturally. Consequently, some fossil pollen grains are, in a sense, artifacts, and can be used to examine certain aspects of behavior, such as subsistence.

Preservation also affects the pollen record. If preservation is so poor that pollen is absent, then interpretation is straightforward though negative. Of greater concern is whether differential preservation—the prospect that one pollen taxon may be better or less well-preserved than other pollen taxa deposited as members of the same suite of grains—might lead to erroneous interpretation (Delcourt and Delcourt 1980). Pollen preservation is often of particular concern in archaeological palynology, as preservation in terrestrial deposits is seldom as good as in lacustrine deposits (Dimbleby 1985; Faegri and Iversen 1989). Further, and all else being equal, the older a terrestrial sample is the more degraded its pollen (Dimbleby 1985).

Preservation factors can be grouped as 1) mechanical, 2) biological, and 3) chemical. Bryant and Holloway (Bryant and Holloway 1983) methodically review each, so only a few comments are presented here:

1) Mechanical degradation can begin during the transportation and sedimentation stages, and can continue following deposition on a surface; soil disturbance by farmers may further enhance it. Other physical factors as well as temperature and moisture can act to alter a pollen grain (Bryant and Holloway 1983). Pollen walls are reported to be especially susceptible to alternating episodes of wetting and drying (Holloway 1989), such as might be expected to occur at most open-air archaeological sites.

2) The vast majority of pollen is consumed by macroscopic and microscopic herbivores; after deposition, bacteria and various fungi can cause extensive pollen destruction. These biological degraders dissolve and penetrate the spore wall and, as several attacks occur simultaneously, several areas of the exine may become weakened, allowing further decomposition of the grain by physical or chemical means (Goldstein 1960). Ultimately, the entire grain is destroyed. To compound matters, some fungi are selective in their pollen preferences (Bryant and Holloway 1983), which may lead to differential preservation problems.

3) Corrosion of the pollen wall also arises from chemical processes (Birks and Birks 1980). Chemical oxidation of pollen grains is an important factor in many types of sediment, with pollen being best preserved in a reducing acidic environment (but see also Martin 1963). Greater amounts of sporopollenin in the pollen wall also enhance the grain's ability to withstand oxidation (Havinga 1964, 1965).

Methodology

The Palynology Laboratories at Texas A&M University processed the pollen samples, using a favored protocol (Jones 2013). First, 10 gram subsamples were collected from each sample and 19,332 grains of European *Lycopodium clavatum* (Danish club moss) spores were added to the samples to serve as tracers for calculating pollen concentrations. Carbonates were removed by soaking the sample in 10 percent hydrochloric acid. The sample was screened and swirled effectively removing larger and heavier materials. Next, the sample was immersed in 50 percent hydrofluoric acid for 12 or more hours to remove unwanted silicates. After the samples were neutralized, they were washed in 2 percent potassium hydroxide to remove humates, followed by an acetolysis treatment (Erdtman 1960) in a solution of nine parts acetic anhydride to one part sulfuric acid to remove unwanted organic materials. After this step, the samples were rinsed repeatedly in water to remove water-soluble humates and were further cleaned by a heavy density separation using sodium polytungstate (Sp. G. 2.00). The lighter organic materials, essentially pollen and charcoal, were collected, dehydrated in absolute ethanol, and curated in vials in glycerine.

Pollen analysis was conducted in the author's laboratory. Pollen extracts were mounted on slides in glycerol and stained with safranin (as warranted) to aid in identification. A Leitz Ortholux compound microscope was used to view the slides at 400× magnification to obtain 200+ grain counts. Pollen grain abundances and taxa (or types) observed were: a) recorded until at least 200 pollen grains had been counted, or b) pollen concentrations were calculated after 75 or more tracer spores were counted yielding values of 1,000 pollen grains per ml of sediment (grains/ml) or less. These standards were chosen: a) because calculation using

Bayesian probability intervals with a resolution of $\pi = 0.0005$ indicates that where a taxon is absent in a count of 200 grains (i.e., $x = 0$, $n = 200$) there is a 95 percent probability that the taxon in question comprises 1.5 percent or less of the population, b) to maximize efficient use of time, and c) because such values indicate that it is less likely the sample contains a pollen concentration sufficient for analysis (Hall 1981). Aggregates or anther fragments, when identified during counting, were noted as they are not efficiently transported by wind, thus indicating a source in the immediate sampling area (Fish 1995:661) or their introduction into the site sediments by humans (Gish 1991). Pollen grain identification was facilitated through the use of the ACS pollen reference collection as well as standard pollen references (e.g., Kapp et al. 2000). Pollen was identified to the finest taxonomic level possible. Those grains that were too degraded to be taxonomically identified were assigned to the indeterminate category but were still tabulated within the 200+ grain count, as such values are of aid in assessing preservation levels and potential biases in the sample.

Pollen percentages were calculated from the 200+ grain count; concentrations (grains/ml) were calculated using the following formula:

$$\text{Concentration} = \frac{\text{Tracer spores added}}{\text{Tracers counted}} \times \frac{\text{Pollen grains counted}}{\text{Sample volume}}$$

Pollen Percentages in the samples are presented in Table 2. Full counts were obtained in all samples, and percentages were calculated for these samples.

Pollen suites from the Staten Island core samples fell into three broad categories: Sediments and pollen of Holocene age exhibiting excellent preservation. Here organics and sediments accumulated in near perfect condition affording pollen counts of local and regional vegetation offering a fair reflection of past environmental conditions. These sediments were generally composed of peat or organic rich materials. Pollen identified in the Staten Island core samples is presented in Table 3.

Some samples of clearly Holocene/Pleistocene age failed to produce counts. These sediments were largely sandy in nature and represent materials that had periodically been exposed to oxidizing conditions resulting in the loss of most or all fossil pollen (and organics) in the samples.

Finally, sediments collected from the deepest sections from these cores were largely or entirely composed of Cretaceous age detritus and pollen, likely collected from the Raritan Formation, sediments underlying much of the region. Identification of Cretaceous age spores was beyond the scope of this study. In all cases, Pleistocene or Holocene grains or spores were absent from those samples carrying an abundance of Cretaceous age spores/grains indicating that the core collected geological age materials rather than Ice Age sediments.

Characterization of Pollen Samples

Fifty-three different pollen taxa were noted in the Staten Island core samples, presented in Table 3. Included in this listing are at least four aquatics, 17 herbs, and 32 arboreal types. Most of the core samples produced 200 pollen grain counts and have pollen concentrations greater than 1,000 grains/ml. Deeper core samples, penetrating into the underlying Cretaceous age sediments contained no Pleistocene/Holocene grains and were not counted. Sandy samples deposited quickly, or were otherwise oxidized due to exposure to wetting and drying episodes proved to be uncountable. Samples containing well-preserved pollen of Pleistocene or Holocene age had concentration values ranging from 1,039 to 128,880 grains per gram of sediment. Preservation was generally excellent though some grains in some samples exhibited a degree of

Table 2. Pollen Percentages from the Staten Island Cores.

Taxon/Sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Alismaceae										1					1										1							
Apiaceae																		2														1
Ambrosia				1						2				7		1	9	19		2	2	6			10	7	2	13		4		6
Solidago									2	2				2	4	1	14	13		8	1	2			4	5		18		6		5
Asteraceae HS									3	2					1			2					1		1					3		
Caryophyllaceae																1																
Cheno/Am										6						8		2		9	2	1			8	4	3					2
Cirsium																				1												
Cyperaceae									49	28			2	8	23	20	15	19	8	1	5	7			1	5		16		4		11
Fabaceae															1		3		1						1			1				
Liliaceae															1											1						
Onagraceae																	1															
Plantago																		1														
Poaceae				1					38	20			1	18	10	14	24	45	12	13	47	45			13	5	12	19		15		11
Polygonaceae																	1	2										1				
Polygonum														3			1		1													
Primulaceae																																
Rosaceae															1		1	3	3							1	1	2		1		
Rubus																																1
Typha/Sparg															3	4										1		1				1
Typha latifolia									3	7				3	6	5	1	1														
Abies																			2													
Acer																		1										1				
Acer Saccharum				1																		1			3	1	2					5
Alnus										2				1			1				1				2							
Anacardiaceae																												1				
Betula									1					1	2	6			3			1			4			2		14		2
Carpinus									1	1				1											1	1				1		
Carya				1					8	26				39	24	24	15	7	3	9	19	17			10		21	14		11		12
Castanea									2					2	1	3	9	4	8	3	2				3	3	8	4		2		8
Cephalanthus															1	1																
Cornus																	1											1				
Fagus									1	3				5	8	5					6	4			1					3		2
Fraxinus														1							3									2		1
Ilex														1	5	1		1										2				
Juglans																2														1		1
Juniperus									1					2	1	3	5	4	3	1	1	2			1	1	1	5		4		3
Liquidambar																1												2				1
Liriodendron																																
Moraceae																				1												
Myrica									2					1		3																
Nyssa aquatica																					1											
Ostrya									1							2					1					1						
Picea																			1							1						
Pinus				2					17	4	2			14	23	15	18	14	42	56	11	35			62	75	51	15		16		37
Platanus																						1					3	2		1		
Prunus																		1														
Quercus				7					66	84			2	84	70	65	70	42	99	89	91	67	1	3	64	64	82	66		97		63
Rhamnaceae															1		1															
Salix										3				2	9	5		3	2	1	1				4					3		3
Tilia																									1					3		
Tsuga																3		6	2			1			2	13	5			4		4
Ulmus									1	1												1										1
Indeterminate				3				1	4	9			1	5	5	7	10	8	10	6	6	9			4	11	9	14		5		19
Total Pollen Sum	**0**	**0**	**0**	**16**	**0**	**0**	**0**	**1**	**200**	**200**	**2**	**0**	**6**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**2**	**3**	**200**	**200**	**200**	**200**	**0**	**200**	**0**	**200**
*Sphagnum **									2	5				1	2	3	1	2		3						1		3		1		
*Osmunda**																1	12			4	1	3			1	2		1		2		
*Lycopodium**	80	129	44	75					3	14	113	120	76	6	6	50	14	284	31	47	13	119	106	87	30	23	12	552	81	55	100	372
Conc. Value	**0**	**0**	**0**	**412**	**0**	**0**	**0**	**0**	**128,880**	**27,617**	**34**	**0**	**153**	**64,440**	**64,440**	**7,733**	**27,617**	**1,361**	**12,472**	**8,226**	**29,742**	**3,249**	**36**	**67**	**12,888**	**16,810**	**32,220**	**700**	**0**	**7,030**	**0**	**1,039**
	all K	all K	all K	15% K	all K	all K	all K	all K	v few K	10% K	v few K	no K	65% K		50% K	1% K	25% K	v few K	v few K	1% K	v few K	1% K	no K		v few K	v few K		v few K	v few K		v few K	v few K

K = Cretaceous * All reproduce by spores; therefore not technically pollen

Table 3. Pollen Types Identified in the Staten Island Core Samples.

Pollen Taxa	Common Name
Alismaceae	Water-plantain family
Apiaceae	Parsley or umbel family
Ambrosia	Ragweed type
Solidago	Goldenrod type
Asteraceae high spine	Sunflower group
Caryophyllaceae	Pink family
Cheno/Am	Goosefoot, pigweed
Cirsium	Thistle
Cyperaceae	Sedge family
Fabaceae	Bean or legume family
Liliaceae	Lily family
Onagraceae	Evening primrose family
Plantago	Plantain
Poaceae	Grass family
Polygonaceae	Knotweed family
Polygonum	Knotweed
Primulaceae	Primrose family
Rosaceae	Rose family
Rubus	Blackberry, raspberry
Typha/Sparganium	Cattail, burreed
Typha latifolia	Broadleaf cattail
Abies	Fir
Acer	Maple
Acer saccharum	Sugar maple type
Alnus	Alder
Anacardiaceae	Cashew family
Betula	Birch
Carpinus	Hornbeam
Carya	Hickory
Castanea	Chestnut
Cephalanthus	Button Bush
Cornus	Dogwood
Fagus	Beech
Fraxinus	Ash
Ilex	Holly, winterberry
Juglans	Walnut
Juniperus	Cedar, juniper
Liquidambar	Sweet gum
Liriodendron	Tulip poplar
Moraceae	Mulberry family
Myrica	Wax myrtle
Nyssa sylvatica	Black tupelo
Ostrya	Hop-hornbeam
Picea	Spruce
Pinus	Pine
Platanus	Sycamore
Prunus	Cherry, plum
Quercus	Oak
Rhamnaceae	Buckthorn
Salix	Willow
Tilia	Basswood
Tsuga	Hemlock
Ulmus	Elm
Indeterminate	Too poorly preserved to identify
Sphagnum	Sphagnum
Osmunda	Cinnamon, royal fern

degradation. Rather than necessarily reflecting an oxidizing environment, these degraded grains may have washed into the sediments from some distance away, or may represent re-worked sediments.

Assemblage Composition

On a gross scale, all of the samples are dominated by arboreal types that are both common in the area, and are prolific pollen producers, including *Carya*, *Castanea*, *Pinus*, *Quercus,* and *Tsuga*. Cyperaceae and Poaceae grains are also well represented in the samples reflecting the dominant taxa in the wetlands/salt marsh area. Cheno-Ams and low spine Asteraceae, important disturbance taxa, are also well represented in the samples indicating that disturbed areas, whether natural or human-created, were present near the sampling locations. Most of these common pollen types are either durable grains, or are easily recognized when worn or degraded, or sometimes both. Most of these common types possess morphologies that allow for their ready identification, even when poorly preserved or highly distorted. The consistent presence of fragile types throughout the sequence, however, argues that minimal erosion or distortion has taken place and that these samples, after accounting for differential pollen production and dispersion, are fairly reflective of past conditions in the sampling area.

Some limitations on the suites of pollen samples exist, and a few factors must be considered before drawing conclusions on past environmental conditions on Staten Island. Pollen was likely introduced into the sediments in a number of ways; many grains were likely to have been carried into the area by the wind, while others were likely to have been washed into the sediments, possibly from some distance away. Identifying grains of an extra-local origin can be difficult, if not impossible. Bioturbation, although thought to be minimal in these cores, could also come into play if not recognized; making the interpretation of vegetation changes through time with mixed sediments a difficult task.

Taxa

Prior to any discussion or interpretation of pollen taxa, it is important to understand factors affecting pollen preservation, production and dispersion of specific taxa. Pollen for this project has been divided into several groups, representative of different environments: Aquatics, Herbs, Arboreal, and Other categories.

Aquatics

Several important taxa make up the aquatic taxa category, including sedges, cattails, Bur-reed, and pickerelweed. Pollen from these taxa are often produced in abundance and should be identified as they are often local to the coring location and are sometimes over-abundant in the sediment cores.

Cyperaceae

Sedge and rush (*Juncus*) pollen grains are generally considered to be fairly fragile, thus these grains are usually found in sediments that exhibit exceptional pollen preservation. Rushes and sedges are most commonly encountered in perennially moist environments such as wet meadows, ponds, and stream banks. Some sedges are tolerant of brackish environments, and they are a common component of salt marshes in the Staten Island area. Sedge pollen is wind-pollinated and is produced in large numbers and can be widely dispersed; most sedge pollen grains cannot be identified below the family level.

Typha

Pollen from cattail can usually be identified to the species level in North American samples, based on the grains occurrence as a single grain (*Typha angustifolia* [narrowleaf cattail]) or as a tetrad (*Typha latifolia* [broadleaf cattail]). These grains are readily recognizable, and are transported by the wind over long distances, but the grains are moderately fragile; thus they tend to be found only in sediments containing well-preserved pollen. Bur-reed (*Sparganium*) pollen is nearly identical in appearance to narrowleaf cattail grains, though the types can only be separated with well-preserved grains. As bur-reed is found in a similar environment to cattails, they have been grouped together for this study.

Alismaceae

Alismaceae (water-plantain family) is another aquatic type possessing diagnostic pollen. One common member of this family is *Sagittaria* or arrow-leaf. These plants favor perennially moist or submerged landscapes, particularly in freshwater ponds.

Herbs

The category "herbs" generally refers to those taxa that are not arboreal or do not form woody stems. Included in this group are weedy or disturbance-indicating taxa and non-economic background types.

Asteraceae

Pollen from members of the Asteraceae (aster family or Composite) family can usually be separated into subfamilies based on the grain's diagnostic morphology. Members of this family that are readily recognized include *Cirsium*-type (thistle) and both high and low spine Asteraceae types. Asteraceae grains from other parts of the world can be subdivided into additional categories, as well.

Insect-pollinated members of this group, though usually poorly represented in archaeological assemblages, were present in some pollen samples. Members of the *Cirsium* group likely represent background weeds. The high spine Asteraceae group encompasses many genera including *Aster* (aster) and *Helianthus (*sunflower*)*. Sunflower was an important indigenous cultigen in this area, though identification of this genus from its pollen is not possible.

Grains from low spine Asteraceae are wind-pollinated and are produced in very large numbers and are dispersed over large areas. Two of the most important members of this group are *Ambrosia* (ragweed) and *Solidago* (goldenrod). These grains also tend to be over-represented in poorly preserved assemblages as their morphology makes them readily recognizable even when the grains are highly degraded. Further, these taxa are important indicators of disturbance in the eastern woodland area (Ogden III 1966; Wright Jr. 1971). Clearing for settlement and agriculture creates an environment favored by members of this group, and *Iva* (sumpweed or marsh elder) is an important cultigen/cultivar in much of the eastern woodlands (Smith 1989; Smith and Yarnell 2009); these factors account for elevated percentage occurrences of low spine Asteraceae grains near archaeological sites during Archaic and Woodland periods.

Cheno-Am

Cheno-Am pollen, representing plants in the Chenopodiaceae family and in the genus *Amaranthus* in the Amaranthaceae family, are among the most commonly encountered grains in North America. This category is comprised of a broad group of plants including those used as food such as amaranth (*Amaranthus* sp.) and goosefoot (*Chenopodium* sp.), as well as a variety of weedy herbaceous plants encouraged by soil disturbance found near sites and agricultural fields (Cummings 1990; Fish 1994). Cheno-Am pollen is often abundant in archaeological assemblages for several reasons. First, the grains are produced in enormous quantities and are widely dispersed over great distances by the wind. Second, the grains are extremely durable, surviving in poorly preserved assemblages long after most grains have deteriorated. Finally, Cheno-Am grains are easily recognized even when degraded. In the eastern woodlands, *Chenopodium* was an important cultivar widely domesticated from Late Archaic times (Asch and Asch 1977). Cheno-Am pollen can also derive from tidal wetland or salt marsh environments. Both Samphire (*Salicornia*) and seablight (*Suaeda*) are often abundant in these settings, and both plants have documented economic value for food (Moerman 1998). Old World domesticated members of the Cheno-Am group include beets (*Beta vulgaris*) and spinach (*Spinacia oleracea*).

Poaceae

All grasses are wind pollinated, producing copious amounts of distinctive pollen; thus these grains generally make up a significant proportion of most pollen assemblages. However, the morphology of grass pollen does not allow for identification below the family level, with the exception of cultivated Old World grains

(Cerealea, including wheat [*Triticum*], barley [*Hordeum*], rye [*Secale*], oats [*Avena*]), and *Zea mays* (corn or maize), where the domestication process with these taxa has led to a significant enlargement of the pollen grains. Other native grass genera, some of which may have been economically important in the area, unfortunately cannot be identified based on their pollen. To some extent, the grasses found here may represent aquatic species as the salt marshes are composed in part of *Spartina* (cord grass), an important aquatic and salt-tolerant grass.

Rhus

Pollen from poison ivy or sumac in the Anacardiaceae family was represented by one grain in one sample. Although generally insect pollinated, *Rhus* grains are very distinctive and are commonly encountered in archaeological sediments. As sumac was an important source of food or beverage by native populations (Yanofsky 1936), the presence of significant quantities of *Rhus* pollen may indicate the ancient use of this potentially important plant.

Rosaceae

Pollen from the insect-pollinated rose family is sometimes fairly common in archaeological assemblages, probably largely due to the sheer abundance of the various members of this family. Most Rosaceae pollen grains are fairly fragile and diagnostic morphological features are easily lost; thus many eroded grains from this family can only be identified to the family level. Some grains in the Rosaceae family can be identified to "type" characteristic of some important economic species if preservation conditions allow. Diagnostic genera include *Malus/Pyrus* (apple or pear), *Rubus* (blackberry), *Rosa* (rose), and *Fragaria* (strawberry). Positive identification to the species level however is usually not possible.

Potential Economic Herbs

Several pollen types encountered in the Staten Island assemblages represent potentially important or economically significant species. Among these potential economics are Polygonaceae (knotweed or smartweed family) and *Polygonum* (knotweed). The Polygonaceae family is widely distributed throughout North America, and a number of species of *Polygonum* (knotweed), *Eriogonum* (wild buckwheat), and *Rumex* have documented economic value among eastern woodland groups (Moerman 1998). Some members of genus *Polygonum* are aquatic and might represent simply local background vegetation.

Other Herbs

A number of the Staten Island pollen types were identifiable only to the family level, including Apiaceae, Caryophyllaceae, Fabaceae, Liliaceae, Onagraceae, and Primulaceae, or to the genus level but is otherwise economically insignificant like *Plantago* (plantain). While economics and ornamentals have representatives in all of these families, each also has native weedy representatives; thus a claim for a definitive economic usage cannot usually be made based on the presence of these grains. Because most of these families are insect-pollinated, they produce relatively low amounts of pollen and their pollen is scarce in the archaeological record.

Arboreal

Most of the pollen identified in the Staten Island core samples comes from arboreal or woody taxa representative of mostly local environments. Eastern woodland trees are largely wind-pollinated; thus they tend to produce large amounts of readily dispersed pollen grains. Their grains can travel great distances; thus some of the Staten Island pollen grains may have originated some distance from the coring location. Some taxa, like maple, are insect-pollinated and their grains are much less common in pollen assemblages from this region. These taxa are probably a reliable indicator of local vegetation.

Abies

Pollen grains from *Abies* (fir) are large and heavy, and tend to stay near where they were produced; once the pollen enters the water, however, their buoyancy allows for these distinctive grains to be carried often significant distances from their source.

Acer

Pollen from maple relies principally on insects for its dispersal, though since fairly large quantities of pollen are produced, many grains are facultatively carried by the wind. Maple grains are fairly fragile and are generally uncommon in pollen assemblages. When found in pristine conditions they can be identified to sub-genus or even species level. Two maple types were encountered in the Staten Island samples: *Acer saccharum* type, and a general *Acer* group.

The *Acer saccharum* type is probably largely represented by *A. saccharum* (sugar maple), but could also include *A. pensylvanicum* (striped maple), a tree more common in the interior woodlands rather than along the eastern shores. The general *Acer* type represents grains whose surfaces have been eroded or distorted and thus cannot be placed into more precise categories. Maples are found in a variety of environments including swamplands, floodplains, and drier uplands.

Alnus

Alder pollen is widely dispersed by the wind and is a common component of pollen samples throughout the Northern Hemisphere. Alders favor bogs, wetlands, and stream sides, as well as poorly drained soils.

Betula

Pollen from birch is widely dispersed by the wind and is a common component of many samples in the northern hemisphere, as these trees are found throughout North America, Europe, and Asia. The grains are fairly durable, though identifications below the genus level are rarely possible.

Carpinus/Corylus

Pollen from hornbeam and hazelnut are similar in appearance and they are abundant components of eastern woodland assemblages. These wind-pollinated grains are fairly durable, though even a small amount of erosion on the grain's surface can make them unidentifiable below the group level. These taxa represent mid-level understory arboreal elements. *Corylus* (hazelnut) produces edible fruits, widely used in the past by Native Americans; these nuts also served as food for game animals including turkey, deer, and bears.

Carya

Pollen from hickory is dispersed by wind action, though the grains are large and moderately heavy. Because of these factors, the grains are not usually dispersed over great distances, but rather tend to largely stay in the area of hickory forests. Despite the thickness of the grains, hickory pollen is actually moderately fragile and is only common in very well-preserved samples. Hickory nuts have been widely exploited as a food both by Native Americans and by game animals.

Castanea

Chestnut pollen is among the smallest of grains, averaging around 15 microns in length. These grains are produced in large numbers and are widely dispersed by both insects and the wind. Chestnut pollen was among the most common of grains until the early to mid-twentieth century when the chestnut blight led to the loss of these important trees from eastern forests. These grains, despite their thinness, are actually moderately durable and often make up a substantial percentage of many pre-twentieth century pollen samples. American chestnut (*Castanea dentata*) has long been an important food item throughout its range, valued by both people and animals.

Cephalanthus

Button bush is a small tree or shrub common in the eastern United States. The tree favors lowlands near streams, rivers, lakes, swamps and wet floodplains (Elias 1980). Grains from this tree are strictly insect pollinated, and are usually an uncommon pollen type in most samples.

Cornus

Dogwood trees of all species are insect-pollinated; hence their grains are produced in low numbers. These moderately durable grains are easily recognized to the genus level in well-preserved samples, and are occasional components of many North American pollen samples. In the eastern United States, dogwood species include *Cornus florida* (flowering dogwood), red-osier dogwood (*C. stolonifera*), alternate-leaf dogwood (*C .alternifolia*), and the small herbaceous *C. canadensis* (bunchberry), all found throughout the northeastern states and Canada.

Fagus

Beech pollen is similar to oak in most respects, but these grains are significantly more fragile. Produced in moderately large numbers, beech pollen is actually an uncommon component of eastern United States archaeological assemblages because it is easily eroded and can be difficult to identify if encountered in less than perfect condition in pollen samples. Nuts produced by beech trees are edible and have served as foods for Native Americans and for game animals, and beech makes up an important part of the eastern mast forest.

Fraxinus

Ash pollen is also fairly fragile, though its distinctive surface makes it identifiable if even a portion of a grain is encountered. Ash pollen is produced in moderate amounts and ash is one of the few members of the olive family that is wind pollinated. Because ash pollen is so easily destroyed by bacterial and fungal activity, these grains are infrequently encountered in archaeological samples.

Ilex

Pollen from holly or winterberry is very diagnostic and durable, though it is strictly insect pollinated and its grains are poorly dispersed; thus its occurrence in sediment samples is usually low. In the project area, *Ilex* can be either a fairly large tree (American holly [*I. opaca*]) or a shrub (common winterberry [*I. verticillata*]).

Juglans

Under ideal circumstances, pollen from butternut or white walnut (*Juglans cinerea*) can be distinguished from black walnut (*J. nigra*) based on features of the grain's pores. Both species produce large amounts of easily recognizable and durable grains, and walnut pollen is a moderately common component of eastern woodland samples. Both butternut and black walnut produce economically valuable nuts widely used in the past as food. All *Juglans* pollen in the Staten Island samples compared favorably to *J. nigra* (black walnut).

Liquidambar

The New York City area is the northernmost range of sweet gum (Elias 1980), a tree more commonly encountered in the southeastern United States. The occurrence of a few grains of this easily recognized wind-pollinated plant would be expected in samples from the area.

Liriodendron

Tulip poplar is a common element of eastern woodland forests, and its diagnostic pollen is often found in well-preserved sediments from throughout the tree's range. This tree is found throughout the eastern woodlands.

Moraceae

Pollen from mulberry is usually produced in large numbers, but the grains are fragile and notoriously difficult to identify. While red mulberry (*Morus rubra*) trees were native to the Staten Island area, these grains could also represent Osage orange (*Maclura pomifera*), formerly indigenous to the area, as well as pollen from nettles (*Urtica* spp.).

Myrica

Sweet gale or wax myrtle pollen is often locally abundant as the grains are produced in huge numbers and are widely dispersed by the wind. The grains are very similar to *Carpinus/Corylus*-type, but these plants tend to favor a different environment of swamp and wetland margins. Internal micro-morphological features of the pollen grains allow for their identification even when the grains are modified through degradation.

Nyssa

Several species are found in the *Nyssa* genus, a swamp and river bottom-loving group composed principally of black gum (*Nyssa sylvatica*), and tupelo (*N. aquatica*). These uncommon grains are pollinated by insects and are produced in low numbers. As the trees often grow next to, as well as in, swampy environments, their flowers are shed directly into wetlands allowing their pollen grains to readily enter into the sediment record.

Ostrya

Pollen from hop-hornbeam is similar to grains from *Carpinus/Corylus*, though with well-preserved samples, genus-level identification is usually possible. *Ostrya* favors a shady woodland environment where it makes up an important part of the forest understory.

Picea

Spruce pollen grains, like pine, are bisaccate and are fairly durable, abundant, and when intact are generally easy to identify. The buoyant grains, aided by their air-filled bladders are known to travel great distances.

Pinus

Pine pollen are among the most commonly encountered grains in North American sediment samples, as pine pollen is abundant, widely dispersed, readily recognizable even when highly degraded, and it is often very durable. Even small fragments of pine pollen are recognizable because of their characteristic bladder reticulations; thus a counting protocol for pine and hemlock addresses the identification of fragments of grains. Pine pollen, like spruce and fir grains, possess buoyant bladders that aid in the grain's dispersal; thus they tend to travel great distances. Pine pollen can often be separated into subgenera based on micro-morphological features; however, these features can usually be seen only on perfectly preserved grains. Many pines produce edible nuts that have been widely harvested in the past.

Platanus

Sycamore grains are generally thought to be fragile and they easily succumb to bacterial and fungal degradation. These grains are produced in copious quantities and can travel great distances on the wind. Sycamore trees are an important component of eastern forests favoring river bottoms and rich soils (Elias 1980).

Prunus

The distinctive pollen from *Prunus* is uncommon in archaeological sediment samples as the grains are produced in low numbers and are dispersed by insects, rarely travelling far from the tree. Native *Prunus* trees in the Staten Island area include *Prunus virginiana* (chokecherry), *P. serotina* (black cherry), *P. americana* (American plum), and *P. pensylvanica* (pin cherry). Most of these plants produce edible fruit. Old World members of the *Prunus* genus are more economically important today and include peach, apricot, plum, cherry, and almond.

Quercus

Oak pollen is produced in large quantities, is durable, and distinctive; thus it is commonly encountered in sediments from the area. Oaks are widespread in the Northern Hemisphere, occurring in a variety of habitats. As these grains can travel great distances, the presence of a few grains might be expected in environmental samples, even if located some distance from oak habitat. Oaks have long been a primary food source for both humans and animals throughout much of their native range, and acorns, along with chestnut, hickory, and several other trees provide an important part of the eastern woodland "mast forest." Oak trees, along with hickory, beech, and chestnuts have been the dominant trees in the Staten Island area since post glacial times (Gaudreau and Webb III 1985).

Rhamnaceae

Pollen from the Rhamnaceae family is fairly distinctive, though usually difficult to identify below the family level. Pollen in this family is insect pollinated and is produced in low numbers. While some members of this family take the form of large shrubs or small trees, most members of this family are herbaceous.

Salix

Willow pollen is produced in large numbers and the grains are largely disseminated by the wind, although insects also play a significant part in transporting *Salix* pollen grains. These grains are small and fairly fragile and are easily lost from many archaeological assemblages, although they are sometimes common in well preserved samples. Willows generally prefer streamside or marshy settings.

Tilia

Basswood or yellow poplar trees are insect pollinated; thus each flower produces relatively low numbers of highly distinctive grains. However, the sheer number of flowers on these trees ensures that there is still an ample quantity of pollen in the vicinity of *Tilia* trees. Low numbers of *Tilia* grains are often found in sediment samples.

TCT

The category TCT consists of pollen grains in the Taxodiaceae (bald cypress family), Cupressaceae (cypress family), and the genus *Thuja* (arborvitae). Grains from this group are difficult to identify even when perfectly preserved; thus palynologists group these cryptic grains into one large category. In the Staten Island core samples, most grains are likely to be from either juniper (*Juniperus*) or Atlantic white cedar (*Chamaecyparis*). Atlantic white cedar favors wet woods and freshwater swamps, as well as peat bogs (Elias 1980), environments much like the Staten Island area. All of these plants produce copious amounts of readily dispersed pollen, and TCT pollen is among the most common pollen throughout most of North America.

Tsuga

Eastern hemlocks are gymnosperms whose pollen is surrounded by a buoyant bladder aiding in grain dispersal. Consequently, these grains, produced in large numbers, are known to travel great distances. Hemlock pollen is distinctive, with a unique surface allowing identification from even small fragments of the pollen grains. Hemlock is an important environmental indicator and is also important as a temporal marker because of the widely studied Middle Holocene "hemlock decline" occurring in the eastern United States between 5,400 and 4,000 BP. The causes of this decline are likely due to insect predation and possibly other pathogenic activity.

Ulmus

Elm is a characteristic tree of the eastern woodlands. Its pollen is distinctive, if not particularly durable. Produced in large numbers, elm pollen is widely disseminated and can be fairly common in eastern archaeological assemblages.

Other

The "other" category consists of pollen grains that are included in the counts, but cannot be placed into a given category.

Indeterminate

In nearly all pollen samples, a number of grains were noted that were distorted, folded, eroded, crumpled, or in some other way unidentifiable. These poorly preserved grains were placed into the category indeterminate. Statistical calculations were made in consideration of this group.

Ferns and Mosses

Spores from most ferns, mosses, and club mosses have limited diagnostic features and can rarely be identified. Many spores are produced in copious quantities; thus spores are an often abundant component of many pollen assemblages. Cinnamon and royal fern in the genus *Osmunda*, however, can be identified and they generally represent a woodland setting. *Sphagnum*, a semi-aquatic or bog-loving moss, were also noted, though other plants may have produced some of these grains. While positive identifications are not usually possible, trends in the appearance and disappearance of ferns often signals clearing, deforestation, and reforestation events. Fern spores were not calculated in the percentages of the Staten Island core samples.

Results

Pollen from 10 cores or borings were examined for this study, representing from one to six samples per core. Each core will be discussed individually by depth, starting from the basal unit.

Core DH 7

Three sediment samples from Core DH 7 were examined, representing Sample 4 from 15.5 to 16.0 feet below surface (BS) dated to 1744-1605 cal BP, Sample 1 collected at 62.5-64 feel BS dated in excess of 43,500 cal BP, and Sample 31, undated, from 128.0-128.5 feet BS. While a few poorly preserved Holocene age grains were noted in Sample 4, a count could not be achieved, as only traces of *Ambrosia*, grass, *Acer*, *Carya*, *Pinus*, *Quercus*, and indeterminate grains were noted, resulting in a concentration value of 412 grains per gram of sediment, a value well below the minimal acceptable threshold of around 2000 grains per gram. Oxidizing conditions here, led to the loss of nearly all grains from the sample. Sample 1 contained only Cretaceous age palynomorphs. These sediments may represent full glacial times, representing Cretaceous age materials eroded from exposed deposits. Glacial age spores were absent from the sample, though and the deposits may represent a time before plant life at the edge of the Laurentian glacier had become established. As no pollen grains were present in the sample, it is impossible to calculate a concentration value for the sample.

Sample 31 contained a very few Cretaceous age grains and spores, but these were heavily oxidized. Thus none of the samples from this core can be used to establish an environmental record. Because of the great depth of this sample, it is likely that the core extended in to primary Cretaceous "bedrock" paleo clay deposit that had previously been heavily oxidized.

Core DH 8

Five samples from Core DH 8 were examined. Samples were collected from 108.0 to 108.5 feet BS (Sample 12) undated, 93.5 to 94.0 feet BS (Sample 11) undated, 88.25 to 89.0 feet BS (Sample 5), dated in excess of 43,500 cal BP, 78.5 to 79.0 feet BS (Sample 3) dated in excess of 43,500 cal BP, and 73.0 to 73.75 feet BS (Sample 2) undated. Pleistocene/Holocene age pollen was absent from all samples, suggesting the sediments may have been deposited when sea levels were lower and down-cutting of Cretaceous age beds was occurring. During full glacial times, it was unlikely that plants were present in the glacial environment. In this setting, palynomorphs from the organic rich clays underlying the region were likely to have been liberated from their matrix, and re-deposited downstream. The natural durability of these grains and spores allowed for their concentration in sediments resulting in a highly concentrated mass of Cretaceous age materials. These pollen and spore-rich sediments make up samples 2, 3, and 5 representing sediments collected between 73.0 and 89.0 feet BS (Samples 3-5). Sediments collected deeper in this core, from 93.5 to 108.5 feet BS (Samples 11 and 12) contain almost no pollen and represents the intrusion of the core into primary Cretaceous age deposits.

Core DH 10

Three sediment samples from Core DH 10 were examined. Sample 6 from 48.0 to 48.7 feet BS representing estuarine mud was dated in excess of 43,500 cal BP, Sample 7 from 55.0 to 55.5 feet BS yielded a date of 44,381-42,881 cal BP, and Sample 8 from 67.5 to 68.25 feet BS provided a date of 47,022 to 44,836 cal BP. Pleistocene age pollen was absent from all three of these samples, though near perfectly preserved Cretaceous palynomorphs were abundant in all samples. These samples may represent re-worked Cretaceous sediments, or a primary deposit of Cretaceous clay or mudstone; Pleistocene grains were missing from all samples from this core.

Core DH 20

Two samples were examined from Core DH 20, with Sample 10 collected at 18.0 to 19.0 feet BS, and Sample 9 collected from 15.75 to 16.5 feet BS. Both samples from this core represent estuarine mud, and Sample 10 has been dated to 3060-2875 cal BP, while Sample 9 yielded a date of 728-664 cal BP. Pollen preservation in both samples was excellent, and Sample 10 had a concentration value of 27,617 grains per gram of sample, while the value for Sample 9 was 128,880 grains per gram. These high values may possibly suggest a slower sedimentation rate for these samples.

Some pollen in Sample 10 likely represents local vegetation, including common sedges and grasses, *Typha*, Alismaceae, and *Alnus*. Disturbance or clearing type taxa were reduced in this sample, and include uncommon *Ambrosia*, *Solidago*, and high spine Asteraceae, as well as Cheno-Ams. Arboreal taxa representative of surrounding forests were dominated by *Carya*, and *Quercus*. Other taxa were represented by lower numbers of grains, and include *Carpinus*, *Fagus*, *Salix*, and *Ulmus*, and *Sphagnum* was represented by the presence of five spores. Interestingly *Pinus* in Sample 10 was noted by only a two percent occurrence; it is not known why the percentage occurrence of pine in this sample is so low. If the samples represent a quickly deposited assemblage, then seasonality might be reflected in the low pine counts; sediments deposited in autumn or winter might contain low numbers of pine grains. Re-worked Cretaceous age palynomorphs made up approximately 10 percent of the grains in this sample.

Pollen grains in Sample 9 present an environmental picture similar to that from Sample 10. Dominant non-arboreal types include sedges and grasses, while other taxa were generally scarce, including *Solidago* and high spine Asteraceae, and *Typha*. Dominant arboreal types include *Carya*, *Pinus*, and *Quercus*. Additional arboreal types noted in the assemblage include *Betula*, *Carpinus*, *Castanea*, *Fagus*, *Juniperus* type, *Myrica*, *Ostrya*, and *Ulmus*, along with two spores from *Sphagnum*. All of these taxa are common components of the eastern deciduous forest of the area. Very few re-worked Cretaceous palynomorphs were noted in the sample.

Core DH 25A

One sample from Core 25A from 15.0 to 15.5 feet below surface was represented by sample number 32. This sediment sample is undated, and analysis of the sediments suggests the sediments were perhaps deposited in a lagoon. Pollen preservation in Sample 32 was generally excellent and a full count of Holocene age pollen grains was obtained from the sample. The sediment sample had a low concentration value of 1,039 grains per gram of sediment, likely reflecting a faster sedimentation rate rather than poor preservation as the Core 25A grains were generally preserved in excellent condition. A few Cretaceous age palynomorphs were noted during scanning, but the sample was composed of perhaps 95 percent Holocene age grains. Major grains in the assemblage were sedges, grasses, hickory, pine, likely reflecting both the immediate island margin environment of sedges and grasses, as well as the composition of forests in the nearby upland regions. Weedy vegetation, likely to have been associated with the local community was minimal, possibly reflecting a degree of clearing in the vicinity. This clearing may reflect local human settlement in the area, or possibly areas near the coastline periodically exposed from tidal or riverine action. Weedy vegetation was scarce, and included low percentages of *Ambrosia*, *Solidago*, Cheno-Ams, Apiaceae, *Rubus*, and *Typha/Sparganium*, none of which taxa were represented by more than a three percent occurrence.

Arboreal types noted in the sample reflect mostly local forest elements located either near the coring location, or growing upstream some distance away. These trees include *Acer saccharum* type, *Betula*, *Castanea*, *Fagus*, *Fraxinus*, *Juglans*, *Juniperus* type, *Liquidambar*, *Salix*, *Tsuga*, and *Ulmus*. Except *Castanea* (4 percent), none of these taxa represent more than a 2 percent occurrence. All of these taxa were likely to have been common post-glacial components of the mixed deciduous forests typical of the region (Delcourt and Delcourt 1985; Delcourt and Delcourt 1980).

Core DH 30

Four sediment samples from Core DH 30 were collected for analysis. Sample 13 was collected from 10.5 to 11.5 feet BS, and was dated to 12,686-12,550 cal BP; Sample 14, collected at 18.5 to 19.0 feet BS yielded a date of 2,539-2,354 cal BP; Sample 15 from 20.0 to 20.5 feet BS had a date of 3,259-3,106 cal BP; and Sample 16 from 25.0 to 25.5 feet BS provided a date of 3,694-3,560 cal BP. The strikingly old date provided by Sample 13 is anomalous, and likely represents a contamination error. Sample 13 is thought to represent lagunal sediments, while Samples 14 through 16 are thought to represent buried stream alluvium. Very few poorly preserved pollen grains were noted in Sample 13, where sedge, grass, *Quercus*, and indeterminate grains were noted; the sample had an exceedingly low concentration value of 153 grains per gram of sample, well below the acceptable minimal threshold of around 2000 grains per gram. These sediments, at one time, may have been raised above water level allowing for oxidation of organic materials. Cretaceous age organic remains, representing maybe 65 percent of the pollen in the sample, were also poorly preserved. Sample 13 may represent rapidly deposited eroded materials accounting for the oxidized sediments and inverted radiocarbon date.

Samples 14, 15, and 16 were all collected within a seven foot interval; these samples had near perfectly preserved pollen and dates obtained on the organics in the core were sequential. All samples are thought to represent buried stream alluvium. All sample assemblages were dominated by sedges and grasses in the non-arboreal component, with *Carya*, *Fagus*, *Pinus*, *Quercus*, and *Salix* making up the bulk of the arboreal types. Most of these taxa probably represent local plants; the consistently high presence of *Carya*, and relatively high numbers of *Fagus* argue that these plants were indeed local to the core environment.

Non-arboreal elements in Sample 16 contain few grains that suggest any local disturbance. The core contained single grains of *Ambrosia* and *Solidago*, along with eight Cheno-Am grains and a single Caryophyllaceae grain. Sample 16 also contained four *Typha/Sparganium*, and five *Typha latifolia* grains. These plants would probably not be expected in a high energy environment, suggesting that the environment of deposition might have been a lagoon or pond. These samples represent the highest percentages of *Typha* spp. in the Staten Island samples, however, *Typha* counts remain fairly low suggesting that cattails were not common plants in the area. Arboreal taxa noted in Sample 16 include *Betula*, *Castanea*, *Cephalanthus*, *Ilex*, *Juglans*, *Juniperus* type, *Liquidambar*, *Myrica*, *Ostrya*, and *Tsuga*. *Sphagnum* was represented by one spore, while 12 *Osmunda* spores were noted, likely signaling a nearby shaded forest. Sample 16 had a moderate concentration value of 7,733 grains per gram, and Cretaceous palynomorphs were rare in the sample.

Sample 15, collected at 20.0-20.5 feet BS and dating to 3,259-3,106 cal BP represents a very similar environment, just a few hundred years later. Non-arboreal types noted include Alismaceae, high spine Asteraceae, Fabaceae, Liliaceae, Rosaceae, and both *Typha/Sparganium* and *Typha latifolia*. Arboreal taxa noted in Sample 15 include *Betula*, *Castanea*, *Cephalanthus*, *Ilex*, *Juniperus* type, and Rhamnaceae. Two *Sphagnum* spores were also noted in the sample. Sample 15 had a high concentration value of 64,440 grains per gram of sediment. Cretaceous age palynomorphs were very common in the sample, and represented perhaps 50 percent of grains present in the sample.

Sample 14, collected about a foot and a half above Sample 15, dated to 2,539-2,354 cal BP. Non-arboreal taxa in this assemblage were generally similar to those noted in Samples 15 and 16, and include *Ambrosia* and *Solidago*, *Polygonum*, *Typha latifolia,* and *Alnus*. Arboreal taxa in the sample includes *Betula*, *Carpinus*, *Castanea*, *Fraxinus*, *Ilex*, *Juniper* type, and *Myrica*. A single *Sphagnum* spore was also noted in the sample, and no Cretaceous palynomorphs were noted in the sample. The concentration value for Sample 14 was the same as Sample 15, with 64,400 grains per gram. Sample 14 sediments were apparently different than 15; Cretaceous spores were absent in Sample 14, and the sample also showed an increase in both *Carya* and *Quercus* grains with a simultaneous decrease in both sedge and grass grains. These differences might be minor, though, and a change in sediment deposition or formation might account for these slight variations between samples. Interestingly, *Cephalanthus*, an ordinarily rare pollen type, was present in both Samples 16 and 15, but was otherwise absent from all other assemblages in this project. *Cephalanthus* or button bush is known to occur in dense thickets surrounding lakes and ponds (Elias 1980). *Typha*, Alismaceae, *Myrica*, and *Salix* all favor a lakeside setting, suggesting that the sediments from Core DH 30 may have been deposited in a pond or lake environment.

Core GP 5

2 sediment samples from Core GP 5 were examined, with Sample 18 collected at 5.0 to 6.0 feet BS, and Sample 17 collected at 2.5 to 2.8 feet BS. Pollen preservation in both samples was excellent, though sample 18, dated at 1063-937 cal BP, had a low concentration value of 1,361 grains per gram of sediment, likely signaling rapid deposition rather than differential pollen preservation. Sample 17, dated at 216-144 cal BP, had a concentration value of 27,617 grains per gram, a high value consistent with a slower deposition rate. The samples date to the late Holocene period based on the shallow nature of these sediments; as historically introduced taxa are not present in the samples, these sections then likely represent late prehistoric age sediments.

The pollen assemblage from Sample 18, representing the deepest sample examined from the core at 5.0 to 6.0 feet, was dominated by *Ambrosia*, *Solidago*, sedge, and grass pollen, much of which probably grew around the basin of deposition. Other uncommon weedy types in the core sample included Apiaceae, high spine Asteraceae, Cheno-Ams, *Plantago*, Polygonaceae, Rosaceae, and *Typha latifolia*. Collectively, these taxa likely composed the marshy plants found along the basin margins, as well as in cleared or seasonally exposed areas. Arboreal elements in Sample 18 were dominated by grains from *Pinus* and *Quercus*, with lesser numbers of *Acer*, *Carya*, *Castanea*, *Ilex*, *Juniperus* type, *Prunus*, *Salix*, and *Tsuga*, along with two spores from *Sphagnum*. The sediments from Sample 18 are thought to represent a buried subsoil beneath beach sand.

Pollen in Sample 17, from 2.5 to 2.8 feet BS was preserved in excellent condition reflected by the sample's high concentration value. The non-arboreal assemblage was dominated by *Ambrosia*, *Solidago*, sedge, and grass, mirroring the types and numbers of grains found in Sample 18. Also noted were Fabaceae, Onagraceae, Polygonaceae, *Polygonum*, Rosaceae, and *Typha latifolia*, all types represented by less than a 1.5 percent occurrence. Major arboreal types include *Carya*, *Castanea*, *Pinus*, and *Quercus*. Additional arboreal types noted in the sample included *Alnus*, *Cornus*, *Juniperus* type, and Rhamnaceae with one *Sphagnum* and 12 *Osmunda* grains representing the ferns. The assemblage overall represents a heavily forested environment with some, probably local clearing. Forest composition appears to be essentially identical to that found in the area during early historical times. Re-worked Cretaceous age palynomorphs make up an estimated 25 percent of the grains in the sample. Sample 17 is thought to represent a buried surface located beneath beach sands.

Core GP 10

A total of six samples were collected from Core GP 10, representing estuarine muds and peat. Sample 24, the deepest sample examined from this sequence at 27.0 to 28.0 feet BS, was dated to 5,659-5,466 cal BP. Sample 23 from 24.0 to 25.0 feet BS was dated at 4,085-3,899 cal BP; Sample 22 from 22.0 to 22,5 feet BS is undated; Sample 21 from 20.5 to 21.0 feet BS was dated to 2,600-2,492 cal BP; Sample 20 collected from 19.0 to 20.0 feet BS was undated; while Sample 19 collected from 18.0 to 19.0 feet BS was dated to 1287-1,172 cal BP. Pollen preservation in Samples 19 through 22 was excellent, with concentration values ranging from 3,249 to 29,742 grains per gram of sediment. Samples 23 and 24, both composed of estuarine mud, were heavily oxidized and only a few highly degraded grains were noted in each sample resulting in concentrations values of less than 100 grains per gram in these samples. These samples had likely been exposed to cyclic wetting and drying, resulting in the loss of most organics from the sediments. No Cretaceous age palynomorphs were present in either sample, having likely suffered the same oxidation as did most Holocene grains and spores. Other samples in the core contained very few Cretaceous grains, as well.

Sample 22, though undated, contained fairly well preserved pollen. Dominant pollen types in the assemblage include grasses representing local vegetation, along with *Carya*, *Pinus*, and *Quercus* representing components of the surrounding forests. Additional non-arboreal types noted in the sample were Cheno-Ams, and sedge. Less common forest elements in the sample included *Acer saccharum*, *Betula*, *Fagus*, *Juniperus* type, *Platanus*, *Tsuga*, and *Ulmus*. Three *Osmunda* spores were also noted in the sample.

Sample 21 contained near perfectly preserved pollen which, in composition and percentage occurrence, mirrors underlying Sample 22. Sediments from Sample 21 are composed of peat rather than estuarine mud which makes up all other samples from this core. Dominant grain in the sample include grasses, *Carya*, *Pinus*, and *Quercus*. Non-arboreal elements in this sample are identical to the suite found in Sample 22, and include *Ambrosia*, *Solidago*, Cheno-Am, and sedge. Woody taxa noted in the sample include *Alnus*, *Castanea*, *Fagus*, *Fraxinus*, *Juniperus* type, *Nyssa aquatica*, *Ostrya*, and *Salix*. Also noted was a single *Osmunda* spore. Again, the elevated grasses likely reflect vegetation once present near the coring location, while arboreal elements represent surrounding regional forests.

Sample 20 contained well preserved pollen, though some evidence of slight oxidation was noted in a few grains. Significant grains in this sample were *Solidago*, Cheno-Ams, and grasses in the non-arboreal component, with *Carya*, *Pinus,* and *Quercus* in the arboreal grains. Grasses in this sample were significantly reduced, from a 23.5 percent in Sample 21 to 6.5 percent occurrence in Sample 20. Additional non-arboreal taxa noted includes *Ambrosia*, *Cirsium*, and sedge. Arboreal taxa noted in the sample included *Castanea*, *Juniperus* type, Moraceae, and *Salix*; *Sphagnum* was represented by three spores and *Osmunda* by four spores. This sample is generally similar to the deeper samples from this core, though there is a notable decrease in grass pollen, with a corresponding slight increase in weeds and Cheno-Ams, possibly suggesting that human-caused disturbance had taken place in the area.

Sample 19, collected at 18.0 to 19.0 feet BS, and dated to 1,287-1,172 cal BP represents the uppermost sample examined from Core GP 10. Pollen preservation in this sample was very good, and the sample had a concentration value of 12,472 grains per gram of sediment. Dominant pollen taxa in Sample 19 included sedge and grass in the non-arboreal group, and *Castanea*, *Pinus*, and *Quercus* among the arboreal taxa. Non-arboreal types were scarce in this sample, and consisted of Fabaceae, *Polygonum*, and Rosaceae. Weedy taxa, including Asteraceae types and Cheno-Ams were absent from the assemblage. Arboreal elements present in low numbers includes *Abies* likely to have washed in from some distance, *Betula*, *Carya*, *Juniperus* type, *Picea*, *Salix*, and *Tsuga*. Overall, the GP 10 core reflects a typical deciduous forest.

Core GP 11

Five sediment samples were collected from Core GP11: Sample 25 was collected from 12.0 to 13.0 feet BS dated to 967-899 cal BP, Sample 26 from 16.0 to 17.0 feet BS dated to 1,714-1,565 cal BP, Sample 27 from 19.0 to 20.0 feet BS dated to 2,505-2,351 cal BP, Sample 28 from 20.0 to 21.0 feet BS undated, and Sample 29 from 22.0 to 22.5 feet BS dated to 3,271-3,140 cal BP. Pollen preservation in the Core GP 11 samples was generally good to excellent, as reflected by the samples' fairly high concentration values; Sample 25 had a value of 12,888 grains per gram of sediment; Sample 26 had a value of 16,810 grains per gram of sediment; Sample 27 had a very high value of 32,220 grains per gram of sediment; Sample 28 had a low value of 700 grains per gram of sediment; and Sample 29 contained no pollen resulting in a concentration value of 0 grains per gram.

Sample 29, the deepest sediments examined from Core GP 11 at 22.0 to 22.5 feet BS, contained no pollen grains. Sediments were likely to have been exposed to cyclic wetting and drying after their deposition, resulting in the loss of organic materials, including pollen. This pattern was noted in Core GP 10, as well. While Holocene age pollen was completely absent from the sample, a very few Cretaceous palynomorphs were noted in the sample. Sample 28, collected from 20.0 to 21.0 feet BS is undated but likely falls between its bracketing sediments. Pollen preservation is only fair, as reflected by the sample's low concentration value of 700 grains per gram. Ordinarily, a sample with a value this low would not have been counted, and the numbers reflected in the sample assemblage should be viewed with caution. Weedy or disturbance type taxa were particularly common in Sample 28, and include *Ambrosia*, *Solidago*, sedge, and grasses. Additional non-arboreal types noted in the sample include Fabaceae, Polygonaceae, Rosaceae, and *Typha/Sparganium*. Common arboreal types include *Carya*, *Pinus*, and *Quercus*, with lesser numbers of Anacardiaceae, *Betula*, *Castanea*, *Cornus*, *Ilex*, *Juniperus* type, *Liquidambar*, and *Platanus*, with one *Osmunda* and three *Sphagnum* spores. The presence of numerous Foramenifera tests in the residue from this sample indicates that the pollen and sediments were likely to have been deposited in a marine setting. The overall environmental picture presented in Sample 28 is a marshy area, perhaps with some clearing in the immediate area, surrounded by typical deciduous hardwood forests.

Sample 27 collected from 19.0 to 20.0 feet BS, contained reduced numbers of herbaceous taxa, with only six percent grass pollen representing the only taxon present in more than a two percent occurrence. Other non-arboreal taxa noted in the sample were *Ambrosia*, Cheno-Ams, and Rosaceae. Arboreal pollen types were fairly common, represented by *Carya*, *Castanea*, *Pinus,* and *Quercus*. Other arboreal grains identified in the assemblage include *Acer saccharum*, *Juniperus* type, *Platanus*, and *Tsuga*. A large quantity of particulate charcoal in this sample hints at burning in the area, perhaps by native populations, though the generally small size of the charcoal fragments indicates that the carbon may be blowing in from some distance from the region. As sedge pollen is lacking in this sample, it is apparent that the environment of deposition changed since the previous deposits accumulated.

Sample 26 from 16.0 to 17.0 feet BS, contained a variety of taxa, though only *Pinus*, *Quercus*, and *Tsuga* were present in notable quantities. Non-arboreal species represented in the assemblage included *Ambrosia*, *Solidago*, Cheno-Ams, sedge, Liliaceae, grass, Rosaceae, and *Typha/Sparganium*, in all cases represented by an occurrence of 3.5 percent or less. Arboreal types noted in Sample 26 included *Acer saccharum*, *Carpinus*, *Castanea*, *Juniper* type, *Ostrya*, and *Picea*. One *Sphagnum* and two *Osmunda* spores were also noted in this sample. Interestingly, *Carya* pollen was absent from this sample. *Carya* pollen is often considered to be a fairly fragile grain, though other fragile grains were present in the sample, including Liliaceae and *Typha/Sparganium*, *Acer*, and *Ostrya* suggesting that poor pollen preservation is not an issue with this sample. Further, the moderately high concentration value of this sample of 16,810 confirms that the assemblage was fairly well preserved. The absence of *Carya* pollen, along with the relative abundance of *Tsuga* grains might indicate that some form of pollen sorting by size or weight has taken place. While small scale differences within the non-arboreal group are present suggesting that local conditions around the environment of deposition have changed, the forest composition surrounding the area has remained fairly constant.

Sample 25, from 12.0 to 13.0 feet BS, represents the uppermost sample in the GP 11 sequence. Pollen preservation in this sample was good, and the non-arboreal types were dominated by *Ambrosia*, Cheno-Ams, and grasses, with lesser numbers of *Solidago,* and high spine Asteraceae, Alismaceae, sedge, and Fabaceae. Arboreal grains in Sample 25 were made up largely of *Carya*, *Pinus*, and *Quercus*, along with lower numbers of *Acer saccharum*, *Alnus*, *Betula*, *Carpinus*, *Castanea*, *Fagus*, *Juniperus* type, *Salix*, *Tilia*, and *Tsuga*. One *Osmunda* spore was also noted in the sample. This sample fits the pattern established by the other Core GP 11 samples with a pond or lagoon-like environment of deposition, surrounding by a typical eastern deciduous forest. The samples overall represent a sequence covering the period from 3,271-3,140 BP to 967-899 BP, and presents a fairly consistent picture of the local and regional environment.

Core GP 12

A single sample (Sample 30) from Core GP 12 was examined, representing sediments collected at 24.0 to 25.0 feet below surface. Pollen preservation in Sample 30 was excellent, and contained a moderate concentration of 7,030 grains per gram of sediment. This sediment sample represents estuarine mud deposits, and has been dated at 3,511-3,381 cal BP. Dominant pollen types in the sample include grasses, *Betula*, *Carya*, *Pinus*, and *Quercus*. Non-arboreal elements were scarce in the sample, and were represented by low numbers of *Ambrosia*, *Solidago*, and high spine Asteraceae, as well as by a few sedges, and a Rosaceae grain. Arboreal pollen types noted in the core G 12 sample included *Carpinus*, *Castanea*, *Fagus*, *Fraxinus*, *Juglans*, *Juniper* type, *Platanus*, *Salix*, *Tilia*, and *Tsuga*. Also noted during the count were two *Osmunda* and one *Sphagnum* spore. Cretaceous-age palynomorphs were absent from the sample. The pollen assemblage from Sample 30 represents a forested region with little apparent disturbance or clearing near the sampling location.

Sediment Types

Sediments collected in cores DH 7, DH 8, and DH 10 contained organic-rich deposits composed entirely of Cretaceous age palynomorphs including abundant pollen and spores. The working assumption was that these deposits represent Pleistocene deposits containing re-worked Cretaceous age pollen and spores liberated from their matrix, deposited during a time of minimal Ice Age pollen production. While the presence of Cretaceous age materials here is not unexpected, the samples lacked any evidence they once contained Ice Age grains. Full glacial times in the Staten Island area may have been devoid of plants, thus Pleistocene age pollen grains may not be expected; some Pleistocene age traces, however, should be present, thus it was recognized that these deposits probably do not represent Pleistocene deposits. These deposits, then, probably represent specific pollen-rich primary Cretaceous age deposits, and the fact that these deposits are only found in these three cores collected in a localized area, might support this idea.

Sediments collected from deep sections of cores DH 7, and DH 8 contain very little organic material; pollen or spores, when encountered in these deposits, were all of Cretaceous age, thus likely represent oxidized Cretaceous age materials, or perhaps mineral-rich Cretaceous age sediments; Cretaceous-age palynomorphs may be preserved, but apparently in only low concentrations.

Most samples examined from these cores including DH 20, DH 25, DH 30, GP 5, GP 10, GP 11, and GP 12 contained mostly well preserved Holocene age grains. These sediments were collected from 2.8 to 25.5 feet below surface, and date from 216-144 cal BP to 3,694-3,560 cal BP. All pollen-bearing sediment samples were composed of typical eastern deciduous forest species, along with conifer pollen including pines, rare firs and spruce, cedar/juniper, and hemlock. Fir and spruce pollen likely represent grains washed in from an upstream source, perhaps some distance from the coring locations. Pollen signatures in the mid-Holocene samples were all similar in composition. Dominant pollen types in the samples were *Carya* and *Quercus*, principle components of the oak hickory forests of the eastern states. The abundant pine pollen noted in most samples is somewhat more problematic. Pine pollen can travel enormous distances aided by its dispersal high in trees, their buoyant bladders on the grain, and the grain's ability to float and survive in water-borne sediments. Whether these grains represent local pines scattered throughout the region, or represent grains washed into the area from upstream cannot be known, though pines are abundant in the nearby New Jersey area. Additional trees making up local forests include *Acer saccharum*, *Castanea*, *Fagus*, *Fraxinus*, *Juglans*, *Juniperus* (probably also including *Chamaecyparis* [Atlantic white cedar], and *Taxodium* [bald cypress]), *Liquidambar*, *Liriodendron*, *Nyssa aquatica*, *Platanus*, *Prunus*, *Salix*, *Tilia*, *Tsuga*, *Ulmus*, and possibly *Morus*. These trees are still common in local forests, and most are prolific pollen producers, thus their grains would be expected in the Staten Island area. Many of these types, however, are considered to be fairly fragile; their presence in the samples attests to the generally excellent pollen preservation in the samples. Understory plants were also well represented in the Staten Island samples, and the list includes *Alnus*, *Betula*, *Carpinus*, *Cephalanthus*, *Cornus*, *Ilex*, *Myrica*, *Ostrya*, and Rhamnaceae.

Dramatic changes in forest composition were absent from all of the Holocene age samples. A simple comparison between Sample 17, the youngest age sample from Core GP 5 at 2.5-2.8 feet BS dated at 216-144 cal BP with Sample 16 from Core from DH 30 from 25.0 to 25.5 feet BS dated to 3,694-3,560 cal BP reveal similar pollen assemblages. Sample 17 shows an increase in *Ambrosia* and *Solidago* Asteraceae, weeds associated with human-caused clearing and development on the island, as well as a general reduction in understory, and less significant arboreal types, again, likely associated with clearing of the understory for historical development. Sample 16 representing a more mature forested setting, shows a general decrease in weeds with a corresponding increase in the diversity of arboreal types; percentages of major pollen types, however remain fairly consistent in both samples.

Sediments collected from basal deposits in Cores GP 10 at 25 and 28 feet BS, and GP 11 at 22.5 feet BS were oxidized resulting in the loss of nearly all pollen grains. These samples were dated between 3,271-3,140 cal BP, and 5,659-5,466 cal BP, representing some of the earliest dated Holocene sediments in the cores. As fluctuation in coastal levels can be extreme in the region, it is not known with certainty at what depth these sediments were deposited. The oxidation apparent in these samples suggests that the sediments were subjected to periodic wetting and drying creating conditions favorable for the fungal and bacterial degradation of grains and spores in the samples. That these are the deepest samples in these cores is consistent with the deposition of sediments laid down prior to the establishment of modern sea level/coastal conditions.

Humans on the Landscape

All of the Holocene age sediment samples were deposited while human populations on Staten Island were present on the landscape. The environments of deposition of the sediments were located in settings probably unfavorable for long-term human occupation and farming, such as brackish lagoons or marshy ponds, little direct evidence of a human presence on Staten Island might be expected. These environments, however, were likely to have been optimal for seasonal brackish or marine resource exploitation by these Native American inhabitants. In areas of minimally disturbed forest, traces of humans would not be expected in the pollen record. The presence of disturbance indicators, then, are generally reduced in the samples, including low spine Asteraceae types (*Ambrosia* and *Solidago* types), Cheno-Ams, and to a lesser degree, grasses. Grass pollen is fairly common in the Staten Island samples, and probably represents coastal marsh grasses rather than weedy types present around site areas or species that were potentially cultivated or encouraged as foods. During Archaic through Formative times, the time when the Holocene age sediments were deposited, humans in the Staten Island area may have cultivated a locally domesticated *Iva* and *Chenopodium*. These plants produce copious quantities of pollen, thus the low occurrence of these specific pollen types indicated that plant cultivation if present in the area, was removed from the coring locations. After domesticates were introduced into the region, including maize (*Zea mays*), beans (*Phaseolus*), and squash (*Cucurbita*), these plants became important resources allowing populations to become permanently settled in one area. These cultigens were wholly absent from the Staten Island core samples suggesting that humans caused minimal impact in these cores. Humans were very likely to have been present on the island landscape, though their resource foraging patterns may have left little evidence of their presence. While charcoal particulates were notably common in some samples, these carbon fragments may have blown into the sediments from some distance away and may not reflect local folk.

Summary

A total of 32 sediment samples collected in cores from Staten Island were examined for fossil pollen content. Seventeen of the sediment samples contained generally well-preserved Holocene age pollen grains, while four samples contained oxidized Holocene samples with few grains. Samples providing pollen counts dated from 216-144 cal BP to 3,694-3,560 cal BP. In addition, eight sediment samples contained palynomorph-rich Cretaceous age materials, and an additional three samples, representing the deepest materials collected from 94 to 128.5 feet below surface, contained pollen-poor Cretaceous age sediments.

Holocene age assemblages indicate the area was generally covered in oak and hickory forests. Chestnut and beech would have also been important trees in the local forests, though pollen from these taxa are less common in the samples. Pines were also very well represented in most of the Holocene age sediments; whether pollen from these trees was common locally, or was blowing in from the surrounding region is not known. Other vegetation in the assemblages represent typical eastern woodland taxa. Aquatic types were also present in many of the samples, reflecting local vegetation near and upstream from the various sediment-accumulating basins, including sedges and cattails. Many grass pollen grains likely represent marsh grass species, as well.

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Appendix E

MACROBOTANICAL ANALYSIS OF FLOTATION SAMPLES

Justine McKnight

APPENDIX E

MACROBOTANICAL ANALYSIS OF FLOTATION SAMPLES SOUTH SHORE OF STATEN ISLAND COASTAL STORM REDUCTION PROJECT RICHMOND COUNTY, NEW YORK

Justine McKnight, Archeobotanical Consultant
January 13, 2019

Recent archaeological and geomorphological investigations along the south shores of Staten Island, Richmond County, New York included the collection and analysis of flotation-recovered macro-plant remains. The project was conducted in advance of the construction of five miles of seawall by the Army Corps of Engineers in an area adversely impacted by Hurricane Sandy. Soil samples were collected from sediments deeply buried beneath up to 25 feet of coastal sands. Samples were secured through soil augering of deposits likely dating to the Middle to Late Holocene, and likely represent brackish-water lagoon habitats that dominated the landscape during these periods.

Eight sediment cores ranging from 50 to 150 milliliters in volume were field-collected into vinyl bags for a brief period of storage. The samples were moist, and moisture levels were maintained in order to maximize the preservation of botanical remains. The samples were not dried prior to flotation processing. Samples were individually processed using a Flote-Tech flotation system equipped with 1.0 mm coarse fraction and 0.284 mm fine fraction screens. The Flote-Tech system is a multi-modal flotation system that facilitates the separation and recovery of plant macro-remains from the soil matrix using water agitation and forced air delivery. Processing resulted in two (light and heavy) fractions of material. Floted portions were air dried. All plant remains recovered through flotation were combined and passed through a 2 mm geological sieve, producing standard size classes of material for analysis.

Organic preservation within the samples was excellent, with non-carbonized botanical remains intact. Recovered floral remains were subjected to a general descriptive analysis, and taxonomic identification of wood, seeds, root/rhizome, and leaf/stem was attempted. Materials 2 mm or greater in size were examined with a binocular microscope under low magnification (10X to 40X) and sample matrices and categories of plant materials (wood, seed, miscellaneous plant material, et cetera.) were described. The less than 2 mm fractions were examined under low magnification for the remains of seeds and fruits. Analysis followed standard practices for the study of flotation-recovered plant macro-remains (Pearsall 2000). Plant artifacts were identified to the genus level when possible, to the family level when limited diagnostic information was available, and to the species level only when the assignment could be made with absolute certainty. All identifications were made with the aid of standard texts (Edlin 1969; Hoadley 1990; Panshin and deZeeuw 1980; Martin and Barkley 1961) and secured against plant specimens from a modern reference collection representative of the flora of New York.

A site total of 1.05 liters of sediment cores were processed, yielding an interesting variety of uncharred plant materials for study. Identified plant remains include herbaceous root material, grass stems, seeds, wood, and a fruit or flower stem (peduncle). An inventory of flotation-recovered plant remains is presented in Table 01. Results are discussed below.

Wood Sample:
A single, 0.05 liter sediment core sample was flotation-processed from DH-30 at a depth of 20.0-20.5 feet. The sample was predominantly composed of unburned wood with adherent sediment. Flotation produced a single, 6.61 gram fragment of unidentifiable deciduous wood and monocot root. The wood was distorted by compression, likely as a result of its deeply buried position in the soil profile. Taxonomic identification was inconclusive, but the specimen was deciduous, with pores compact and solitary or in radial multiples. The specimen compared favorable in some respects to *Diospyros virginiana, Carya*, and *Juglans* species. This core was collected from lagoon-like sediments.

Fibrous Organic Samples:
Seven of the collected soil cores contained visible fibrous organic material. Flotation of a total of one liter of this type of sample were processed from contexts DH20 (15.75’-16.5’), DH20 (18.0’-19.0’), GP10 (18.0’-18.25’), GP10 (19.75’-20.0’), GP11 (12.0’-13.0’), GP11 (16.0’-17.0’), and GP11 (19.0’-20.0’). Sample matrices were composed of unidentifiable organic conglomerate material (probably partially decomposed herbaceous litter), with small marine shell fragments, small quantities of sand and gravel, and the remains of insects. Identified plant materials were all uncharred, and included monocot root material, rhizome fragments (which compare favorably to common reed *[Phragmites australis]*), grass *(Poaceae)* stem fragments, a peduncle, and seeds of wetland plants.

Figure 01: Floted light fraction from DH-20. Grass stem and monocot root and rhizome fragments are visible against a 1mm background grid.

Figure 02: Seeds of wetland sedges were the most common seed type identified (background grid is 1mm).

Organic fibers identified as grass *(Poaceae)* stem and monocot root/rhizome tissue were the most abundant material type documented within these flotation samples. The rhizome compares favorably to *Phragmites australis*, the common reed. *Phragmites* is a perennial grass which reproduces primarily through vegetative growth. *Phragmites* is common throughout the project area today. Ongoing genomic research on the history of this species reveals that the strain of *Phragmites* now abundant along the Atlantic Coast is in fact a non-native variety that is competitively aggressive. Over the past 150 years, the invasive strain has largely displaced the native variety of *Phragmites australis*, particularly along the eastern seaboard. It is impossible to discern the taxonomy of the recovered rhizome tissue from the deep core samples based on gross morphology, but any *Phragmites* recovered from Middle or Late Holocene deposits on the Atlantic Coast would represent the native type.

Sample DH20 at 15.75'-16.5' produced the greatest concentrations of seeds, with three taxa (knotweed family, rose family, and bulrush) identified. A fruit or flower stem (peduncle) was also recovered from this core. Seeds were also present in cores from DH20 (18.0'-19.0'), GP10 (18.0'-18.25'), GP10 (19.75'-20.0'), and GP11 (16.0'-17.0'). Seeds belonging to the sedge family *(CYERACEAE)*, which includes the genus *Scirpus* (bulrush) were the most common seed identified site-wide, accounting for 96 percent of the total seeds recovered.

The sediment cores collected from the South Shore of Staten Island reveal details of this coastal setting from the Middle or Late Holocene. All of the taxa represented within the analyzed samples are indicators for wetland habitats, and would have been endemic to brackish-water lagoon edges lying between barrier islands and the mainland. The wood recovered from sample DH30 suggests that this context was from an area of shoreline that supported trees along stream margins or swamp. Plants identified within the other seven samples would have tolerated varying levels of water salinity and thrived along lagoon margins.

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Table 01: Inventory of flotation results from the South Shore Staten Island project.

context	**DH20**	**DH20**	**DH30**	**GP10**	**GP10**	**GP11**	**GP11**	**GP 11**	**8 samples**
depth (feet)	**15.75-16.5**	**18.0-19.0**	**20.0-20.5**	**18.0-18.25**	**19.75-20.0**	**12.0-13.0**	**16.0-17.0**	**19.0-20.0**	
original soil volume (milliliters)	**100**	**100**	**50**	**150**	**150**	**150**	**150**	**200**	**1050**
MATRIX DESCRIPTION, presence									
organic conglomerate	x	x		x	x	x	x	x	
monocot root material	x	x	x	x	x	x	x	x	
cf. Phragmites australis rhizome fragments	x	x		x	x	x	x	x	
insect body parts	x	x		x	x				
insect egg cases	x								
Poaceae stem fragments	x								
marine shell							x		
WOOD, NON-CARBONIZED	0	0	1	0	0	0	0	0	1
weight (grams)	0	0	6.61	0	0	0	0	0	6.61
Deciduous, unidentifiable. Compressed and distorted, pores compact, radial multiples and solitary, cf. Diospyros, Carya, Juglans sp.			1						
MISCELLANEOUS, NON-CARBONIZED (specimen count)	1	0	0	0	0	0	0	0	1
weight (grams)	<0.005	0	0	0	0	0	0	0	<0.005
peduncle (fruit or flower stem)	1								
SEEDS, NON-CARBONIZED (specimen count)	47	9		2	1		2		61
weight (grams)	0.01	0.005		<0.005	<0.005		<0.005		~0.02
cf. Polygonaceae (knotweed) seed	1								1
Rosaceae (rose) seed fragment	1								1
Scirpus sp. (bulrush) seed	45	9		1	1		2		58
Cyperaceae (sedge) seed				1					1

Appendix F

DIATOM ANALYSIS

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DIATOM PALEOENVIRONMENTAL ANALYSIS OF SEDIMENT SAMPLES FROM A BORING ON THE SOUTHEAST SHORE OF STATEN USLAND, RICHMOND COUNTY, NEW YORK

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INTRODUCTION

Diatoms are unicellular, eukaryotic algae that are distinguished by the presence of a silica cell wall. They live in a wide variety of habitats, including soil, moss, damp rocks, caves, rivers, streams, ponds, lakes, bogs, lagoons, marshes, swamps, mud flats, salt and mud flats, estuaries, bays and oceans. Many species are cosmopolitan, found in different parts of the world under similar environmental conditions, making it possible to predict their environmental requirements and tolerances. Diatoms can be identified to species level and a large and growing body of information exists on the range and ecological tolerances of many of the common forms. They are often good indicators of water chemistry, depth, pH, salinity, habitat, substrate, nutrient concentrations and pollution levels. Because of their silica cell walls they are often preserved in sedimentary deposits, making them well-suited for use in paleoenvironmental reconstruction. The purpose of this investigation is to analyze the diatoms in a set of samples from a boring on the Southeast shore of Staten Island, whose provenance includes coastal floodplain, lagoon, barrier island and beach environments (Table 1).

METHODS

For each sample, 15 ml of sediment was placed in a 500-ml beaker with sodium hypochlorite (bleach). Each sample was agitated, then covered and allowed to stand overnight. The next day, the samples were transferred to 50 ml tubes, which were filled with reverse osmosis de-ionized (RODI) water and centrifuged at 3,000 rpm, after which the supernatant was poured off. This rinse was repeated four times to remove the bleach, after which they were screened through 500 micron mesh. Then all samples received a 2.5 hour treatment in hot bleach. Treatment with hot bleach was repeated, as necessary, to remove excess organics. The samples were then transferred to 15 ml tubes, rinsed using RODI water, and centrifuged for 3 minutes at 3,000 rpm. This rinse step was repeated four more times until the sample reached neutral pH. Due to the presence of large quantities of minute organic debris, the samples were centrifuged at high speeds for short intervals to improve viewing. The remaining fraction, containing diatoms, phytoliths, and silt-sized particles, was transferred to 1.5 ml plastic vials for storage. We saved the screen contents and examined them at PaleoResearch Institute, looking for shell particles. None were observed.

The sample material was dried onto cover slips and mounted on glass slides with Naphrax®. The slides were scanned at x1500 magnification, and the first 500 diatoms encountered in randomly chosen fields were identified and recorded. If there were few diatoms, the entire slide was scanned and all diatoms and diatom fragments were counted.

RESULTS

The results of the diatom paleoenvironmental analysis varied among the five samples. Samples 2 and 3 were very diatomaceous and a full count was done on these samples. Samples 1, 4 and 5 contained few or no diatoms (Table 2). Overall in the 5 samples 27 species were identified.

DISCUSSION

An ecological code system for paleoenvironmental reconstruction in tide-influenced coastal wetlands that includes diatom life form, salinity, pH, nutrients, temperature, tides and current velocity has been developed (Vos and de wolf 1993). The ecological information provided by these authors and others, including Vos and de Wolf, 1988, Van Dam et al., 1994, McQuoid et al., 1998, Witkowski et al, 2000, Cremer et al., 2007, Hein et al., 2008) is summarized on Table 3 and provides the basis for paleoenvironmental reconstruction of the environments represented by the samples in this investigation. Diatom studies from the New York, New Jersey coast include Cooper et al., 2010, Potapova et al., 2016 and Desianti et al., 2017.

The diatoms found in these samples are a mixture of freshwater, brackish and marine species. Because these diatoms do not live in the same habitats, under the same environmental conditions they must be a combination of autochthonous (living at the place of deposition) and allochthonous (transported to the site from elsewhere by water, wind or birds) species. In coastal tide-influenced settings, influx by tidal currents and storm-driven winds can be significant, depending on the energy level of the site.

Sample one contained many small diatom fragments but only three complete or nearly complete valves (Table 2). These are marine/brackish taxa, but they may very well have been transported to the site. The poor preservation is a result of chemical dissolution and mechanical destruction. Fragmentation may result from transport, but leaching, predation, diagenesis and compaction are also factors (Voss and de Wolf, 1988). Reworking of older deposits also cannot be excluded.

Samples two and three contained almost all whole diatom valves. The overwhelming dominant in both of these samples is *Diploneis interrupta* (Kützing) Cleve, at 68% of the population in sample 2 and 72% in sample 3. Two other species were relatively common. *Diploneis smithii* (Brébisson) Cleve accounted for 13% of the population in sample 2 and 9% in sample 3. *Paralia sulcata* (Ehrenberg) Cleve comprised 8.4% of the valves counted in sample 2 and 6% of those counted in sample 3. The remaining taxa were present in much lower numbers (Table 2).

Vos and de Wolf (1988) classified diatoms into ecological groups for use in paleoenvironmental reconstruction of Holocene coastal deposits of the Netherlands. They defined the ecological habitat of the "*Diploneis interrupta* Group" as benthic, epipelic, and aerophilic on supratidal mud that is irregularly flooded, with a large salinity range of 500-18000 mg Cl/L; and the sedimentary environment as a supratidal salt marsh or periodically dry pool within a back levee marsh. In British salt marshes *Diploneis interrupta* is typical of the brackish (mesohalobous) mud marsh environment (Zong and Horton, 1998). In the Netherlands it is reported to be alkalibiontic (occurring exclusively at pH>7) and mainly occurring in water bodies, also rather regularly on wet and moist places (Van Dam, 1994).

Diploneis smithii is a marine/brackish epipelic species that was common in estuarine sediment cores collected in the Pamlico and Neuse River estuaries of North Carolina, increasing in abundance after about 1725, with European land clearance (Cooper et al., 2010). It has also been recorded from plankton, stromatolites, sand, algal mats and debris in tropical shallow marine habitats in the Bahamas (Hein et al., 2008). It is also alkalibiontic.

Paralia sulcata is a brackish/marine coastal, littoral, planktonic and benthic diatom with a broad salinity range, found on rocks, sand and macroalgae. It is abundant in tidal mud flats and salt marshes, very common in cool, temperate and tropical estuarine waters, in both littoral and sublittoral zones, prefers well-mixed, nutrient-rich highly saline water, often a bottom dweller, usually associated with sandy habitats, but also thrives in fine-grained sediments, and has fairly wide tolerance ranges for many ecological values. It is a robust diatom that survives transport better than many species and may have been living at the site or washed in with high tides; therefore it is not useful in identifying a particular paleoenvironment.

Only four diatom fragments were observed in sample 4 and no diatom remains were found in sample 5. It is interesting to note that the sediments from the freshwater plain underlying the coastal lagoon, represented by sample 5, yielded no diatoms, while the lower coastal lagoon sediments, represented by sample 4, yielded only a few diatom fragments.

CONCLUSIONS

Estuarine and shallow coastal environments are highly dynamic because they change configuration relatively frequently due to variations in winds, tides, and river discharges, and are open systems, actively exchanging materials and energy with adjacent systems (Trobajo and Sullivan, 2010). In samples 2 and 3, the two most abundant diatoms, *Diploneis interrupta* and *Diploneis smithii,* are benthic species that were most probably living where they were collected. The environmental characteristics of these two species provide the best interpretation of the paleoenvironmental setting.

Although sedimentation patterns within estuarine systems are extremely variable in both space and time (Cooper et al., 2010), the similarity in diatom composition of samples 2 and 3 means that the paleoenvironments represented by these samples, collected from the upper and middle zones of the coastal lagoon sediment, respectively, must have been quite similar in terms of salinity, moisture (frequency and duration of submergence) and substrate composition. The most likely paleoenvironment was probably a very shallow salt marsh or vegetated mud flat that was emergent part of the time. The alkalibiontic preference of the two most abundant diatoms implies that the pH of the water may have been above 7 when these diatoms were growing. The remaining species are usually found in circumneutral or alkaline water.

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TABLE 1

PROVENIENCE DATA FOR SAMPLES FROM SITE NO. SSSI, UNIT DH23, SOUTH SHORE STATEN ISLAND, RICHMOND COUNTY, NEW YORK

Sample No.	Feature	Level (Stat)	Depth (cmbs)	Provenance/ Description
1	Landward side of barrier island	Back barrier	13.5-14'bs	Late Holocene sand beneath modern beach sand
2	Upper zone of coastal lagoon sediment	Upper lagoon	15.5-16'bs	Organic-rich silt and clay from beneath back barrier sands of upper zone
3	Middle zone of coastal lagoon sediments	Mid-lagoon	18.5-19'bs	Organic-rich silt and clay from beneath back barrier sands of middle zone
4	Lower zone of coastal lagoon sediments	Lower lagoon	21-21.5'bs	Organic-rich silt and clay from beneath back barrier sands of base
5	Freshwater floodplain under coastal lagoon	Floodplain	22.5-23'bs	Freshwater floodplain beneath Late Holocene coastal lagoon

TABLE 2

DIATOM DISTRIBUTION IN SAMPLES FROM THE SOUTH SHORE OF STATEN ISLAND, RICHMOND COUNTY, NEW YORK

Name Sample #	1	2	3	4	5	Total
Actinoptychus senarius (Ehrenberg) Ehrenberg		1				1
Amphicocconeis disculoides (Hustedt) De Stefano & Marino			2			2
Aulacoseira Italica (Ehrenberg) Simonsen			4			4
Auliscus sculptus (Wm. Smith) Ralfs		3	2			5
Caloneis oregonica (Ehrenberg) Patrick		2				2
Cyclotella striata (Kützing) Grunow		2	4			6
Dimerogramma minor (Gregory) Ralfs		2	1			3
Diploneis bombus Ehrenberg		2	8			10
Diploneis interrupta (Kützing) Cleve		343	360			703
Diploneis smithii (Brébisson) Cleve		67	45			112
Grammatophora macilenta W. Smith		4	3			7
Hyalodiscus scoticus (Kützing) Grunow			2			2
Lyrella sulcifera (Hustedt) Witkowski			5			5
Navicula digitoconvergens Lange-Bertalot			2			2
Navicula kefvingensis (Ehrenberg) Ehrenberg			1			1
Navicula salinicola Hustedt	2					2
Odontella aurita (Lyngbye) C. Agardh			2			2
Odontella pulchella Gray			12			12
Paralia sulcata (Ehrenberg) Cleve		42	28			70
Opephora pacifica (Grunow) Petit	1					1
Pinnularia brebissonii (Kützing) Rabenhorst		20				20
Planothidium quarnerensis (Grunow) Witkowski			1			1
Rhabdonema adriaticum Kützing		2	1			3
Rhaphoneis amphiceros (Ehrenberg) Ehrenberg		3	2			5
Rhopalodia gibberula (Ehrenberg) O. Müller		4	15			19
Tabularia fasciculata (C. Agardh) D.M. Williams & Round		2				2
Tryblionella granulata (Grunow) Mann		1				1
Total diatom valves counted	3	500	500	0	0	1003
Unidentified diatom fragments	40	-	-	4	0	44

TABLE 3

ECOLOGICAL CHARACTERISTICS OF DIATOMS FOUND IN THE FIVE SAMPLES FROM THE SOUTH SHORE OF STATEN ISLAND, RICHMOND COUNTY, NEW YORK

Name	Ecology
Actinoptychus senarius (Ehrenberg) Ehrenberg	Marine, plankton, littoral and tidal channels, tidal flats, and mud flats
Amphicocconeis disculoides (Hustedt) De Stefano & Marino	Marine/brackish, widespread in the Atlantic littoral, reported from surface sediments in coastal lagoons in New Jersey and New York
Aulacoseira Italica (Ehrenberg) Simonsen	Fresh to weakly brackish, planktonic and benthic, lakes, ponds, pools, rivers, streams, also regularly in moist places
Auliscus sculptus (Wm. Smith) Ralfs	Marine, plankton and benthic on sand grains (epipsammon), broad salinity tolerance, littoral and tidal channels
Caloneis oregonica (Ehrenberg) Patrick	Brackish/marine
Cyclotella striata (Kützing) Grunow	Brackish/marine plankton, estuarine, tidal channels, salt marshes, wet places
Dimerogramma minor (Gregory) Ralfs	Marine/brackish, littoral, benthic, epipsammon, living on sand grains in intertidal shoals, sand flats and beaches
Diploneis bombus Ehrenberg	Marine/brackish epipelon, common on Atlantic coast
Diploneis interrupta (Kützing) Cleve	Brackish, estuaries, bays, supratidal, frequent on salt marshes, epipelic (on mud), aerophilic (on damp sediment, rock, moss, temporarily wet habitats), supratidal, alkalibiontic (occurring exclusively at pH>7)
Diploneis smithii (Brébisson) Cleve	Marine/brackish, epipelon and saline inland waters, common in estuarine sediment cores collected in the Pamlico and Neuse River estuaries of North Carolina, with increased abundance after about 1725, corresponding to European land clearance, alkalibiontic
Grammatophora macilenta W. Smith	Marine/brackish, epiphytic (attached to plants and larger algae)
Hyalodiscus scoticus (Kützing) Grunow	Marine/brackish, epiphyte in brackish lagoons and bays

Lyrella sulcifera (Hustedt) Witkowski	Marine/brackish
Navicula digitoconvergens Lange-Bertalot	Freshwaters with average to high electrolyte concentrations and in brackish waters of the marine littoral, tidal flats, alkaliphilous
Navicula kefvingensis (Ehrenberg) Ehrenberg	Brackish
Navicula salinicola Hustedt	brackish/marine, reported from surface sediments in coastal lagoons in New Jersey and New York
Odontella aurita (Lyngbye) C. Agardh	Marine plankton, tychoplankton (benthic but suspended in water column during turbulent conditions), benthic, littoral, optimal depth 3-10 Meters, littoral, prefers cold surface waters, coastal waters and estuaries including Long Island Sound, tidal flats, polyhalobous
Odontella pulchella Gray	Marine, benthic, on sand
Paralia sulcata (Ehrenberg) Cleve	Brackish/marine, coastal, littoral zone, planktonic and benthic, broad salinity range (polyhalobous), on rocks, sand, silt and macroalgae, abundant in tidal mud flats, hypersaline lagoons, and salt marshes, very common in temperate and tropical estuarine waters, littoral and sublittoral zones, has fairly wide tolerance ranges for many ecological values including salinity, tolerates intertidal exposure
Opephora cf. pacifica (Grunow) Petit	Marine/brackish, littoral, epipsammon, living on sand grains in intertidal shoals, sand flats and beaches
Pinnularia brebissonii (Kützing) Rabenhorst	High conductivity freshwater and brackish, coastal water
Planothidium quarnerensis (Grunow) Witkowski	Marine, coastal
Rhabdonema adriaticum Kützing	Marine, littoral
Rhaphoneis amphiceros (Ehrenberg) Ehrenberg	Marine, plankton, tychoplankton, littoral, tidal channels, subtidal
Rhopalodia gibberula (Ehrenberg) O. Müller	Marine/brackish, epiphyte on water plants in shallow brackish lagoons
Tabularia fasciculata (C. Agardh) D.M. Williams & Round	Marine/brackish epiphyte on water plants in shallow brackish lagoons with *Rhopalodia gibberula*, supratidal, pools in back levee marshes, tidal lagoons, low energy environments
Tryblionella granulata (Grunow) Mann	Marine/brackish epipelon, especially common on mud flats

Appendix G

PARTICLE SIZE ANALYSIS

U.S. Army Corps of Engineers, Baltimore District
Materials and Instrumentation Unit

R. Estes and D. Ray

U.S. Army Corps of Engineers

Baltimore District

Materials and Instrumentation Unit

South Shore,

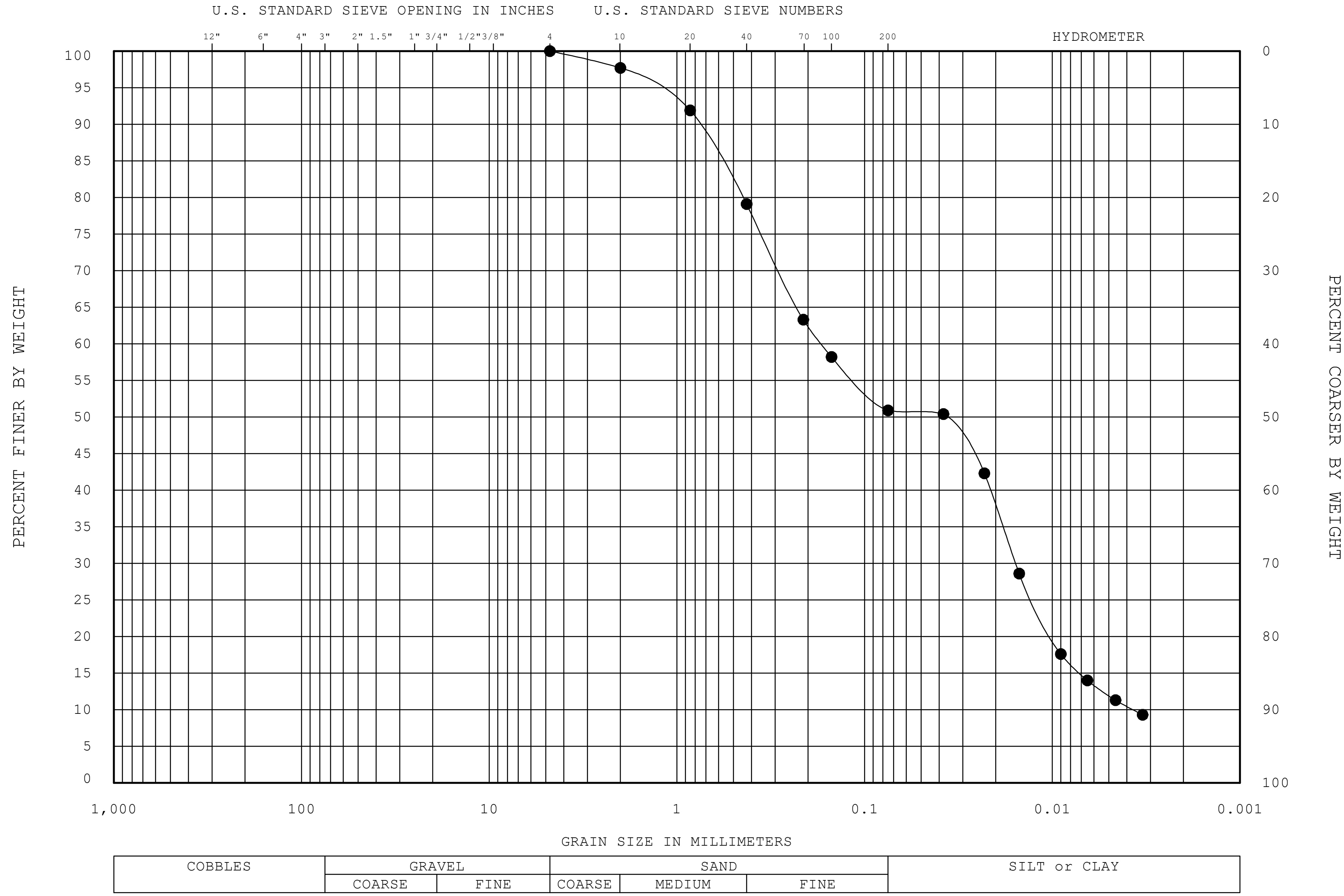
Staten Island, NY.

Date: February 2020

Pages: 1-45 of 45

Prepared by: Estes, R.

Ray, D.



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Bag-1	34.0-40.0	SANDY ELASTIC SILT	MH		84	56	28
☒								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

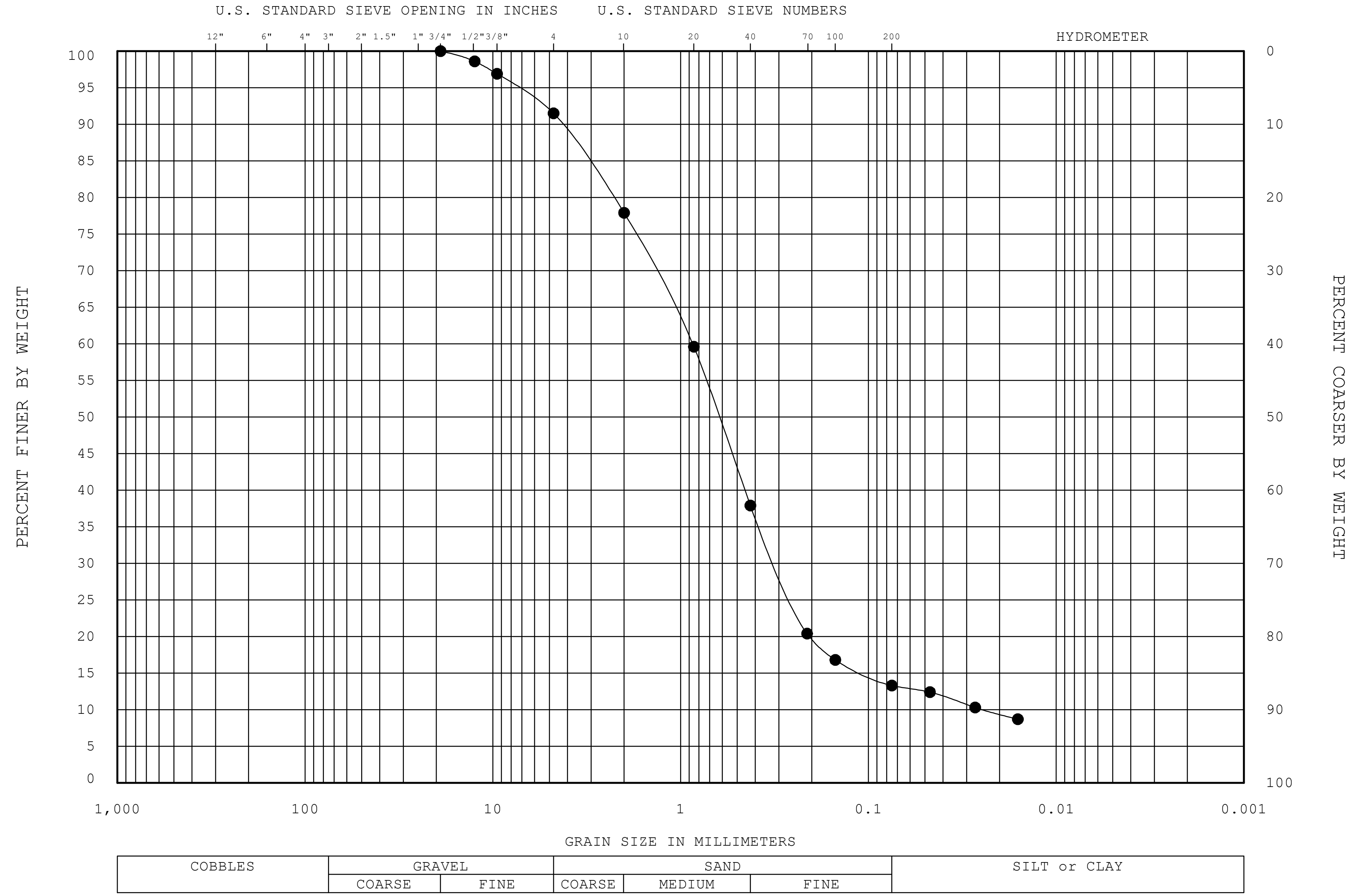
BORING NO.: *Cedar Grove*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Bag-1	8.0-16.0	SILTY SAND SM				
☒							
▲							
★							

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

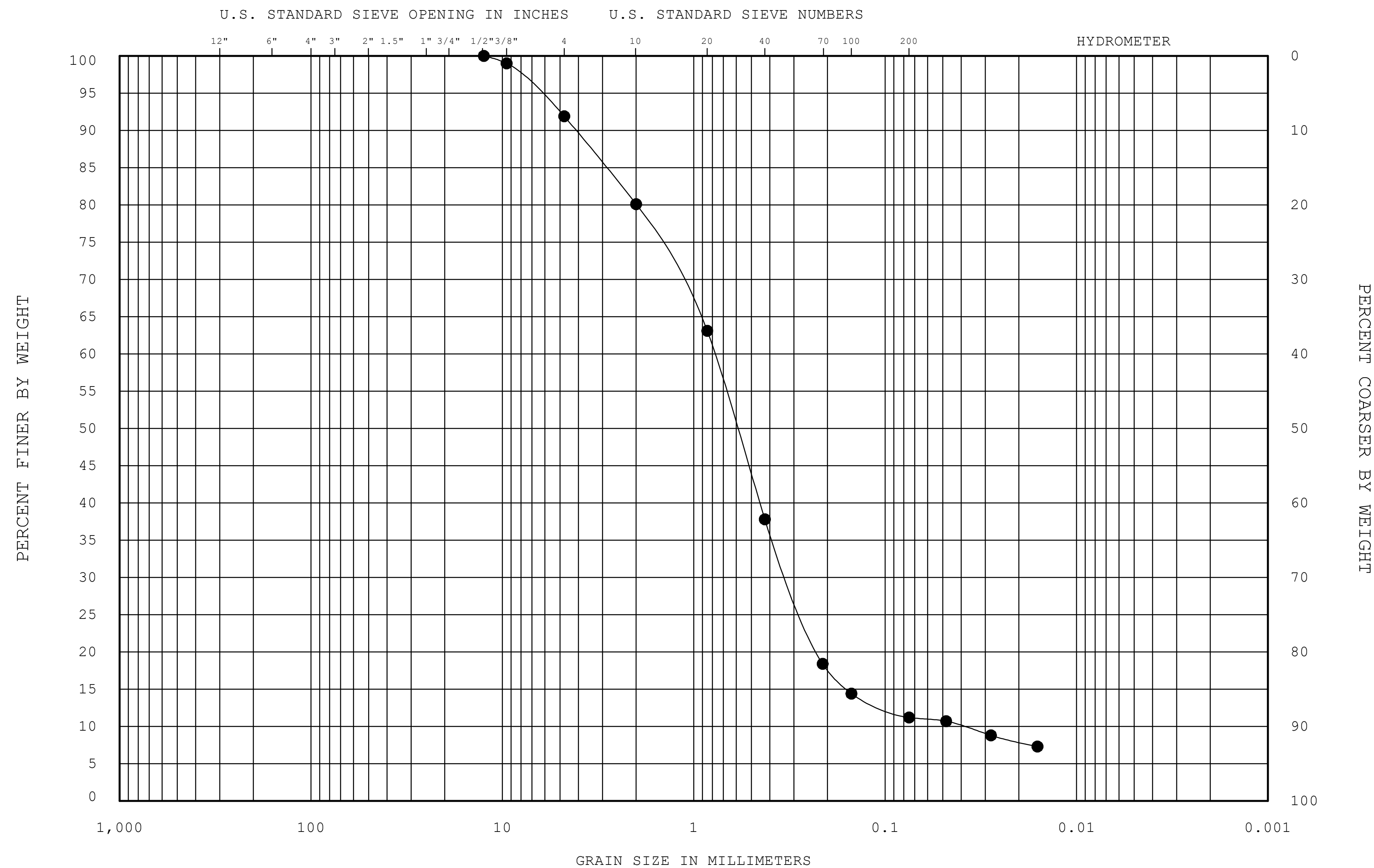
AREA: *South Shore*

BORING NO.: *GP-8 10-15' Advance*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-2	16.0-24.0	WELL-GRADED SAND with SILT	SW-SM				
—⊠—								
—▲—								
—★—								

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

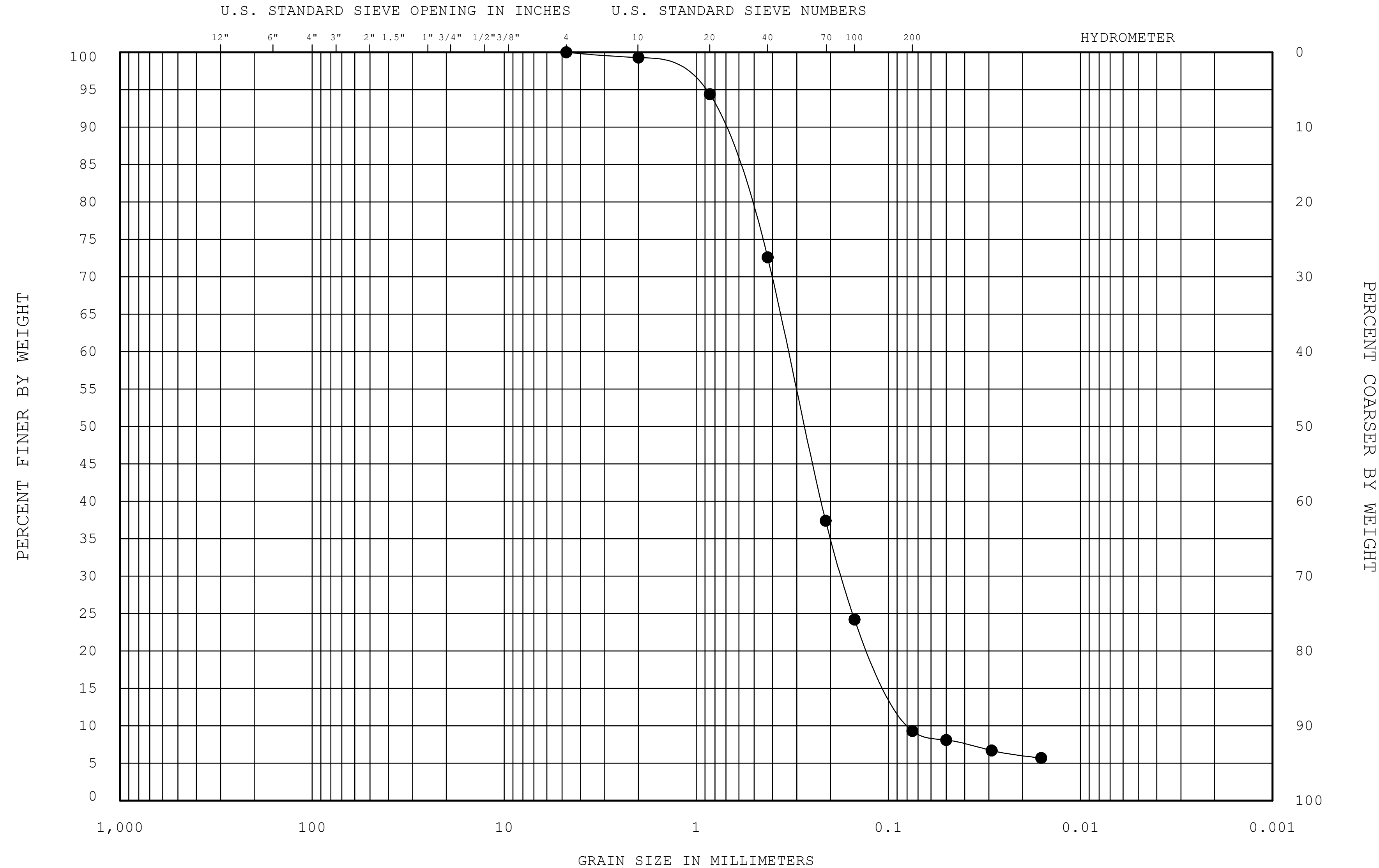
AREA: *South Shore*

BORING NO.: *GP-8 10-15' Advance*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

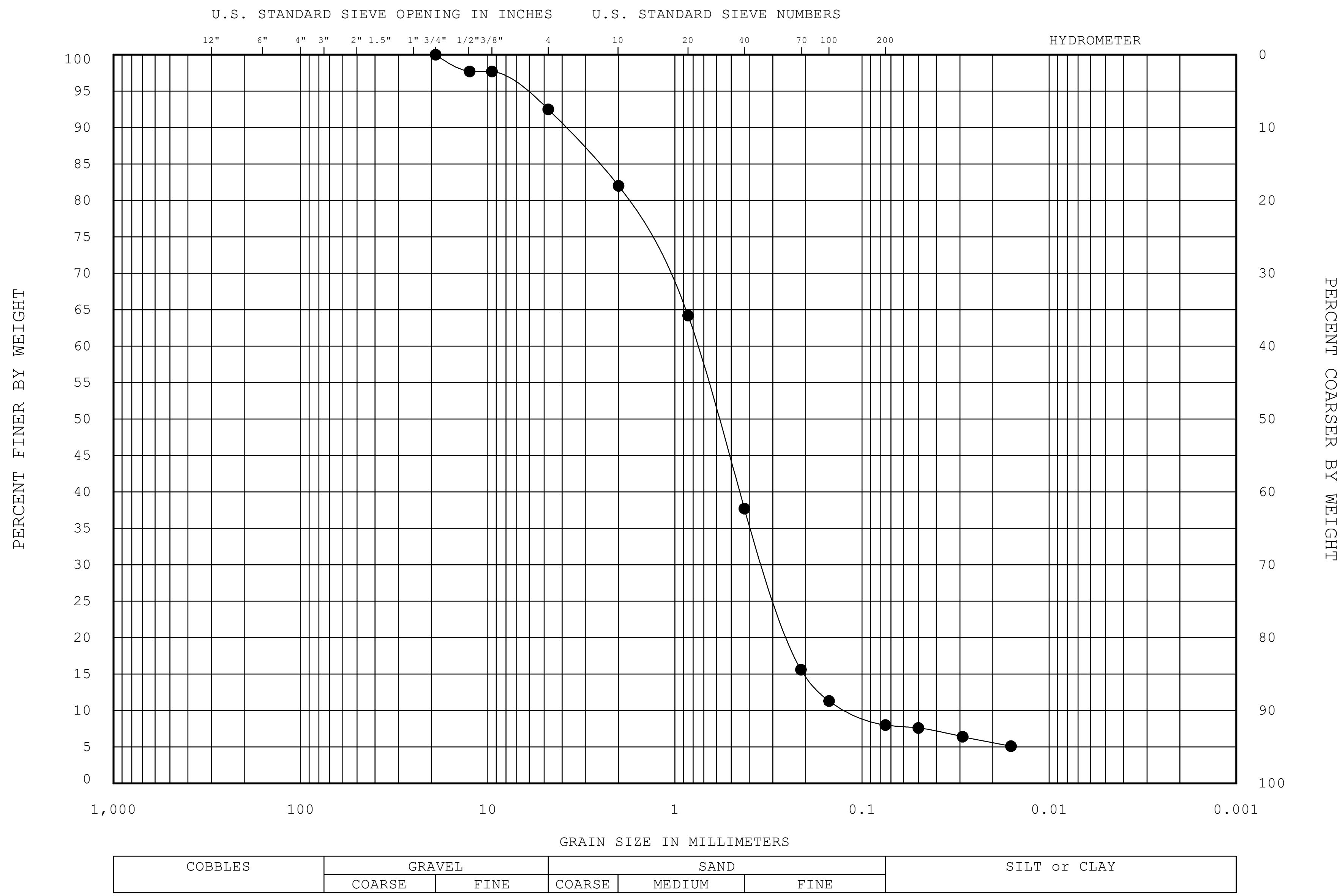
Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-3	24.0-34.0	POORLY GRADED SAND with SILT	SP-SM				
—⊠—								
—▲—								
—★—								

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT:	*Staten Island South Shore*
AREA:	*South Shore*
BORING NO.:	*GP-8 10-15' Advance*
DATE:	

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	***Depth (ft)***	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-1	0.0-12.0	WELL-GRADED SAND with SILT	SW-SM				
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

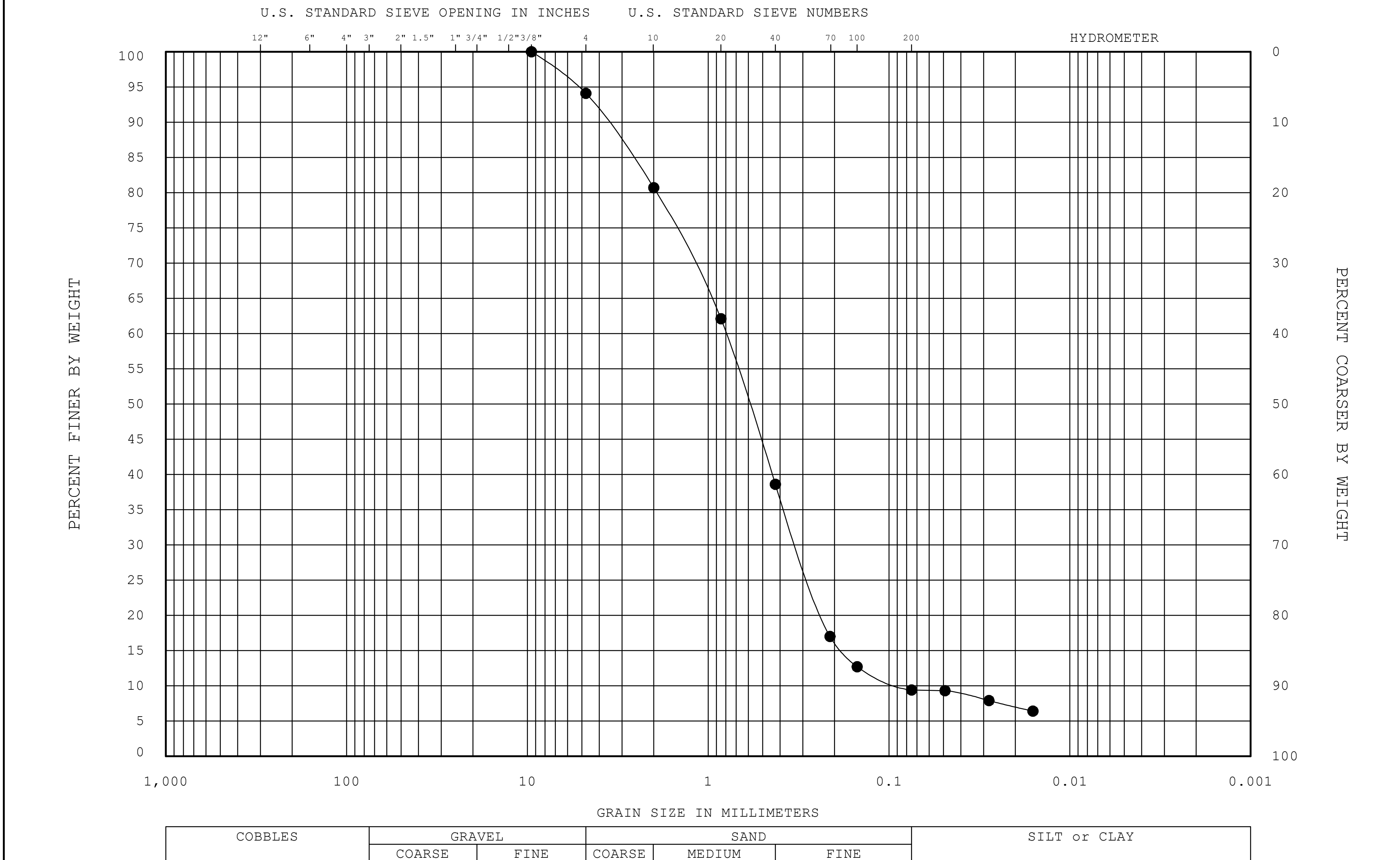
BORING NO.: *GP-8 15-20' Advance*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Bag-2	24.0-36.0	WELL-GRADED SAND with SILT	SW-SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

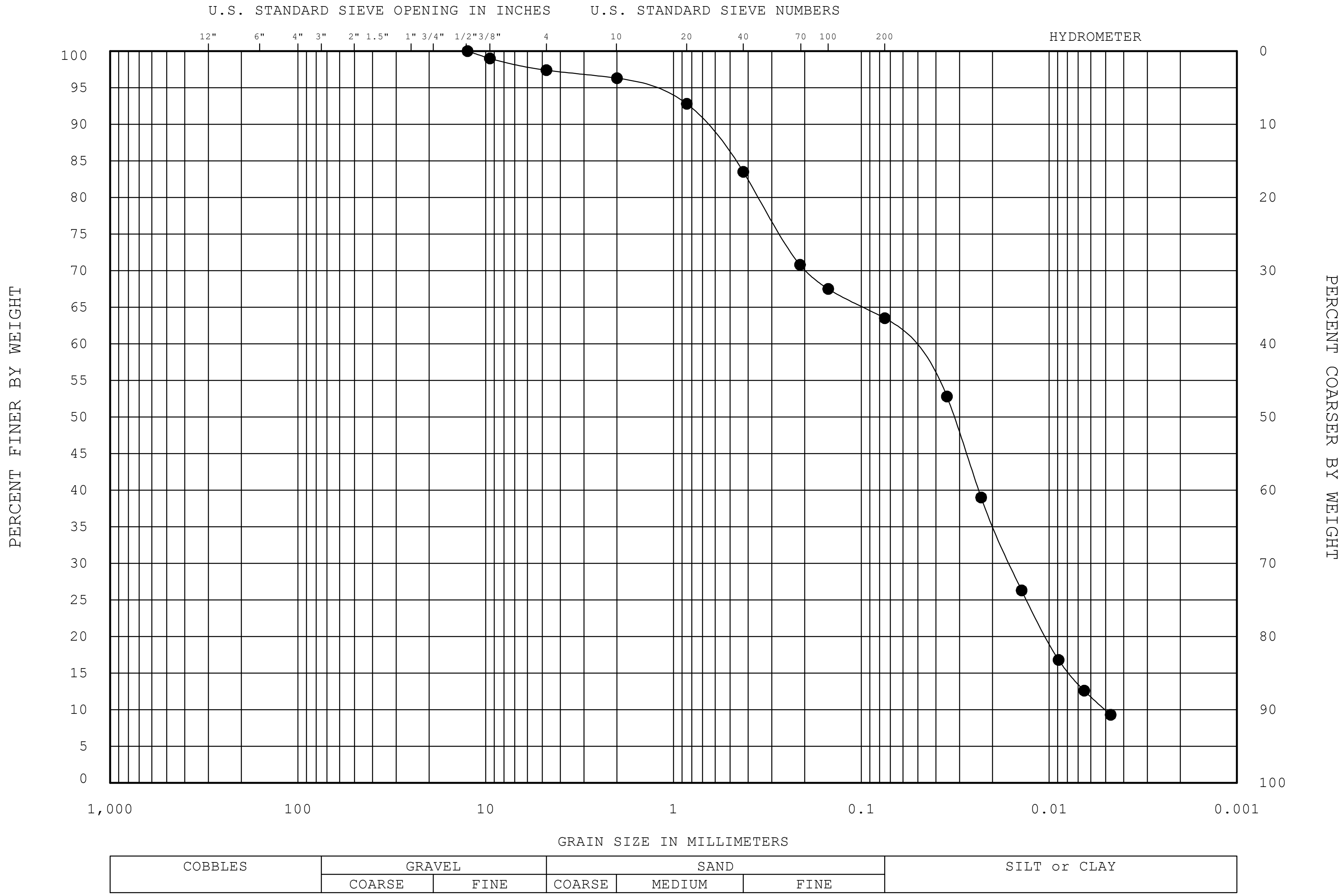
BORING NO.: *GP-8 15-20' Advance*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-1	3.0-7.0	SANDY SILT	ML		42	30	12
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

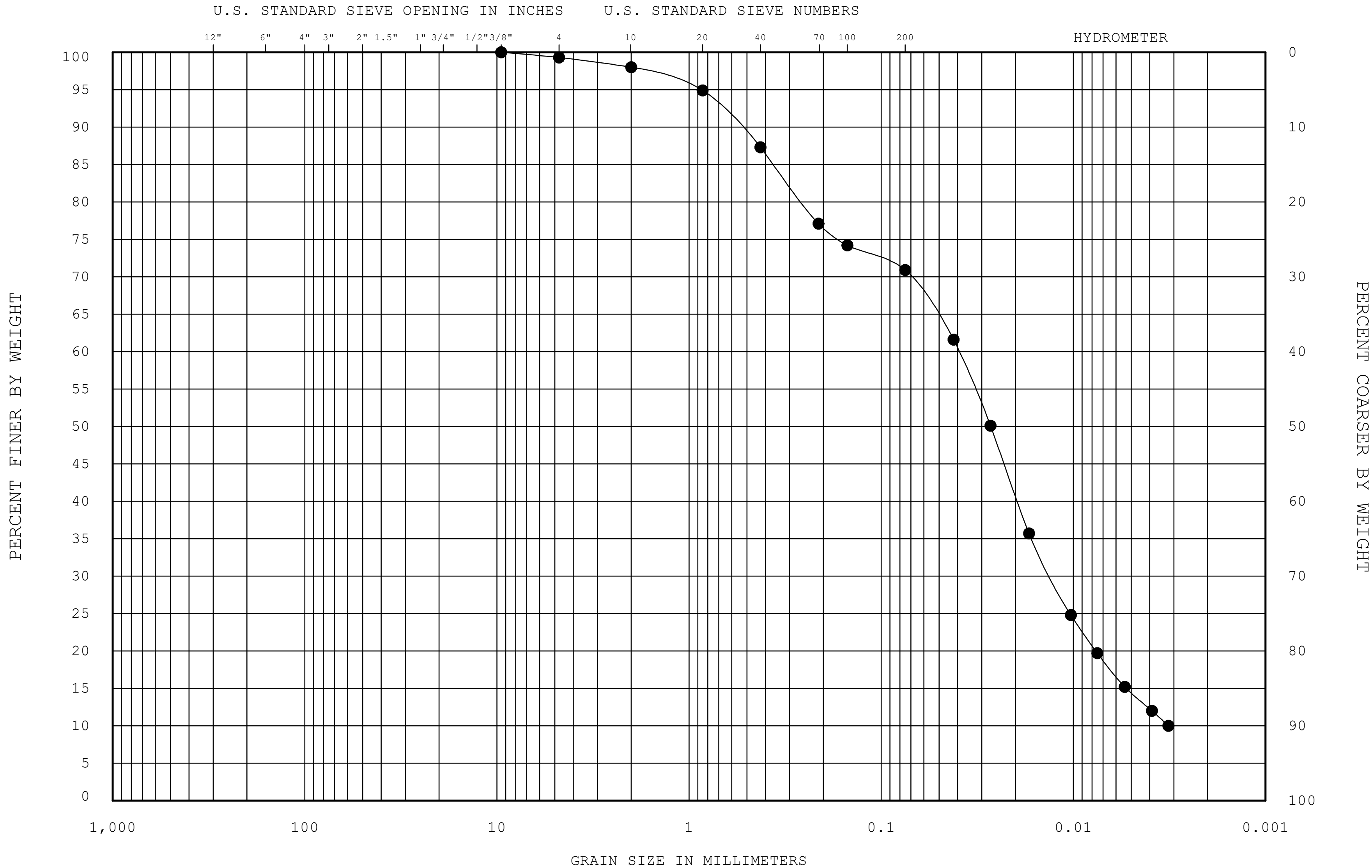
BORING NO.: *Woodlot*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-2	10.0-14.0	SILTY CLAY with SAND	CL-ML		27	21	6
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

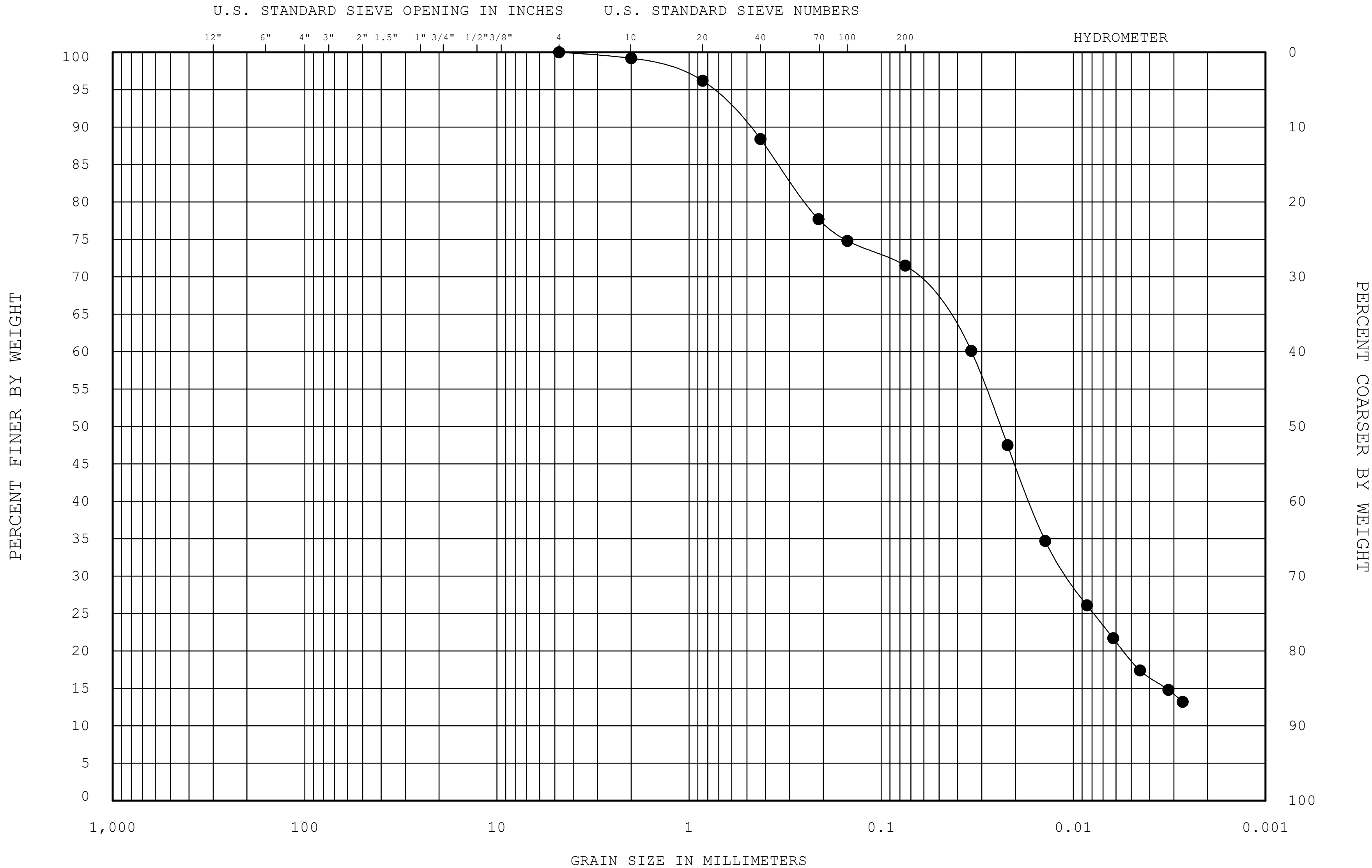
BORING NO.: *Woodlot*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Bag-3	14.0-18.0	SILTY CLAY with SAND	CL-ML		24	19	5
☒								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

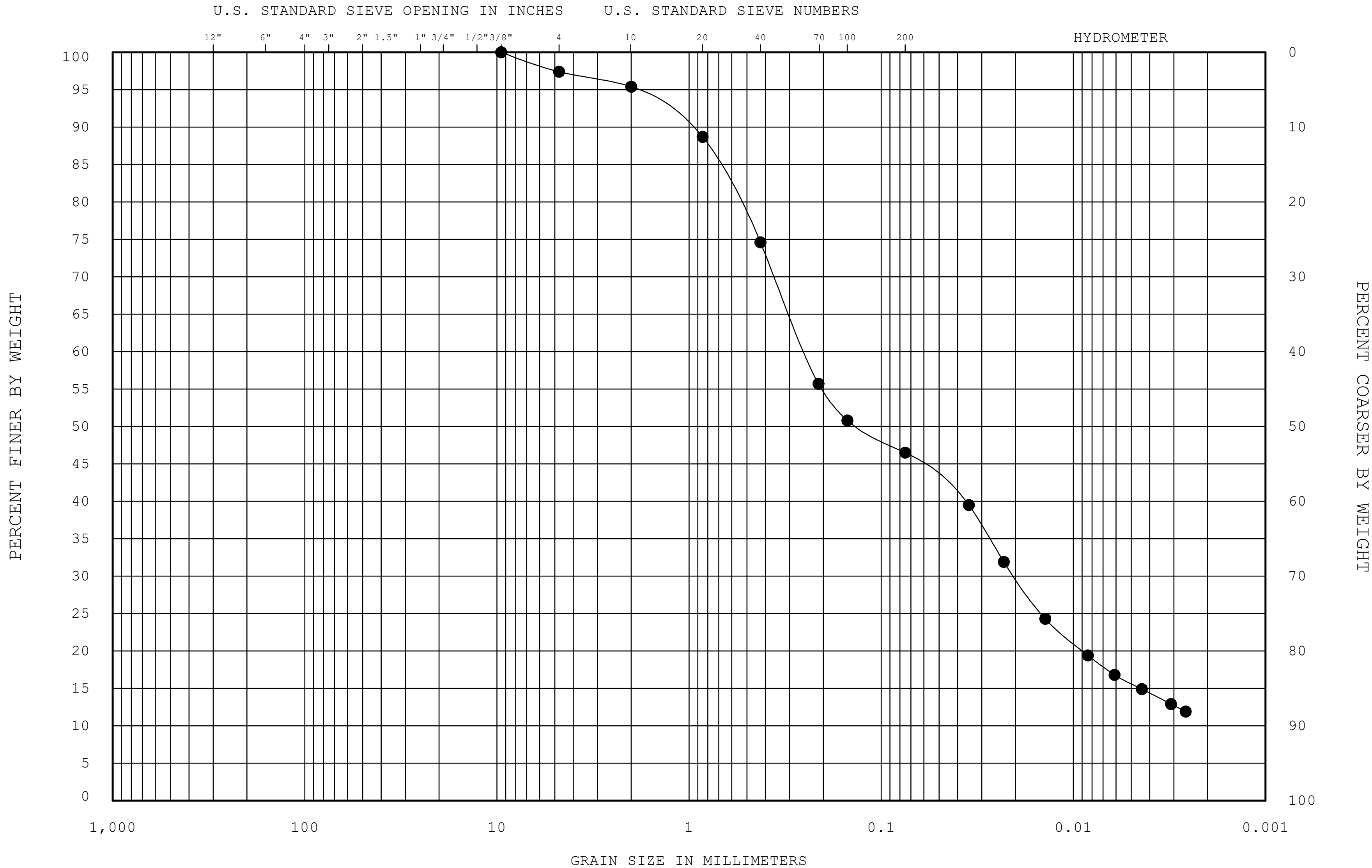
BORING NO.: *Woodlot*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-4	22.0-26.0	CLAYEY SAND	SC		28	18	10
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

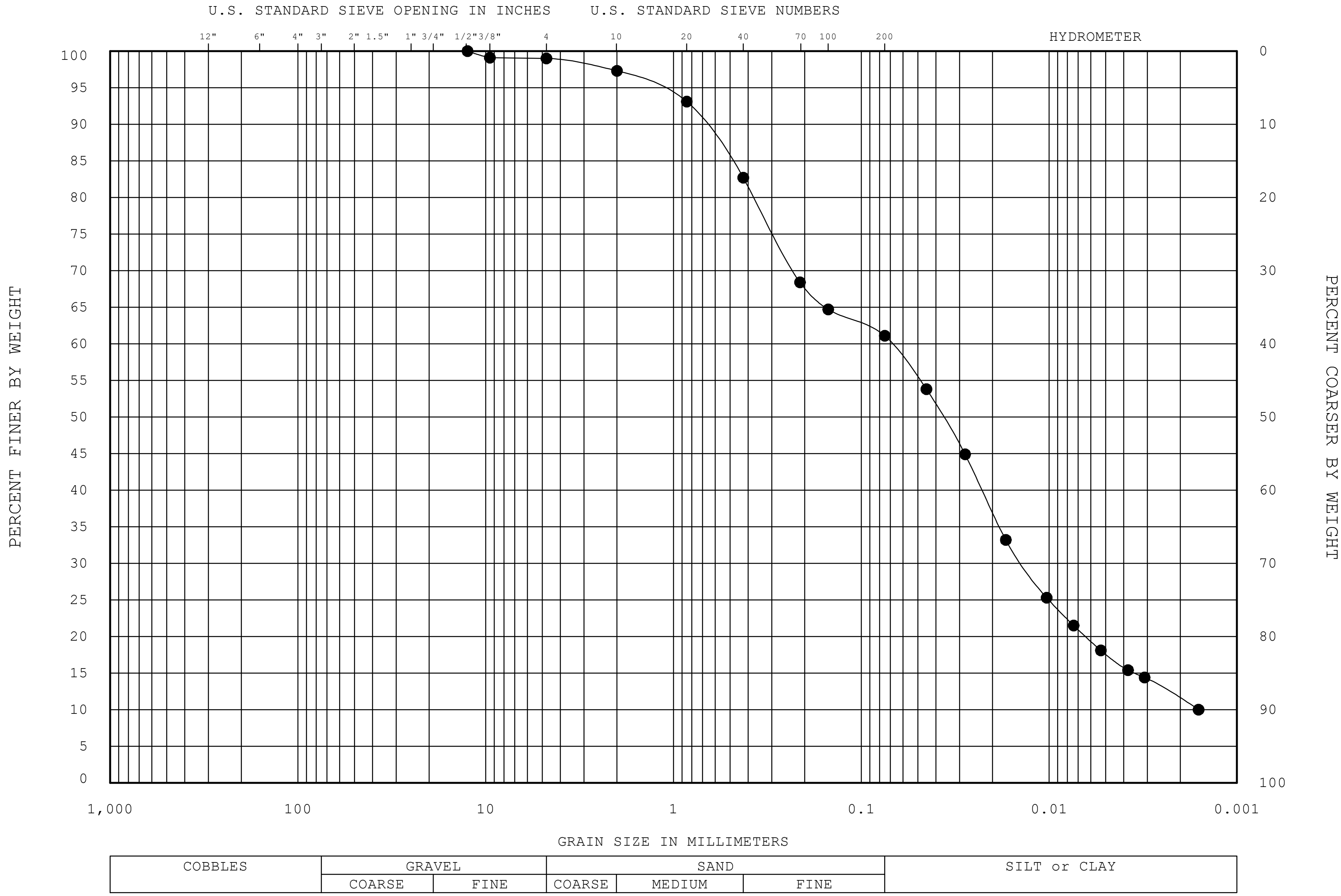
BORING NO.: *Woodlot*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Bag-5	26.0-28.0	SANDY LEAN CLAY	CL		28	19	9
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

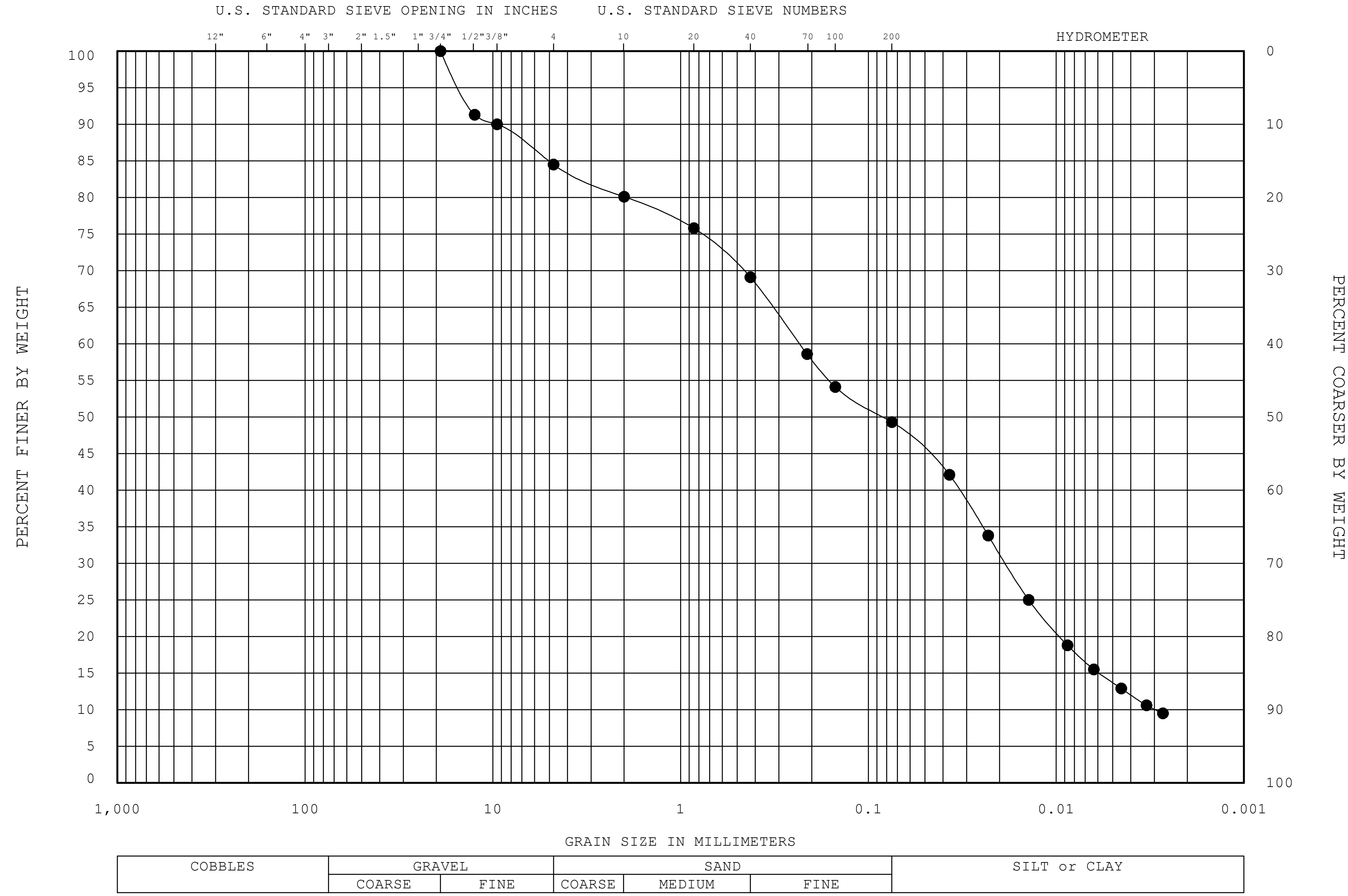
BORING NO.: *Woodlot*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

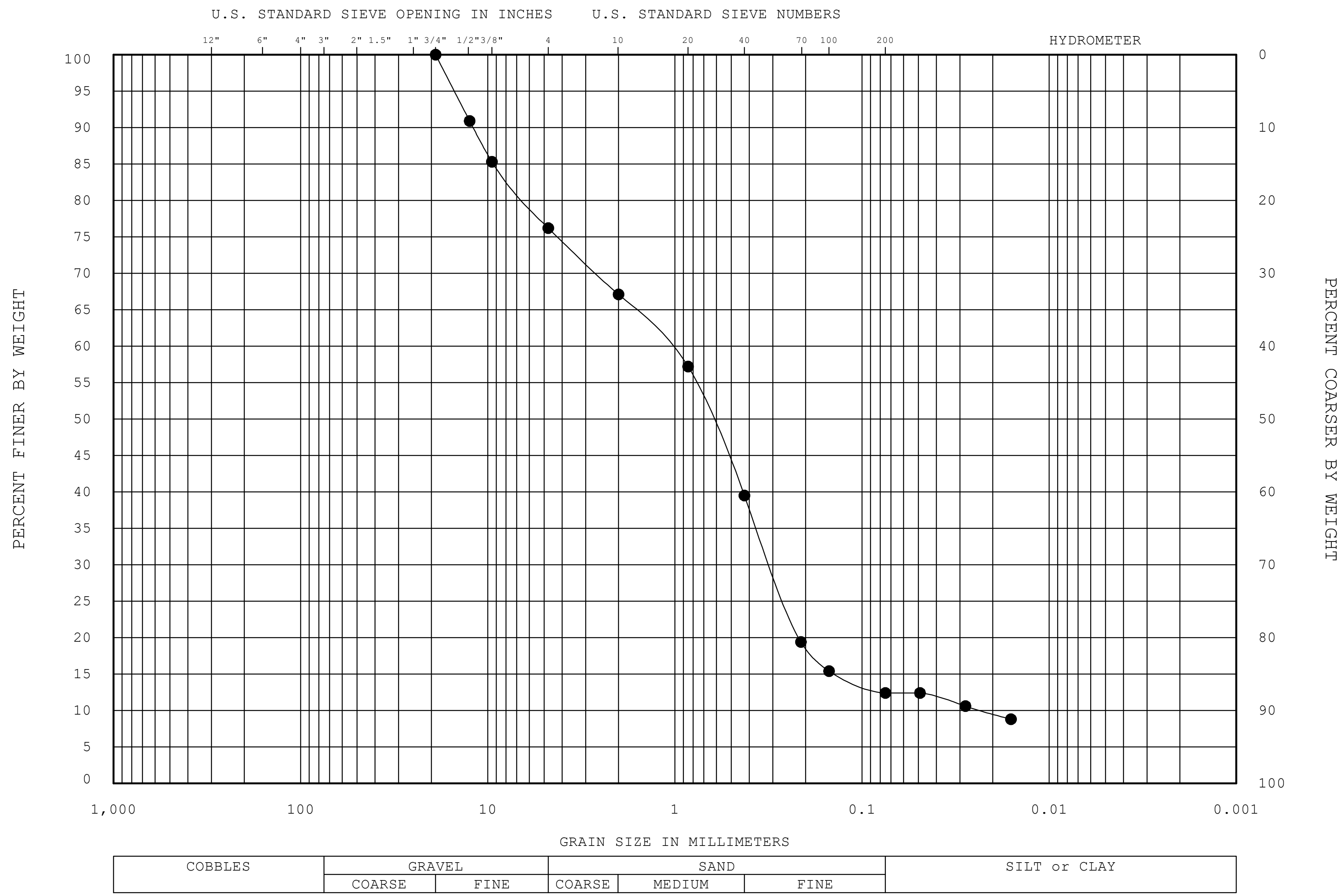


Legend	Sample No.	***Depth (ft)***	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-3	5.0-6.5	SILTY SAND with GRAVEL	SM				
⊠								
▲								
★								

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

PROJECT:	*Staten Island South Shore*
AREA:	*South Shore*
BORING NO.:	*DH-14*
DATE:	

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-4	7.5-9.0	SILTY SAND with GRAVEL	SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

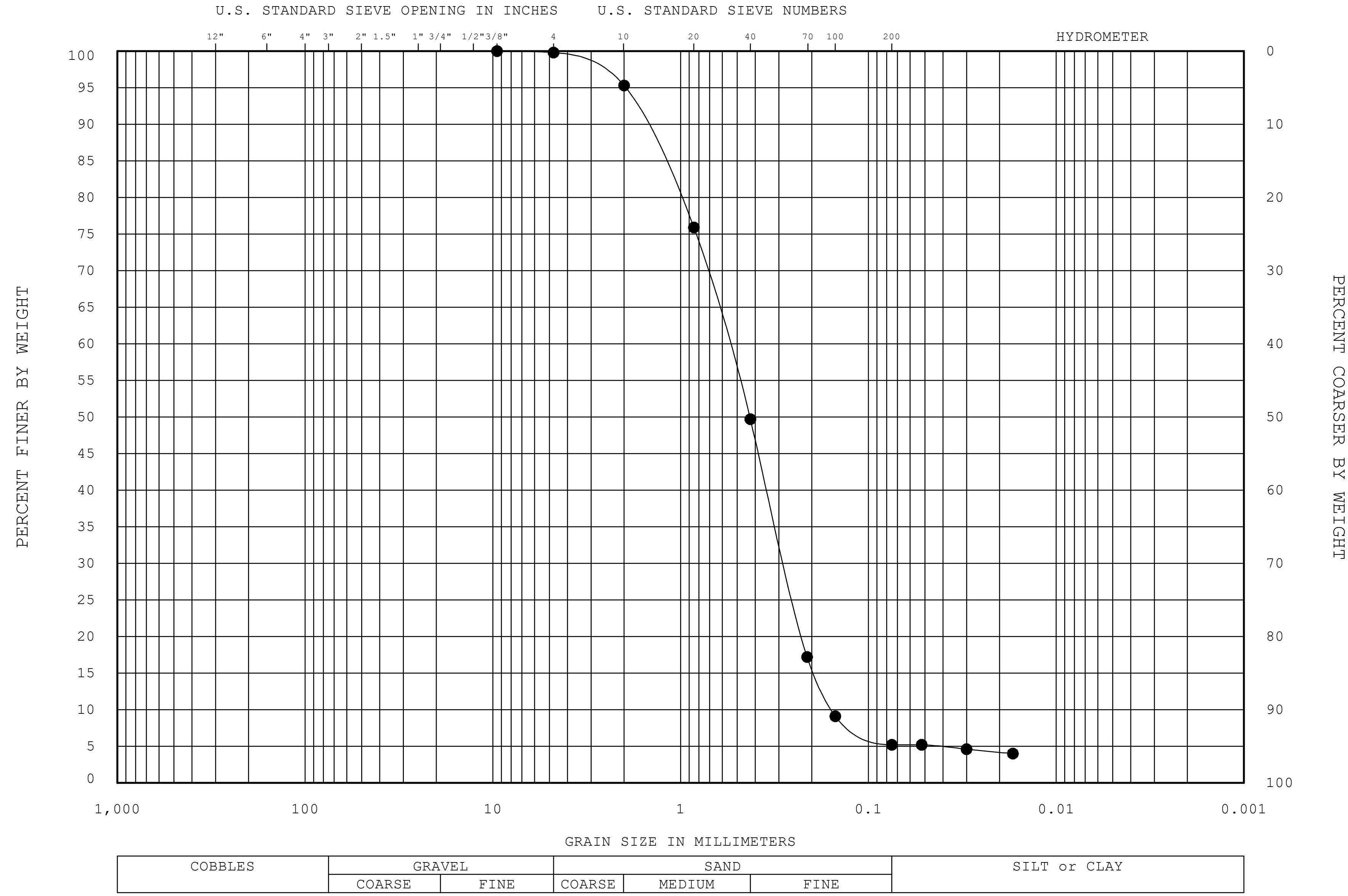
BORING NO.: *DH-14*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-6	12.5-14.0	POORLY GRADED SAND with SILT SP-SM				
⊠							
▲							
★							

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

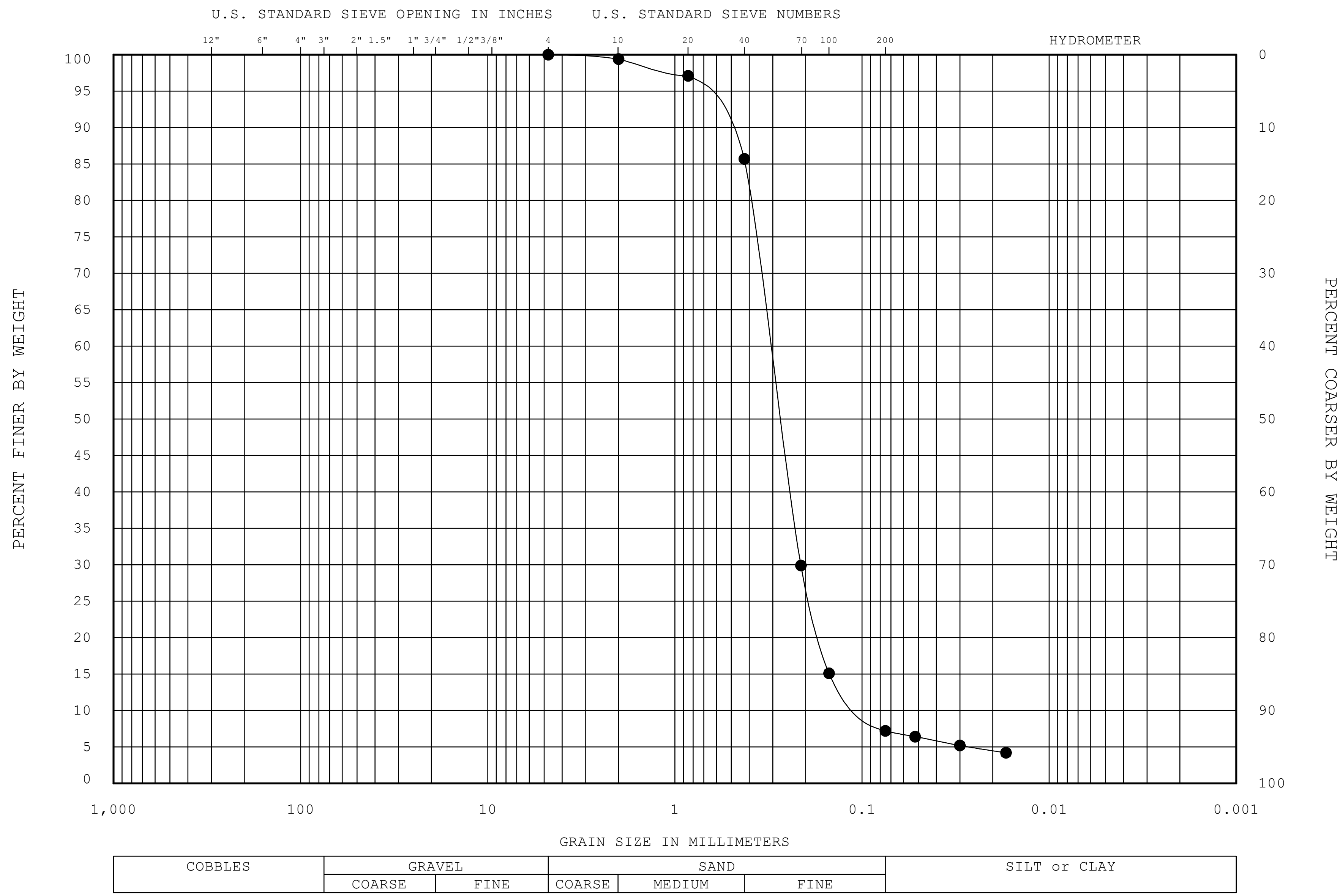
AREA: *South Shore*

BORING NO.: *DH-16*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

PROJECT: *Staten Island South Shore*

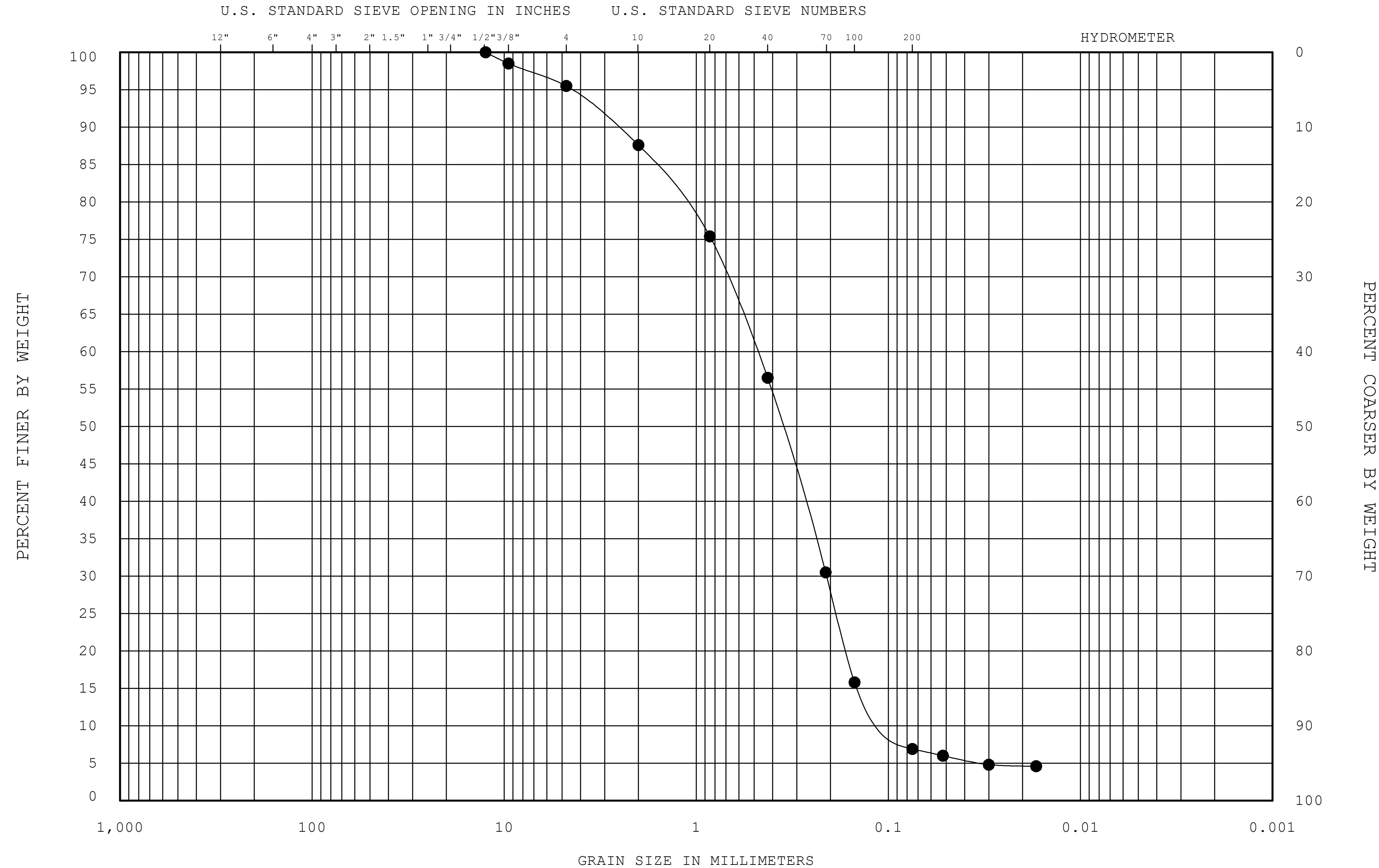
AREA: *South Shore*

BORING NO.: *DH-16*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-8	17.5-19.0	POORLY GRADED SAND with SILT SP-SM				
⊠							
▲							
★							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

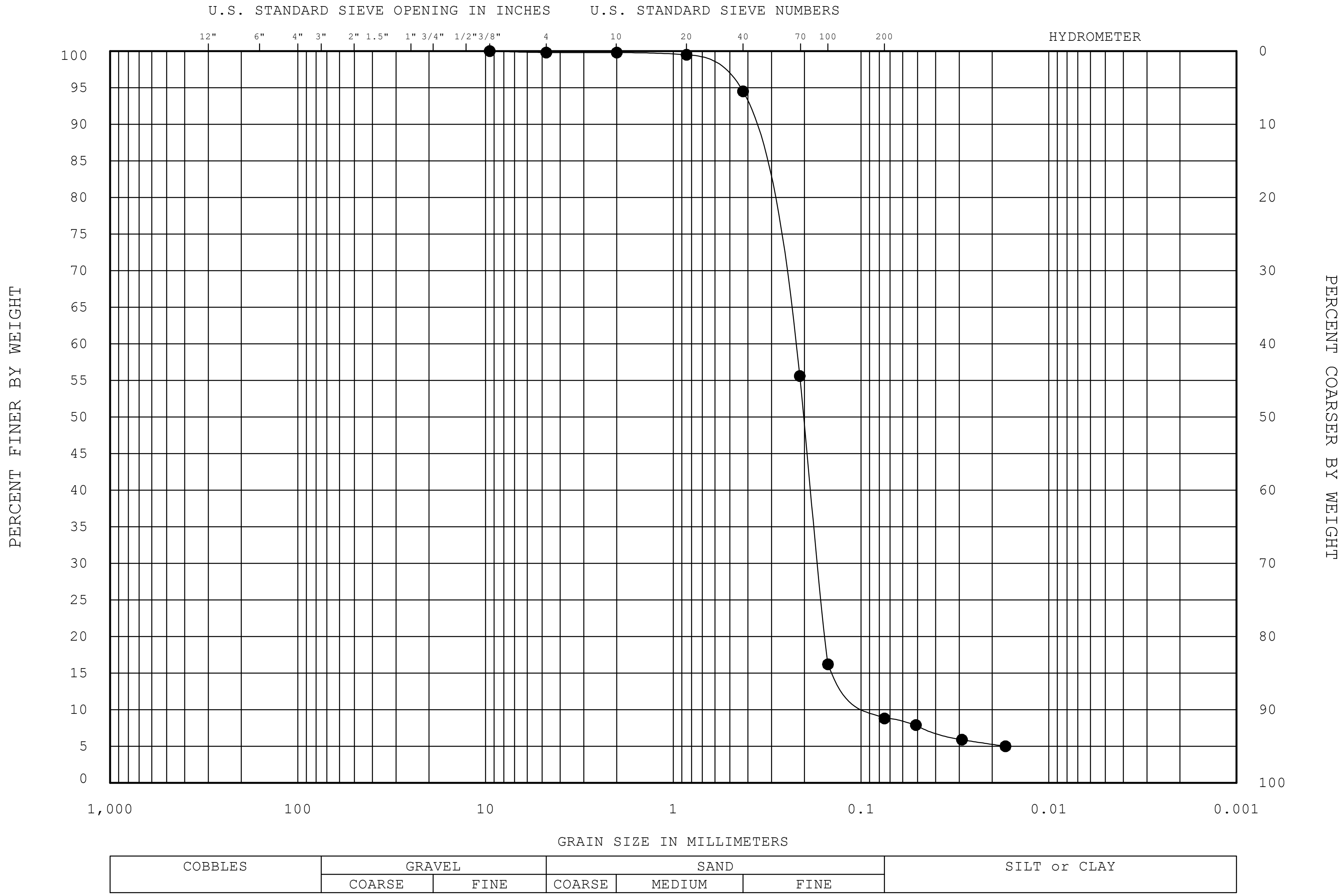
BORING NO.: *DH-16*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Bag-1	15.5-16.0	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

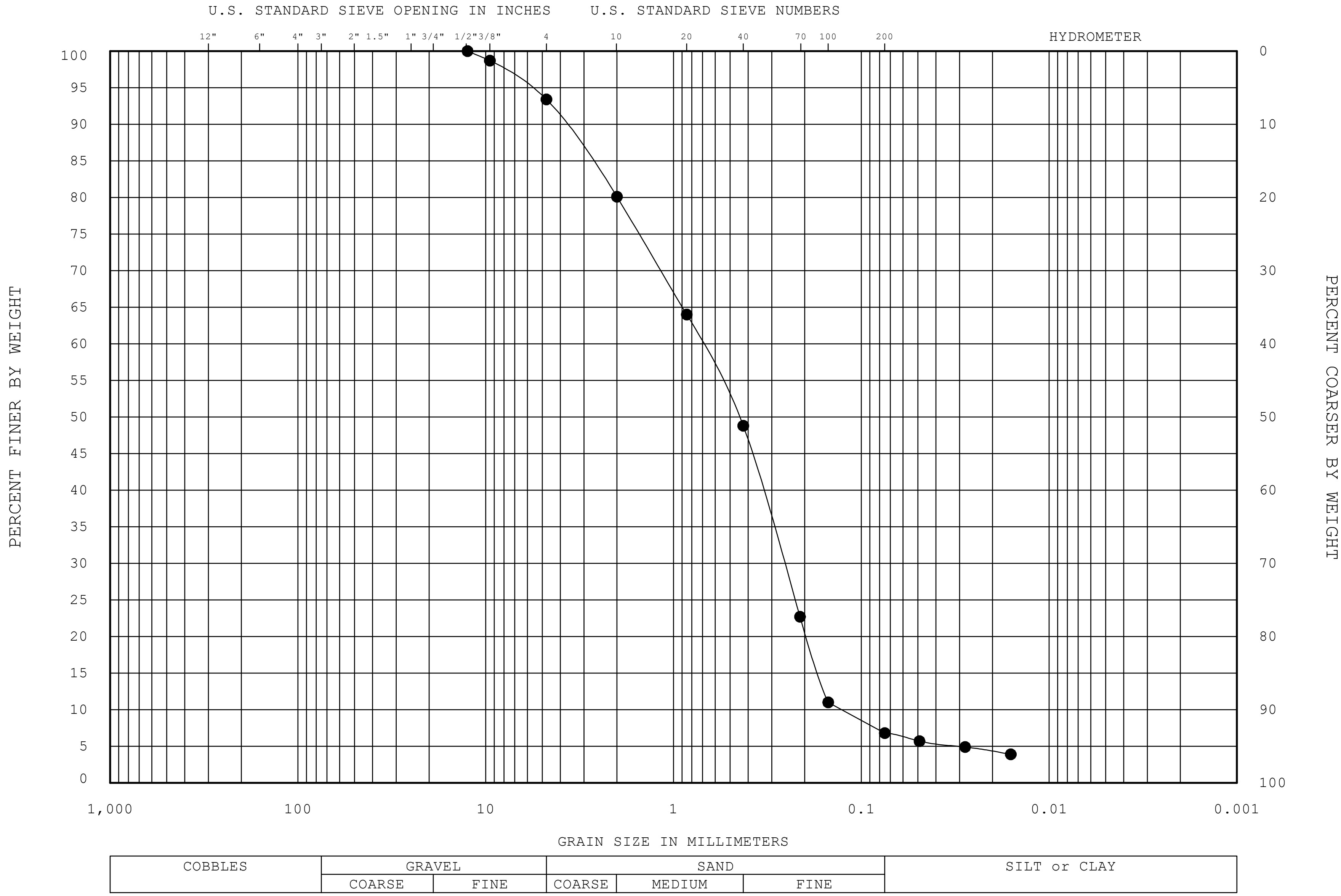
BORING NO.: *DH-19*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-6	12.5-14.0	POORLY GRADED SAND with SILT	SP-SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

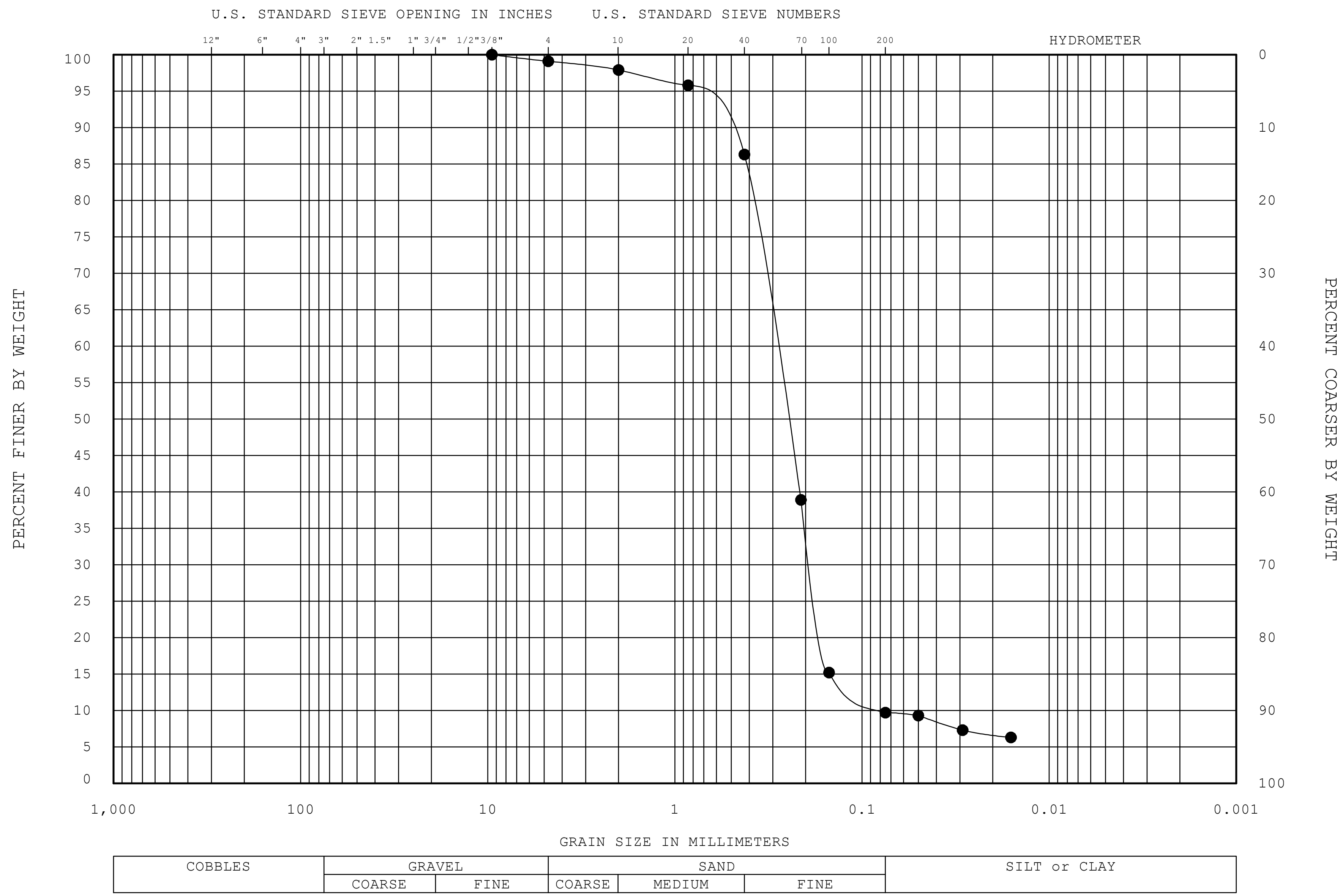
BORING NO.: *DH-19A*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-7	15.0-16.5	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

PROJECT: *Staten Island South Shore*

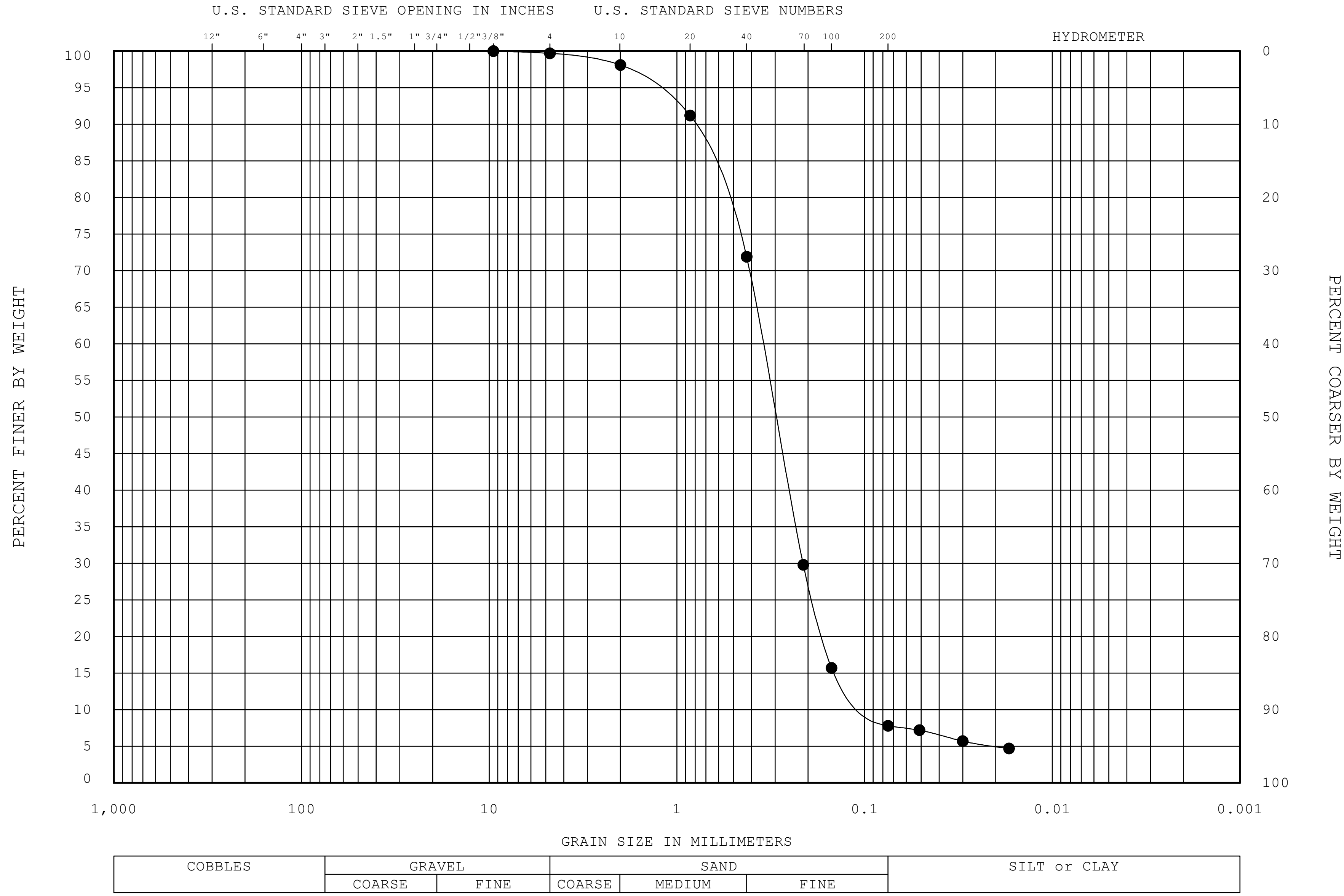
AREA: *South Shore*

BORING NO.: *DH-19A*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

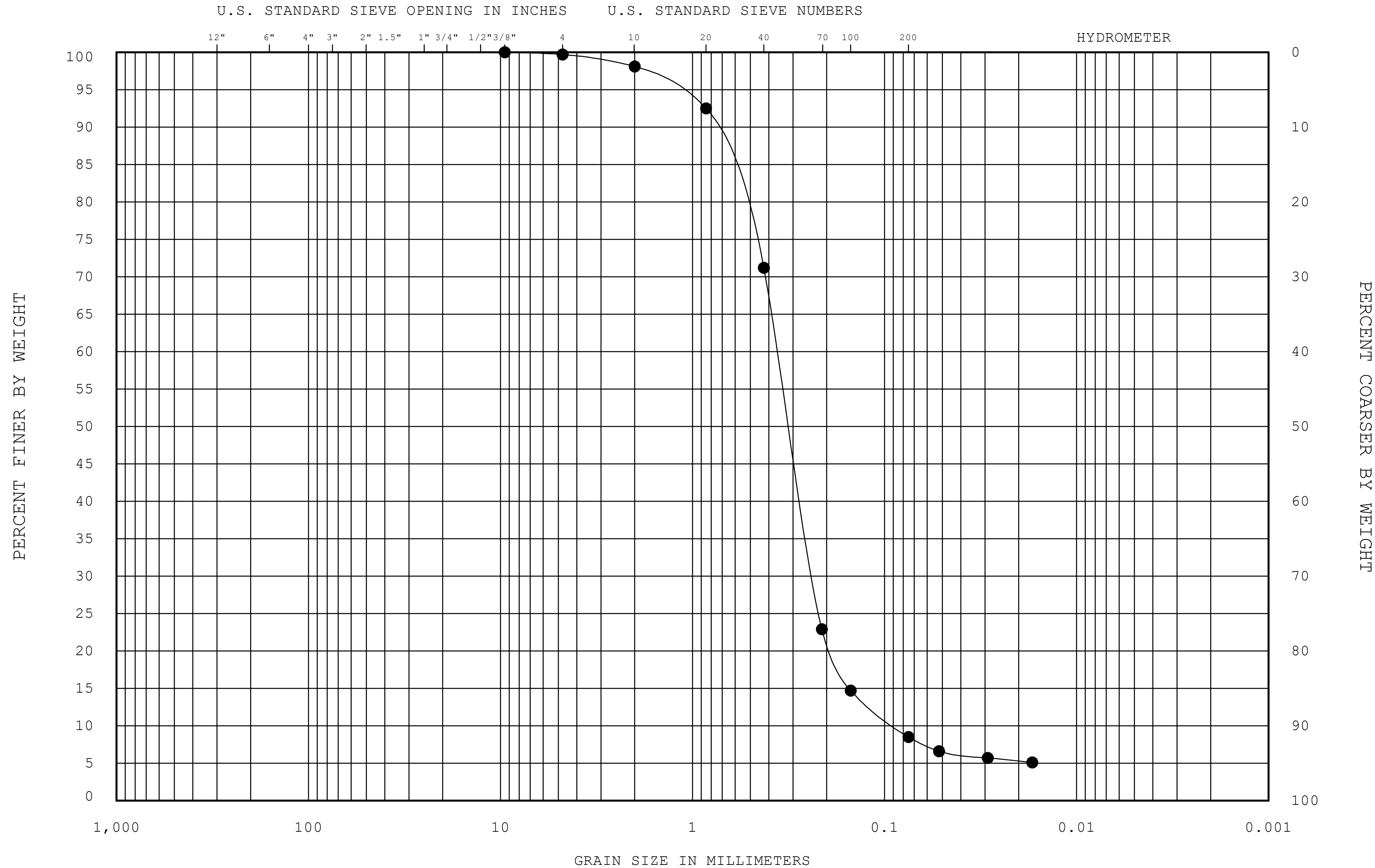


Legend	Sample No.	***Depth (ft)***	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-8	17.5-19.0	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

PROJECT:	*Staten Island South Shore*
AREA:	*South Shore*
BORING NO.:	*DH-19A*
DATE:	

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-10	22.5-24.0	POORLY GRADED SAND with SILT SP-SM				
⊠							
▲							
★							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

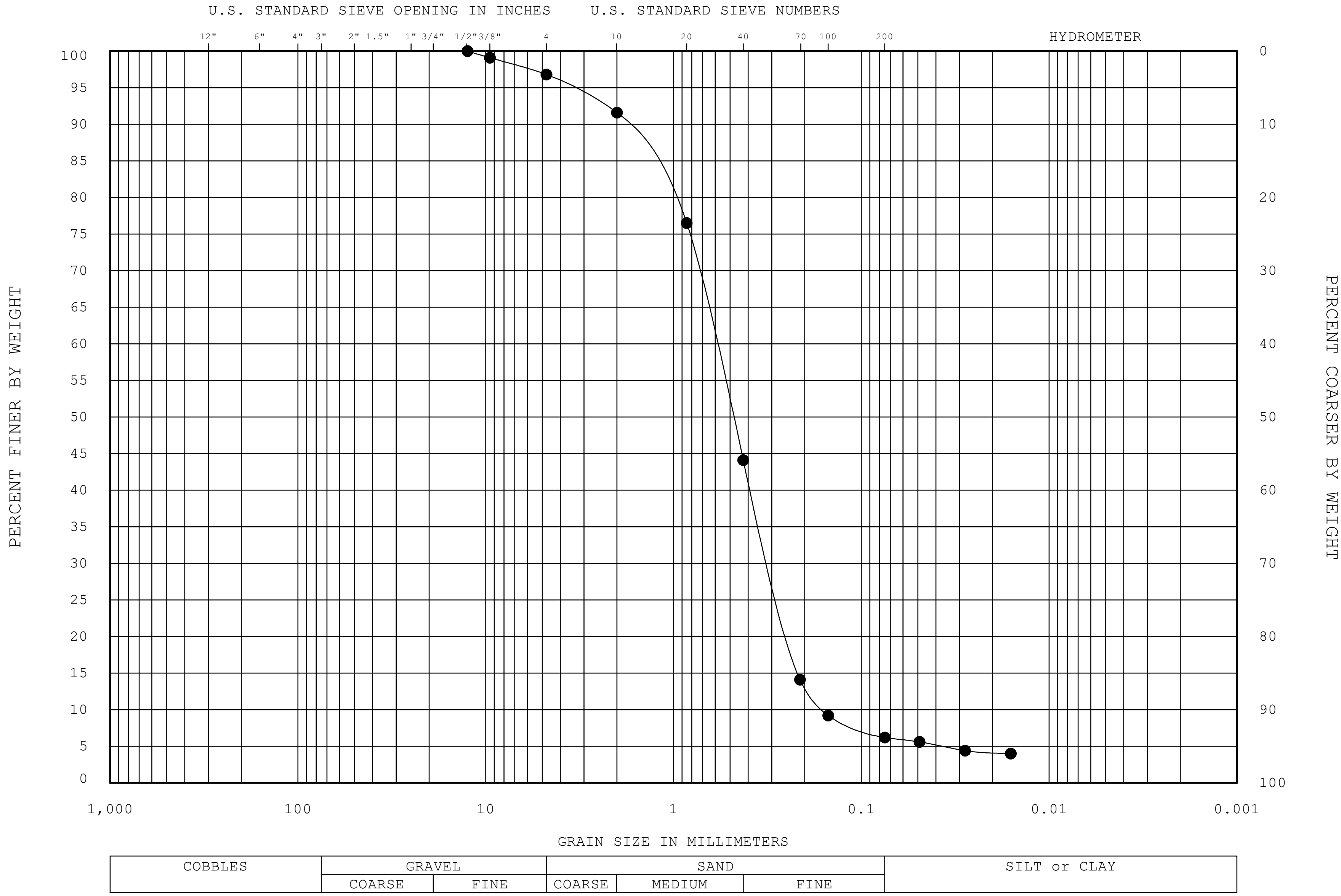
BORING NO.: *DH-19A*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-6	10.0-11.5	POORLY GRADED SAND with SILT	SP-SM				
☒								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

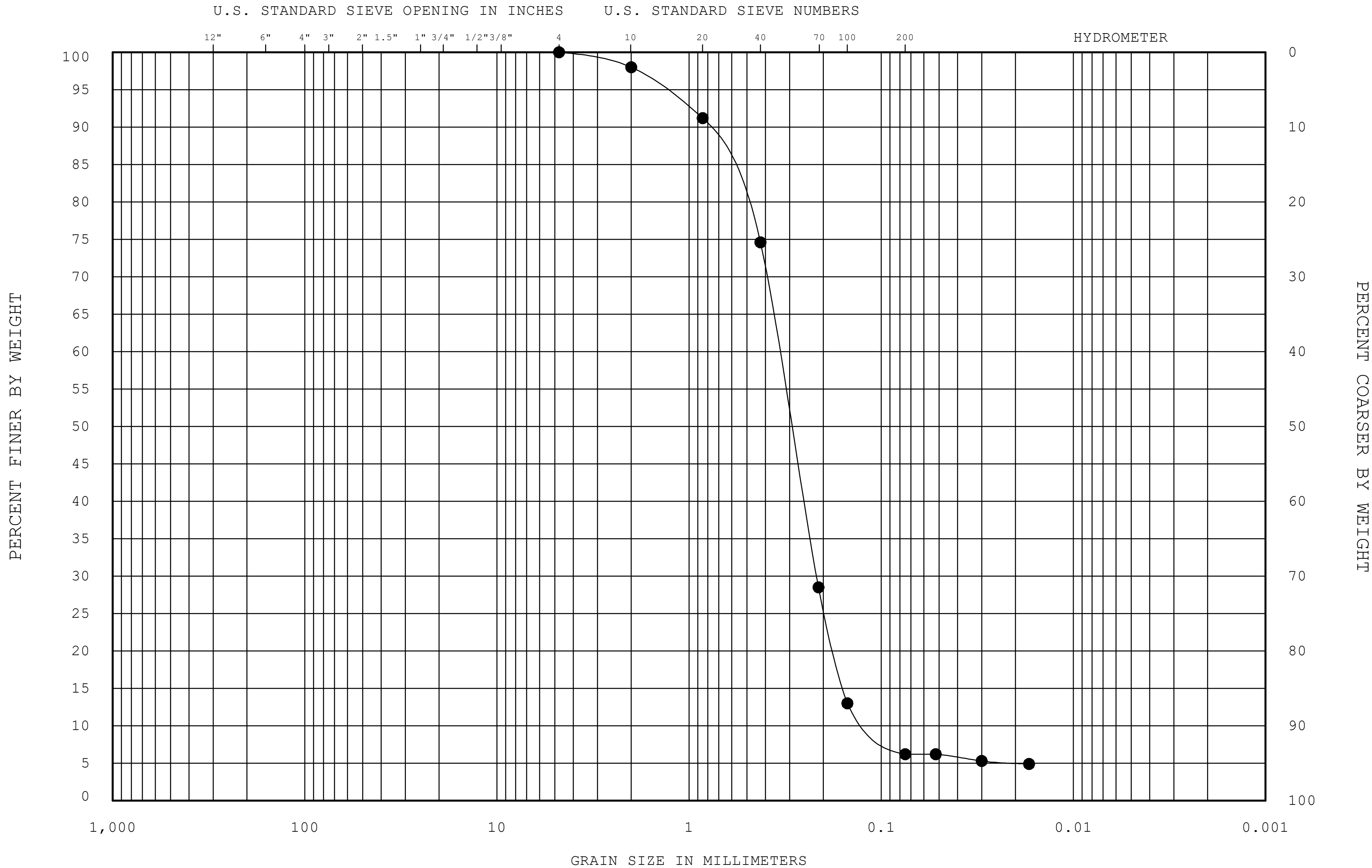
BORING NO.: *DH-21*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-7	12.5-14.0	POORLY GRADED SAND with SILT SP-SM				
⊠							
▲							
★							

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

PROJECT: *Staten Island South Shore*

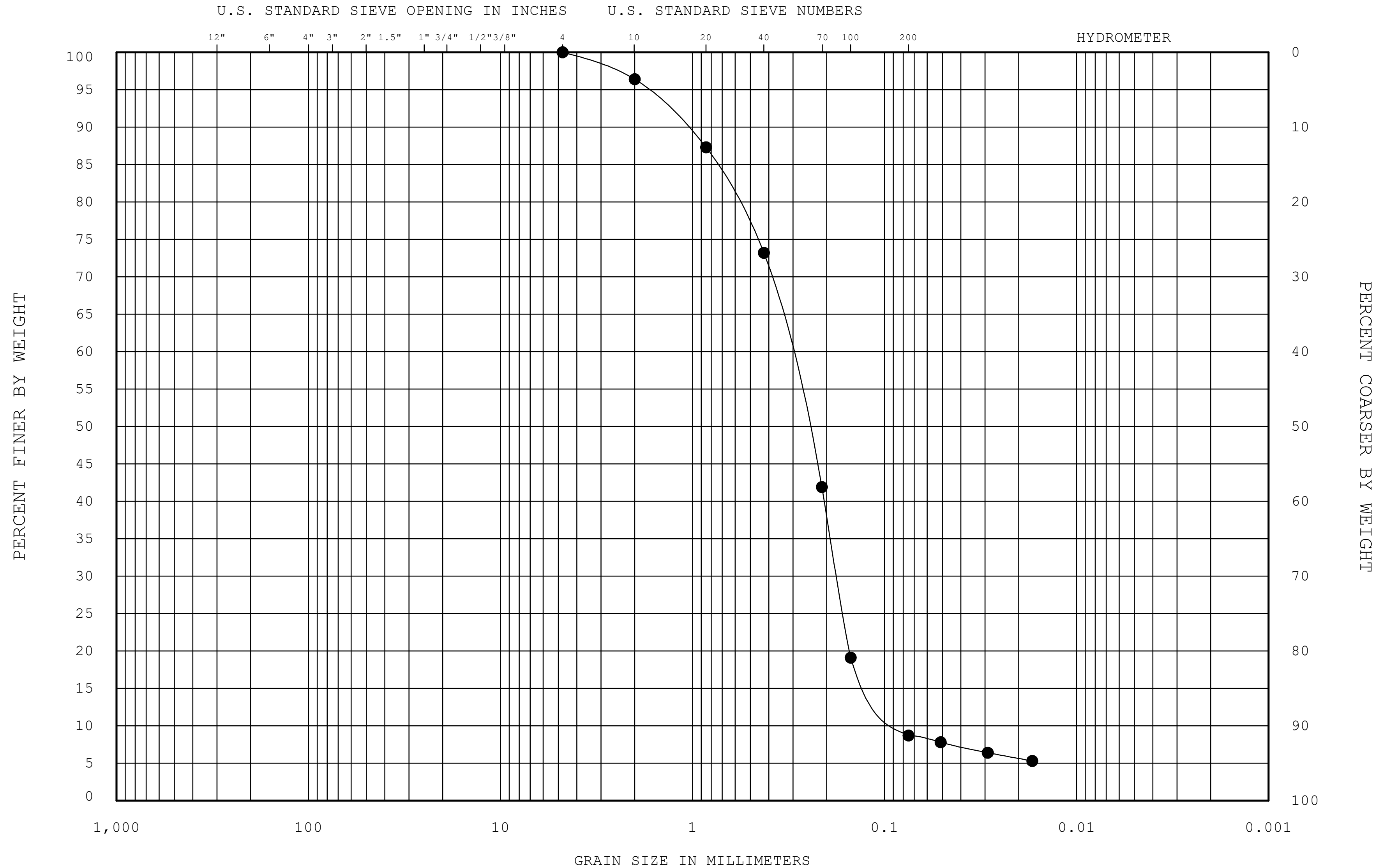
AREA: *South Shore*

BORING NO.: *DH-21*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-8	15.0-16.5	POORLY GRADED SAND with SILT	SP-SM				
⊠								
▲								
★								

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

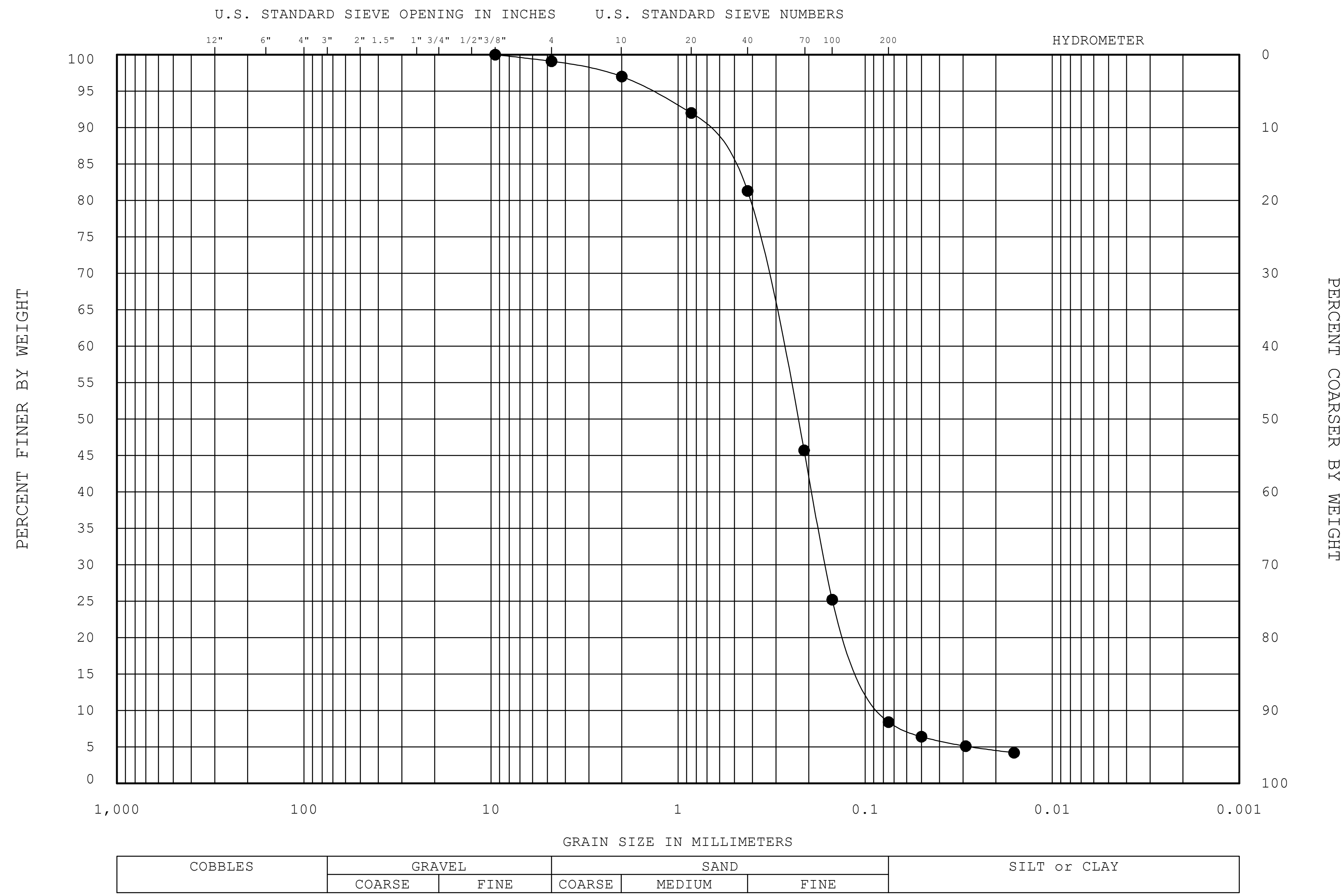
AREA: *South Shore*

BORING NO.: *DH-21*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar-9	17.5-19.0	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

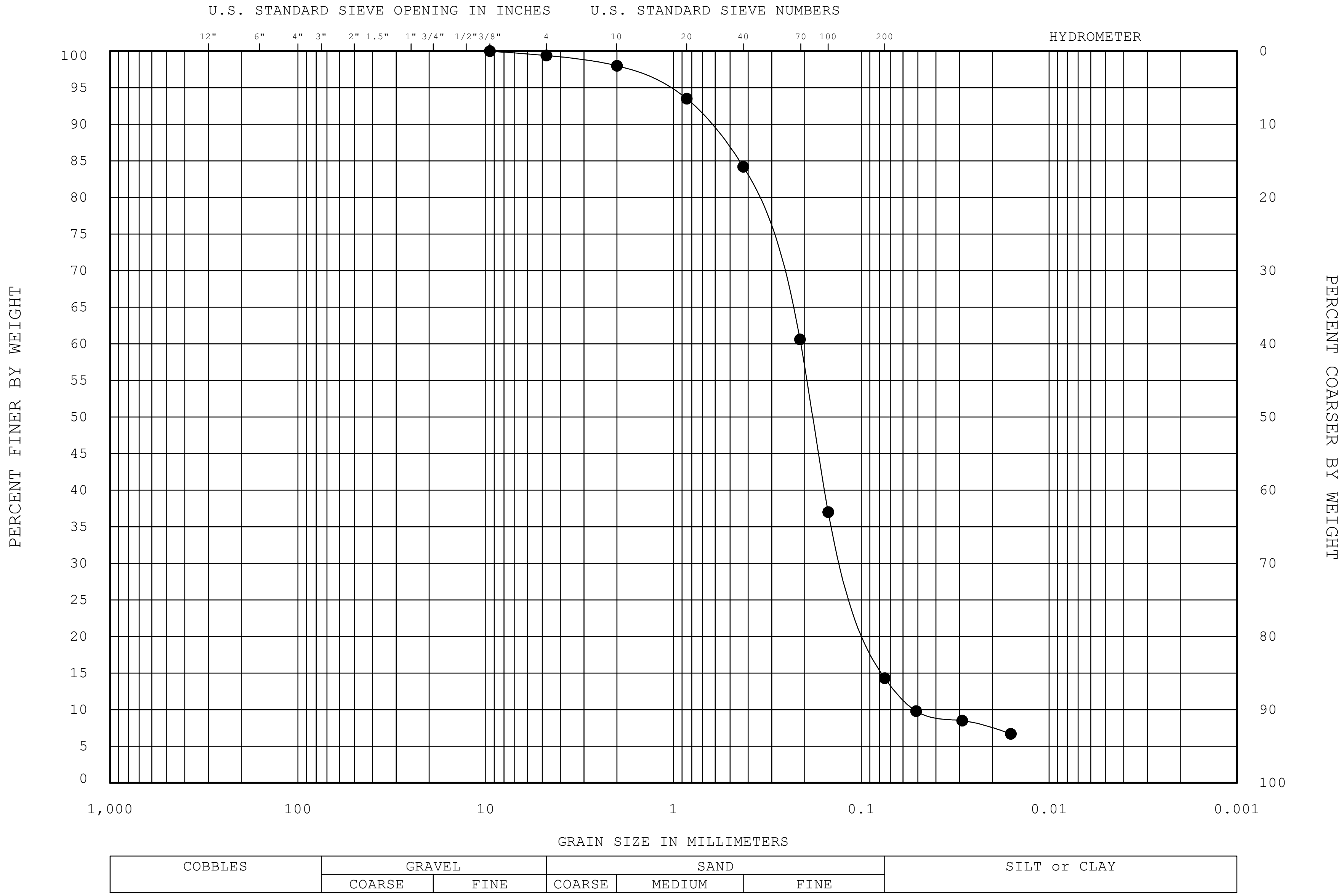
BORING NO.: *DH-21*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-10	20.0-21.5	SILTY SAND	SM				
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

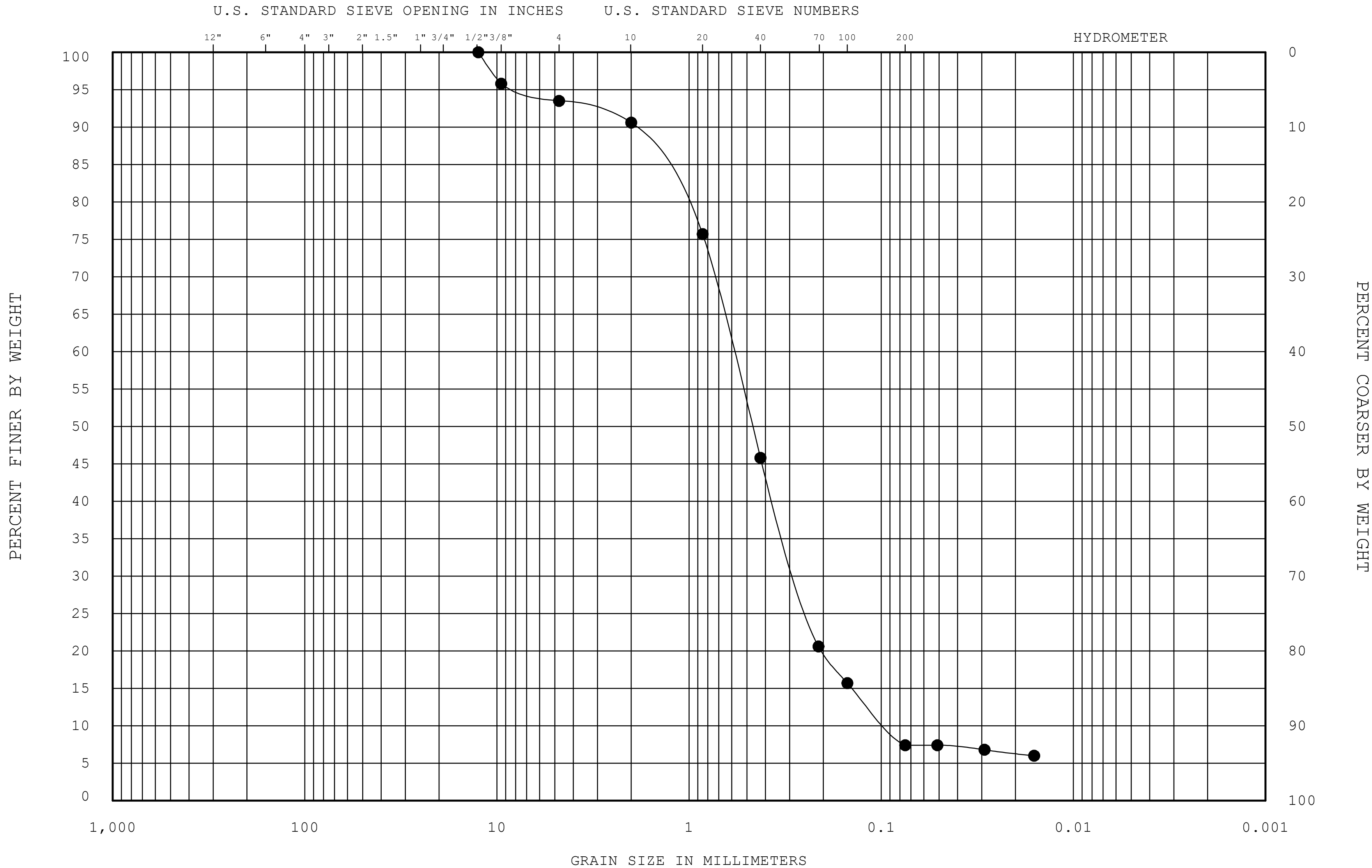
BORING NO.: *DH-21*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-12	22.5-24.0	WELL-GRADED SAND with SILT	SW-SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

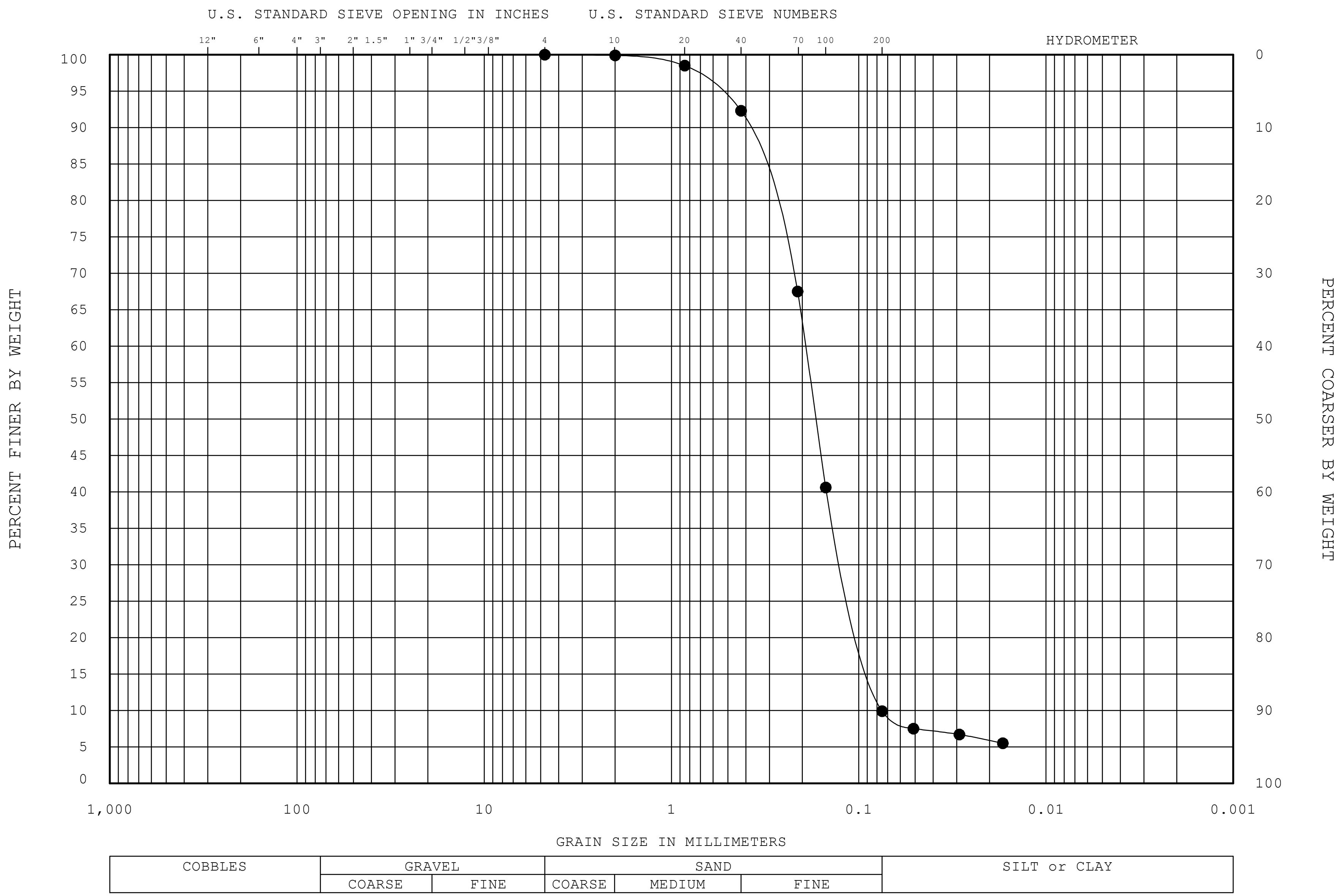
BORING NO.: *DH-24*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-13	25.0-26.5	POORLY GRADED SAND with SILT	SP-SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

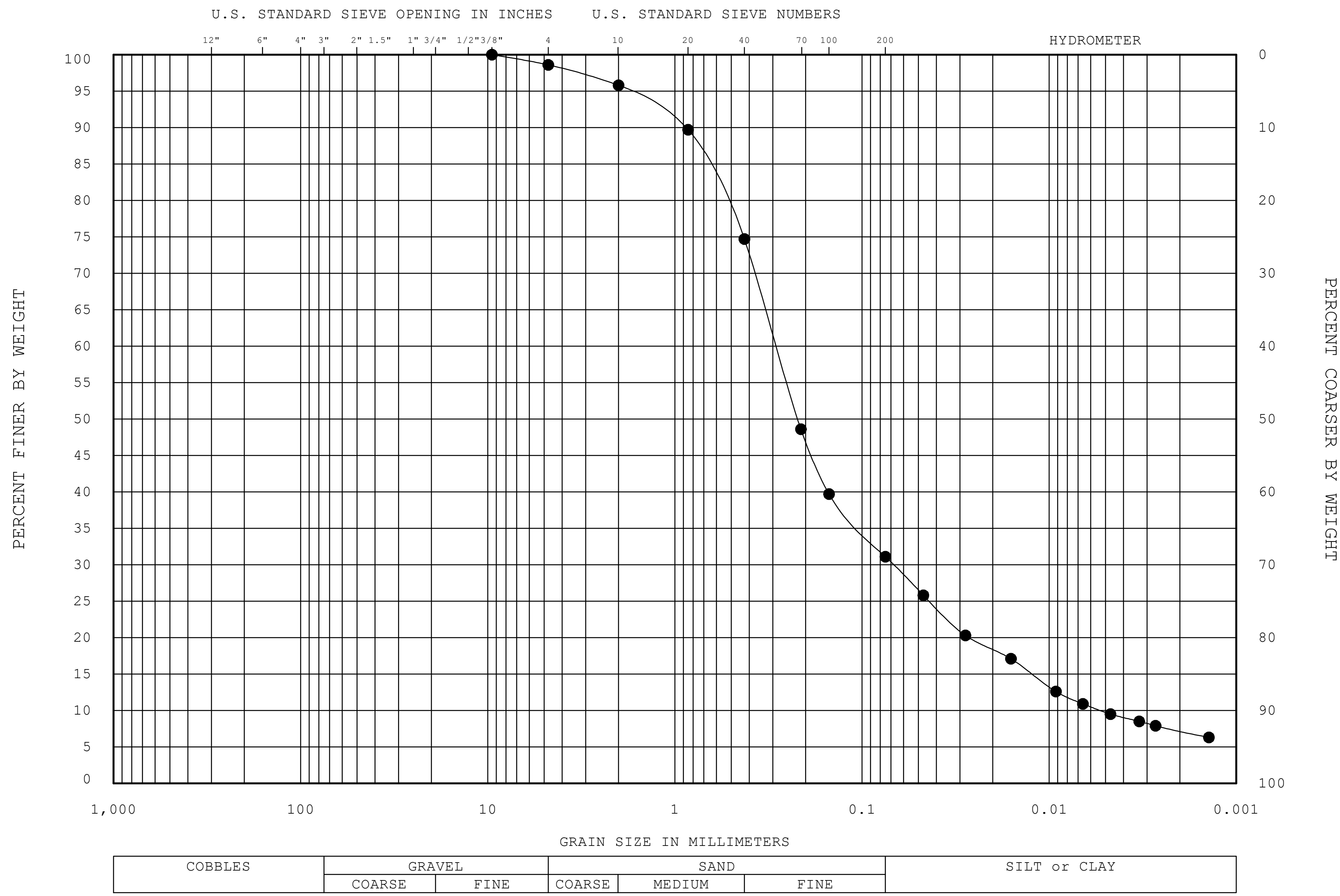
BORING NO.: *DH-24*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	***Depth (ft)***	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-14	27.5-29.0	SILTY SAND	SM				
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

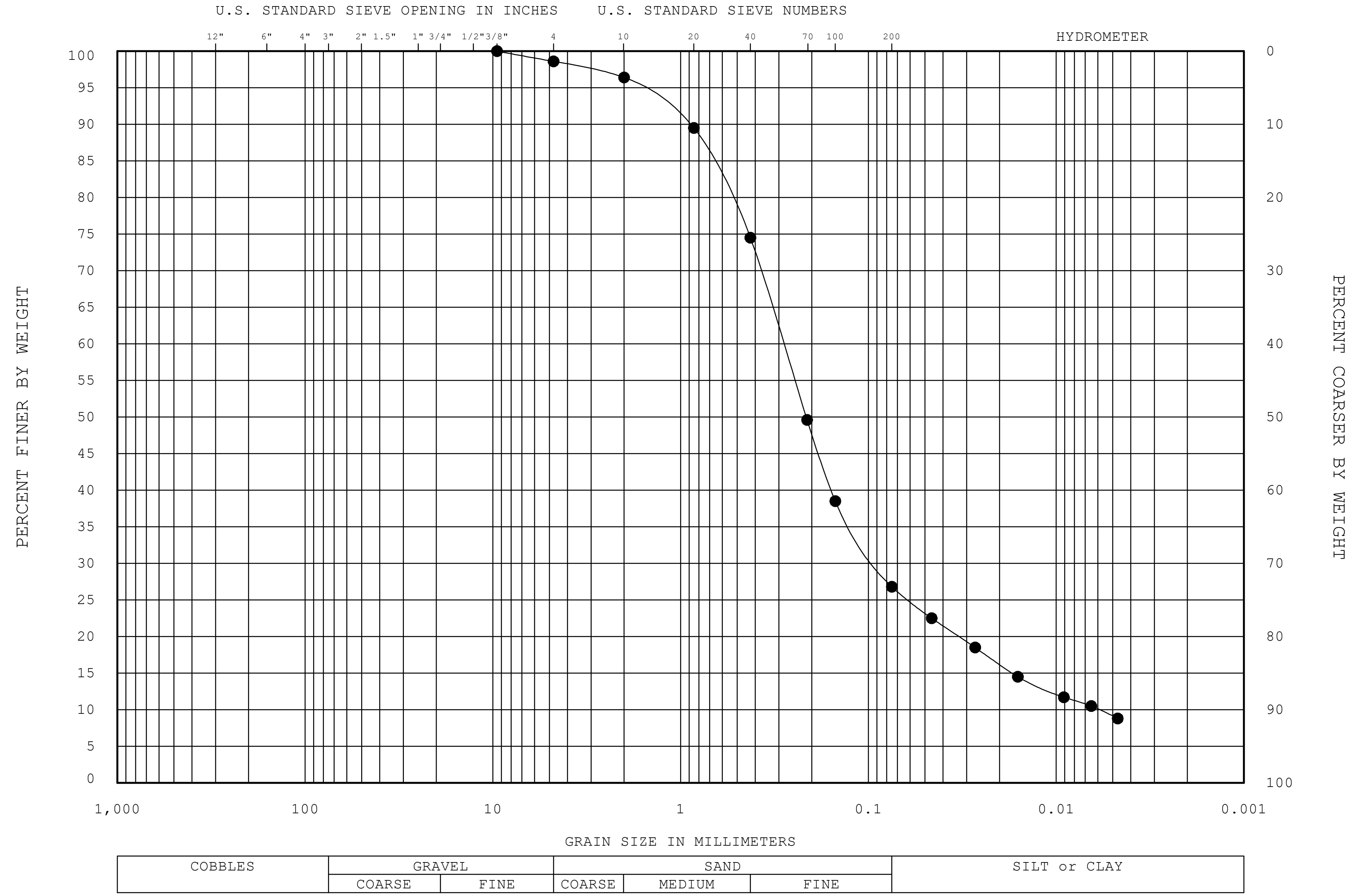
BORING NO.: *DH-24*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar-11	22.5-24.0	SILTY SAND SM				
⊠							
▲							
★							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

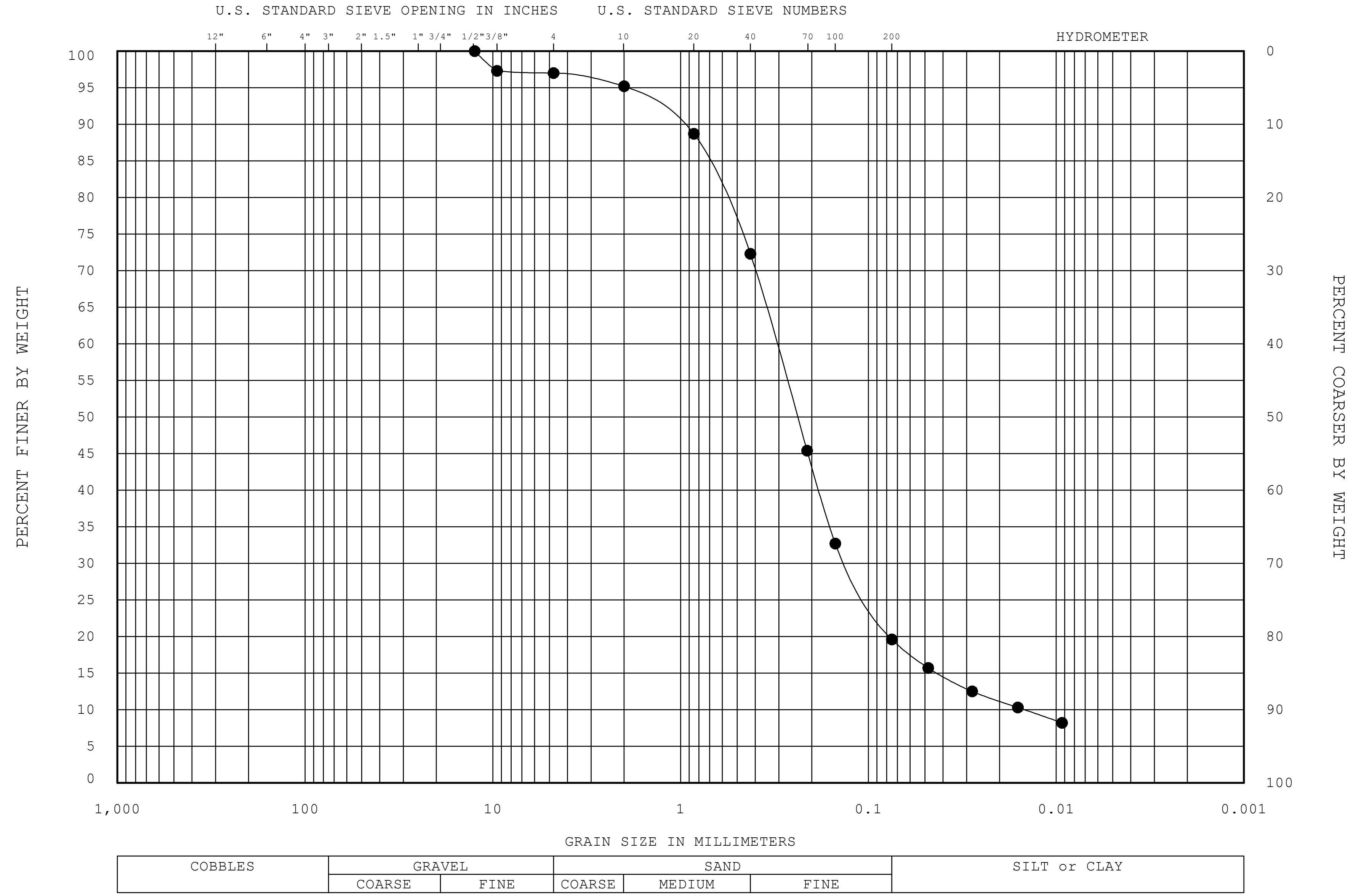
BORING NO.: *DH-27*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-12	25.0-26.5	SILTY SAND	SM				
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▲								
★								

REMARKS : ATTERBERG TEST WAS NOT RUN. .

PROJECT: Staten Island South Shore

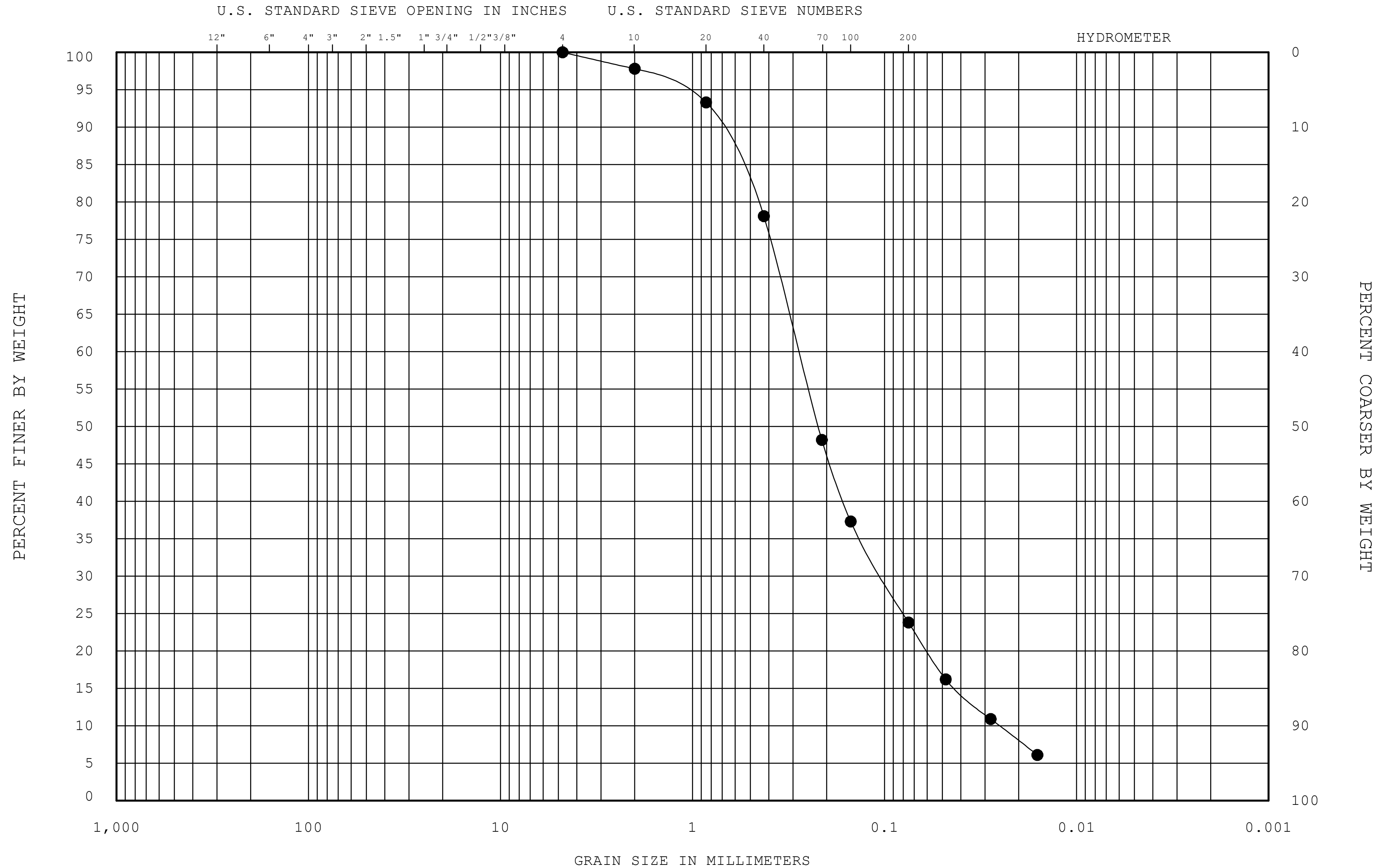
AREA: South Shore

BORING NO.: DH-27

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-14	27.5-29.0	SILTY SAND	SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

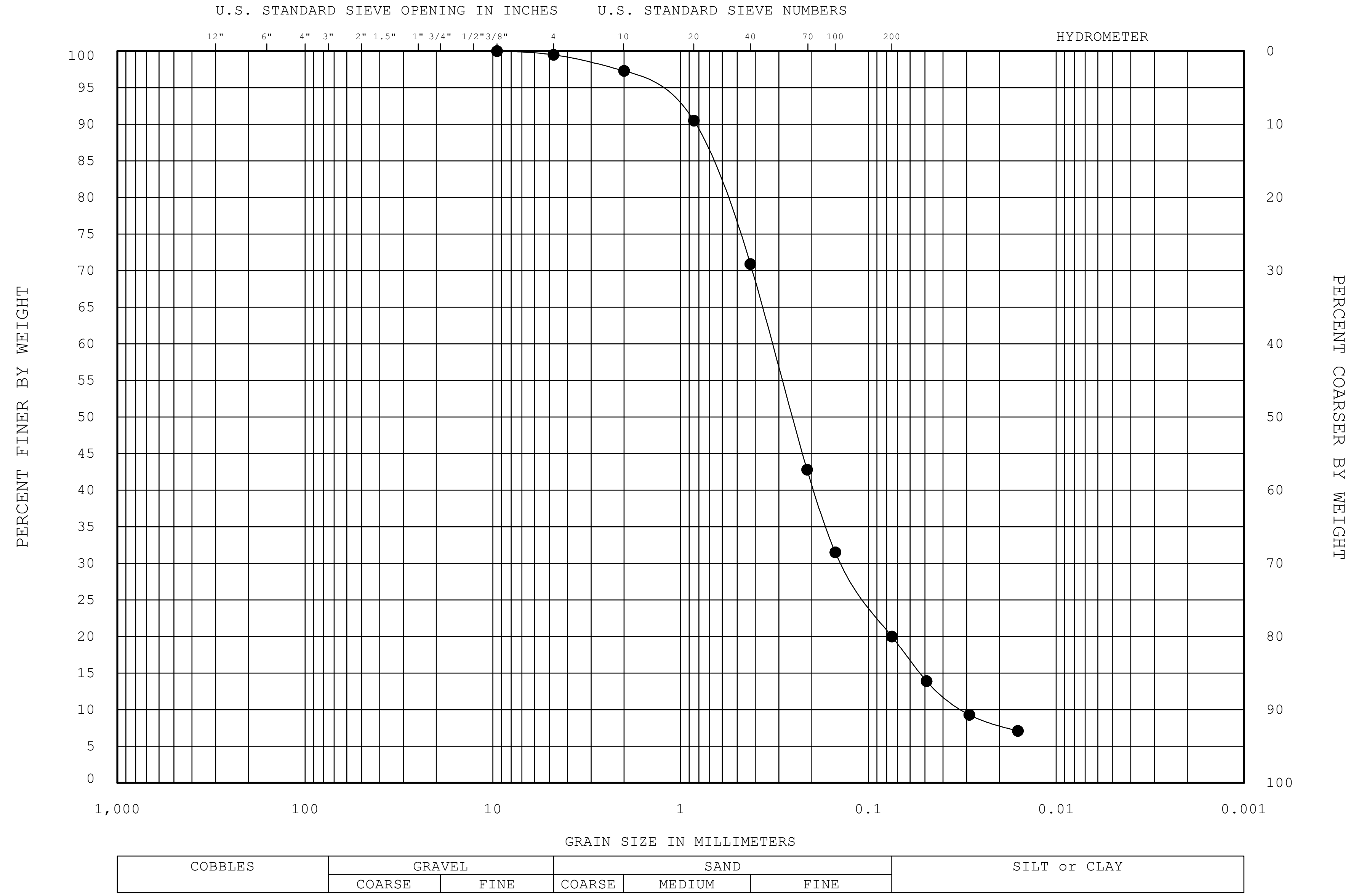
BORING NO.: *DH-27*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-10	22.5-24.0	SILTY SAND	SM				
⊠								
▲								
★								

PROJECT: Staten Island South Shore

AREA: South Shore

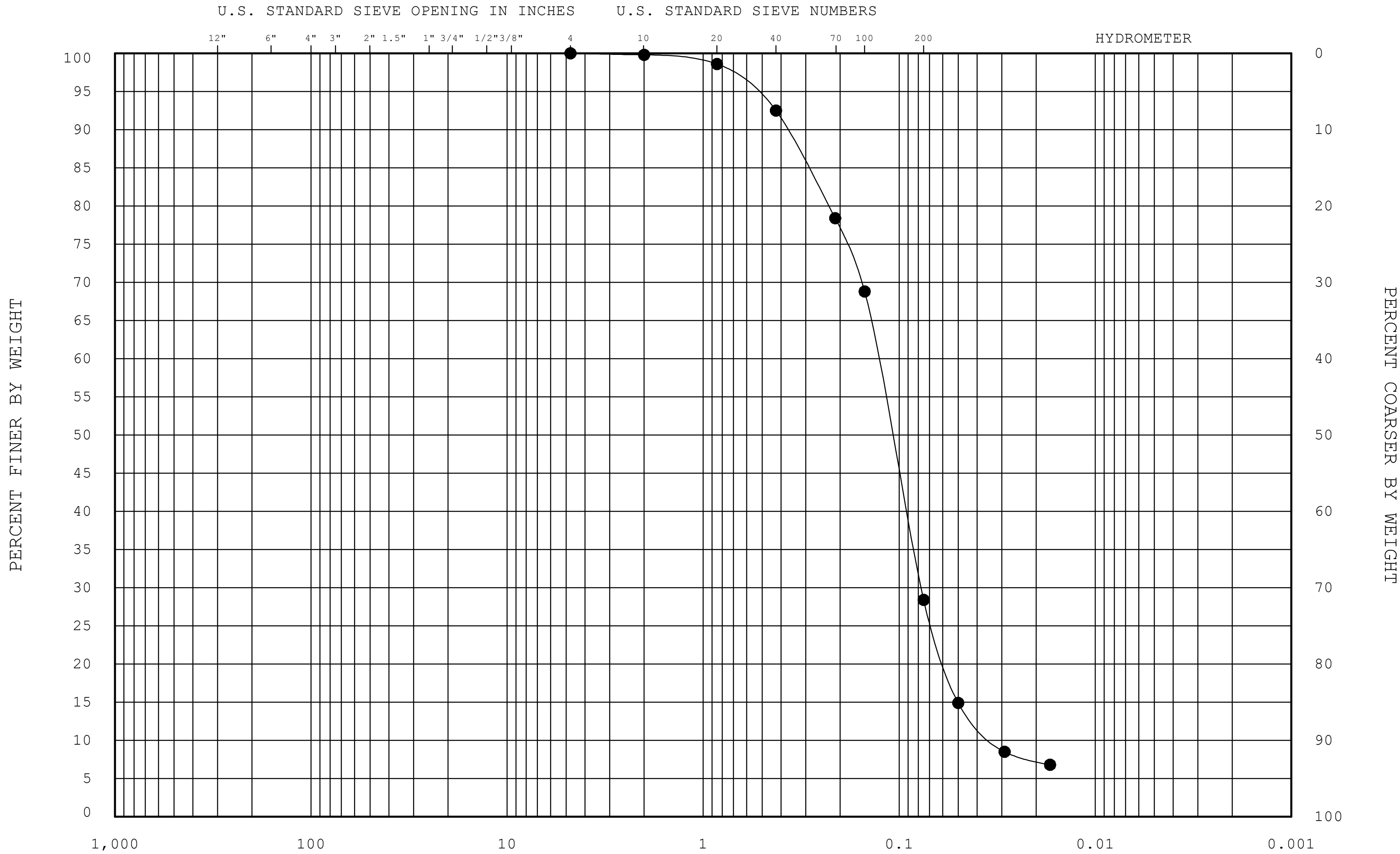
BORING NO.: DH-28

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	***Depth (ft)***	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar-11	25.0-26.5	SILTY SAND	SM				
—⊠—								
—▲—								
—★—								

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

PROJECT: *Staten Island South Shore*

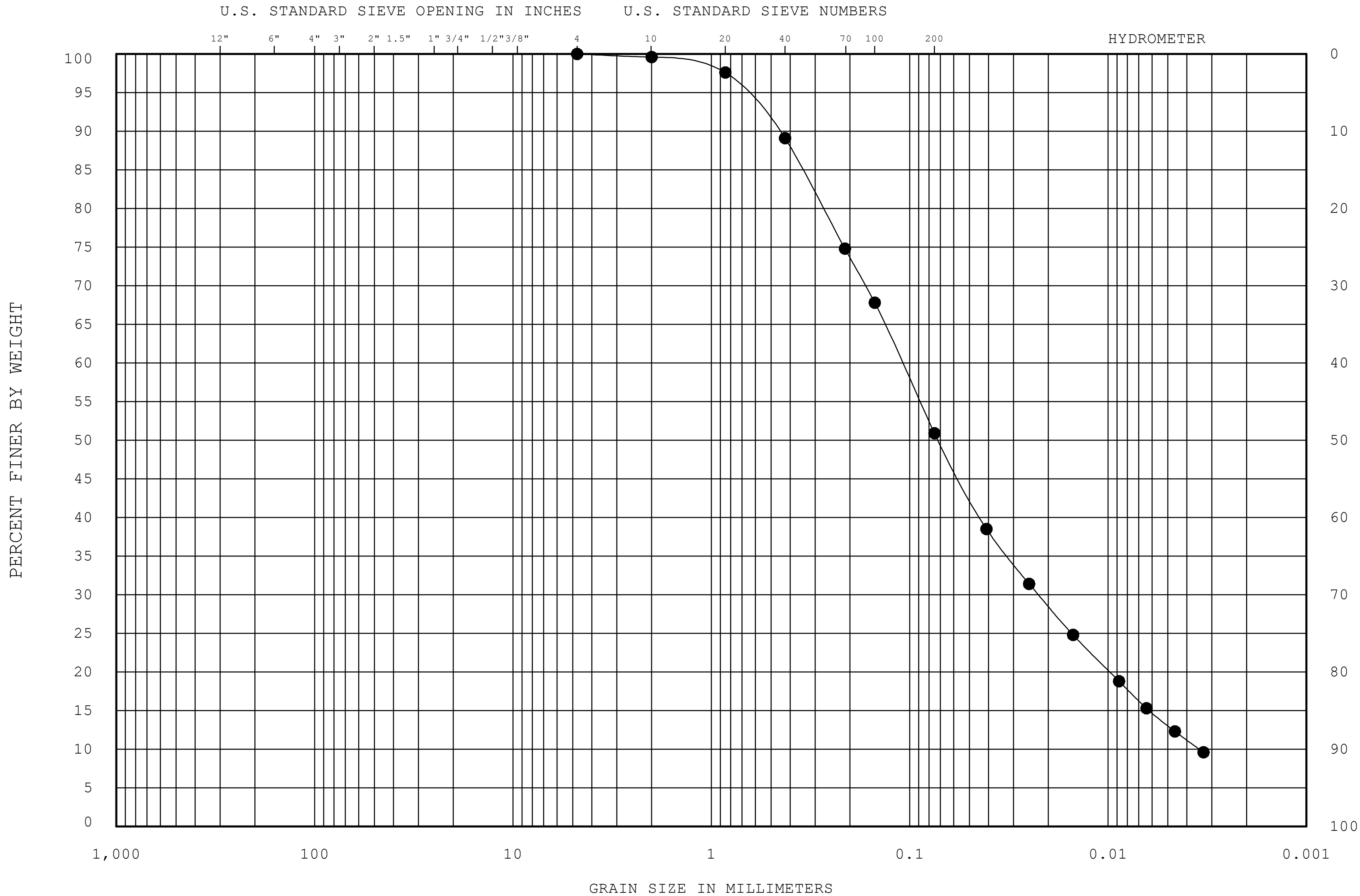
AREA: *South Shore*

BORING NO.: *DH-28*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-12	27.5-29.0	SANDY SILT	ML				
⊠								
▲								
★								

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

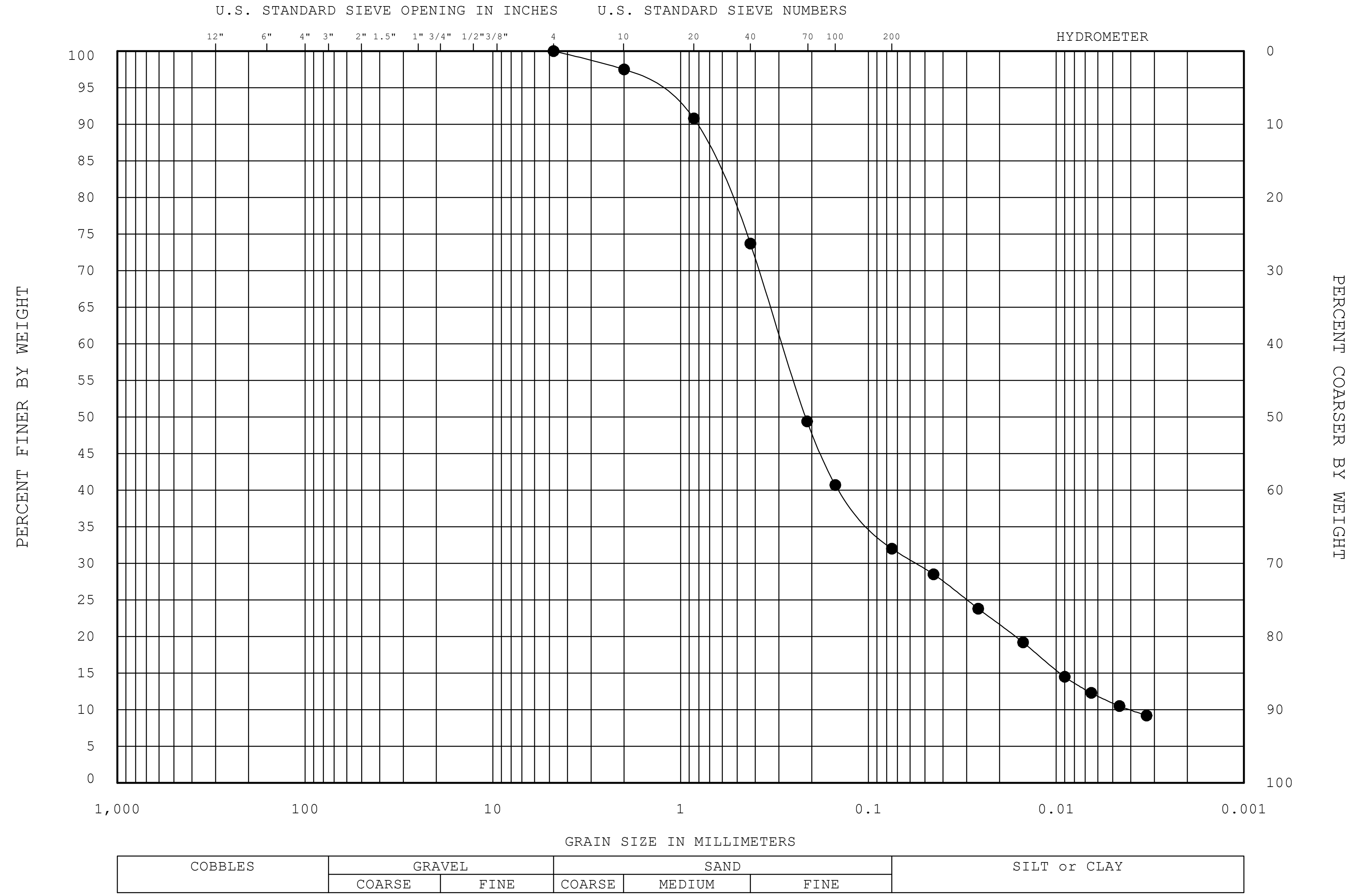
AREA: *South Shore*

BORING NO.: *DH-28*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-13	25.0-26.5	CLAYEY SAND	SC		29	21	8
⊠								
▲								
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PROJECT: *Staten Island South Shore*

AREA: *South Shore*

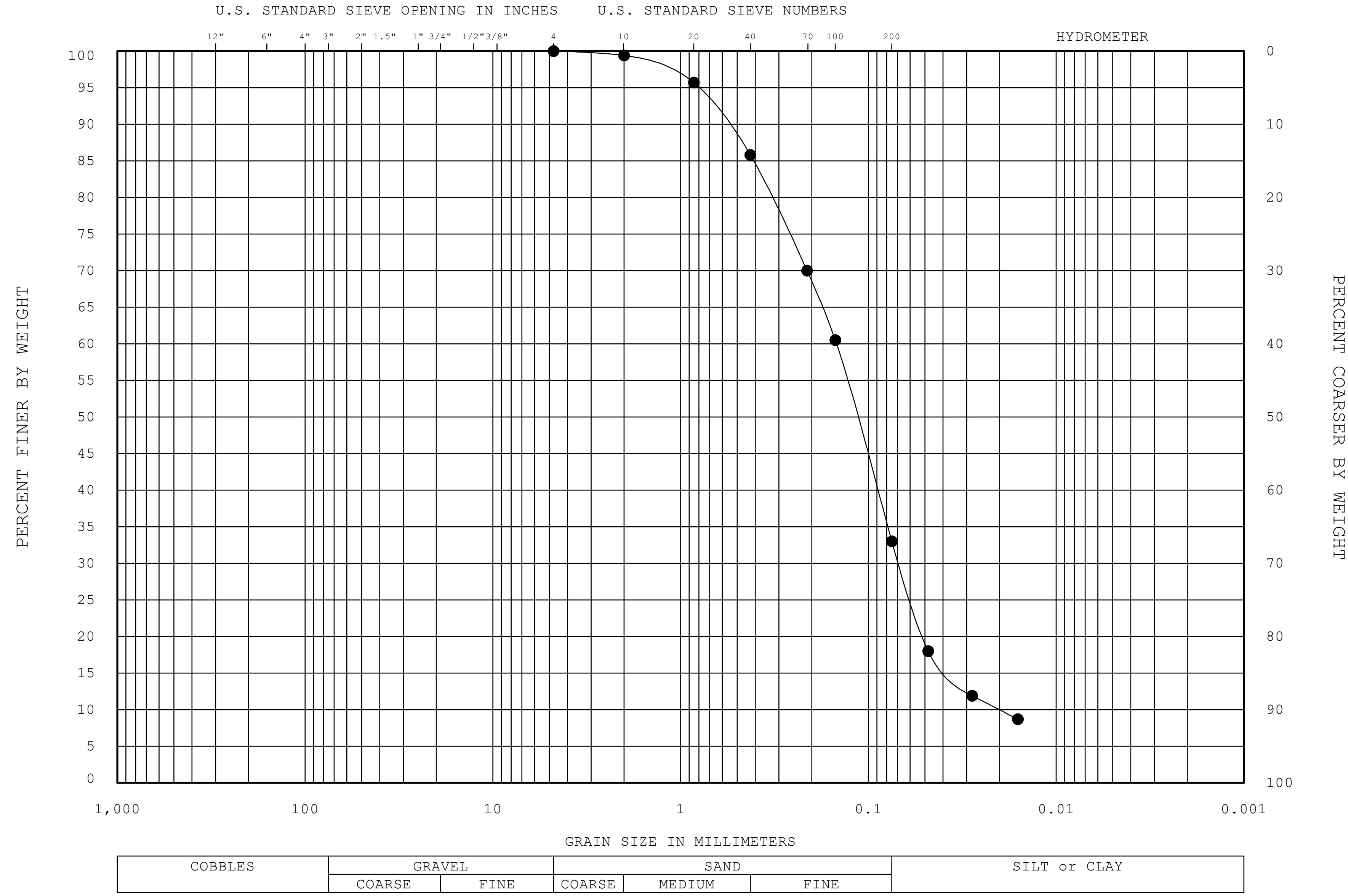
BORING NO.: *DH-30*

DATE:

REMARKS :

ENG FORM ENG2087SSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-16	27.5-29.0	SILTY SAND	SM				
⊠								
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★								

PROJECT: *Staten Island South Shore*

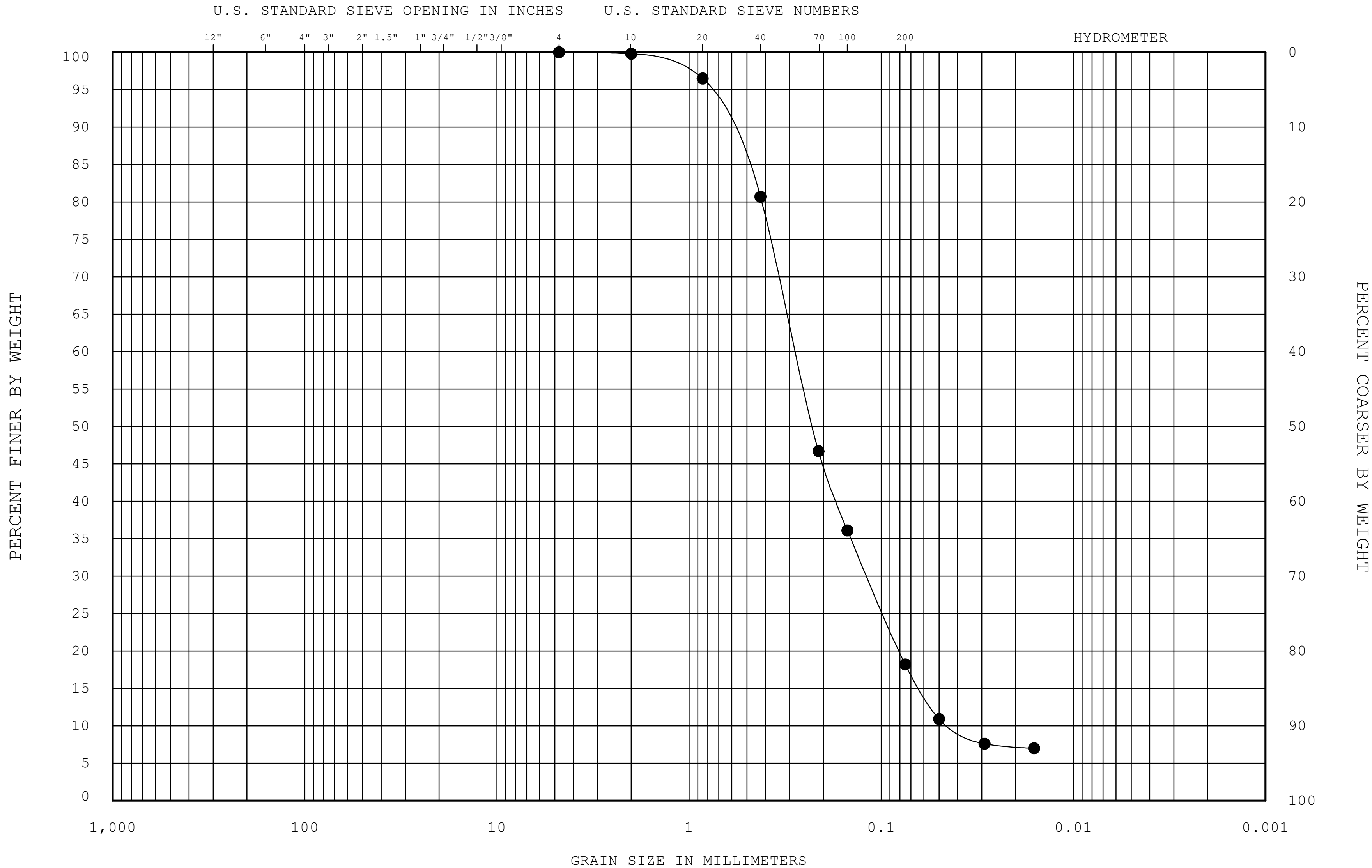
AREA: *South Shore*

BORING NO.: *DH-30*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ **GRADATION CURVES** TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar-17	30.0-31.5	SILTY SAND	SM				
⊠								
▲								
★								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

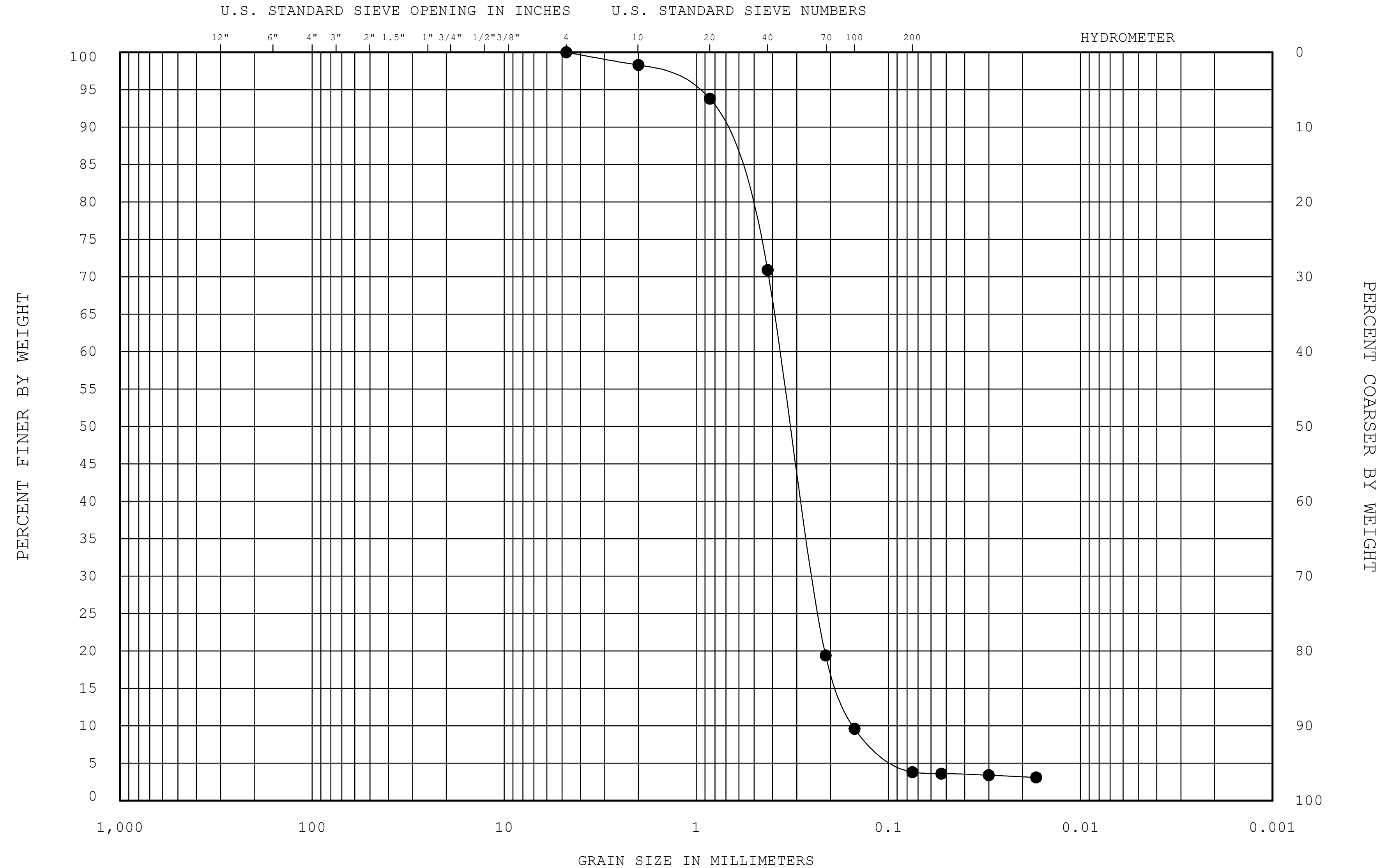
BORING NO.: *DH-30*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar S-10	22.5-24.0	POORLY GRADED SAND	SP				
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

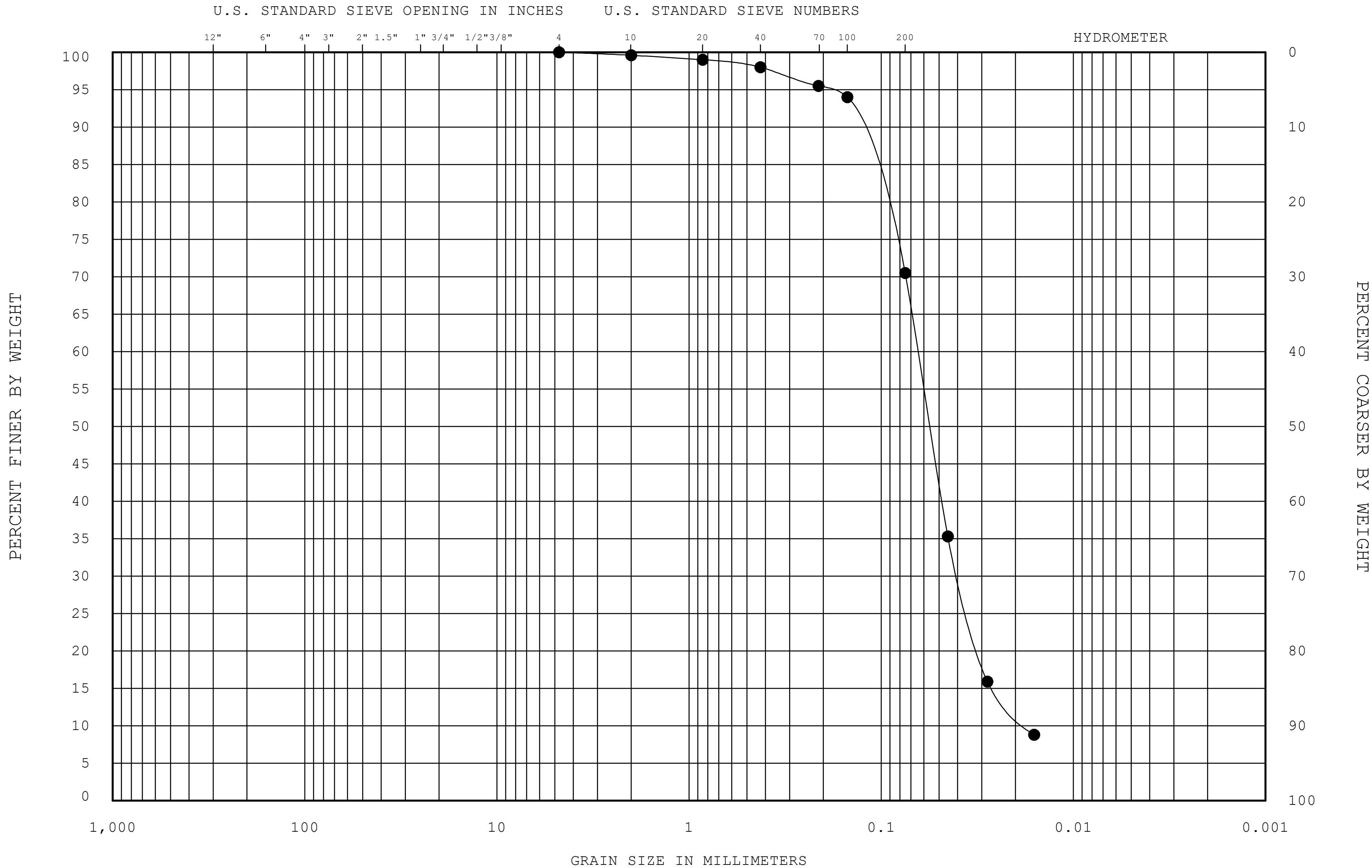
BORING NO.: *DH-31*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
●	Jar S-12	25.4-26.5	SILT with SAND	ML				
⊠								
▲								
★								

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

PROJECT: *Staten Island South Shore*

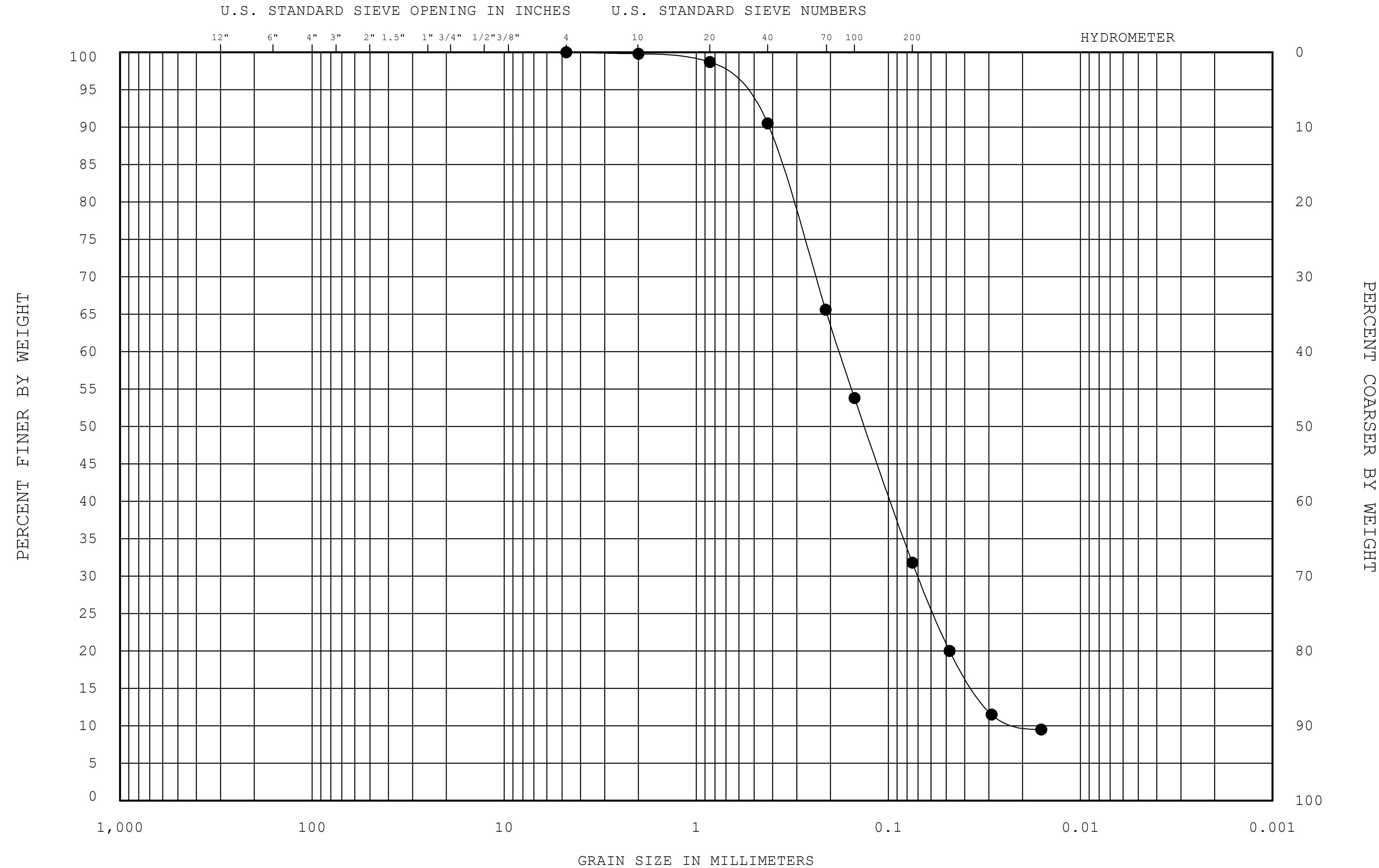
AREA: *South Shore*

BORING NO.: *DH-31*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	Depth (ft)	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar S-13	27.5-29.0	SILTY SAND	SM				
—⊠—								
—▲—								
—★—								

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

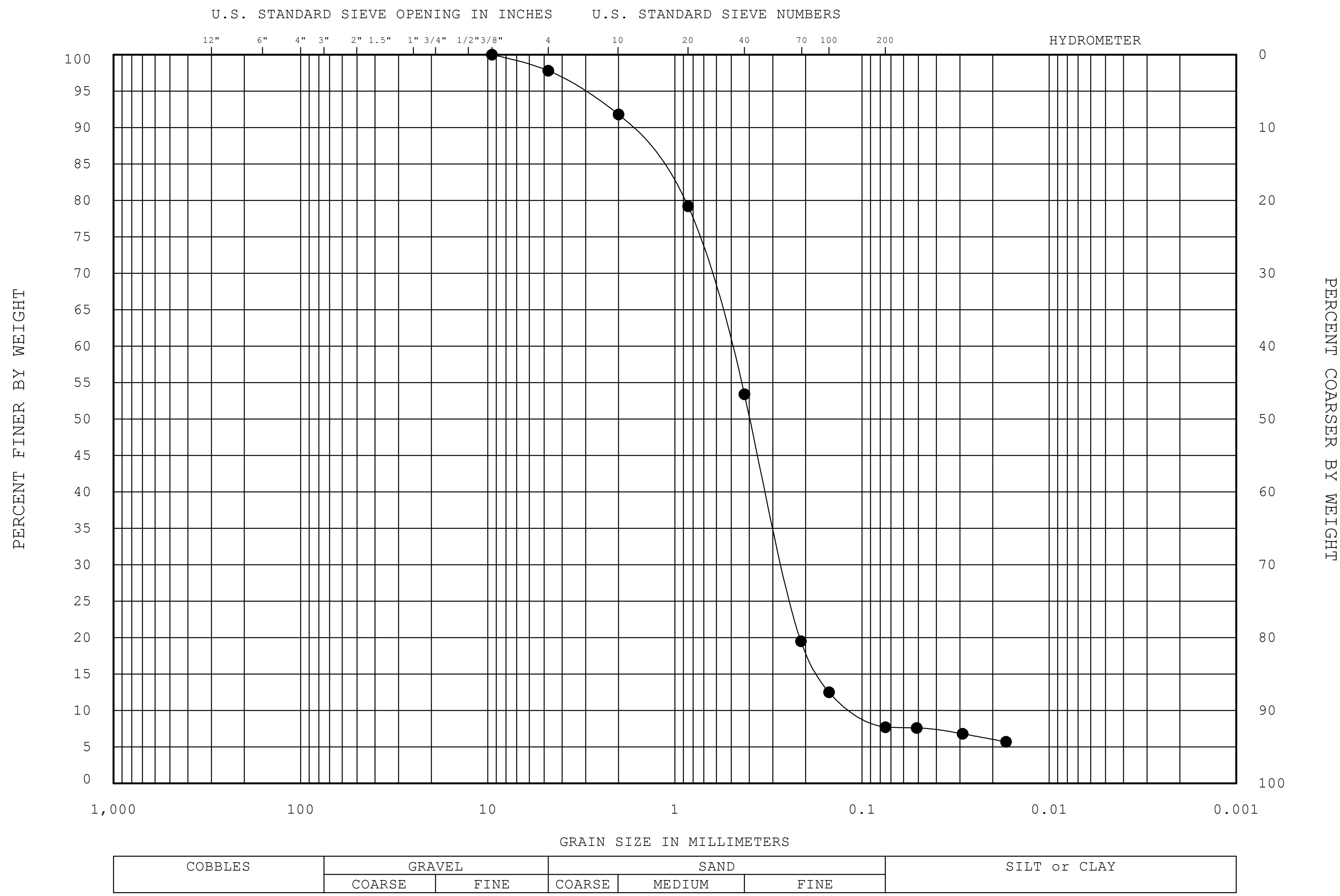
AREA: *South Shore*

BORING NO.: *DH-31*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
●	Jar S-6	12.5-14.0	POORLY GRADED SAND with SILT SP-SM				
⊠							
▲							
★							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

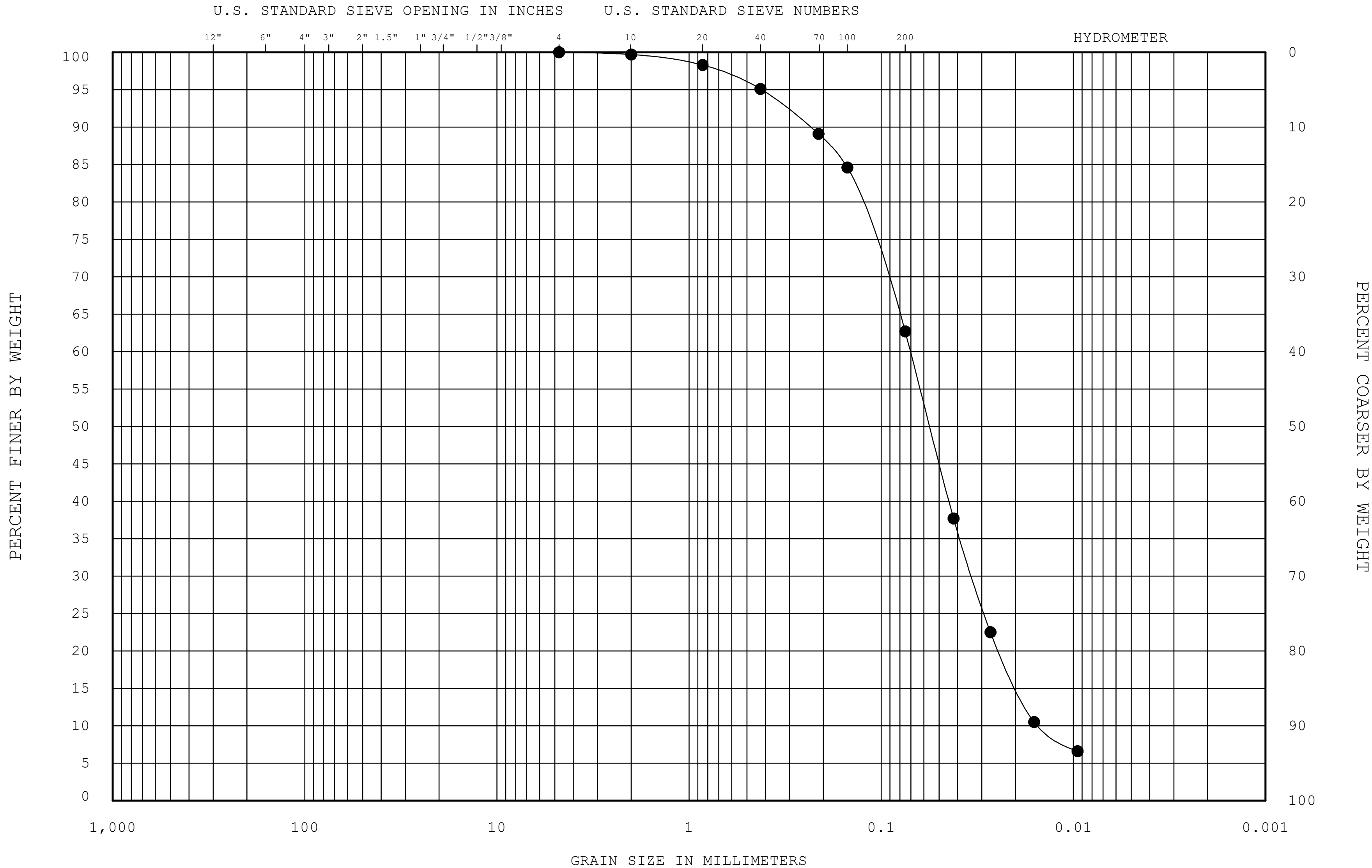
BORING NO.: *DH-32*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar S-7	15.5-16.5	SANDY SILT ML				
—⊠—							
—▲—							
—★—							

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

PROJECT: *Staten Island South Shore*

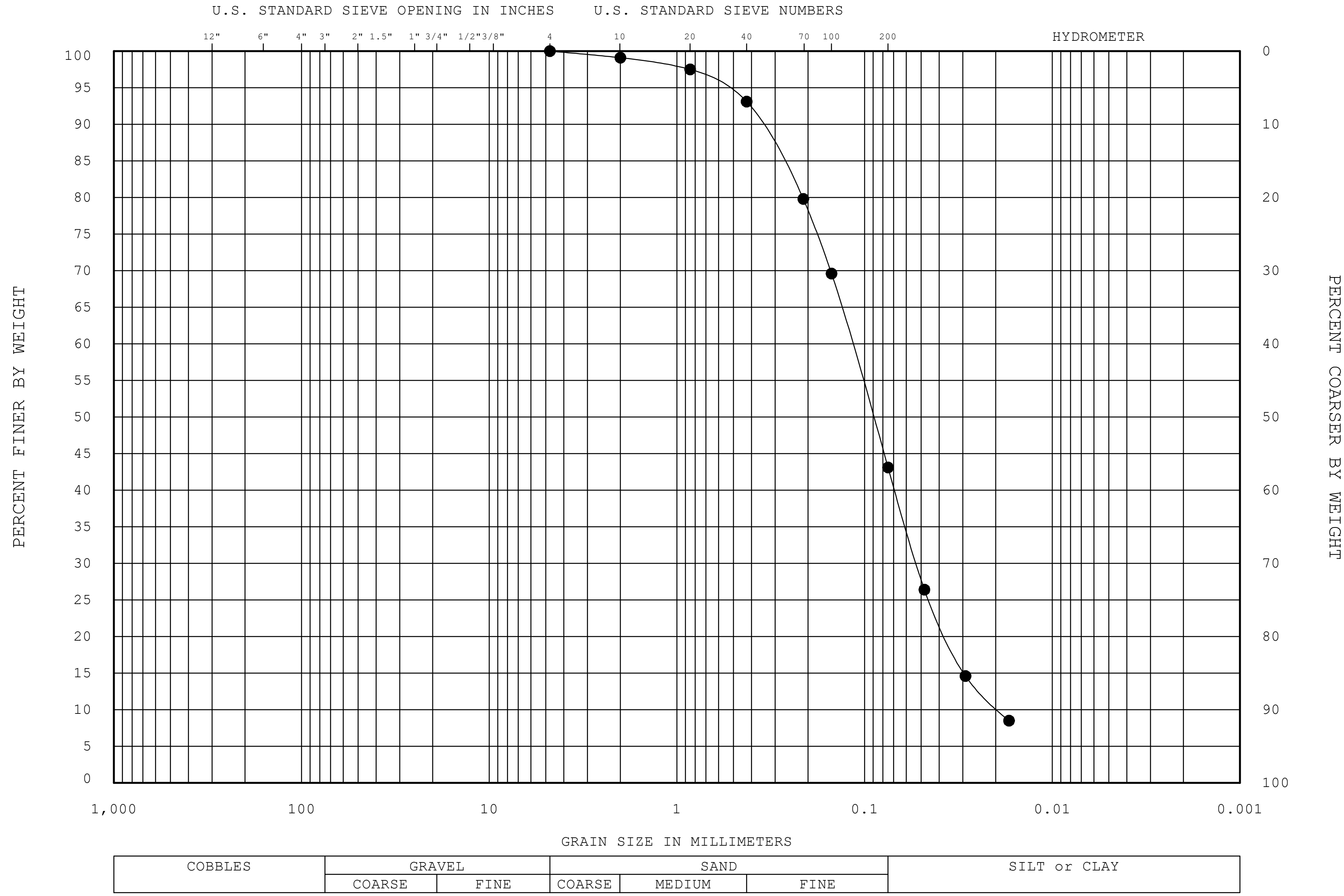
AREA: *South Shore*

BORING NO.: *DH-32*

DATE:

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)		Nat wc%	LL	PL	PI
—●—	Jar S-9	17.5-18.0	SILTY SAND	SM				
—⊠—								
—▲—								
—★—								

PROJECT: *Staten Island South Shore*

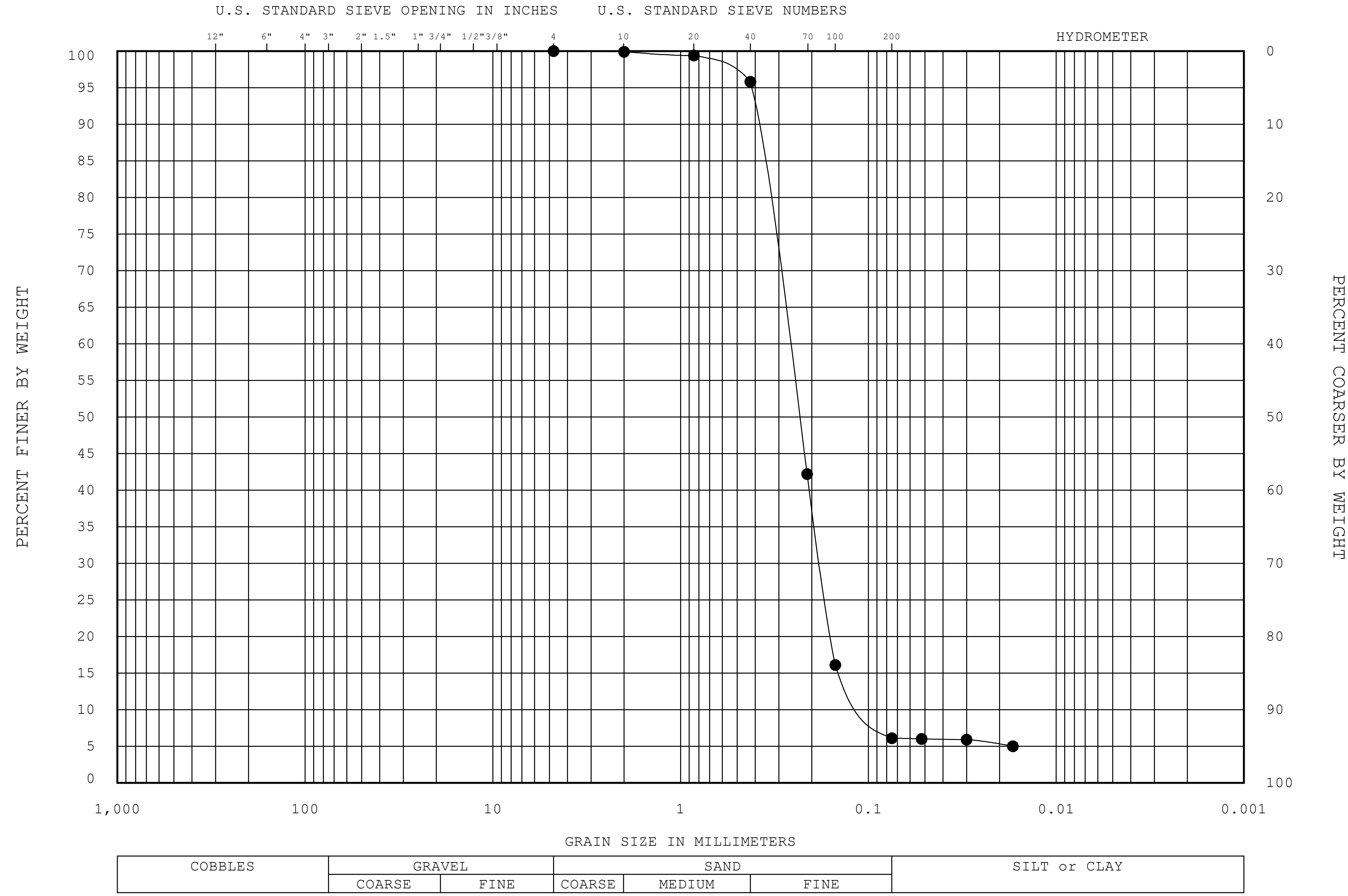
AREA: *South Shore*

BORING NO.: *DH-32*

DATE:

REMARKS : *ATTERBERG TEST WAS NOT RUN.*

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216



Legend	Sample No.	*Depth (ft)*	Classification (ASTM D 2487)	Nat wc%	LL	PL	PI
—●—	Jar S-10	20.0-21.5	POORLY GRADED SAND with SILT SP-SM				
—⊠—							
—▲—							
—★—							

PROJECT: *Staten Island South Shore*

AREA: *South Shore*

BORING NO.: *DH-32*

DATE:

REMARKS : ***ATTERBERG TEST WAS NOT RUN.***

ENG FORM ENG2087 NO ATTSSSSI PART 4 FEB2020.GPJ

GRADATION CURVES TEST METHODS: ASTM D 422, D4318, D2216

Appendix H

RESUMES

JAMES S. LEE, III, M.A., RPA
Vice President
Principal Investigator/Archaeologist

EDUCATION

M.A., Archaeology, University of Durham, Durham, United Kingdom, 1996

B.A., Anthropology and History, Rutgers University, New Brunswick, New Jersey, 1995

EXPERIENCE

2015-present — Vice President/Principal Investigator/Archaeologist
Hunter Research, Inc., Trenton, NJ

Vice President of firm providing archaeological and historical research, survey, excavation, evaluation, report preparation and public outreach services in the Northeastern United States. Responsible for:

- Project management, budgeting and scheduling
- Technical and synthetic writing
- Proposal preparation, contract negotiation and management
- Hiring and supervision of personnel
- Supervision of research, fieldwork, analysis and report preparation

2001-2015 — Principal Investigator
Hunter Research, Inc., Trenton, NJ

Technical and managerial responsibilities for survey, evaluation and mitigation of selected archaeological projects. Technical and managerial responsibility for report production. Participation in:

- overall site direction and day-to-day management
- development and implementation of research, excavation and analysis strategies for prehistoric and historic archaeological sites
- supervision of cartographic and GIS product, graphic design and report layout
- hiring and supervision of personnel

2001 — Crew Chief
Kittatinny Archaeological Research, Stroudsburg, Pennsylvania

- survey and excavation
- supervision of field personnel
- stratigraphic and artifact analysis

1997-2001 — Principal Investigator/Project Manager
Cultural Resource Consulting Group, Highland Park, New Jersey

- overall site direction and day-to-day management
- development and implementation of research, excavation and analysis strategies for prehistoric and historic archaeological sites
- report and proposal preparation
- hiring and supervision of personnel

1997-2000 Laboratory Supervisor
Cultural Resource Consulting Group, Highland Park, New Jersey

Technical and managerial responsibilities for laboratory components of archaeological projects. Participation in:

- management of laboratory operations
- supervision of laboratory personnel
- computerization of artifact data
- prehistoric and historic ceramic analysis
- preparation of artifact inventories and writing of artifact sections of reports

1996-1997 Field Technician
Cultural Resource Consulting Group, Highland Park, New Jersey

SPECIAL SKILLS AND INTERESTS

- canals and associated water control structures
- waterpowered mill sites
- iron manufacture
- prehistory of the northeastern United States
- prehistoric lithic technology
- historic sites interpretation and public outreach

CERTIFICATIONS

Secretary of the Interior's Professional Qualification Standards for Archaeologists (36 CFR Part 61)
Register of Professional Archaeologists
OSHA 40-hour Initial Training, 2002
OSHA 8-hour Refresher Course, 2012

PROFESSIONAL AFFILIATIONS

Society for Industrial Archaeology
Archaeological Society of New Jersey, Member at Large
Society for Pennsylvania Archaeology
New York State Archaeological Association
Canal Society of New Jersey
Warren County Morris Canal Committee
Eastern States Archaeological Federation
Middle Atlantic Archaeological Conference

SELECTED PRESENTATIONS

"The Fishkill Supply Depot: Archaeological Synthesis" Paper presented to the Friends of the Fishkill Supply Depot, October 25, 2015.

"Archaeological Investigations at the Tulpehacken Nature Center, Abbott Marshlands, Mercer County, New Jersey." Paper presented to the Archaeological Society of New Jersey, March 21, 2015.

"The Last 100 Years at Morris Canal Plane 9 West." Paper presented to the Canal Society of New Jersey, November 21, 2014 (with James Lee Jr.).

“Ephrata Tract Archaeological Assessment.” Paper presented to the Moravian Historical Society, October 20, 2014.

“Archaeological Investigations in the Shadow of the Gap, I-80 Weigh Station Site (28Wa290).” Paper presented to the Society for Pennsylvania Archaeology, Forks of the Delaware Chapter 14. April 3, 2013.

“Exploring the Industrial Archaeological Resources of Waterloo Village.” Paper presented to the Canal Society of New Jersey, March 15, 2013 (with Richard W. Hunter).

“Archaeological Investigations at Morris Canal Lock 2 East, Wharton, New Jersey.” Paper presented to the Canal Society of New Jersey, March 16, 2012.

“Delaware and Raritan Canal Lock #1, Hamilton Township, Mercer County, New Jersey.” Paper presented to the Canal Society of New Jersey, December 1, 2010 (with Richard W. Hunter).

“The Archaeological Potential of the Morris Canal.” Paper presented to the Archaeological Society of New Jersey, March 19, 2007.

“Planes and Plans: The Morris Canal in Warren County.” Paper presented to the New Jersey Historic Preservation Conference, April 23, 2004.

Richard W. Hunter
PRESIDENT

Patrick Harshbarger
VICE PRESIDENT

James S. Lee
VICE PRESIDENT

ERYN C. BOYCE
Architectural Historian/Historian, MS

EDUCATION

M.S., Historic Preservation, University of Pennsylvania, 2015
B.A., History, Hamilton College, 2013

EXPERIENCE

June 2016-present	Architectural Historian/Historian Hunter Research, Inc., Trenton, New Jersey Execution of research in support of historic, historic architectural and archaeological studies including: • review of primary and secondary source materials • title research • genealogical investigation • review of historic cartographic materials • selected contributions to reports
December 2015-June 2016	Program Associate New Jersey Historic Preservation Office, Trenton, New Jersey ▪ performed Section 106 reviews on above-ground projects. ▪ determined eligibility of resources ▪ studied buildings' historic contexts ▪ evaluated project effects
December 2015-June 2016	Intern Heritage Consulting, Inc., Philadelphia, Pennsylvania • conducted background research • compiled written reports • edited grants and strategic plans • assisted principal during stakeholder meetings.
September 2013-June 2016	Site Assistant/Interpreter Fonthill Castle, Doylestown, Pennsylvania • developed, implemented, and evaluated tours, programs and special events • led the planning and execution of annual Old-Fashioned Fourth of July event • assisted with interviewing, training and supervision of volunteers
December 2014-March 2015	Research Assistant/Teaching Assistant University of Pennsylvania, Philadelphia, Pennsylvania • researched literature on identity • teaching assistant for American Architecture class
May 2014-August 2014	Property Care Intern Historic New England, Boston, Massachusetts • compiled background information Eustis Estate in Milton, MA • wrote conditions assessment report for Eustis Estate
May 2013-August 2013	Museum Education/Marketing Intern Erie Canal Museum, Syracuse, New York • planned, developed and implemented series of eight family programs • designed and implemented marketing campaign for family programs

June 2012- August 2012 — Museum Education Intern
Strawberry Banke Museum, Portsmouth, New Hampshire
- developed lesson plans for summer camp activities
- worked at four summer camps and led camp activities

May-Aug 2011, May-Aug 2010 — Intern
Fonthill Castle, Doylestown, Pennsylvania
- gave tours
- developed activities for summer camps and birthday parties

SPECIAL SKILLS
Proficient with Microsoft Office Suite, Adobe Creative Suite and ArcGIS

Richard W. Hunter
PRESIDENT

Patrick Harshbarger
VICE PRESIDENT

James S. Lee
VICE PRESIDENT

RICHARD W. HUNTER
President/Principal Archaeologist, Ph.D., RPA

EDUCATION

Ph.D., Geography, Rutgers University, New Brunswick, New Jersey, 1999.
Dissertation Title: *Patterns of Mill Siting and Materials Processing: A Historical Geography of Water-Powered Industry in Central New Jersey*

M.A., Archaeological Science, University of Bradford, England, 1975

B.A., Archaeology and Geography, University of Birmingham, England, 1973

EXPERIENCE

1986-present President/Principal Archaeologist
Hunter Research, Inc., Trenton, NJ

Founder and principal stockholder of firm providing archaeological and historical research, survey, excavation, evaluation, report preparation, historic exhibit development and public outreach services in the Northeastern United States. Specific expertise in historical and industrial archaeology (mills, iron and steel manufacture, pottery manufacture), historical geography, historic landscape analysis, historic interpretive design and public outreach products. Participation in:

- Project management, budgeting and scheduling
- Proposal preparation and client negotiation
- Hiring and supervision of personnel
- Supervision of research, fieldwork, analysis and report preparation
- Historic exhibit development, popular and academic publications and public presentations

1999-2004 Faculty Member, Certificate in Historic Preservation
Office of Continuing Education, Drew University, Madison, NJ

Courses: The Role of Archaeology in Preservation
25 Years of Public Archaeology in New Jersey

1983-1986 Vice-President/Archaeologist
Heritage Studies, Inc., Princeton, NJ

Principal in charge of archaeological projects. Responsibilities included:

- Survey, excavation, analysis, and reports
- Client solicitation, negotiation, and liaison
- Project planning, budgeting, and scheduling
- Recruitment and supervision of personnel

1981-1983 Principal Archaeologist
Cultural Resource Group, Louis Berger & Associates, Inc., East Orange, NJ

Directed historical and industrial archaeological work on major cultural resource surveys and mitigation projects in the Mid-Atlantic region. Primary responsibility for report preparation and editing.

1979-1981 Archaeological Consultant, Hopewell, NJ

1978-1981 Adjunct Assistant Professor, Department of Classics and Archaeology, Douglass College, Rutgers University, NJ

1978-1979 Research Editor
Arete Publishing Company, Princeton, NJ

Prepared and edited archaeological, anthropological, and geographical encyclopedia entries (*Academic American Encyclopedia*, 1980).

1974-1977 Archaeological Field Officer
Northampton Development Corporation, Northampton, England

Supervised archaeological salvage projects executed prior to development of the medieval town of Northampton (pop. 230,000).

Experience included:

- Monitoring of construction activity
- Supervision of large scale urban excavations
- Processing of stratigraphic data and artifacts
- Preparation of publication materials

1969-1970 Research Assistant
Department of Planning and Transportation, Greater London Council

SPECIAL SKILLS AND INTERESTS

- water-powered mill sites
- canals and urban water powers
- iron and steel manufacture
- pottery manufacture
- historic cartography
- scientific methods in archaeology
- historic sites interpretation and public outreach

SELECTED PUBLICATIONS

"New York's Urban Archaeology. The Forts Landscape Reconstruction Project: Central Park's Revolutionary War Forts." *Archaeological Institute of America, New York Society News*, Winter 2015:6-8.

Sartori to Sacred Heart: Early Catholic Trenton. Sacred Heart Church [2014] (with Patrick Harshbarger).

"Historical Archaeology in Trenton: A Thirty-Year Retrospective." In *Historical Archaeology of the Delaware Valley, 1600-1850*, edited by Richard Veit and David Orr. University of Tennessee Press, Knoxville, Tennessee [2013] (with Ian Burrow).

"A Sugar Bowl of William Young & Sons or William Young's Sons." *Trenton Potteries* 13 (1):1-3 [2013].

"Internal Oxidation of Cast Iron Artifacts from an 18th-century Steel Cementation Furnace." *Journal of Archaeological Science* XXX, 1-8 [2012] (with Colin Thomas and Robert Gordon).

"Steel Away: the Trenton Steel Works and the Struggle for American Manufacturing Independence." In *Footprints of Industry: Papers from the 300th Anniversary Conference at Coalbrookdale, 3-7 June 2009*, edited by Paul Belford, Marilyn Palmer and Roger White. *BAR British Series* 523 [2010] (with Ian Burrow).

"Early Milling and Waterpower." In *Mapping New Jersey: An Evolving Landscape*, edited by Maxine N. Lurie and Peter O. Wacker, pp. 170-179. Rutgers University Press [2009].

"On the Eagle's Wings: Textiles, Trenton, Textiles, and a First Taste of the Industrial Revolution." *New Jersey History* 124, Number 1, 57-98 [2009] (with Nadine Sergejeff and Damon Tvaryanas).

"The Historical Geography and Archaeology of the Revolutionary War in New Jersey." In *New Jersey in the American Revolution*, edited by Barbara J. Mitnick, pp.165-193. Rutgers University Press [2005] (with Ian C.G. Burrow).

"Lenox Factory Buildings Demolished." *Trenton Potteries* 6 (2/3):1-9 [2005].

Fish and Ships: Lamberton, the Port of Trenton. New Jersey Department of Transportation and Federal Highway Administration [2005] (28-page booklet).

Power to the City: The Trenton Water Power. New Jersey Department of Transportation and Federal Highway Administration [2005] (24-page booklet).

Rolling Rails by the River: Iron and Steel Fabrication in South Trenton. New Jersey Department of Transportation and Federal Highway Administration [2005] (24-page booklet).

Quakers, Warriors, and Capitalists: Riverview Cemetery and Trenton's Dead. New Jersey Department of Transportation and Federal Highway Administration [2005] (24-page booklet) (with Charles H. Ashton).

"Keeping the Public in Public Archaeology." In: *Historic Preservation Bulletin*, pp. 6-9. New Jersey Department of Environmental Protection, Division of Parks and Forestry, Historic Preservation Office [2004].

"A Coxon Waster Dump of the Mid-1860s, Sampled in Trenton, New Jersey." In: *Ceramics in America*, edited by Robert Hunter, pp. 241-244. University Press of New England [2003] (with William B. Liebeknecht and Rebecca White).

"The Richards Face – Shades of an Eighteenth-Century American Bellarmine." In: *Ceramics in America*, edited by Robert Hunter, pp. 259-261. University Press of New England [2003] (with William B. Liebeknecht).

"The Pottery Decorating Shop of the Mayer Arsenal Pottery Company." *Trenton Potteries* 4(2):1-7 [2003].

"Minutes of the Potters Union (Part 2)." *Trenton Potteries* 4(1):1-5 [2003].

"Minutes of the Potters Union (Part I)." *Trenton Potteries* 3(4):1-5 [2002].

"Eighteenth-Century Stoneware Kiln of William Richards Found on the Lamberton Waterfront, Trenton, New Jersey." In: *Ceramics in America*, edited by Robert Hunter, pp. 239-243. University Press of New England [2001].

"William Richards' Stoneware Pottery Discovered!" *Trenton Potteries* 1(3):1-3 [2000]. Reprinted in *Bulletin of the Archaeological Society of New Jersey* 59:71-73 [2004].

"Trenton Re-Makes: Reviving the City by the Falls of the Delaware." *Preservation Perspective* XVIII (2): 1, 3-5 [1999]

"Mitigating Effects on an Industrial Pottery." *CRM* 21(9):25-26 [1998] (with Patricia Madrigal).

From Teacups to Toilets: A Century of Industrial Pottery in Trenton, Circa 1850 to 1940, Teachers Guide sponsored by the New Jersey Department of Transportation, 1997 (with Patricia Madrigal and Wilson Creative Marketing).

"Pretty Village to Urban Place: 18th Century Trenton and Its Archaeology." *New Jersey History*, Volume 114, Numbers 3-4, 32-52 [Fall/Winter 1996] (with Ian Burrow).

Hopewell: A Historical Geography. Township of Hopewell [1991] (with Richard L. Porter).

"Contracting Archaeology? Cultural Resource Management in New Jersey, U.S.A." *The Field Archaeologist* (Journal of the Institute of Field Archaeologists) 12, 194-200 [March 1990] (with Ian Burrow).

"American Steel in the Colonial Period: Trenton's Role in a 'Neglected' Industry." In *Canal History and Technology Proceedings* IX, 83-118 [1990] (with Richard L. Porter).

"The Demise of Traditional Pottery Manufacture on Sourland Mountain, New Jersey, during the Industrial Revolution." Ch. 13 in *Domestic Potters of the Northeastern United States, 1625-1850.* Studies in Historical Archaeology, Academic Press [1985].

PROFESSIONAL AFFILIATIONS

Register of Professional Archaeologists (RPA) [formerly Society of Professional Archeologists] (accredited 1979; certification in field research, collections research, theoretical or archival research)
Preservation New Jersey (Board Member, 1994 - 2003)
New Jersey State Historic Sites Review Board (Member, 1983 -1993)
Society for Historical Archaeology
Society for Industrial Archaeology
Society for Post-Medieval Archaeology
Historical Metallurgical Society
Council for Northeast Historical Archaeology
Professional Archaeologists of New York City
Archaeological Society of New Jersey (Life Member; Fellow, 2011)

OTHER AFFILIATIONS

Mercer County Cultural & Heritage Commission (Commissioner, 2011 – present)
Trenton Downtown Association (Board Member, 1998 – present; Board Chair, 2007 - 2008)
Trenton Museum Society, (Trustee, 2011 – present)
Hopewell Township Historic Preservation Commission (Member, 1998 - 2006; Chair 2003 - 2004)
Hopewell Valley Historical Society (Trustee, 2014 – present)

John M. Stiteler
201 Connecticut Hill Rd.
Newfield, NY 14867
Cell – 717-215-7207
stitelerjohn@gmail.com

Title:

Soil scientist/geomorphologist
Archaeologist

Education:

B.A., Anthropology, The Pennsylvania State University, University Park, PA., 1985
M.S., Soil Science, The Pennsylvania State University, University Park, PA., 1997

Responsibilities:

Archaeologist responsible for conducting Phase I, II, and III archaeological investigations including fieldwork, background research, artifact analysis, site interpretation, and report preparation.

Soil scientist/geomorphologist responsible for analysis of soils and landforms of archaeological sites. Foci include assessment of landform and land surface stability; interpretation of depositional and erosional environments; determination of age of soils; assistance in interpretation of paleoenvironmental conditions.

Experience:

1997-Present
Freelance consultant – Conduct studies of soils and geomorphology prior to and during archaeological investigations to guide methodology and aid in site interpretation. Act as field director or crew member on archaeological projects as requested.

1997-2014
Archaeologist and Soil scientist/geomorphologist, Gannett Fleming, Inc, Camp Hill Pa. – Conduct Phase I, II and III archaeological investigations and analyze and interpret soils and settings of archaeological sites.

1992-1997
Graduate Assistant, Land Analysis Lab, The Pennsylvania State University, University Park Conducted research on M.S. thesis "Comparison of Hydrology and Nutrient Balances in Two Small Watersheds in Northeastern Pennsylvania" and other projects. Collected water samples, maintained stream gaging and sampling stations, mapped and characterized soils, analyzed samples and data, and assisted in report preparation.

1994-1996
Biological Aide (soils), U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) Assisted in verifying accuracy and quality of soil mapping boundaries; collected soil data in field; assisted in on-site evaluations and interpretation for NRCS projects; and assisted in collecting crop yield estimates and woodland site indices.

1985-1992
Field Director, Archaeological & Historical Consultants, Inc., Centre Hall, PA. Responsible for conducting Phase I, II, and III archaeological investigations. Directed operations in the field; mapped sites using transit; analyzed artifacts; wrote reports on excavations; and conducted background research and informant interviews.

Selected Projects, 1997-present:

South Shore Staten Island Seawall Project (2018-present). Soil scientist and geomorphologist responsible for examining and describing split-spoon and Geoprobe cores in five-mile long corridor for proposed US Army Corps of Engineers seawall construction. Focus was identification of intact surfaces beneath fill and Late Holocene coastal marine sands and late-glacial through Holocene paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation. Data analysis and report preparation in progress.

Anacostia Streetcar Project, District of Columbia (2016). Soil scientist and geomorphologist responsible for examining and describing Geoprobe and bucket auger cores in proposed mass transit corridor on left bank of Anacostia River. Focus was identification of intact surfaces beneath fill and paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation. Report prepared and submitted to Dovetail Cultural Resource Group, Fredericksburg, VA for submission to DC HPO.

Walter Reed Army Medical Center Transfer Project, District of Columbia (2016). Soil scientist and geomorphologist responsible for examining and describing backhoe trench profiles and bucket auger cores in western third of WRAMC campus. Focus was identification of areas of cut and graded surface, areas of intact surface beneath fill, and paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation prior to transfer of property to Department of State. Report prepared and submitted to Gannett Fleming Engineers for submission to DC HPO.

Prescott Quarry Expansion and Tulpehocken Creek Realignment Projects, Myerstown, Lebanon County, PA (2016). Soil scientist and geomorphologist responsible for conducting walkover and bucket augering of 150 acre parcel slated for quarry expansion and relocation of creek channel. Focus was identification of intact surface beneath existing quarry spoil, identification of former Pennsylvania Union Canal route within study area, and paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation. Report prepared and submitted to Rue Environmental for submission to PA SHPO.

I-95 Improvements, Port Richmond, Philadelphia, PA (2014-2015). Soil scientist and geomorphologist responsible for examining and describing split-spoon and bucket auger cores at 40 acre highway and drainage improvement project area adjacent to Delaware River. Focus was identification of intact surfaces beneath fill and paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation. Report prepared and submitted to Gannett Fleming Engineers, Valley Forge, PA.

Riverside Building 5, 59th Street and Riverside Drive, New York, New York (2013-2015). Soil scientist/geomorphologist responsible for examining and describing GeoProbe cores at proposed development site. Focus was identification of intact surfaces within and beneath fill and paleoenvironmental reconstruction of study area to assist in design of Phase Ib archaeological investigation. Conducted monitoring of fill removal and interpreted soil profiles in Phase I-B archaeological investigation during second phase of project. Reports prepared and submitted to Langan, New York, New York.

WSSC Water Treatment Plant expansion, Potomac, Maryland (2013-2014). Field director and soil scientist/geomorphologist for Ph I and II archaeological investigations at proposed water intake, boat ramp, and access road construction areas within C&O Canal National Historical Park on Potomac River. Report prepared and submitted to Washington Sanitary Services Commission and National Park Service, National Capital Region.

Mashipacong Island Phase II, Montague Township, Sussex County, New Jersey (2013-2014). Soil scientist/geomorphologist for combined Phase II and III archaeological investigation conducted prior to construction of natural gas pipeline. Duties included description of archaeological excavation block profiles and conducting auger probes along proposed pipeline alignment. Report submitted to HRA Gray and Pape LLC, Houston, Texas for inclusion in Phase II/III report.

Cold Spring Gathering Line, Carroll County, Ohio (2013). Soil scientist/geomorphologist responsible for description and interpretation of geomorphology, sediments, and stratigraphy at Phase Ib archaeological investigations of multiple natural gas pipeline crossings of wetlands and streams. Report submitted to Public Archaeology Facility, SUNY Binghamton for inclusion in Phase Ib report.

Moorefield Municipal Water Treatment Plant Expansion, Moorefield, West Virginia (2013). Soil scientist/geomorphologist responsible for description and interpretation of geomorphology, sediments, and stratigraphy at Phase Ib archaeological investigation on South Branch of South Fork Potomac River. Report submitted to Heberling Associates, Alexandria, Pa for inclusion in Phase Ib report.

Valley Forge National Historic Park Asbestos Remediation Project, Valley Forge National Historic Park, Chester County, Pennsylvania (2012). Soil scientist/geomorphologist for Phase Ib archaeological investigation conducted prior to asbestos removal and remediation work within National Park boundaries. Report submitted to Hunter Research, Inc., Trenton, NJ for inclusion in Phase Ib report.

US Route 15 Slide Remediation Project, Tioga Township, Tioga County, Pennsylvania (2011). Field Director and soil scientist/geomorphologist for Phase I and II archaeological investigations conducted by Gannett Fleming Inc. at area proposed for placement of fill to stabilize roadbed, along with Phase I investigations of proposed borrow areas and haul roads. Phase I investigation identified ruins of mid-19th century farmstead at proposed fill area, where Phase II investigation was subsequently conducted. Report prepared and submitted to PennDOT District 3, Montoursville, Pa.

Standard Chlorine Chemical Company Site, Town of Kearney, Hudson County, New Jersey (2011). Soil scientist/geomorphologist for Phase Ib archaeological investigation conducted simultaneously with site remediation work at 60 acre US EPA Superfund site in New Jersey Meadowlands adjacent to Hackensack River. Also served as part of 2-person team conducting archaeological fieldwork at site. Report submitted to United States Environmental Protection Agency, Region 2, New York, New York and to New Jersey State Department of Environmental Protection, Historic Preservation Office, Trenton, NJ.

US Route 1 Improvements, Frederica, Kent County, Delaware (2009). Soil scientist/geomorphologist responsible for description and interpretation of geomorphology, sediments, and stratigraphy for Phase II and III archaeological investigations at location of proposed intersection improvement project, conducted by Archaeological and Historical Consultants, Inc. for DelDOT and Federal Highway Administration. Report submitted to Archaeological and Historical Consultants, Centre Hall, Pa.

Aughwick Creek Watershed (Watershed 12C) Study, Huntingdon and Juniata Counties, Pennsylvania (2008-2009)**.** Soil scientist/geomorphologist responsible for conducting fieldwork and analysis in collaboration with Heberling Associates, Inc.; Dr. Frank Vento, Professor of Geology, Clarion University; and paleobotanist Lucinda McWeeney. Study focus was reconstruction of Quaternary geomorphology and environment in Aughwick Creek drainage in south-central Pennsylvania, particularly formation and relationships of alluvial landforms. Methodology included backhoe trenching, soil augering, sample collection, and analysis of LIDAR and USGS stream-flow data. Study sponsored as alternative mitigation under agreement between PennDOT and Pennsylvania Historical and Museum Commission. Draft report submitted to PennDOT

I-80 Weigh Station Improvements, Delaware Water Gap, New Jersey (2004-2009). Soil scientist/geomorphologist for Phase II and III archaeological investigation at proposed truck weigh station expansion project on alluvial terrace of Delaware River. Reports prepared and submitted to Hunter Research Inc., Trenton, New Jersey.

I-80 Section 078 Bridge Improvements Project, Columbia County, Pennsylvania (2007-2008). Field Director and soil scientist/geomorphologist for Phase I archaeological survey of proposed improvements to I-80 bridge over North Branch Susquehanna River. Phase I report submitted to PennDOT and Pennsylvania Historical and Museum Commission, Harrisburg, Pa.

Strattan Mill Creek Project, Kirkwood Center, Broome County, New York (2007-2009). Soil scientist/geomorphologist responsible for description and interpretation of geomorphology, sediments, and stratigraphy at Phase III archaeological investigation on North Branch Susquehanna River, conducted by the Public Archaeology Facility, SUNY Binghamton for NYDOT. Report submitted to PAF SUNY Binghamton..

PaDEP Watershed 10-D Study, Lycoming, Montour, Northumberland, and Sullivan Counties, Pennsylvania **(**2006-2007). Soil scientist/geomorphologist responsible for conducting literature review and fieldwork and preparing report on late Pleistocene through Holocene geomorphic history of Muncy Creek and Chillisquaque Creek watersheds. Project conducted as adjunct to PP&L water pipeline project. Research focused on comparison of soil and landform formation in glaciated and unglaciated portions of watershed. Report prepared and submitted to Kittatinny Archaeological Research, Inc., Stroudsburg, Pa

Walters Business Park Expansion Project, Sproul, Blair County Pennsylvania (2006). Soil scientist/geomorphologist for Phase II and III archaeological investigations of Paleo-Indian – Early Archaic site within proposed access road relocation APE. Research focused on site formation processes and paleoenvironmental reconstruction. Report submitted to Archaeological and Historical Consultants, Inc, Centre Hall, Pa.

Holtwood PP&L Hydroelectric Plant Expansion Project, Holtwood, Lancaster County, Pennsylvania (2006). Soil scientist/geomorphologist responsible for conducting fieldwork, interpreting soil auger core data and preparing report for study of structure and depositional history of Piney Island and environs in lower Susquehanna River. Report submitted to Hunter Research Incorporated, Kleinschmidt Engineers and Pennsylvania Power and Light Corp.

Kingston Armory Expansion Project, Kingston, Ulster County, New York (2005-2006). Soil scientist/geomorphologist responsible for description and interpretation of geomorphology, sediments, stratigraphy and disturbance prior to and during Phase II and III archaeological investigations at US Army Reserve facility. Report prepared and submitted to Louis Berger Associates, Albany, New York.

Connoquenessing Watershed Study, Butler**,** Beaver and Lawrence Counties, Pennsylvania **(**2005). Soil scientist/geomorphologist responsible for conducting fieldwork, interpreting soil auger core data and preparing report for study of alluvial landforms in Connoquenessing Creek watershed as adjunct to PennDOT Main Street and Wayne Street bridge replacement projects, Butler, Pa. Report prepared and submitted to Archaeological & Historical Consultants, Inc., Centre Hall, PA. and PennDOT District 10.

Garden State Parkway Improvement Project, Ocean, Burlington and Atlantic Counties, NJ (2003). Field Director and soil scientist/geomorphologist for Phase I archaeological investigation along fifty miles of proposed highway improvement project area. Report prepared and submitted to the New Jersey Department of Transportation.

Appomattox River Water Authority Cemetery Site, Chesterfield County, VA (2002-2003). Field Director and soil scientist/geomorphologist for Phase I, II and III archaeological investigations and exhumations of ninety-six 19th century burials at water treatment facility expansion project. Report prepared and submitted to the Appomattox River Water Authority, Petersburg, VA.

Wayne Street and Main Street Bridge Replacement Projects, Butler, Pennsylvania**.** (1999-2001). Soil scientist/geomorphologist responsible for on-site monitoring of split-spoon sampling of soils and sediments along proposed construction corridor over Connoquenessing Creek. Monitored excavation by truck-mounted rig of 25 soil cores from surface to bedrock, described and interpreted soils and sediments revealed in core samples. Used information gained from cores, along with background research and observations of local geomorphology, to reconstruct Late Pleistocene and Holocene development of uplands and floodplain adjacent to Connoquenessing Creek, determine degree of site disturbance within historic era, and assess potential for intact archaeological resources in project areas. Soil scientist for Phase I archaeological investigation – supervised excavation of backhoe trenches; described and interpreted soils and sediments revealed in trenches and archaeological excavation units. Report prepared and submitted to Archaeological & Historical Consultants, Inc., Centre Hall, PA.

U.S. Route 15 Improvements, Tioga County, Pennsylvania **(**1998-2000). Soil scientist/geomorphologist responsible for interpretation of deposition dynamics, site stability, and degree of a disturbance at Phase I, II and III archaeological investigations. Examined soil profiles in backhoe trenches and archaeological excavation units on the Tioga River floodplain to reconstruct post-glacial history and prehistoric occupation of Tioga River Valley in the project area. Reports submitted to Louis Berger Associates, East Orange, New Jersey and to the Pennsylvania Historical & Museum Commission, Harrisburg, PA.

Vineland Chemical Company Superfund Remediation Project, Vineland, NJ, (1998). Soil scientist/geomorphologist responsible for monitoring split-spoon sampling of floodplain sediments from the Blackwater Branch of Maurice River and examining shovel test profiles on adjacent uplands at a U.S. EPA Superfund site. All fieldwork conducted in U.S. EPA Level C PPE. Focus of study was to reconstruct geomorphic history and determine the potential for intact archaeological resources at this arsenic-contaminated site slated for remediation. Report prepared and submitted Hunter Research, Inc., Trenton, NJ. for inclusion in archaeological site report submitted to U.S. Army Corps of Engineers [USACOE], Philadelphia District, and U.S. Environmental Protection Agency [USEPA], Region II.

Ohio River Islands Refuge Project, PA, OH, WV, and KY (1997). Soil scientist/geomorphologist responsible for conducting reconnaissance survey of nine islands over a 400-mile stretch of the Ohio River. Examined and described soils using shovel tests, auger probes, and exposures in erosion faces in order to assess age, rates of sediment accretion, and stability of islands; assessed potential for presence of historic and prehistoric archaeological sites on islands. Prepared and submitted report to USF&WS as part of a larger report submitted by Archaeological & Historical Consultants, Inc. Served as Field Director and Soil Scientist at follow-up Phase I archaeological survey on Manchester Island #2, near Maysville, Kentucky. Prepared and submitted report to USF&WS as part of report submitted by Archaeological & Historical Consultants, Inc., Centre Hall, Pennsylvania.

Selected Reports, Publications and Presentations:

Diamanti, M., J. Stiteler, and J. Pollack. "Archaeological Reconnaissance of Ohio River Islands National Wildlife Refuge in Pennsylvania, West Virginia, and Kentucky and Phase I Archaeological Survey of Manchester Island No. 2, Kentucky." Report submitted to U.S. Fish and Wildlife Service, Hadley, MA, 1998.

Day, R.L., M.A. Calmon, J.M. Stiteler, J.D. Jabro, and R.L. Cunningham. "Water balance and flow patterns in a fragipan using an in-situ soil block." Soil Science 163(7), 517-528, 1998.

Sams, J.I., R.L. Day, J. Stiteler, and M.S. Srinivasan. "Influence of land use and open-water wetlands on water quality in the Lake Wallenpaupack basin, northeastern Pennsylvania." Water Resources Investigation Report 98-4186, U.S. Geological Survey, Lemoyne, Pennsylvania, 1999.

Coppock, G.F., J.M. Stiteler, and F.J. Vento. Assessing Intra-Watershed Paleoenvironment and Landform Development: A Case Study from South-Central Pennsylvania. *North American Archaeologist* 32(3):193-247, Spring 2012.

"Late Quaternary Surficial Geology of the Delaware River Valley at Trenton, New Jersey." Paper delivered at Society for American Archaeology annual meeting, Philadelphia, PA, April 2000, as part of symposium "Public Archaeology at the Falls of the Delaware: The Lamberton 'Tunnel', N.J. Rt. 29."

"Late Quaternary Surficial Geology of the Delaware River Valley at Trenton." Paper delivered at Archaeological Society of New Jersey Winter Meeting, January 20, 2001, New Jersey State Museum, Trenton, NJ.

"The Role of Soil and Landscape Analysis in Archaeology." Paper delivered to annual meeting of West Virginia Association of Professional Soil Scientists, June 2003, Shepherdstown, WV.

"The ABC's of Pedology." Joint paper delivered with Margaret Sams, Skelly and Loy Engineers, to open symposium coordinated by PennDOT District 4, December 2004, Keystone Bldg., Harrisburg, PA.

"A Geoarchaeological/Paleoenvironmental Investigation of the Aughwick Creek Watershed". Paper presented in conjunction with Dr. Frank Vento and Gary Coppock, M.A., at 2009 PennDOT Byways to the Past Conference, Harrisburg, PA.

"A Geoarchaeological/Paleoenvironmental Investigation of the Aughwick Creek Watershed in South-Central Pennsylvania: A Summary of Results". Paper presented March 25, 2012 at Middle Atlantic Archaeological Conference 2012 meetings, Virginia Beach, Virginia.

Professional Affiliations:

American Quaternary Association
Geological Society of America, Archaeological Geology and Quaternary Geology and Geomorphology Divisions
Middle Atlantic Archaeological Conference
Society for Pennsylvania Archaeology

Other Experience and Certifications:

40 hr HAZWOPER certified
US Army veteran 1972-1975 (Vietnam Era, Vietnam Theatre)

Appendix I

PROJECT ADMINISTRATIVE DATA

APPENDIX I

Project Administrative Data

HUNTER RESEARCH, INC.
PROJECT SUMMARY

Project Name:	Geomorphological/Archaeological Study, South Shore of Staten Island, Coastal Storm Reduction Project, Borough of Staten Island, Richmond County, New York
Level of Survey:	
HRI Project Reference:	17056
Date of Report:	May 2020
Client:	U.S. Army Corps of Engineers, New York District
Prime:	Princeton Hydro
Review Agency:	New York State Historic Preservation Office
Artifacts/Records Deposited:	n/a

PROJECT CHRONOLOGY

Date of Contract Award:	8/18/17
Notice to Proceed:	8/18/17
Background Research:	Fall 2018
Fieldwork:	August-November 2018, May-April 2019
Analysis:	Fall 2019
Report Written:	January-April 2019

PROJECT PERSONNEL

Principal Investigator(s):	Richard Hunter, James Lee
Background Researcher(s):	Eryn Boyce
Field Supervisor(s):	n/a
Field Assistant(s):	n/a
Analyst(s):	n/a
Draftperson(s):	Evan Mydlowski
Report Author(s):	John Stiteler, James Lee, Eryn Boyce, Richard Hunter
Subconsultant(s):	John Stiteler, Soil Scientist