U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science Directorate
Geologic Resources Division

Gateway National Recreation Area

GRI Ancillary Map Information Document

Produced to accompany the Geologic Resources Inventory (GRI) Digital Geologic Data for Gateway National Recreation Area

gate_geology.pdf

Version: 10/1/2014

Geologic Resources Inventory Map Document for Gateway National Recreation Area

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Geologic Resources Inventory Map Document

Gateway National Recreation Area, New York and New Jersey

Document to Accompany Digital Geologic-GIS Data

gate_geology.pdf

Version: 10/1/2014

This document has been developed to accompany the digital geologic-GIS data developed by the Geologic Resources Inventory (GRI) program for Gateway National Recreation Area, New York and New Jersey (GATE).

Attempts have been made to reproduce all aspects of the original source products, including the geologic units and their descriptions, geologic cross sections, the geologic report, references and all other pertinent images and information contained in the original publication.

National Park Service (NPS) Geologic Resources Inventory (GRI) Program staff have assembled the digital geologic-GIS data that accompanies this document.

For information about the status of GRI digital geologic-GIS data for a park contact:

Tim Connors
Geologist/GRI Mapping Contact
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2093
fax: (303) 987-6792
email: Tim_Connors@nps.gov

For information about using GRI digital geologic-GIS data contact:

Stephanie O'Meara
Geologist/GIS Specialist/Data Manager
Colorado State University Research Associate, Cooperator to the National Park Service
1201 Oak Ridge Drive, Suite 200
Fort Collins, CO 80525
phone: (970) 491-6655
fax: (970) 225-3597
e-mail: stephanie.omeara@colostate.edu

About the NPS Geologic Resources Inventory Program

Background

Recognizing the interrelationships between the physical (geology, air, and water) and biological (plants and animals) components of the Earth is vital to understanding, managing, and protecting natural resources. The Geologic Resources Inventory (GRI) helps make this connection by providing information on the role of geology and geologic resource management in parks.

Geologic resources for management consideration include both the processes that act upon the Earth and the features formed as a result of these processes. Geologic processes include: erosion and sedimentation; seismic, volcanic, and geothermal activity; glaciation, rockfalls, landslides, and shoreline change. Geologic features include mountains, canyons, natural arches and bridges, minerals, rocks, fossils, cave and karst systems, beaches, dunes, glaciers, volcanoes, and faults.

The Geologic Resources Inventory aims to raise awareness of geology and the role it plays in the environment, and to provide natural resource managers and staff, park planners, interpreters, researchers, and other NPS personnel with information that can help them make informed management decisions.

The GRI team, working closely with the Colorado State University (CSU) Department of Geosciences and a variety of other partners, provides more than 270 parks with a geologic scoping meeting, digital geologic-GIS map data, and a park-specific geologic report.

Products

Scoping Meetings: These park-specific meetings bring together local geologic experts and park staff to inventory and review available geologic data and discuss geologic resource management issues. A summary document is prepared for each meeting that identifies a plan to provide digital map data for the park.

Digital Geologic Maps: Digital geologic maps reproduce all aspects of traditional paper maps, including notes, legend, and cross sections. Bedrock, surficial, and special purpose maps such as coastal or geologic hazard maps may be used by the GRI to create digital Geographic Information Systems (GIS) data and meet park needs. These digital GIS data allow geologic information to be easily viewed and analyzed in conjunction with a wide range of other resource management information data.

For detailed information regarding GIS parameters such as data attribute field definitions, attribute field codes, value definitions, and rules that govern relationships found in the data, refer to the NPS Geology-GIS Data Model document available at: http://science.nature.nps.gov/im/inventory/geology/GeologyGISDataModel.cfm

Geologic Reports: Park-specific geologic reports identify geologic resource management issues as well as features and processes that are important to park ecosystems. In addition, these reports present a brief geologic history of the park and address specific properties of geologic units present in the park.

For a complete listing of Geologic Resource Inventory products and direct links to the download site visit the GRI publications webpage http://www.nature.nps.gov/geology/inventory/gre_publications.cfm

GRI geologic-GIS data is also available online at the NPS Data Store Search Application: http://irma.nps.gov/App/Reference/Search. To find GRI data for a specific park or parks select the appropriate park (s), enter “GRI” as a Search Text term, and then select the Search Button.

For more information about the Geologic Resources Inventory Program visit the GRI webpage: http://www.nature.nps.gov/geology/inventory, or contact:

Bruce Heise
Inventory Coordinator
National Park Service Geologic Resources Division
P.O. Box 25287
Denver, CO 80225-0287
phone: (303) 969-2017
fax: (303) 987-6792
email: Bruce_Heise@nps.gov

The Geologic Resources Inventory (GRI) program is funded by the National Park Service (NPS) Inventory and Monitoring (I&M) Division.

GRI Digital Maps and Source Map Citations

The GRI digital geologic-GIS maps for Gateway National Recreation Area, New York and New Jersey (GATE):

***Geomorphologic Maps*:**

Digital Geomorphologic Map of the Sandy Hook, Jamaica Bay and Staten Island Units, Gateway NRA, New Jersey and New York *(GRI MapCode GATE)*

Psuty, N.P., McLoughlin, S.M., Schmelz, W., Spahn, A., Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey: Institute of Coastal and Marine Sciences, Rutgers University, Sandy Hook, New Jersey, 3 maps, scale 1:6,000. *(GRI Source Map ID 75949)*

The following 3 maps are extracts from the above source map.

Digital Geomorphologic Map of the Jamaica Bay Unit, Gateway NRA, New York *(GRI MapCode JABA)*

Digital Geomorphologic Map of the Staten Island Unit, Gateway NRA, New York *(GRI MapCode STIS)*

Digital Geomorphologic Map of the Sandy Hook Unit, Gateway NRA, New Jersey *(GRI MapCode SAHO)*

***Large Scale Geologic Maps*:**

Digital Surficial Geologic Map of the Sandy Hook and Long Branch Quadrangles and Vicinity, New Jersey *(GRI MapCode SHSF)*

Stanford, Scott D., 2002, Surficial Geology of the Elizabeth Quadrangle, Essex, Hudson, and Union Counties, New Jersey: New Jersey Geological Survey, Open-file Map OFM 42, scale 1:24,000. *(GRI Source Map ID 55336)*

Stanford, Scott D, 2000, Surficial Geology of the Sandy Hook Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map OFM 39, scale 1:24,000. *(GRI Source Map ID 2584)*

Stanford, Scott D., 2000, Surficial Geology of the Long Branch Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map OFM 38, scale 1:24,000. *(GRI Source Map ID 47707)*

Stanford, Scott D, 1999, Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles, Middlesex and Union Counties, New Jersey: New Jersey Geological Survey, Open-file Map OFM 28, scale 1:24,000. *(GRI Source Map ID 47711)*

Stanford, Scott D., 1995, Surficial Geology of the Jersey City Quadrangle, Hudson and Essex Counties, New Jersey: New Jersey Geological Survey, Open-file Map OFM 20, scale 1:24,000. *(GRI Source Map ID 2585)*

Digital Bedrock Geologic Map of the Sandy Hook and Long Branch Quadrangles, New Jersey *(GRI MapCode SHBR)*

Minard, J.P., 1969, Geology of the Sandy Hook Quadrangle in Monmouth County, New Jersey: U.S. Geological Survey, Bulletin 1276, scale 1:24,000. *(GRI Source Map ID 2583)*

Stanford, S.D. and Sugarman, P.J., 2010, Bedrock Geology of the Long Branch Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map OFM 78, scale 1:24,000. *(GRI Source Map ID 75557)*

***<u>Small Scale Geologic Maps</u>*:**

Digital Surficial Geologic Map of Gateway National Recreation Area and Vicinity, New Jersey and New York *(GRI MapCode GWSF)*

Cadwell, D.H., Connally, G.G., Dineen, R.J., Fleisher, P.J., Fuller, M.L., Sirkin, Les, and Wiles, G.C., 1991, Surficial Geologic Map of New York: Lower Hudson Sheet: New York State Museum, Map and Chart Series 40, scale 1:250,000. *(GRI Source Map ID 1574)*

Pristas, R. P., 2007, Surficial Geology of New Jersey: New Jersey Geological Survey, Digital Geodata Series DGS 07-2, scale 1:100,000. *(GRI Source Map ID 74858)*

Digital Bedrock Geologic Map of Gateway National Recreation Area and Vicinity, New Jersey and New York *(GRI MapCode GWBR)*

Pristas, R. P., 2004, Bedrock Geology of New Jersey: New Jersey Geological Survey, Digital Geodata Series DGS 04-6, scale 1:100,000. *(GRI Source Map ID 7285)*

Rickard, L.V., Isachsen, Y.W., and Fisher, D.W., 1970, Geologic Map of New York: Lower Hudson Sheet: New York State Museum, Map and Chart Series 15, scale 1:250,000. *(GRI Source Map ID 7288)*

Additional information pertaining to each source map is also presented in the GRI Source Map Information (GATEMAP) table included with the GRI geology-GIS data.

Geomorphologic Map Unit List

The geomorphologic units present in the digital geologic-GIS data produced for Gateway National Recreation Area, New York and New Jersey (GATE) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Rps - Artificial planar surface). Units are generally listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (GATEUNIT) table included with the GRI geology-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI, the unit's source map symbol, name and/or age appears with the unit's source map description.

Geomorphologic Units

Recent Deposits

Anthropogenic Features
Rps - Artificial planar surface
Rsr - Elevated surface/ridge
Rbu - Bulkhead
Rpd - Pier/dock
Rjg - Jetty/groin
Rs - Seawall

Holocene Deposits

Active Coastline
Hbe - Beach
Hfd - Foredune
Hsf - Sand flat
Hwl - Wetland

Abandoned Coastline
Hfda - Major abandoned foredune
Hfdi - Minor abandoned foredune
His - Inter-ridge swale
Hbd - Back dune slope
Hcb - Cliff/bluff/scarp

Pleistocene Deposits

Glacial Deposits
PEtm - Terminal moraine
PEop - Outwash plain

Surficial Geologic Map Unit List

The surficial geologic units present in the digital geologic-GIS data produced for Gateway National Recreation Area, New York and New Jersey (GATE) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qaf - Artificial fill). Units are generally listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (GWSFUNIT) table included with the GRI geology-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI, the unit's source map symbol, name and/or age appears with the unit's source map description.

Cenozoic Era

Quaternary Period
Qaf - Artificial fill
Qaft - Trash fill
Qb - Beach and nearshore marine sand
Qbi - Barrier Island
Qm - Estuarine and salt-marsh deposits
Qal - Alluvium
Qs - Swamp and Marsh Deposits
Qcal - Colluvium and Alluvium
Qe - Eolian deposits
Qhkl - Glacial Lake Hackensack, lake-bottom deposits
Qbn - Glacial Lake Bayonne deposits, sand and gravel (deltaic deposits)
Qbnl - Glacial Lake Bayonne deposits, silt, clay and fine sand (lake-bottom deposits)
Qbnf - Glacial Lake Bayonne deposits, lacustrine-fan deposits
Qls - Lacustrine sand
Qrw - Rahway Outwash
Qrt - Raritan terrace deposits
Qld - Lacustrine delta
Qk - Kame deposits
Qt - Rahway Till, continuous
Qtt - Rahway Till, discontinuous
Qty - Rahway Till, yellow phase
Qpt - Lower Passaic terrace
Qwf - Late Wisconsinan glaciofluvial deposits
Qwfv - Late Wisconsinan glaciofluvial plain deposits
Qwlb - Late Wisconsinan glacial lake-bottom deposits
Qez - Elizabeth River deposits
Ql - Uncorrelated glacial-lake deposits
Qsp - Pre-advance stratified sediment
Qic - Ice-contact deposits
Qwb - Glacial Lake Woodbridge deposits
Qab - Glacial Lake Ashbrook deposits, sand, pebbly sand and minor pebble-to-cobble gravel
Qabl - Glacial Lake Ashbrook deposits, silt, clay and fine sand
Qsu - Uncorrelated sand and gravel deposits
Qpf - Plainfield outwash
Qmt - Metuchen outwash

Qpa - Perth Amboy outwash
Qtm - Till of the terminal moraine
Qsw - Weathered shale
Qtl - Lower stream terrace deposits
Qcl - Lower colluvium
Qcm2 - Cape May Formation, unit 2
Qcm1 - Cape May Formation, unit 1
Qtu - Upper stream terrace deposits
Qcu - Upper colluvium

Quaternary and Tertiary Periods
QTgl - Upland gravel, lower phase
QTg - Upland gravel
QTuc - Upland colluvium

Tertiary Period
Tp - Pensauken Formation
Tpg - Pensauken Formation, glauconitic phase
Tbh - Beacon Hill gravel

Mesozoic to Cenozoic Eras

Cretaceous to Tertiary Periods
Tkr - Weathered bedrock

Bedrock Map Unit List

The bedrock geologic units present in the digital geologic-GIS data produced for Gateway National Recreation Area, New York and New Jersey (GATE) are listed below. Units are listed with their assigned unit symbol and unit name (e.g., Qtm - Tidal-marsh deposits). Units are generally listed from youngest to oldest. No description for water is provided. Information about each geologic unit is also presented in the GRI Geologic Unit Information (GWBRUNIT) table included with the GRI geology-GIS data. Some source unit symbols, names and/or ages may have been changed in this document and in the GRI digital geologic-GIS data. This was done if a unit was considered to be the same unit as one or more units on other source maps used for this project, and these unit symbols, names and/or ages differed. In this case a single unit symbol and name, and the unit's now recognized age, was adopted. Unit symbols, names and/or ages in a unit descriptions, or on a correlation of map units or other source map figure were not edited. If a unit symbol, name or age was changed by the GRI, the unit's source map symbol, name and/or age appears with the unit's source map description.

Cenozoic Era

Quaternary Period
Qtm - Tidal-marsh deposits
Qga - Glacial and alluvial deposits
Qal - Alluvium
Qbs - Beach sand
Qfc - Foraminiferal clay
Qgs - Glauconitic sand

Tertiary Period
Tch - Cohansey Formation
Tkw - Kirkwood Formation
Tkl - Kirkwood Formation, lower member
Tsr - Shark River Formation
Tmq - Manasquan Formation
Tvt - Vincentown Formation
Tht - Hornerstown Formation

Mesozoic Era

Cretaceous Period
Kbr - Cretaceous bedrock (Cretaceous?)
Km - Monmouth Group, Matawan Group and Magothy Formation, undivided
Kt - Tinton Formation
Krs - Red Bank Formation, Shrewsbury Member
Krsh - Red Bank Formation, Sandy Hook Member
Kns - Navesink Formation
Kml - Mount Laurel Formation
Kw - Wenonah Formation
Kmt - Marshalltown Formation
Ket - Englishtown Formation
Kwb - Woodbury Formation
Kmv - Merchantville Formation
Kcq - Cheesequake Formation
Kmg - Magothy Formation
Kr - Raritan Formation, undivided

Krw - Raritan Formation, Woodbridge Clay Member
Krf - Raritan Formation, Farrington Sand Member
Kp - Potomac Formation

Jurassic and Triassic Period
Jd - Jurassic Diabase
JTRp - Passaic Formation, undivided
JTRpms - Passaic Formation, mudstone facies
JTRps - Passaic Formation, sandstone and siltstone facies

Triassic Period
TRpg - Passaic Formation, gray bed
TRb - Brunswick Formation
TRp - Palisade Diabase sill
TRl - Lockatong Formation
TRla - Lockatong Formation, arkosic sandstone facies
TRs - Stockton Formation

Paleozoic Era

Ordovician Period
Ohr - Harrison Gneiss

Cambrian to Ordovician Periods
OCi - Inwood Marble

Neoproterozoic to Ordovician Periods
OZs - Serpentinite
OZm - Manhattan Formation

Geomorphologic Map Unit Descriptions

Descriptions of all geomorphologic map units, generally listed from youngest to oldest, are presented below.

Anthropogenic

Rps - Artificial planar surface (Holocene)

Conceptual Basis
A human-made flat or planar surface that has been leveled to site a structure such as a highway or building. Underlying topography is destroyed or covered up.

Physical Description and Identification
Elevation of surface is nearly or completely homogeneous and level. Abrupt interruption of adjacent naturally occurring topography. Boundary of surface is often clearly visible on the orthophotos. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Rsr - Elevated surface/ridge (Holocene)

Conceptual Basis
Area where the land has been intentionally elevated by humans for the construction of buildings or to assist in military operations. Such features include gun and mortar batteries built into dunes or disguised as dunes, as well as sites constructed to conceal missile locations.

Physical Description and Identification
Marked by variability in elevation, and often with the appearance of a dune or large topographic high. Specific sites can be identified from orthophotos and their boundaries determined based on LiDAR. They do not display the same homogeneity in elevation that is evident with cultural planar surfaces. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Rbu- Bulkhead (Holocene)

Conceptual Basis
Vertical wall of wood, metal, or concrete, defining an edge in the landform feature

Physical Description and Identification
Erosion control structures are primarily identified from orthophotographs. These structures have been constructed in many parts of the barrier spit over the course of its modern use. They are usually at the water's edge and are defining the margin of a landform or an anthropogenic feature. They are plotted in the report by Dallas et al. (2011). *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Rpd - Pier/dock (Holocene)

Conceptual Basis
A structure built into the water to accommodate the mooring of ships and boats

Physical Description and Identification
Projections from the shoreline into the water, either as single units or in groups to constitute a marina or boat basin. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Rjg - Jetty/groin (Holocene)

Conceptual Basis
Jetty – hard structure at the terminus of a beach, meant to prevent sediment from entering a navigation channel;
Groin – in the beach, perpendicular to shoreline, reducing rates of alongshore transport

Physical Description and Identification
Erosion control structures are primarily identified from orthophotographs. These structures have been constructed in many parts of the barrier spit over the course of its modern use. They are usually at the water's edge and are defining the margin of a landform or an anthropogenic feature. They are plotted in the report by Dallas et al. (2013). *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Rs - Seawall (Holocene)

Conceptual Basis
A dike constructed to rise above the landform and prevent storm surge from penetrating inland.

Physical Description and Identification
Erosion control structures are primarily identified from orthophotographs. These structures have been constructed in many parts of the barrier spit over the course of its modern use. They are usually at the water's edge and are defining the margin of a landform or an anthropogenic feature. They are plotted in the report by Dallas et al. (2013). *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Active Coastal

Hbe - Beach (Holocene)

Conceptual Basis
Wave-deposited accumulation of sediment, specifically the bare sand area seaward of the foredune. Regularly inundated by waves during high-water phases of the tidal cycle and modest storms. Dominant direction of wave approach determines the alongshore sediment pathway.

Physical Description and Identification
Area of low, nearly planar elevation exposed to waves on oceanside and bayside margins of the barrier spits. A very prominent feature that tends to be broad, continuous, and have sparse to no vegetation. Extends from the lowest tide level to the toe of the active foredune. *(GRI Source Map ID 75949)* (

Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hfd - Foredune (Holocene)

Conceptual Basis
Sand ridge formed by eolian (wind-blown) and water processes at the inland margin of a beach, parallel to the coastline. Vegetated by pioneer species that help trap sediment. Dune is actively participating in seasonal sediment exchange with the beach.

Physical Description and Identification
A continuous, linear feature of elevated topography (positive relief) that is parallel to the shoreline and immediately adjacent to the beach. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hsf - Sand flat (Holocene)

Conceptual Basis
A relatively level, low elevation (within tidal range), sandy area formed by processes other than ocean waves on beaches.

Physical Description and Identification
Subtle, linear feature that is often narrow and discontinuous, in the vicinity of the beach, and has sparse to no vegetation. Usually occurring on the bayside of the barrier spit, often forming on the margin of a wetland. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hwl - Wetland (Holocene)

Conceptual Basis
A general term describing an area of very low elevation vegetated by saltwater, brackish water, and freshwater plants. Often found in areas sheltered from ocean waves such as in bays, estuaries, or on the baysides of spits.

Physical Description and Identification
Wetlands are roughly approximated by areas of very low (nearly sea-level) elevation. Marsh vegetation is often distinctly visible on orthophotos. In places where the exact position of the wetland boundary is uncertain in the topography, vegetation maps may depict their extent. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Abandoned Coastal

Hfda - Major abandoned foredune (Holocene)

Conceptual Basis
A previously active foredune that is no longer in active sediment transfer with the beach. Often found parallel to or adjacent to an active foredune. May have been reworked by winds into parabolic, hummocky, or dissected features.

Physical Description and Identification

Foredune ridge may be generally linear and intact or dissected, depending on the age of the feature and the influence of wind, waves, and human activity. The original, relatively high elevation is often preserved long after the dune has been abandoned. Usually in relatively close proximity to the active foredune ridge; i.e. ridges not separated by a major interdune swale. A dune is considered major if its ridge has an elevation above 4 meters. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hfdi - Minor abandoned foredune (Holocene)

Conceptual Basis

A previously active foredune which is no longer in active sediment transfer with the beach. Often found parallel or adjacent to active foredune. May have been reworked by winds into parabolic, hummocky, or dissected features. A minor abandoned dune either did not fully develop before being abandoned or has since lost elevation by the reworking of winds.

Physical Description and Identification

Foredune ridge may be generally linear and intact or dissected, depending on the age of the feature and the influence of wind and other natural and/or cultural activities. The original elevation is often preserved long after the dune has been abandoned. Usually in relatively close proximity to the active foredune ridge; i.e. ridges not separated by a major interdune swale. A dune is considered minor if its ridge has an elevation below 4 meters. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

His - Inter-ridge swale (Holocene)

Conceptual Basis

Seaward accumulation of dune sand that forms during time of abundant sediment supply (shoreline progradation), between the growth of sequential, parallel foredune ridges.

Physical Description and Identification

A linear hollow or topographic depression between parallel dune ridges that may be parallel to the shoreline. Swale will have lower elevation and negative relief in relationship to the adjoining dune ridges. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hbd - Back dune slope (Holocene)

Conceptual Basis

Area immediately inland of the inland slope of a dune system.

Physical Description and Identification

Elevation is generally low and tends to decreases toward bay side (i.e. slopes away from dune system). *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Hcb - Cliff/bluff/scarp (Holocene)

No unit description available.

Glacial Features

PEtm - Terminal moraine (Quaternary and Tertiary?)

Conceptual Basis
Glacial deposit at the margin of the extent of the glacial advance. Consists of unsorted till deposited on earlier landscape.

Physical Description and Identification
A large hummocky ridge, usually an abrupt change in topography, rising quickly to the greatest heights in the area. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

PEop - Outwash plain (Quaternary and Tertiary?)

Conceptual Basis
A broad surface emanating from the terminal moraine. Created by meltwaters discharging beyond the terminal moraine and depositing sediment by glacio-fluvial processes.

Physical Description and Identification
A low planar surface sloping downward beyond the margins of the terminal moraine. It is frequently fan-shaped, leading from gaps or low areas in the terminal moraine. May have kettle holes caused by stranded blocks of ice. *(GRI Source Map ID 75949)* (Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey)

Surficial Geologic Map Unit Descriptions

Descriptions of all surficial geologic map units, generally listed from youngest to oldest, are presented below.

Qaf - Artificial fill (Holocene)

Artificial Fill (Holocene)
Sand, silt, clay, gravel; brown, gray, yellowish brown; may include demolition debris (concrete, brick, asphalt, glass) and trash. As much as 20 feet thick. In road and railroad embankments and made land. Many small areas of fill in urban areas are not shown. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Artificial Fill (Holocene)
Sand, silt, clay, gravel; brown, gray, yellowish brown; may include demolition debris (concrete, brick, asphalt, glass) and trash. As much as 50 feet thick. In road and railroad embankments, solid-waste landfills, and made land. Many small areas of fill in urban areas are not shown. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

af - Artificial Fill (Holocene)
Artificially emplaced sand, grave, silt, clay, and rock; and man-made materials including cinders, ash, brick, concrete, wood, slag, metal, glass, and trash. color variable but generally dark brown, gray, or black. As much as 40 feet thick but generally less than 20 feet thick. Mapped only where it forms distinct landforms such as highway and railroad embankments, or where it covers salt-marsh deposits. the extent of fill is based on aerial photographs taken in 1979 and 1986. The extent of fill over salt-marsh deposits is based, in part, on the position of shorelines and salt marshes shown on maps by Douglas (1841), Vermuele (1897), and Merrill and others (1902). Fill is also present in all urban areas as thin layer (generally less than 10 feet thick) or fill or mixed fill and natural material overlying the mapped surficial material. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

af - Artificial Fill (Holocene)
Excavated sand, silt, clay, gravel, rock, and till, and man-made materials (bricks, cinders, ash, slag, glass, construction materials and minor amounts of trash). Color is variable, but generally gray to black. In railroad and road embankments, and made land. As much as 50 feet thick but generally less than 20 feet thick. Mapped only where it forms distinct landforms, or where it covers salt-marsh deposits and large floodplains. The extent of fill is based on aerial photographs taken in 1979 and 1986. The extent of fill over salt-marsh deposits and floodplains is based, in part, on the position of shorelines, salt marshes, and alluvial deposits shown on maps in Darton and others (1908) and Ries and Kummel (1904). Fill also occurs in all urban areas, and in most former clay and sand pits, as a thin layer (generally less than 10 feet thick) of fill, or mixed fill and natural material, overlying the mapped surficial material. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Artificial Fill (Holocene)
Artificially emplaced sand, grave, silt, clay, and rock; and man-made materials including cinders, ash, brick, concrete, wood, slag, metal, glass, and trash. color variable but generally dark brown, gray, or black. As much as 40 feet thick but generally less than 20 feet thick. Mapped only where it covers salt-marsh, alluvial, or swamp deposits. Fill is also present in all urban areas as a layer generally less than 10 feet thick, except in highway and railroad fills, where it may be as much as 40 feet thick. The extent of fill is based, in part, on the position of shorelines and salt marshes shown in Salisbury (1895), N. J. Geological Survey (1889), and Merrill and others (1902). *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

af - Artificial Fill (Holocene)
No unit description available. *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qaft - Trash fill (Holocene)

Trash and construction materials mixed and covered with excavated clay, silt, sand, gravel, rock, and till. As much as 50 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qb - Beach and nearshore marine sand (Holocene)

Qbs - Beach and Nearshore Marine Sand (Holocene)
Sand, very pale brown to light gray; and pebble gravel. As much as 150 feet thick but generally less than 20 feet thick. Silt and clay, dark gray to black, as much as 10 feet thick, overlie the sand and gravel in Sandy Hook Bay. Deposited during Holocene sea-level rise. Underlain in places by estuarine deposits. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qbs - Beach and Nearshore Marine Sand (Holocene)
Sand, very pale brown to light gray; and pebble gravel. As much as 100 feet thick but generally less than 20 feet thick. Deposited during Holocene sea-level rise. Underlain by estuarine deposits in places. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qb - Beach Deposits (Holocene)
Sand and pebble gravel. As much as 15 feet thick (estimated). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qbs - Beach and Nearshore Marine Sand (Holocene)
Sand and pebble gravel, very pale brown to light gray. As much as 50 feet thick but generally less than 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qbi - Barrier island (Quaternary)

Sand and gravel deposit as barrier island, south shore of Long Island, May have associated dunes, thickness variable. *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qm - Estuarine and salt-marsh deposits (Holocene and Pleistocene (late Wisconsinan))

Qmm - Estuarine Deposits (Holocene)
Salt-marsh peat, organic silt and clay; dark brown to black; sand and minor pebble gravel; very pale brown, white, gray. As much as 100 feet thick. Deposited during Holocene sea-level rise. Commonly underlain by lower terrace deposits. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qm - Estuarine and Salt-Marsh Deposits (Holocene)
Organic silt and clay, and salt -marsh peat, with some sand; black, dark brown, and dark gray. Contains some shells. As much as 300 feet thick in the Hudson valley. As much as 40 feet thick, but generally less than 20 feet thick, in the Newark Bay-Kearny area. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qmm - Estuarine Deposits (Holocene)
Salt-marsh peat, organic silt and clay; dark brown to black; sand and minor pebble gravel; very pale brown, white, gray. As much as 100 feet thick. Deposited during Holocene sea-level rise. Commonly underlain by lower terrace deposits. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qm - Estuarine and Salt-Marsh Deposits (Holocene)
Peat and organic clay and silt, brown to dark gray; minor sand and shells. Locally, at base, may include alluvial sand and gravel deposited before marine inundation. As much as 100 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qm - Estuarine and Salt-Marsh Deposits (Holocene)
Organic silt and clay, and peat, with some sand and fine gravel; black, dark-brown, and dark-gray. As much as 25 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qmm - Salt- Marsh and Estuarine Deposits (Holocene)
Silt, sand, peat, clay, minor pebble gravel; brown, dark-brown, gray, black. As much as 300 feet thick in the Hudson valley, 100 feet thick elsewhere. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qal - Alluvium (Holocene and Pleistocene (late Wisconsinan))

Qal - Alluvium (Holocene and late Pleistocene)
Sand, silt, clay, peat; yellowish brown, dark brown, gray; and pebble gravel. Abundant organic matter. Sand is chiefly quartz, with some glauconite and mica. Gravel is quartz and quartzite with minor ironstone. As much as 15 feet thick. Deposited in floodplains, channels, and ground-water seepage areas. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qal - Alluvium (Holocene and late Pleistocene)
Sand, silt, clay, peat; yellowish brown, dark brown, gray; and pebble gravel. Abundant organic matter. Sand is chiefly quartz, with some glauconite and mica. Gravel is quartz and quartzite with minor ironstone. As much as 15 feet thick. Deposited in floodplains, channels, and ground-water seepage areas. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qal - Alluvium (Holocene and Pleistocene)
Sand, silt, clay, pebble gravel; minor cobble gravel. Contains variable amounts of organic matter. Fine sediment is reddish-brown to dark brown. Gravel and sand composition similar to that of surficial deposits and outcropping bedrock in the drainage basin. Fine sediment is deposited as overbank material on the floodplain and may be as much as 15 feet thick. It generally overlies sand and gravel deposited in the stream channel. The gravel is generally less than 5 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qal - Alluvium (Holocene and Pleistocene)
Sand, silt, minor gravel and clay; dark-brown, gray, reddish-brown. As much as 30 feet thick. Many

small deposits along streams and in valley bottoms in urban areas, now covered by fill, are not mapped. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qal - Alluvium (Holocene)
Sand, silt, minor gravel; dark brown to gray. As much as 20 feet thick. In subsurface only, beneath unit Qm. Inferred from records of test borings (table 1). *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qal - Alluvium (Holocene and Pleistocene)
Sand, gravel, silt, minor clay and peat; reddish brown, yellowish brown, brown, gray. As much as 20 feet thick. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qs - Swamp and marsh deposits (Holocene and Pleistocene (late Wisconsinan))

Qs - Swamp and Marsh Deposits (Holocene and late Pleistocene)
Freshwater peat and organic silt, sand, and clay; dark brown to black. As much as 10 feet thick. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qs - Swamp and Marsh Deposits (Holocene and late Pleistocene)
Freshwater peat and organic silt, sand, and clay; dark brown to black. As much as 10 feet thick. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qs - Swamp and Marsh Deposits (Holocene and late Pleistocene)
Gray to brown organic silt and clay, overlain by dark-brown to black peat. As much as 15 feet thick (estimated). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qs - Swamp Deposits (Holocene and late Pleistocene)
Organic silt and clay, and peat. As much as 10 feet thick (estimated). The deposits are inferred from historical maps (N. J. Geological Survey, 1889) and are now entirely covered by fill. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

pm - Swamp deposits (Holocene and Pleistocene)
Peat-muck, organic silt and sand in poorly drained areas, un-oxidized, may be overlying marl and lake silts, potential land instability, thickness generally 2-20 meters. *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qs - Swamp and Marsh Deposits (late Pleistocene and Holocene)
Peat and organic clay, silt, and minor sand; gray, brown, black. As much as 40 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qcal - Colluvium and alluvium (Holocene and late Pleistocene)

Qcal - Colluvium and Alluvium (Holocene and late Pleistocene)
Interbedded alluvium and colluvium in headwater valleys. As much as 15 feet thick. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qcal - Colluvium and Alluvium (Holocene and late Pleistocene)
Interbedded alluvium and colluvium in headwater valleys. As much as 15 feet thick. *(GRI Source Map ID*

47707) (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qcal - Alluvium and Colluvium (Holocene and late Pleistocene)
Interbedded alluvium as in unit Qal and colluvium as in units Qcg, Qcb, Qcd, Qcs, Qcc, Qccb, and Qcl. As much as 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qe - Eolian deposits (Holocene and Pleistocene (late Wisconsinan))

Qe/Qt - Eolian Deposits (Holocene and late Pleistocene?)
Fine sand, minor silt; very pale brown. As much as 30 feet thick (Salisbury and Peet, 1895) but generally less than 10 feet thick. Extent of deposits is based, in part, on mapping in Merrill and others (1902). In places these deposits may have been removed during urbanization. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qe - Eolian Deposits (late Pleistocene and Holocene)
Fine-to-medium sand, very pale brown to reddish yellow. Sand is chiefly quartz with minor glauconite and mica in places. As much as 20 feet thick. Forms dunes and sand sheets. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qe - Eolian Deposits (Holocene and late Pleistocene?)
Fine sand, minor silt; very pale brown. As much as 10 feet thick (Russell, 1880; Salisbury and Peet, 1895). Extent of deposits based, in part, on mapping in Merrill and others (1902). In places these deposits may have been removed during urbanization. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qe - Eolian deposits (late Pleistocene, locally of early to middle Pleistocene and Pliocene age on uplands)
Windblown fine sand and silt; very pale brown, yellowish brown. As much as 15 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qhkl - Glacial Lake Hackensack, lake-bottom deposits (Pleistocene (late Wisconsinan)

Silt, clay, fine sand; gray to reddish-brown, varved to thinly-layered. As much as 30 feet thick. In subsurface only (sections AA', DD'). Lower contact is an approximate timeline marking the estimated position of the lake-bottom surface when Lake Bayonne lowered to the Lake Hackensack level. It does not represent a physical discontinuity. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Glacial Lake Bayonne Deposits

Deltaic, lake-bottom, and lacustrine-fan deposits on both sides of the Palisades Ridge. Deltaic deposits are of indistinct form and include low sandy terraces rising to about 30 to 40 feet above sea level at the west base of the Palisades Ridge in Jersey City, and low sandy islands (including Ellis and Liberty Islands) rising to about 30 feet above sea level along the west shore of the Hudson from Constable Hook to Hoboken. Lake-bottom sediment is continuous beneath units Qm and Qhkl in the Newark Bay-Kearny lowland and generally present beneath unit Qm between the Palisades and Hudson River. It is also present, in places, beneath distal parts of deltaic deposits (section AA’, BB’, EE’). Lacustrine-fan sediment is inferred from records of test borings and occurs sparsely between the Palisades and the Hudson River. Some of the mapped deltaic deposits may include lacustrine-fan sediment in the subsurface.*(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Deltaic, lake-bottom, and lacustrine-fan deposits. Deltaic deposits (Qbn) include the delta in downtown Newark and other low hills or terraces of sand and gravel of indistinct form within the Lake Bayonne basin. The deltaic deposits mapped in Newark Airport and to the north are former islands in the salt marsh that rose to elevations between 20 and 30 feet (N. J. Geological Survey, 1889). They are now graded away and covered by fill; their extent and composition is from N. J. Geological Survey (1889) and Merrill and others (1902). Lake-bottom sediment (Qbnl) is nearly continuous beneath units Qm and Qpt and locally extends beneath the distal parts of deltaic deposits. It may also occur locally beneath readvance till in the northern and eastern parts of Elizabeth. Lacustrine-fan deposits (Qbnf) are inferred from records of test borings and occur in places at the bottom of the Newark-Harrison valley fill. Some of the deltaic deposits also include lacustrine-fan sediment in the subsurface. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Include lake-bottom deposits (Qbnl), and some minor lacustrine-fan deposits (Qbn) beneath marsh deposits in the Woodbridge Creek, Arthur Kill, and lower Rahway valleys (sections A-A', B-B'), and some outcropping lake-bottom deposits near Port Rending. A deltaic deposit mapped by Darton and others (1908) north of Perth Amboy (the "Maurer delta", indicated as (Qbn) on the map) has been mined away. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qbn - Glacial Lake Bayonne deposits, sand and gravel (deltaic deposits) (Pleistocene (late Wisconsinan))

Qbn - Deltaic deposits (Pleistocene)
Sand, reddish-yellow, light reddish-brown, gray; some pebble gravel; minor cobble gravel. Sediment is generally well-sorted and stratified. Gravel clasts are chiefly red and gray sandstone and mudstone; with lesser amounts of gneiss, diabase, quartz, quartzite, serpentinite, and schist. Sand is chiefly quartz, feldspar, and red and gray mudstone fragments; with lesser amounts of mica and gneiss, diabase, and schist fragments. As much as 100 feet thick. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qbn - Deltaic deposits (Pleistocene)
Fine-to-coarse sand, reddish-brown, light reddish-brown, gray; some pebble gravel; minor cobble gravel. Well-sorted and stratified, with planar to cross-bedding in fluvial topset beds of pebbly sand and pebble-to-cobble gravel in the upper 10 to 15 feet of the Newark delta; and dipping planar to ripple-crossbedded foreset and bottomset beds, which may be locally deformed by collapse, in the rest of the deposits. As much as 100 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qbn - Sand and gravel (Pleistocene (late Wisconsinan))
Sand and gravel. As much as 30 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qbnl - Glacial Lake Bayonne deposits, silt, clay and fine sand (lake-bottom deposits) (Pleistocene (late Wisconsinan))

Qbnl - Lake-bottom deposits (Pleistocene)
Silt, clay, and fine sand; gray to reddish-brown, thinly-layered to varved. Sediment is well sorted and stratified. As much as 150 feet thick. In subsurface only (all sections). *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qbnl - Glacial Lake Bayonne Deposits (Pleistocene)
Silt, clay, fine sand. As much as 40 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qbnl - Lake-bottom deposits (Pleistocene)
Silt, clay, and fine sand; gray to reddish-brown. Well sorted and thinly layered to varved. As much as 200 feet thick. In subsurface only (all sections). *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qbnf - Lacustrine-fan deposits (Pleistocene (late Wisconsinan))

Qbnf - Lacustrine-fan deposits (Pleistocene (late Wisconsinan stage))
Sand, minor silt; reddish-brown to gray; and gravel. Sediment is moderately- to well-sorted, stratified. Sand and gravel composition likely similar to Qbn. As much as 100 feet thick. In subsurface only (sections AA', CC', EE'). *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qbnf - Lacustrine-fan Deposits (Pleistocene (late Wisconsinan))
Fine to coarse sand, minor silt; reddish-brown to gray; and pebble-to-cobble gravel. Moderately to well-sorted, stratified. As much as 100 feet thick. In subsurface only (BB' and DD'). *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qls - Lacustrine sand (Quaternary)

Sand deposits associated with large bodies of water, generally a near-shore deposit or near a sand source, well sorted, stratified, generally quartz sand, thickness variable (2-20 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qrw - Rahway Outwash (Pleistocene (late Wisconsinan))

Qrw- Rahway Outwash (Pleistocene (late Wisconsinan))
Sand, pebble to cobble gravel, minor silt. As much as 45 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

og - Outwash sand and gravel (Pleistocene (late Wisconsinan))
Coarse to fine gravel with sand, proglacial fluvial deposition, well rounded and stratified, generally finer texture away from ice border, thickness variable (2-20 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qrt - Raritan terrace deposits (Pleistocene (late Wisconsinan))

Sand, silt, pebble gravel, minor clay and cobble gravel. Fine sediment is gray, brown, and reddish-brown. Sand is predominantly quartz, with some shale fragments and feldspar, and minor glauconite and mica. Gravel is predominately quartz and quartzite; with some red and gray mudstone and shale; and minor chert, gneiss, and sandstone. As much as 40 feet thick. Deposit is on grade with the Plainfield outwash upstream in the Raritan valley and so is, in part, of late Wisconsinan age. It includes both glacially-derived sediment from bedrock to the north and east of the Raritan basin, and nonglacial sediment from bedrock, Coastal plain formation, and surficial deposits with the basin. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qld - Lacustrine delta (Quaternary)

Coarse to fine gravel and sand, stratified, generally well sorted, deposited at a lake shoreline, thickness variable (3-15 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qk - Kame deposits (Quaternary)

Includes kames, eskers, kame terraces, kame deltas, coarse to fine gravel and/or sand, deposition adjacent to ice, lateral variability in sorting, coarseness and thickness, locally firmly cemented with calcareous cement, thickness variable (10-30 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qt - Rahway Till, continuous (Pleistocene (late Wisconsinan))

Qt/Qtt - Rahway Till (Pleistocene)
Reddish-brown to reddish-yellow silty sand to sandy silt, containing some to many subrounded and subangular pebbles and cobbles and few subrounded boulders. Poorly sorted, nonstratified, generally compact below the soil zone. As much as 50 feet thick. Gravel includes, in approximate order of abundance, red and gray mudstone and sandstone, gneiss, diabase (on and east of the Palisades Ridge), conglomerate, quartzite, and quartz. Sand is chiefly quartz, feldspar, and red and gray mudstone fragments; with lesser amounts of gneiss and diabase fragments. The clasts are derived from bedrock and preglacial surficial deposits to the north and northwest along the line of ice flow. Unit Qtt delineates areas where Qt is discontinuous and generally less than 10 feet thick. The extent of unit Qtt is based, in part, on Salisbury and Peet (1895) and Merrill and others (1902). *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qt/Qtt - Rahway Till (Pleistocene)
Reddish-brown clayey, silty-sand to clayey, sandy-silt with some to many subrounded and subangular pebbles and cobbles and very few subrounded boulders. Gravel includes, in approximate order of abundance, red and gray mudstone and sandstone, quartz, gneiss, conglomerate, and basalt (table 2). Boulders are chiefly gneiss and quartzite. The clasts arc derived from bedrock and preglacial surficial deposits to the north and northeast, along the line of ice flow. The quartz pebbles are eroded from the Pensauken Formation, which formerly covered the entire quadrangle. Where till overlies Cretaceous deposits, it includes blocks, deformed layers, and pebble-sized pieces of gray clay, white to yellow

kaolinitic quartz sand, and brown ironstone eroded from the Cretaceous formations. Where it overlies Pensauken Formation, it may include lenses and blocks of yellow arkosic sand and quartz gravel. The till includes both compact, matrix-supported zones, which may have a weak subhorizontal fissility; and noncompact sandy or gravelly zones that may be weakly stratified in places. As much as 50 feet thick; generally 10 to 30 feet thick. Qt delineates areas where till is continuous and generally more than 10 feet thick. Qtt delineates areas where till is discontinuous and generally thinner. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qr - Rahway Till (Pleistocene)
Reddish-brown to light-reddish-brown silty sand to sandy clayey silt containing some to many subrounded and subangular pebbles and cobbles and a few subrounded boulders. Poorly sorted, nonstratifed, generally compact below the soil zone. May include thin, discontinuous beds and lenses of sorted sand and gravel. As much as 90 feet thick but generally less than 20 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

t - Till (Pleistocene (late Wisconsinan))
Variable texture (e.g. clay,silt-clay, boulder clay), usually poorly sorted diamict, deposition beneath glacier ice, relatively impermeable (loamy matrix), variable clast content - ranging from abundant well-rounded diverse lithologies in valley tills to relatively angular, more limited lithologies in upland tills, tends to be sandy in areas underlain by gneiss or sandstone, potential land instability on steep slopes, thickness variable (1-50 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qwtr - Rahway Till (late Pleistocene, late Wisconsinan)
Clayey silt to sandy silt with some to many pebbles and cobbles and few boulders; reddish brown, reddish yellow, yellowish brown, brown. As much as 100 feet thick, generally less than 40 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qtt - Rahway Till, discontinuous (Pleistocene (late Wisconsinan))

Qt/Qtt - Rahway Till (Pleistocene)
Reddish-brown to reddish-yellow silty sand to sandy silt, containing some to many subrounded and subangular pebbles and cobbles and few subrounded boulders. Poorly sorted, nonstratified, generally compact below the soil zone. As much as 50 feet thick. Gravel includes, in approximate order of abundance, red and gray mudstone and sandstone, gneiss, diabase (on and east of the Palisades Ridge), conglomerate, quartzite, and quartz. Sand is chiefly quartz, feldspar, and red and gray mudstone fragments; with lesser amounts of gneiss and diabase fragments. The clasts are derived from bedrock and preglacial surficial deposits to the north and northwest along the line of ice flow. Unit Qtt delineates areas where Qt is discontinuous and generally less than 10 feet thick. The extent of unit Qtt is based, in part, on Salisbury and Peet (1895) and Merrill and others (1902). *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qt/Qtt - Rahway Till (Pleistocene)
Reddish-brown clayey, silty-sand to clayey, sandy-silt with some to many subrounded and subangular pebbles and cobbles and very few subrounded boulders. Gravel includes, in approximate order of abundance, red and gray mudstone and sandstone, quartz, gneiss, conglomerate, and basalt (table 2). Boulders are chiefly gneiss and quartzite. The clasts arc derived from bedrock and preglacial surficial deposits to the north and northeast, along the line of ice flow. The quartz pebbles are eroded from the Pensauken Formation, which formerly covered the entire quadrangle. Where till overlies Cretaceous deposits, it includes blocks, deformed layers, and pebble-sized pieces of gray clay, white to yellow kaolinitic quartz sand, and brown ironstone eroded from the Cretaceous formations. Where it overlies

Pensauken Formation, it may include lenses and blocks of yellow arkosic sand and quartz gravel. The till includes both compact, matrix-supported zones, which may have a weak subhorizontal fissility; and noncompact sandy or gravelly zones that may be weakly stratified in places. As much as 50 feet thick; generally 10 to 30 feet thick. Qt delineates areas where till is continuous and generally more than 10 feet thick. Qtt delineates areas where till is discontinuous and generally thinner. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qty - Rahway Till, yellow phase (Pleistocene (late Wisconsinan))

Till as above, except that fine sediment is a reddish-yellow to yellow sandy silt to silt; and diabase and serpentinite clasts are more abundant. Incorporates weathered diabase of the Palisades Ridge and weathered serpentinite in Hoboken. Gradational contact with unit Qt. As much as 20 feet thick. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Qpt - Lower Passaic terrace (Pleistocene (late Wisconsinan))

Qpt - Lower Passaic Terrace (Holocene and Pleistocene?)
Fine-to-coarse sand and some silt, light reddish-brown, light-gray, very pale brown; some pebble gravel. Moderately to well-sorted; stratified. As much as 40 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qst1 - Lower Postglacial Stream Deposits (Holocene and latest Pleistocene)
Deposits forming stream terraces with surfaces 5 to 15 feet above the modern floodplain. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qwf - Late Wisconsinan glaciofluvial deposits (late Pleistocene, late Wisconsinan)

Sand and pebble-to-cobble gravel, minor silt; yellowish brown to reddish brown. As much as 50 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qwfv - Late Wisconsinan glaciofluvial plain deposits (late Pleistocene, late Wisconsinan)

Sand, pebble-to-cobble gravel, minor silt; yellowish brown to reddish brown. As much as 80 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qwlb - Late Wisconsinan glacial lake-bottom deposits (late Pleistocene, late Wisconsinan)

Silt, clay, fine sand; gray, brown, yellowish brown, reddish brown. As much as 200 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qez - Elizabeth River deposits (Pleistocene (late Wisconsinan))

Fine to coarse sand, minor silt; reddish-brown, light reddish-brown, gray; and pebble-to-coarse-cobble gravel. Moderately to well-sorted, plane- to cross-bedded with possible inclined planar foreset and ripple-cross-bedded bottomset beds in lacustrine parts of the deposit. As much as 150 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Ql - Uncorrelated glacial-lake deposits (Pleistocene (late Wisconsinan))

Fine-to-coarse sand, minor silt, reddish-brown to light reddish-brown; pebble-to-coarse-cobble gravel; and sandy silty diamicton. Moderately to well-sorted, stratified. As much as 100 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qsp - Pre-advance stratified sediment (Pleistocene (late Wisconsinan))

Sand, gravel, some silt and clay; reddish-brown to gray. As much as 50 feet thick. In subsurface only, beneath till (wells 155, 160, 167, 171, 172, section CC'). *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Qic - Ice-contact deposits (Pleistocene (late Wisconsinan))

Qic - Ice-contact deposits (Pleistocene)
Pebble-to-cobble gravel and pebbly sand, reddish-brown, poorly-to-moderately sorted, weakly stratified to massive. Strata may be steeply dipping or deformed. Contains beds and lenses of till and deformed Cretaceous sand and clay. As much as 40 feet thick (estimated). Forms two hills in Carteret and Woodbridge; these hills may contain or consist largely of Cretaceous sediment. They may have been deposited in ice-walled basins or by ice-push at recessional ice margins. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qwic - Ice-Contact Deposits (late Pleistocene, late Wisconsinan)
Silt, clay, fine sand; gray, brown, yellowish brown, reddish brown. As much as 200 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Glacial Lake Woodbridge Deposits

Includes deltaic and lacustrine-fan deposits (Qwb) in the South Branch valley. Small lake-bottom deposits may underlie alluvium in this valley, especially in the floodplain south of Menlo Park, but do not crop out. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qwb - Glacial Lake Woodbridge deposits (Pleistocene (late Wisconsinan))

Qwb - Sand, pebbly sand, minor pebble-to-cobble gravel. (Pleistocene (late Wisconsinan))
As much as 30 feet thick (estimated). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qwb - Glacial Lake Woodbridge deposits (Pleistocene (late Wisconsinan))
Fine-to-coarse sand, minor silt, reddish-brown to light reddish-brown; pebble-to-coarse-cobble gravel; and sandy silty diamicton. Moderately to well-sorted, stratified. As much as 100 feet thick. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

Glacial Lake Ashbrook Deposits

Includes deltaic and lacustrine-fan deposits (Qab), and lake-bottom deposits (Qabl). In addition to their outcrop, lake-bottom deposits may underlie swamp and alluvial deposits in Ash Brook swamp. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qab - Glacial Lake Ashbrook deposits, sand, pebbly sand and minor pebble-to-cobble gravel (Pleistocene (late Wisconsinan))

Qab - Sand, pebbly sand, minor pebble-to-cobble gravel. (Pleistocene (late Wisconsinan))
As much as 70 feet thick (estimated). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qabl - Glacial Lake Ashbrook deposits, silt, clay and fine sand (Pleistocene (late Wisconsinan))

Qabl - Silt, clay, fine sand. (Pleistocene (late Wisconsinan))
As much as 50 feet thick (estimated). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qsu - Uncorrelated sand and gravel deposits (Pleistocene (late Wisconsinan))

Sand, pebbly sand, minor pebble-to-cobble gravel. As much as 20 feet thick. Include small deltaic deposits laid down in glacial ponds on uplands above the levels of lake Ashbrook, Woodbridge, and Bayonne; and overriden sand and gravel deposits beneath till (section C-C'). These overriden sediments are also most probably deltaic deposits laid down in lakes pounded in front of advancing ice. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qpf - Plainfield outwash (Pleistocene (late Wisconsinan))

Pebbly sand, minor pebble-to-cobble gravel. May include lacustrine sand and silt in the subsurface. Total thickness as much as 60 feet. Crops out as a plain west of Metuchen and occurs in preglacial valleys beneath the terminal moraine northeast of Metuchen (section C-C') and west of Potters (wells 4-7). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qmt - Metuchen outwash (Pleistocene (late Wisconsinan))

Pebble-to-cobble gravel and pebbly sand. As much as 40 feet thick (estimated). Forms a river plain leading from the terminal moraine down the Mill Brook valley. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qpa - Perth Amboy outwash (Pleistocene (late Wisconsinan))

Pebble-to-cobble gravel and pebbly sand. As much as 70 feet thick (estimated). Crops out as a plain leading from the terminal moraine at Perth Amboy and occurs beneath the moraine to the north (wells 151, 157-159, 343). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Note: This unit appears on OFM 28 but is not present in the map extent extracted from this publication by the GRI.

Qtm - Till of the terminal moraine (Pleistocene (late Wisconsinan))

Qtm - Till of the Terminal Moraine (Pleistocene (late Wisconsinan))
Till, forming knoll, ridge, and basin topography of the terminal moraine. As much as 130 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

tm - Till moraine (Pleistocene (late Wisconsinan))
More variably sorted than till, generally more permeable than till, deposition adjacent to ice, more variably drained, may include ablation till, thickness variable (10-30 meters). *(GRI Source Map ID 1574)* (Surficial Geologic Map of New York, Lower Hudson Sheet).

Qwmtr - Late Wisconsinan Terminal Moraine Deposits, Rahway Till (Pleistocene (late Wisconsinan))
Rahway Till as in unit Qt forming morainic ridges and knolls. As much as 200 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qsw - Weathered shale (Pleistocene)

Qsw - Weathered Shale (Pleistocene)
Poorly sorted, nonstratified to weakly stratified, reddish-brown to yellowish-red silty clay to clayey silt with some to many angular to subangular chips of red (and minor gray) shale. Derived from mechanical and chemical decomposition of shale of the Passaic Formation of Triassic and Jurassic age. Where Pensauken Formation overlies or is upslope from weathered shale, material may include some white to yellow quartz pebbles and yellow sand derived from cryoturbation or bioturbation of the overlying or colluviated Pensauken sediment. Generally less than 10 feet thick. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qws - Weathered Shale, Mudstone, and Sandstone (Pleistocene)
Silty sand to silty clay with shale, mudstone, or sandstone fragments; reddish brown, yellow, light gray. As much as 10 feet thick on shale and mudstone, 30 feet thick on sandstone. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qtl - Lower stream terrace deposits (late Pleistocene)

Qtl - Lower terrace deposits (late Pleistocene)
Sand and minor silt; yellow, yellowish brown, reddish yellow; and pebble gravel. Sand is chiefly quartz with some glauconite and mica. Gravel is quartz and quartzite with minor ironstone. As much as 50 feet thick. Form stream terraces with surfaces 5 to 20 feet above the modern floodplain. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qtl - Lower stream terrace deposits (late Pleistocene)
Sand and minor silt; yellow, yellowish brown, reddish yellow; and pebble gravel. Sand is chiefly quartz with some glauconite and mica. Gravel is quartz and quartzite with minor ironstone. As much as 30 feet thick. Forms stream terraces with surfaces 5 to 20 feet above the modern floodplain. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qtl - Lower stream terrace deposits (late Pleistocene, late Wisconsinan)
Sand, pebble gravel, minor silt and cobble gravel; reddish brown, yellowish brown, reddish yellow. As much as 30 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qcl - Lower colluvium (late Pleistocene)

Qcl - Lower Colluvium (late Pleistocene)
Sand, silt, minor clay; yellow, yellowish brown, reddish yellow, light gray; some quartz and ironstone pebbles. As much as 20 feet thick, generally less than 10 feet thick. Forms aprons graded to lower terraces or the modern floodplain. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qcl - Lower Colluvium (late Pleistocene)
Sand, silt, minor clay; yellow, yellowish brown, reddish yellow, light gray; some quartz and ironstone pebbles. As much as 20 feet thick, generally less than 10 feet thick. Forms aprons graded to lower terraces or the modern floodplain. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qcl - Lower Colluvium (late Pleistocene)
Sand, silt, minor clay and pebble gravel; yellow, yellowish brown, reddish yellow, light gray. As much as

20 feet thick, generally less than 10 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Cape May Formation

Qcm2 - Cape May Formation, unit 2 (late Pleistocene)

Qcm2 - Cape May Formation, Unit 2 (late Pleistocene)
Sand, minor silt and clay; very pale brown, yellow, white, olive yellow; and pebble gravel. Sand is chiefly quartz with minor glauconite and mica; gravel is quartz and quartzite. As much as 50 feet thick. Forms a shore-facing terrace with surface elevation between 15 and 40 feet. Deposited in beach and estuarine settings during the Sangamon sea-level highstand between 120,000 and 130,000 years ago. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qcm2 - Cape May Formation, Unit 2 - Unit 6 Surficial Geology of the Long Branch Quadrangle, Monmouth County, New Jersey (late Pleistocene)
Sand, minor silt and clay; very pale brown, yellow, white, olive yellow; and pebble gravel. Sand is chiefly quartz with minor glauconite and mica; gravel is quartz and quartzite. As much as 50 feet thick. Forms a shore-facing terrace with surface elevation between 15 and 40 feet. Deposited in beach and estuarine settings during the Sangamon sea-level highstand between 120,000 and 130,000 years ago. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qcm2 - Cape May Formation, Unit 2 (late Pleistocene)
Sand, pebble gravel, minor silt, clay, peat, and cobble gravel; very pale brown, yellow, reddish yellow, white, olive yellow, gray. As much as 200 feet thick on the Cape May peninsula, generally less than 50 feet thick elsewhere. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qcm1 - Cape May Formation, unit 1 (middle? Pleistocene)

Qcm1 - Cape May Formation, Unit 1 (middle? Pleistocene)
Sand, minor silt and clay; very pale brown, yellow, reddish yellow; and pebble gravel. Sand is chiefly quartz, with minor glauconite and mica; gravel is quartz and quartzite. As much as 30 feet thick. Forms a shore-fronting marine terrace with surface elevation between 50 and 75 feet. Deposited in beach and estuarine settings during a middle? Pleistocene sea-level highstand. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qcm1 - Cape May Formation, Unit 1 (early to middle? Pleistocene)
Sand, minor silt, clay, and pebble gravel; very pale brown, yellow, reddish yellow. As much as 50 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qtu - Upper stream terrace deposits (middle Pleistocene)

Qtu - Upper Terrace Deposits (middle Pleistocene)
Sand, minor silt; yellow, reddish yellow; and pebble gravel. Sand is chiefly quartz; glauconite and mica are generally less abundant than in the lower terrace deposits and alluvium. Gravel is quartz, quartzite, and minor ironstone. As much as 20 feet thick. Form terraces with surfaces 20 to 50 feet above the modern floodplain. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qtu - Upper Terrace Deposits - Unit 6 Surficial Geology of the Long Branch Quadrangle, Monmouth County, New Jersey (middle Pleistocene)
Sand, minor silt; yellow, reddish yellow; and pebble gravel. Sand is chiefly quartz; glauconite and mica are generally less abundant than in the lower terrace deposits and alluvium. Gravel is quartz, quartzite, and minor ironstone. As much as 20 feet thick. Forms terraces with surfaces 20 to 50 feet above the modern floodplain. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qtu - Upper Stream Terrace Deposits (middle to late Pleistocene)
Sand and pebble gravel, minor silt and cobble gravel; yellow, reddish yellow, yellowish brown. As much as 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Qcu - Upper colluvium (middle Pleistocene)

Qcu - Upper Colluvium (middle Pleistocene)
Sand, silt, minor clay; pale brown, yellow, reddish yellow; some quartz, quartzite and ironstone pebbles. As much as 20 feet thick. Forms aprons graded to upper terraces. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qcu - Upper Colluvium (middle Pleistocene)
Sand, silt, minor clay; pale brown, yellow, reddish yellow; some quartz, quartzite and ironstone pebbles. As much as 20 feet thick. Forms aprons graded to upper terraces. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Qcu - Upper Colluvium (middle Pleistocene)
Sand, silt, minor clay and pebble gravel; pale brown, yellow, reddish yellow. As much as 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

QTgl - Upland gravel, lower phase (late Pliocene to middle Pleistocene)

TQg - Upland Gravel, Lower Phase (late Pliocene-middle Pleistocene)
Sand, minor silt; yellow to reddish yellow; and pebble gravel. Sand is chiefly quartz with minor glauconite and mica; gravel is quartz and quartzite. As much as 10 feet thick. Caps lower uplands and interfluves. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

TQg - Upland Gravel, Lower Phase (late Pliocene-middle Pleistocene)
Sand, minor silt; yellow to reddish yellow; and pebble gravel. Sand is chiefly quartz with minor glauconite and mica; gravel is quartz and quartzite. As much as 20 feet thick. Caps lower uplands and interfluves. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Tog - Upland Gravel, Lower Phase (late Pliocene-middle Pleistocene)
Sand, clayey sand, and pebble gravel, minor silt; yellow to reddish yellow. As much as 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

QTg - Upland gravel (Pliocene to early Pleistocene)

Tg - Upland Gravel (Pliocene-early Pleistocene)
Sand, yellow to reddish yellow, and pebble gravel; minor fine-cobble gravel. Sand is chiefly quartz, with minor glauconite in places; gravel is quartz and quartzite with minor weathered chert. Locally iron-

cemented. As much as 20 feet thick. In erosional remnants on hilltops and interfluves. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

Tg - Upland Gravel (Pliocene-early Pleistocene)
Sand, clayey sand, pebble gravel, minor cobble gravel; yellow to reddish yellow. Locally iron-cemented. As much as 20 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

QTuc - Upland colluvium (Pliocene-early Pleistocene)

Sand, clayey sand, pebble gravel, minor silt; white, yellow, reddish yellow. As much as 15 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Tp - Pensauken Formation (Pliocene)

Tp - Pensauken Formation (Pliocene)
Sand, pebbly sand, and minor pebble-to-cobble gravel, reddish-yellow to yellow. Sand is predominantly quartz; with some feldspar; and minor red shale, mica, and glauconite. Some of the feldspar in the sand is weathered to clay. Gravel is predominantly white to light gray (stained reddish-yellow to yellow) quartz and quartzite; with some chert, red to gray mudstone and sandstone; and minor ironstone (from Coastal Plain formations), gneiss, schist, and diabase. All the clasts except quartz, quartzite, chert, and ironstone generally have thick weathering rinds or are fully decomposed. Cobble gravel channel deposits are restricted to the basal few feet of the deposit and contain abundant clasts of quartzite, sandstone, and mudstone, and scattered clasts of gneiss, schist, and diabase. Tabular, planar cross-bedded sand with minor pebble gravel dominates the deposit above the basal gravel. The pebble gravel is chiefly quartz and quartzite with some chert and minor mudstone.

Salisbury and Knapp (1917) defined and mapped the Pensauken Formation. Owens and Minard (1979) reassigned the Pensauken deposits north of Trenton to the Bridgeton Formation (a higher fluvial sand and gravel in southern New Jersey), based on projection of the elevations of the deposits from their type areas in southern New Jersey. This usage was followed by Martino (1981) and Stanford (1993, 1995). However, the deposits north of Trenton are continuous in both extent and elevation with those at the Pensauken type locality, so the original nomenclature is used here. The age of the Pensauken is not firmly established. Berry and Hawkins (1935) describe plant fossils from the New Brunswick area that they consider to be of early Pleistocene age. Owens and Minard (1979) assign a late Miocene age based on correlation to units in the Delmarva Peninsula. Pollen from the Pensauken near Plainsboro, New Jersey (about 18 miles southwest of Metuchen), include a few pre-Pleistocene species, suggesting a Pliocene age (G. Brenner, written communication, 1991). This age is also consistent with the geomorphic and stratigraphic relation of the Pensauken to late Pliocene or early Pleistocene till and middle to late Miocene marine and fluvial deposits (Standford, 1993). *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Tp - Pensauken Formation (Pliocene)
Sand, clayey sand, pebble gravel, minor silt, clay, and cobble gravel; yellow, reddish yellow, white. Sand typically includes weathered feldspar. Locally iron-cemented. As much as 140 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Tpg - Pensauken Formation, glauconitic phase (Pliocene)

Sand, clayey sand, and pebble gravel, minor silt and clay; reddish yellow to yellowish brown. Sand typically includes glauconite. As much as 40 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

Tbh - Beacon Hill gravel (late Miocene)

Sand, clayey sand, pebble gravel, minor cobble gravel; reddish yellow to yellow. Locally iron-cemented. Feldspathic gravel clasts and sand are weathered to clay. As much as 30 feet thick. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

TKr - Weathered bedrock (Cretaceous(?) to Tertiary)

Qwcp - Weathered Coastal Plain Formations (Cretaceous(?) to Tertiary)
Exposed sand and clay of Coastal Plain bedrock formations. May be overlain by thin, patchy alluvium and colluvium. Quartz and ironstone pebbles left from erosion of surficial deposits may be present on the surface and in the upper several feet of the formation. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Qwcp - Weathered Coastal Plain Formations (Cretaceous(?) to Tertiary)
Exposed sand and clay of Coastal Plain bedrock formations. May be overlain by thin, patchy alluvium and colluvium. Quartz and ironstone pebbles left from erosion of surficial deposits may be present on the surface and in the upper several feet of the formation. *(GRI Source Map ID 47707)* (Surficial Geology of the Long Branch Quadrangle (OFM 38)).

K - Cretaceous Deposits (Cretaceous)
Gray, white, yellow, pink, red clay and fine-to-coarse quartz sand, minor quartz granule gravel. May contain mica, lignite, and ironstone. Massive to laminated; clays may be jointed. Sand may include white kaolinite clay from decomposition of feldspar. Exposed in former clay and sand pits, where it is generally overlain by fill or regraded natural material. *(GRI Source Map ID 47711)* (Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)).

Qwcp - Weathered coastal plain deposits (Chiefly Pleistocene, locally Miocene and Pliocene)
Exposed sand and clay of Coastal Plain bedrock formations. Includes thin, patchy alluvium and colluvium, and pebbles left from erosion of surficial deposits. *(GRI Source Map ID 74858)* (Surficial Geology of New Jersey (DGS 07-2)).

r - Bedrock
Large and/or former bedrock outcrops. May be partly covered by fill or construction, or no longer exposed. See GIS data for more information. *(GRI Source Map ID 55336)* (Surficial Geology of the Elizabeth Quadrangle (OFM 42)).

r - Bedrock
Large and/or former bedrock outcrops. May be partly covered by fill or structures, or no longer exposed. See GIS data for more information. *(GRI Source Map ID 2585)* (Surficial Geology of the Jersey City Quadrangle (OFM20)).

Bedrock Map Unit Descriptions

Descriptions of all bedrock geologic map units, generally listed from youngest to oldest, are presented below.

Qtm - Tidal-marsh deposits (Pleistocene and Recent)

Tidal-marsh sediments include deposits in swampy areas near the mouths of streams and on the islands in the Navesink River estuary that are subject to tidal flooding. They consist largely of organic-rich saturated muds containing minor amounts of sand, and are characterized by aquatic plant growths. Some fill has been placed on these deposits; but because of their limited extent, the fills have not been mapped separately. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Qga - Glacial and alluvial deposits (Quaternary)

Underlying bedrock geology unknown. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

Qal - Alluvium (Pleistocene and Recent)

Deposits in and along present streams and accumulations at the bases of some steep slopes are mapped as Recent alluvium. The deposits are derived mainly from the underlying and nearby formations and therefore reflect the local lithologies. The Recent deposits are composed largely of sand and gravel, but they contain silt, clay, and peat. The deposits are generally small in areal extent and thin (5-10 ft thick), but locally are as thick as 20 feet. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Qbs - Beach sand (Pleistocene and Recent)

Beach and dune sands make up all of Sandy Hook spit, the offshore bar from which the spit extends, the south shore of Sandy Hook Bay, and all or parts of some of the islands in the Navesink River estuary. Similar deposits along the shores of the Navesink River estuary were not mapped because of their narrow, thin, and discontinuous nature.

The beach sand is composed principally of quartz from underlying and nearby formations; however, glauconite grains mainly reworked from the nearby older formations, form as much as several percent of the beach sand. The glauconite grains impart a dark-green to dark-gray speckled appearance to the sand. Grain size ranges from clay to small pebbles, but the sand is mainly medium to coarse. The sand is fairly clean and loose; it therefore shifts about readily.

The dune sand is chiefly medium grained and better sorted than the beach sand. The dunes, which are mostly on Sandy Hook, are partly stabilized and fairly well covered by bushes and grass. The thickness of the deposits ranges from a few feet in the narrow strips along the shores to more than 160 feet on Sandy Hook.

Sandy Hook has lengthened appreciably during the past half century. Comparison of the "Geologic Map of New Jersey" (Lewis and Kümmel, 1912) with the U.S. Geological Survey, Sandy Hook 72-minute quadrangle (revised 1954) indicates an increase in length of about 4,000 feet during that time interval. Aerial photographs (fig. 9) show that during the 21 years between 1940 and 1961, the spit was extended northward about 1,000 feet, and an area of about 65 acres was added to the end of Sandy Hook. Some of this growth was at the expense of the spit elsewhere, particularly along the open-ocean front. Yasso (1965, p. 704) reports a considerable loss of sand at Spiral Beach (fig. 10) and also from the crescentric beach at the lower right of photograph B (fig. 9) during a, storm in March 1962. A comparison of the outlines of approximately the northern third of the spit, as recorded on the vertical aerial photographs in 1940 and 1961, is shown in figure 10. It seems that more sand has been added to some parts of the spit than has been removed from others. Therefore, some sand must have been obtained from farther south and possibly some from the ocean bottom. Groins, along the northern part of the spit, and a large seawall, along the barrier bar and southern part of the spit, have been constructed to curtail the loss of sand from the open ocean side of Sandy Hook. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Qfc - Foraminiferal clay (Pleistocene and Recent)

Deposits of foraminiferal clay underlie parts of Sandy Hook spit, but they are not exposed. The depths and thicknesses of these deposits were determined by cuttings from five auger holes, three of which were located east of Spermaceti Cove. The deposit is important because of its stratigraphic position, fauna, and age.

The foraminiferal clay is composed of medium- to dark-gray or dark-greenish-gray glauconitic silt and slay, containing as much as 26 percent very fine to medium quartz sand (table 1). Glauconite occurs as rounded dusky-green and moderate-green silt to fine sand. Colorless and green chloritized mica and sand-sized clusters of pyrite crystals are present. Some samples contain much fresh, dusky-brown plant matter, and several samples initially had faint to strong odors of hydrogen sulfide. Kaolinite, chlorite, and mica are the major clay minerals. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Qgs - Glauconitic sand (Pleistocene and Recent)

The glauconitic sand is largely well-stratified medium to very coarse alluvial sand. Some gravel occurs as thin layers throughout the unit, but mostly in the base, where it is locally cemented by iron oxide. Pebbles, 2 inches or less in diameter, are also scattered throughout the unit. Layers of clay, silt, and peat are locally present. Colors range from shades of gray and greenish gray to shades of brown. Sand is composed chiefly of quartz and some feldspar. Glauconite generally constitutes 2-10 percent of the sand, and is locally even more abundant near the base where the unit rests on glauconite-bearing formations. Pebbles are composed chiefly of rounded quartz and less amounts of rounded pieces of ironstone, sandstone, and argillite; igneous and metamorphic pebbles are sparse. The sand beds are mainly thin and horizontal, but some are cross stratified. Near the base of hills, slabs of ironstone, derived from the topographically higher Cohansey, Tinton, and Red Bank Sands, are common in the upper few feet of the deposit. These slabs probably reached their present position by slope wash and creep.

The largest areas of the glauconitic sand are in the western and north-central parts of the land area of the quadrangle. The sand ranges in thickness from a few feet to as much as 30 feet.

A radiocarbon date of 14,150 B.P. ± 450 years was obtained from peat lying on stratified glauconitic sand exposed in a drainage ditch about 1,000 feet south of Highland Road and about 800 feet east of

Sleepy Hollow Road (dating by Meyer Rubin, U.S. Geological Survey, written commun., 1964, sample W-1457). This date suggests that the underlying sand is at least that old at this location, but the date does not necessarily hold for other glauconitic sand deposits. Some deposits are probably younger, and some older, than the dated deposit.

The deposits underlie the hill slopes below 100 feet altitude, valley bottoms bordering streams, and the broad, flat areas bordering Sandy Hook Bay and the south side of Navesink River. Exposures are limited mainly to pit walls and cutbanks. One pit is located south of Route 35 at the west edge of the quadrangle; one just east of Route 35, southeast of the junction with Mountain Hill Road; and one along the south side of McClees Creek, just north of Cooper Road. The distribution of the deposits was determined largely from small outcrops and by angering. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Tch - Cohansey Formation (middle Miocene)

Tch - Cohansey Formation (Miocene? and Pliocene?)
The Cohansey is composed chiefly of somewhat pebbly medium to coarse quartz sand; however, much fine and very coarse sand and granules are also present (table 1). The distinctive characteristic of the sand is the well-formed cross-stratification (fig. 7) of planar, trough, and festoon types (McKee and Weir, 1953, p. 387), or flow and plunge structure types (Salisbury, 1894, p. 198). The sand is typically yellowish gray and grayish to pale yellowish orange, except where stained grayish red to moderate brown by iron oxide.

About 1 percent clay is present as a coating on sand grains or, locally, as pinkish- or yellowish-gray thin layers near the base of the sand. Weathered feldspar is present in small amounts, and ilmenite is abundant (2-3 percent by weight), particularly in the base. Scattered grains of mica, chiefly colorless, but some black, are also present. Quartz grains are chiefly subangular to subrounded, but some are well rounded and frosted; a few abraded quartz crystals are present. The upper part of the Cohansey contains many small pebbles, most of which are less than 1 inch in diameter. A few pebbles are larger, and one cobble 8 inches long was found. The pebbles are mainly of quartz but some are of chert or sandstone, and a few are from metamorphic rocks. Most of the upper gravel layers are firmly cemented by iron oxide into resistant ledges, which probably are responsible for the high hills and considerable relief in this quadrangle. Cemented layers are also locally present throughout the entire formation and may include layers of clean loose sand.

In the clay-sized fraction, kaolinite and quartz are the common minerals. Detrital heavy minerals include abundant dark opaques and zircon.

The basal contact is distinct and unconformable. In most outcrops the cross-stratified quartz sand beds of the Cohansey lie on the massive-bedded glauconitic quartz sand of the Vincentown. Locally, however, the basal contact is highly irregular and cuts down through the underlying formations, so that the Cohansey lies on the Tinton. In the large pit on the south side of Route 36, south of Hilton, two channels have been cut down through the Vincentown and Hornerstown (fig. 8). The channels are about 50-100 feet wide, and the contact has as much as 15 feet of relief within a horizontal distance of 20-25 feet. Blocks of Vincentown, 4-6 feet across, are lying in the channels and are completely engulfed by the Cohansey. Here, some of the basal beds in the Cohansey are fine to very fine micaceous sand and silt, and resemble the Kirkwood Formation of Miocene age, which underlies the Cohansey nearly everywhere in the New Jersey Coastal Plain. Because of their limited extent and discontinuous nature, these beds are not mapped separate from the Cohansey.

No fossils were found in the formation in the Sandy Hook quadrangle, and it is generally unfossiliferous elsewhere. Woolman (1897), however, reported molluscan fossils from the Cohansey interval near Millville, N.J., and Hollick (1900, p. 197-198) reported well-preserved fossil-plant remains from one locality near Bridgeton, N.J., both in the southwestern part of the State. Hollick considered the flora more nearly comparable with certain European upper Miocene types than with collections of Eocene and Miocene plants from the Western United States. He further explained that European flora supposedly was more advanced; therefore, the Miocene of Europe compares with the Pliocene of America. Kiimmel and Knapp (in Ries and others, 1904, p. 139) state that, although the paleontologic evidence did not allow determination of the age of the beds, it suggested a Pliocene age.

The soil developed on the formation is very sandy and locally contains many ironstone fragments. The vegetative cover is somewhat open and consists chiefly of oaks, but much laurel is present as undergrowth.

The Cohansey is the unit that covers most of the emerged Coastal Plain in New Jersey. It is presently considered to be of Miocene (?) and Pliocene (?) age and is the youngest Tertiary Formation in the Sandy Hook quadrangle. To the southwest, it is underlain by the Kirkwood Formation of Miocene age, but the Kirkwood is absent in the Sandy Hook quadrangle; and although a. few local thin beds in the base of the Cohansey resemble the Kirkwood, they are included in the Cohansey here. The formation ranges in thickness from several feet to as much as 66 feet.

The Cohansey underlies the upper slopes and tops of the highest hills in the southeastern part of the quadrangle. Excellent exposures are present in the large pits along Route 36, south of Hilton, and in the side of the hill (alt 266 ft.), 0.7 mile east of these pits. Other exposures are in small pits in the hilltops south of Waterwitch and Highlands; in the upper part of the bluff at Waterwitch; in the bluff just northwest, of Hart horizontal control station along the north side, of Navesink River; and in the pits in the hilltop along Monmouth Avenue west of Navesink. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Tch - Cohansey Formation (Miocene?)
Fine-to-coarse quartz sand, with thin beds of very coarse sand to very fine pebbles; very pale brown, white, yellow, light gray. Weakly horizontally bedded to cross-bedded. Sand and very fine pebbles consist of quartz with minor (<5%) quartzite and chert. Coarse-sand beds are locally iron-cemented. As much as 30 feet thick in the Long Branch quadrangle. In hilltop erosional remnants above 140-160 feet in elevation in the southwest corner of the quadrangle. Latest middle Miocene in age, based on pollen (Owens and others, 1988, 1998). Unconformably overlies the Kirkwood Formation. (*GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Tch - Cohansey Formation (middle Miocene, Serravallian)
Sand, white to yellow with local gravel and clay. Locally stained red or orange brown by iron oxides and (or) cemented into large blocks of ironstone. Unweathered clay is typically dark gray, but commonly weathers white where interbedded with thin beds of ironstone. Unit is a complex of interfingering marine and nonmarine facies. Sand is typically medium grained and moderately sorted although it ranges from fine to very coarse grained and from poorly to wellsorted. Sand consists of quartz and siliceous rock fragments. Some beds are locally micaceous, and in the Lakehurst area, Ocean County, some beds have high concentrations of “black” sand (pseudorutile) that was once extensively mined. In general, the sand is crossbedded, although the style of crossbedding varies significantly with the paleoenvironment. Trough crossbedding predominates, especially in the nonmarine channel fill deposits, and the scale of the crossbeds varies from small to large. In some areas, planar bedding is well developed in sections that have abundant marine burrows (mostly the clay-lined trace fossil Ophiomorpha nodosa). Such marine-influenced beds (largely foreshore deposits) occur on the central sheet west of Asbury Park, near Adelphia, Monmouth County, north of th Lakehurst Naval Air Station, Ocean County, and at Juliustown, Burlington County (Owens and Sohl, 1969), and on the southern sheet as far north as Salem, Salem County. Gravel beds occur locally, especially in updip areas such as near New Egypt, Ocean County, in

the Atlantic Highlands and in the highlands west of Barnegat, Ocean County, in the southern part of the central sheet and in mixed marin and nonmarine facies in the northeastern part of the southern sheet where gravel occurs in well-defined channels. Most of the gravel is 1.3 to 2.5 cm (0.5-1.0 in) in diameter, but pieces as long as 10 cm (4 in) are present. The gravel is composed of quartz with small amounts of black chert and quartzite. Clay commonly occurs as discrete, thin, discontinuous beds, is dark gray where unweathered, white or red where weathered. Lesser, thin laminated clay strata also are present. Locally, as near Lakehurst, thick, dark-gray, very lignitic clay was uncovered during the mining of ilmenite and is informally called the Legler lignite (Rachele, 1976). An extensive, well-preserved leaf flora was collected from a thick clay lens in a pit near Millville, Cumberland County. The leaf flora was dominated by Alangium sp., a tree no longer growing in eastern North America (J.A. Wolfe, written commun., 1992). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Tkw - Kirkwood Formation (early Miocene)

Very-fine-to-fine quartz sand, minor medium-to-coarse sand and very fine pebbles, with thin beds of silt and clay; very pale brown, white, yellow, light gray. Sand is unstratified to horizontally bedded. Silt and clay are interlaminated or thinly interbedded with very fine-to-fine sand. Sand consists of quartz with minor mica and a trace (<1%) of glauconite in places in the lowermost several feet of the formation. As much as 75 feet thick. Early Miocene in age based on diatoms (Woolman, 1895; Sugarman and Owens, 1994), foraminifera (Miller and others, 2006), and strontium-isotope ratios (Sugarman and others, 1993). Unconformably overlies the Manasquan and Vincentown Formations. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Tkl - Kirkwood Formation, lower Member (Tertiary)

Sand and clay. Upper sand facies: sand, typically fine- to medium-grained, massive to thick-bedded, locally crossbedded, light-yellow to white, locally very micaceous and extensively stained by iron oxides in near-surface beds. The thick bedded strata commonly consist of interbedded fine-grained, micaceous sand and gravelly, coarse- to fine-grained sand. Some beds are intensely burrowed. Trough crossbedded strata with high concentrations of ilmenite and a few burrows are most commonly seen in the Lakewood quadrangle. Lower clay facies: clay and clay-silt, massive to thin-bedded, dark-gray, micaceous, contains wood fragments, flattened lignitized twigs, and other plant debris. Locally, the clay has irregularly shaped sand pockets, which may represent some type of burrow. In the least weathered beds, the sand of the upper sand facies is principally quartz and muscovite with lesser amounts of feldspar. The light-mineral fraction of the dark-colored clay has significantly more feldspar (10-15 percent) and rock fragments (10-15 percent) than the upper sand facies, where the feldspar was probably leached during weathering. The basal beds have a reworked zone 0.3 to 1.2 m (1-4 ft) thick that contains fine- to very coarse grained sand and, locally, gravel. These beds are very glauconitic and less commonly contain wood fragments. Reworked zones are present throughout the lower member. The lower member consists of a lower fine-grained, clayey, dark-colored, micaceous sand (transgressive) and an upper massive or thick-bedded to crossbedded, light-colored sand (regressive). The lower, dark clayey unit was formerly called the Asbury Park Member. The clay-silt was previously called the Asbury Clay by Kümmel and Knapp (1904).

The upper sand facies has been observed only in pits and roadcuts. It is poorly exposed because of its sandy nature. In the central sheet, the lower clay facies is exposed in pits north of Farmingdale, Monmouth County; in a few cuts along the Manasquan River, north of Farmingdale; and along the Shark River, northeast of Farmingdale. In the southern sheet, the lower clay facies is exposed only where the Coastal Plain was deeply entrenched and stripped away. In the southwestern most part of the southern sheet, for example, the Cohansey Formation and much of the upper sand facies were stripped away by successive entrenchments of the Delaware River.

On the central sheet, the lower member ranges in thickness from 20 to 30 m (66-98 ft) along strike, but thickens to over 60 m (197 ft) to the southeast. On the southern sheet, the unit ranges in thickness from 15 to 25 m (49-82 ft). The age of the lower member is based on the presence of the diatom *Actinoptychus heliopelta*, which was recovered from an exposure southwest of Farmingdale near Oak Glen, Monmouth County (Goldstein, 1974). This diatom places the lower member in the lower part of the ECDZ 1 of Andrews (1987), indicative of an early Miocene (Burdigalian) age (Andrews, 1988). Sugarman and others (1993) report strontium-isotope ages of 22.6 to 20.8 Ma, thereby extending the age of the unit to Aquitanian. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Tsr - Shark River Formation (Tertiary)

Glauconite sand, silt, and clay, medium- to coarse-grained, light-brown to medium-gray, locally indurated at top and noncalcareous throughout. Mollusk impressions (mainly *Venericardia perantiqua*) were observed in the Farmingdale quadrangle. The Shark River is exposed only at a few localities in the central sheet near Farmingdale, Monmouth County, along the Manasquan and Shark Rivers and in several tributaries to Deal Lake near Asbury Park in the Asbury Park quadrangle (Sugarman and Owens, 1994). Most outcrops are small, less than 3 m (10 ft) in height. The contact with the underlying Manasquan Formation was not observed. The Shark River is about 18 m (59 ft) thick and consists of two fining-upward cycles: a glauconite sand is present at the base and a clay or silt is present at the top of each cycle. Calcareous nannofossils in subsurface Shark River sections indicate Zones NP 14 through NP 18 (Martini, 1971) (middle Eocene and early late Eocene). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Tmq - Manasquan Formation (early Eocene)

Tmq - Manasquan Formation (Eocene)
Glauconitic (15-30%) clayey-silty very-fine-to-fine sand to fine-sandy clayey silt; olive and olive-gray where unweathered, olive-brown to brown where weathered; unstratified. As much as 80 feet thick. Early Eocene in age based on calcareous nanofossils (Sugarman and others, 1995; Owens and others, 1998; Miller and others, 2006) and foraminifera (Miller and others, 2006). Described by drillers as "green sand" or "green clay". Unconformably overlies the Vincentown Formation. (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Tmq - Manasquan Formation (lower Eocene, Ypresian) - Consists of several lithologies. In the northern part of the central sheet, unit consists of a lower, clayey, quartz-glauconite sand, which is exposed intermittently along the Manasquan River near Farmingdale, Monmouth County, and an upper, fine-grained quartz sand or silt, which is exposed along Hog Swamp Brook west of Deal, Monmouth County. The Farmingdale Member and the Deal Member (of Enright, 1969) are not used on this map because they are not continuous through the outcrop belt or in the subsurface. The formation is best exposed in the central sheet from the Fort Dix Military Reservation, Burlington County, southwestward to the Medford Lakes quadrangle. Here the lower part of the formation consists of 5 m (16 ft) of medium- to coarse-grained, massive, dark-grayish-green, glauconite-quartz sand. The lowest 1 m (3 ft) mostly contains calcareous debris and phosphatized internal fossil molds reworked from the underlying Vincentown Formation. The upper part of the formation is approximately 8 m (26 ft) thick and is mostly a very clayey, blue-green to pale-gray, quartz-glauconite (about 20 percent glauconite) sand. Locally, the glauconite content of this interval is variable, and the unit becomes almost a bluegreen clay-silt, especially near Pemberton, Burlington County (Owens and Minard, 1964a). Casts and molds of mollusks (especially *Venericardia perantiqua*) occur in outcrop. The age of the formation was determined from microfauna in unweathered subsurface beds. Calcareous nannofossils indicates upper Zone NP 9 to mid Zone NP 14 (early Eocene). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Tvt - Vincentown Formation (late Paleocene)

Tvt - Vincentown Formation (Paleocene)
The Vincentown is thick- to massive-bedded medium glauconitic (15 percent) quartz sand. It is typically light greenish to yellowish gray, but locally, is oxidized to mottled moderate red and moderate olive brown. Some iron oxide cementation is present at or near the base of weathered sections. One- to two-inch pods of nearly pure glauconite sand occur near the base. Glauconite constitutes nearly half the sand fraction in the basil few feet. Grain size ranges from clay to coarse sand, but generally more than half is medium sand (table 1). Coarse grains constitute only a few percent; these are mainly quartz, but they include a few grains of glauconite. Quartz grains are generally sub-angular to subrounded, but many angular and some rounded grains are present; glauconite grains are botryoidal. Muscovite and green chloritized mica are present. Much of the sand is fairly loose and clean, but in some outcrops as much as 25 percent clay and silt are present. A small amount of feldspar is present as light-gray weathered grains. In the clay-sized fraction, kaolinite and mica are the common minerals. Characteristic detrital heavy minerals are tourmaline and staurolite. Mica is fairly abundant. Glauconite, both detrital and authigenic, is abundant in the heavy-mineral suite.

The contact with the underlying Hornerstown appears gradational. Although the basal few feet are highly glauconite, the underlying Hornerstown is much more so. The contact is placed at the base of the quartzose glauconite sand, and in some outcrops, is marked by clay-ironstone layers. Animal boring or pods, filled by glauconite or quartz sand, are present both above and below the contact. The glauconite-filled borings or pods are chiefly in the base of the Vincentown; the quartz-filled ones, in the upper part of the Hornerstown.

No fossils were found in the formation within the quadrangle; but elsewhere, the formation is one of the most fossiliferous in the Coastal Plain of New Jersey, and contains abundant Foraminifera and Bryozoa. Weller (1907, p. 161-171) and many others have described the paleontology of this unit; for reference to several of the more important papers, see Minard and Owens (1962). The nearest outcrop of the well-known basal shell bed of *Oleneothyris harlani* (Morton) and *Gryphaea dissimilaris* Weller probably is in the Long Branch quadrangle, at Turtle Mill near Eatontown, N.J. (Rogers, 1836, p. 51-53).

Because of the narrow steep outcrop characteristic of the formation in the Sandy Hook quadrangle, very little soil is developed on it. Elsewhere, a loose sandy soil, which supports a fairly open vegetative cover, is developed.

The Vincentown is of Paleocene age. Before 1928 the formation was thought to be of Late Cretaceous age (Weller, 1907); but faunal evidence by Cooke and Stephenson (1928) suggested the early Tertiary age which has been confirmed by many subsequent workers. It crops out almost continuously in the Coastal Plain in New Jersey and is present in Delaware and Maryland, where it is called the Aquia Formation. The formation ranges in thickness from 0 to 35 feet in the Sandy Hook quadrangle, and is as much as 50 to 60 feet thick in the New Egypt area (Millard and Owens, 1962; Bascom and others, 1909, p.14). The formation underlies steep, middle and upper slopes of the high hills in the southeastern part of the quadrangle and forms a narrow band of outcrop around these hills. The thickest sections are downdip, in the southeast area. The formation thins to zero updip to the northwest, where it is truncated by the overlying Cohansey Sand. The Vincentown is well exposed near the tops of the same bluffs in which the Hornerstown is exposed, in the same pits along Route 36, and in the pit in the hillside about. 0.35 mile west of Navesink Light. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle

(Bulletin 1276)).

Tvt - Vincentown Formation (late Paleocene?)
Glauconitic (5-20%) silty medium-to-coarse quartz sand, some fine-to-medium sand, some very coarse sand to very fine pebbles; yellow, reddish-yellow, olive-yellow, olive-brown; unstratified to weakly horizontally stratified. Coarse sands are locally iron-cemented into beds and masses as much as 10 feet thick. Lowermost 10-20 feet of the formation is silty fine-to-medium sand, with more glauconite than upsection. Total thickness of formation is 180 feet. Late Paleocene in age, based on foraminifera (Olsson and Wise, 1987; Miller and others, 2006) and calcareous nannofossils (Sugarman and others, 1991). Unconformably overlies the Hornerstown Formation. (*GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Tvt - Vincentown Formation (upper Paleocene, Selandian)
Sand, quartz, medium-grained, well- to poorly sorted, dusky-yellow to pale-gray; weathers orange brown or red brown, typically very glauconitic and clayey near base; glauconite decreases up section. Feldspar and mica are minor sand constituents. Unit best exposed in the Pemberton, New Egypt, and Mount Holly quadrangles of the central sheet where the overlying formations have been stripped away. The Vincentown Formation is as much as 30 m (98 ft) thick and averages 3 to 15 m (10-49 ft) in its subcrop belt. Where unweathered the unit is generally a shelly sand; where weathered the unit is largely a massive quartz sand. The unweathered sand of the Vincentown is exposed intermittently along the Manasquan River near Farmingdale, Monmouth County. The calcareous nature of the unweathered Vincentown was observed in several coreholes in the vicinity of Farmingdale. The contact with the underlying Hornerstown Formation is disconformable; locally shell beds (bioherms) up to 1.5 m (5 ft) thick are found along the contact. Shells in the bioherms are typical of a restricted environment and contain the brachiopod *Oleneothyris harlani* (Morton) in the lower beds and the oyster *Pycnodonte dissimilaris* in the upper beds. The basal contact and the *Oleneothyris* bioherms are exposed along Crosswicks and Lahaway Creeks and their tributaries. Where bioherms are absent, the basal contact is difficult to place within a sequence of glauconite beds. In general, glauconite beds of the Vincentown are darker gray than glauconite beds of the Hornerstown, and the Vincentown has more quartz sand. Upper beds of the Vincentown are as much as 12 m (39 ft) thick and are mostly silty, darkgray to green-gray, massive, glauconite sand that contains a small percentage of quartz. Calcarenite or coquina, characterized by an abundance of bryozoans, occurs locally along the western belt. These fossiliferous beds, 6 to 7.5 m (20-25 ft) thick, are best exposed along Shingle Run in the New Egypt quadrangle area and in streams that cross the Vincentown outcrop belt in the Pemberton quadrangle.

Calcareous nannofossils, present in some Vincentown outcrops, are from Zones NP 5 (the *Oleneothyris* beds) and NP 9 (late Paleocene). Vincentown sediments are much more fossiliferous in the subsurface and contain Zones NP 5 through NP 9, inclusive. Therefore, the Vincentown corresponds in age with the Aquia Formation of Virginia and Maryland. Numerous studies of the foraminifera of the Vincentown from calcareous beds in the western outcrop belt indicate that the Vincentown includes the planktic foraminifera Zones P3b through P6a (Olsson and others, 1988). A potassium-argon age of 56.4±18 Ma was determined for basal beds near New Egypt, Ocean County (Owens and Sohl, 1973). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Tht - Hornerstown Formation (early Paleocene)

Tht - Hornerstown Sand (Paleocene)
The Hornerstown typically is dusky-green to grayish-olive and grayish-olive-green massive-bedded clayey glauconite sand. In the Sandy Hook quadrangle, it is oxidized in the upper few feet to moderate reddish brown and dusky red. This oxidation probably is largely due to its topographic position above the water table and the good internal drainage in the sand above. Several percent quartz sand is present throughout the unit, and as much as 30 percent occurs in the basal and upper 1 or 2 feet. Grain size in

the entire unit ranges from clay to coarse sand (table 1). Clay and silt constitute about half the formation here. This high percentage of fines may be due in part to the advanced stage of weathering and breakdown of the soft glauconite grains. In some outcrops the intensely weathered and oxidized upper 1 or 2 feet is nearly all clay. In other outcrops the upper few inches to several feet consists of clay ironstone. Glauconite grains are chiefly medium to coarse in size, and botryoidal. Quartz grains are mainly medium, but they range from fine to coarse. A little mica is present as coarse to very coarse plates.

In the clay-sized fraction, glauconite is the only common mineral, a characteristic which is unique to this formation throughout most of its outcrop in New Jersey. Some other formations contain glauconite in the clay-sized fraction, but not to the nearly complete exclusion of other clay-sized material. Glauconite is abundant in the heavy-mineral suite. but detrital heavy minerals are sparse; these include hornblende, muscovite, staurolite, tourmaline, and zircon.

The contact with the underlying Tinton is distinct and unconformable. In most outcrops, green to olive-gray glauconite of the Homers-town lies on highly oxidized, iron oxide-crusted, and indurated quartzglauconite sand of the Tinton. Evidence for the unconformity is (1) truncation and overlap, by the Hornerstown, of increasingly older units toward the southwest; (2) reworked material in the base of the Hornerstown; and (3) the irregular, eroded upper surface of the Tinton.No fossils were found within the Hornerstown here, although to the southwest, fossils are present at the base. These fossils have almost certainly been reworked from the underlying formation. They include *Cucullaea vulgaris* (Morton), gastropods, and rarely, *Sphenodiscus lobatus* (Tuomey) (Minard and others, 1964), Weller (1907, p. 155-160) lists about 20 different fossils from the Hornerstown. The author, however, thinks that most of these are actually from the overlying Vincentown as discussed by Minard and others (1964), and were placed in the Hornerstown by Weller, only with reservation (1907, p. 159).

Because of the narrow steep outcrop that is characteristic of the formation here, very little soil is developed on it. Elsewhere, it is a rich loamy friable soil similar to that on the Navesink.

The Hornerstown is one of the most distinctive and easily recognizable units in the Coastal Plain in New Jersey. It is of Paleocene age and is the basal unit of the Tertiary System in New Jersey. It also occurs in Delaware and eastern Maryland as an almost equally distinctive unit. Very little controversy existed among previous workers regarding the lithic identity of thickness of this unit. It ranges in thickness from about 5 to 15 feet in the Sandy Hook quadrangle, and is about 30 feet thick in the type area at Hornerstown in New Egypt quadrangle to the southwest (Minard and Owens, 1962). Formerly, it was thought to be of late Cretaceous age, but Cooke and Stephenson (1928, p. 139-148) furnished faunal evidence that suggested a lower Tertiary age for the Hornerstown, as well as for the overlying Vincentown and Manasquan Formations.

The formation underlie middle to upper slopes of the highest hills in the southeastern part of the quadrangle and forms a narrow band of outcrop around these hill. It is well exposed near the tops of several bluffs; one at Waterwitch on Sandy Hook Bay, and those near the horizontal control stations, Lower and Hart, along the north side of the Navesink River. It also is well exposed in several pits, three of which are along Route 36 in the southeastern part of the quadrangle; two of these pits, one on each side of the highway, are south of Hilton, and one is north of the highway, about 0.7 mile east. Other pits in which the Hornerstown is exposed are near the hilltop along Monmouth Avenue, about 1 mile west of the town of Navesink, and one is in the hillside, about 0.35 mile west of Navesink Lighthouse. The formation also crops out in the roadbank along the south side of Navesink Avenue where it joins Route 36, and in the roadbank in the side of the high hill along the north side of Riverside Drive. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Tht - Hornerstown Formation (early Paleocene)
Glauconite (>50%) clay and silty clay; olive, dark green, black where unweathered, olive-brown with

brown to reddish-brown mottles where weathered; unstratified. Glauconite occurs primarily in soft grains of fine-to-medium sand size. Thickness is 25 to 30 feet. Early Paleocene in age, based on foraminifera (Olsson and others, 1997; Landman and others, 2004; Miller and others, 2006) and calcareous nannofossils (Sugarman and others, 1991; Miller and others, 2006). Unconformably overlies the Tinton Formation. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Tht - Hornerstown Formation (lower Paleocene, Danian) - Sand, glauconite, fine- to medium-grained, locally clayey, massive, dark-gray to dusky-green; weathers dusky yellow or red brown, extensively bioturbated, locally has a small amount of quartz at base. Glauconite grains are typically dark green and have botryoidal shapes. The Hornerstown weathers readily to iron oxide because of its high glauconite content. The Hornerstown in most areas is nearly pure glauconite greensand. The Hornerstown crops out in a narrow belt throughout most of the western outcrop area. In the northern part of the central sheet, it is extensively dissected and occurs as several outliers. Throughout its outcrop belt in the central sheet, the Hornerstown unconformably overlies several formations: the Tinton Formation in the extreme northern area; the Red Bank Formation in the northwestern and west-central areas; and the Navesink Formation in the west-central and southern areas. In the southern sheet, it unconformably overlies the Mount Laurel Formation. The unconformable basal contact locally contains a bed of reworked phosphatic vertebrate and invertebrate fossils. For the most part, however, the basal contact is characterized by an intensely bioturbated zone in which many burrows filled with bright green glauconite sand from the Hornerstown Formation project down into the dark-gray matrix of the underlying Navesink Formation. In a few exposures, a thin layer of medium- to coarse-grained quartz sand separates the Hornerstown from the underlying unit. The Hornerstown is 1.5 to 7 m (5-23 ft) thick.

A Cretaceous age was assigned to this unit by Koch and Olsson (1977) based, in part, on a vertebrate fauna found at Sewell, Gloucester County. However, early Paleocene calcareous nannofossil Zones NP 2-4 were found in a core at Allaire State Park, Monmouth County. This is the only locality in New Jersey where Zone NP 2 was observed; otherwise, the Hornerstown is confined to Zones NP 3 and NP 4. Lowermost Paleocene Zone NP 1 was not identified, and it is thought that the Cretaceous-Tertiary boundary in New Jersey may be unconformable. A complete Cretaceous-Tertiary boundary section was recovered at the Bass River borehole (ODP Leg 174AX). It contained the uppermost Maastrichtian calcareous nannofossil *Micula prinsii* Zone below a spherule layer and the basal Danian planktonic foraminiferal *Guembeletria cretacea P0* Zone just above the layer (Olsson and others, 1997). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kbr - Cretaceous bedrock (Cretaceous?)

No unit description available. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Km - Monmouth Group, Matawan Group and Magothy Formation, undivided (Cretaceous)

Km - Manmouth Group, Matawan Group, and Magothy Formation (Upper Cretaceous)
Silt clay, glauconitic sandy clay, sand, gravel. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

Km - Magothy Formation (Cretaceous)
No description provided. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kt - Tinton Formation (Late Cretaceous (Maestrichtian))

Kt - Tinton Formation (Late Cretaceous)
The Tinton is massive-bedded clayey medium to very coarse feldspathic quartz-glauconite sand to glauconitic quartz sand. In the Sandy Hook quadrangle the sand is stained, crusted, and cemented by iron oxide. Color ranges from dark yellowish orange and light brown to moderate brown and moderate yellowish brown and from light olive gray to grayish olive. The Tinton is poorly sorted; grain size ranges from clay and silt (10-30 percent) to very coarse (table 1). Rounded to angular very coarse sand grains and granules of quartz and feldspar are abundant in the upper part of the formation; one small pebble, 9 millimeters in diameter, was noted. Glauconite constitutes as much as 60-80 percent of the sand fraction in the upper part of the formation. Both glauconite content and grain size decrease downward. In the lower part of the formation the sand is largely medium to coarse, and glauconite constitutes only about 15-20 percent of the sand fraction; the bulk of the remainder is quartz. Glauconite grains are chiefly botryoidal, but many accordian-shaped and tabular grains are present.

In some outcrops the Tinton has conspicuous irregular concentric weathering patterns, several inches to several feet in diameter (fig. 6). Iron oxide and iron carbonate cement thin bands of sand in these concretionary patterns. In several outcrops the cemented upper few feet of the sand form an indurated ledge of weathered reddish-brown sandstone beneath the overlying unconsolidated dusky-green Hornerstown Sand.

X-ray diffraction patterns of the clay-sized fraction were poor, and minerals were indeterminate, probably because of intense weathering and oxidation. Glauconite is abundant in the heavy-mineral suite, but detrital heavy minerals are very sparse. A few grains of muscovite, tourmaline, and staurolite were noted.

The contact with the underlying Shrewsbury Member of the Red Bank Sand is gradational over several feet and is placed at the base of poorly sorted fairly glauconitic quartz sand. The underlying Shrewsbury Member is better sorted (about 70-80 percent fine to medium grained), less clayey, and contains, at most, only a few percent glauconite.

Many fossils are present at Tinton Falls (Long Branch quadrangle to the south) and Beers Hill (Keyport quadrangle to the west), but only poorly preserved molds of a pelecypod (Camptonectes) and animal borings were found in the sand in the Sandy Hook quadrangle. Weller (1907, p. 146) lists about a dozen different species and Norman F. Sohl, U.S. Geological Survey, has identified many more species from Tinton Falls (written commun., Oct. 22, 1965). In some localities, fossil molds and casts are thickly coated by vivianite.

A clayey sandy soil, developed on the few level upland areas, supports a fairly thick and varied vegetative cover.

The Tinton Sand is here mapped and described as a separate formation. Previously, it was described as the uppermost member of the Red Bank Sand. Cook (1868, p. 261, 268-269) probably was the first to recognize it as a distinct unit and referred to it as the "Indurated green earth." Weller (1905, p. 159) states that "for both faunal and stratigraphic reasons the indurated green earth of Cook is separated from the Red Bank Sand, and is recognized as a distinct formation to which the name Tinton beds is applied." Weller, however, did not map the unit separately. Mansfield (1922, p1. 3) showed the Tinton as a separate map unit (as mapped by George Knapp in Mansfield, 1922, p. 4), but still considered it a member of the Red Bank Sand. This member status continued through the many subsequent reports, including the New Jersey State geological report by Kümmel (1940, p. 119). Kümmel recognized it as different from the Red Bank but did not show it separately on the State map. Olsson (1963, p. 653), in one of the most recent papers describing the Tinton, considered it a separate formation but also did not show it on a map.

The Tinton, like the Red Bank, is exposed only in the northern part of the Coastal Plain in New Jersey. It is as much as 20 feet thick in the Sandy Hook quadrangle. Weller (1907, p. 145) considered it 22 feet thick in the type area at Tinton Falls, N.J., Long Branch quadrangle, and he and Olsson (1963, p. 653) believed that the Tinton thinned southwest and wedged out near Red Valley in the Roosevelt quadrangle, New Jersey. Mansfield (1922, pl. 3) showed the Tinton wedging out near Smithburg, just east of the Roosevelt quadrangle. Mansfield's interpretation better agrees with the relations found in the eastern part of the Roosevelt quadrangle (Minard, 1964) where many auger holes penetrated the glauconite sand of the Hornerstown and passed directly down into the slightly glauconitic feldspathic quartz sand of the typical upper Red Bank. The unit Weller and Olsson interpreted as the Tinton in the Roosevelt quadrangle was mapped by Minard (1964) as a transitional bed in the Red Bank. At Emleys Hill, in the southwestern part of the Roosevelt quadrangle, this transitional bed lies below the upper quartz sand of the Red Bank (Shrewsbury Member) and above the lower glauconite sand of the Red Bank (equivalent to the Sandy Hook Member), not at the top of the Red Bank as would be true if it were the Tinton. Farther southwest the upper quartz sand is absent, and the transitional unit lies at the top of the Red Bank section. Previous workers were possibly misled by the apparent higher stratigraphic position of the transitional beds (which resemble the Tinton); whereas the units are only higher topographically, because of the domal structure at Emley's Hill (Minard and Owens, 1966).

The Tinton generally has received only' cursory attention and most descriptions are inadequate. Cook (1868, p. 268) merely referred to it as greenish indurated earth; Clark (1898, p. 185), as greenish-gray or reddish clay; Weller (1905, p. 155), as glauconitic indurated sand; and Mansfield (1922, p. 11), as green indurated clayey and sandy glauconitic marl. Kümmel (1940, p. 119) virtually repeated Mansfield's description. Olsson (1963, p. 653) gives the best and most detailed description of the unit, in and near the type area. The sand is variable in Ethology, color, and outcrop expression. In its type area at Tinton Falls it is chiefly greenish-gray coarse indurated quartz-glauconite sand that is very fossiliferous. At the well-known Beers Hill locality, in the roadcut at the west end of Crawford Hill in the Key-port quadrangle, it is largely a glauconite sand containing minor amounts of quartz.

The Tinton underlies steep, middle to upper slopes of the highest hills in the southeastern part of the quadrangle. It is well exposed in the bluffs at Waterwitch and along the north side of the Navesink River near its mouth, and in the pits along Route 36 south of Hilton. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kt - Tinton Formation (Late Cretaceous)
Glauconitic (5-30%) silty medium-to-coarse and fine-to-medium quartz sand; reddish-brown, reddish-yellow, yellowish-brown where weathered, grayish-brown, brown, olive-brown where unweathered; unstratified to weakly horizontally stratified. Commonly iron-cemented into beds and masses as much as 15 feet thick. Uppermost 4-6 feet, just below contact with Hornerstown Formation, is a brown to olive-gray glauconitic clayey-silty fine sand to fine-sandy silt-clay ("New Egypt Formation" of Landman and others, 2004). Total thickness of Tinton is 30 to 40 feet. Late Cretaceous (late Maestrichtian) in age based on foraminifera, nannofossils, and ammonites (Landman and others, 2004) and strontium-isotope ratios (Sugarman and others, 1995). Overlies the Shrewsbury Member of the Red Bank Formation. Contact with Shrewsbury is not exposed in the Long Branch quadrangle. It is gradational over several feet in the Sandy Hook quadrangle, north of the Long Branch quadrangle (Minard, 1969), but may be unconformable in the Marlboro quadrangle, west of the Long Branch quadrangle (Sugarman and Owens, 1996). *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kt - Tinton Formation (Upper Cretaceous, upper Maastrichtian)
Sand, quartz, and glauconite in varying proportions, very clayey and locally indurated by siderite into hard, massive ledges. Sand is dark gray to dark yellow where unweathered; where weathered, siderite changes color of unit to orange brown because of iron oxides, and the formation is stained or cemented

in exotic patterns. The Tinton crops out in the northern part of the central sheet from Sandy Hook, Monmouth County, to the northernmost part of the Roosevelt quadrangle, near Perrineville. Unit unconformably overlies the Red Bank Formation in the high hills of the northern Coastal Plain, most notably near Perrineville and Morganville, Monmouth County. In these updip areas, fine gravel, 1 cm (0.4 in) maximum diameter, or large shell concentrations are found along the basal contact. The typical basal bed is a massive, glauconitic (10-35 percent), fine to medium-grained quartz sand with scattered gravel. The massive character of the basal bed is the result of extensive bioturbation. Burrows, filled with glauconite sand of the Tinton, project down into the quartz sand of the underlying Red Bank Formation.

At lower elevations downdip, the Tinton is less weathered, much darker, more glauconitic, and typically indurated. The type locality on Pine Brook at Tinton Falls, Monmouth County, is in this downdip area. At Tinton Falls, 7 to 8 m (23-26 ft) of the Tinton is exposed and has a higher glauconite content than in the updip area. Glauconite at Tinton Falls is light green to pale yellow, and many of the grains have a smooth polished surface that is almost lustrous. Thin sections of the Tinton reveal that many of the grains are oolitic (Owens and Sohl, 1973). X-ray analyses indicate the presence of mixed clay minerals; therefore, the unit is not pure glauconite.

The Tinton Formation at Tinton Falls has scattered molds of calcitic fossils and aragonitic shells. Richards (1958) recorded 30 species of mollusks from the Tinton in this area. Of importance are *Sphenodiscus lobatus, Cucullaea (Idonearca) littlei*, and *Scabrotrigonia cerulia*. In New Jersey, *Scabrotrigonia cerulia* is restricted to the Tinton. All three species are common to the upper Maastrichtian *Haustator bilira* Zone of Sohl (*in* Owens and others, 1977). Strontium-isotope analysis on calcareous shells from the Tinton yielded ages of 66.2 to 65.6 Ma or a late Maastrichtian age (Sugarman and others, 1995). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Red Bank Sand (Upper Cretaceous)

Red Bank Formation (Upper Cretaceous)
The Red Bank Sand is a thick formation which is exposed only in the northern part of the Coastal Plain in New Jersey. It is as much as 120 feet thick in this quadrangle, but thins and wedges out about 40 miles to the southwest (Owens and Minard, 1962). The type area, described by Clark (1894, p. 337), is near the town of Red Bank, N.J., in the quadrangle adjacent to the south, although the best exposures are in the Sandy Hook quadrangle.

The formation is subdivided into lower and upper members, as was previously done in the New Egypt quadrangle (Minard and Owens, 1962), although they were not then given formal names. In the Sandy Hook quadrangle, these members are assigned the names proposed by Olsson (1963, p. 651-652); the lower member is the Sandy Hook, the upper member is the Shrewsbury.

The Red Bank Sand underlies the middle and upper slopes of most of the high hills in the southwestern part of the quadrangle and the lower and middle slopes of the hills in the southeastern part. It is exposed in many roadcuts and cutbanks in the south-central and southeastern parts of the quadrangle and in pits along Route 36. Excellent exposures can be seen in the bluffs along the northern side of Navesink River. Almost, continuous exposures are present for hundreds of yards along the bases of these bluffs. The lower member is well exposed west of Locust Point, whereas the upper member is largely exposed in the bluffs near the horizontal control stations, Hart and Lower.

Excellent exposures also are present in the bluffs along Sandy Hook Bay, from the mouth of Navesink River west to Atlantic Highlands Yacht Harbor. The best and most complete exposure is in the bluff along Bay View Street at Waterwitch, about 300 feet southeast of a slump block. Except for a few feet of the base, the entire 120-foot section is nearly continuously exposed. In addition, four of the overlying formations also are exposed in the top of the bluff. The underlying Navesink Formation can be seen in contact with the lower member of the Red Bank Sand in the roadbank about 800 feet southeast of the bluff exposure. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Note: this unit does not appear on source map.

Red Bank Formation (Upper Cretaceous, upper and middle Maastrichtian)
Consists of two thick named lithofacies and one thin unnamed lithofacies. In the northernmost outcrop belt of the central sheet, Olsson (1963) named the upper thick facies the Shrewsbury Member and the lower thick facies the Sandy Hook Member. These lithofacies merge with an unnamed thin, dark-gray, very micaceous, quartz-glauconite sand to the southwest. This unnamed glauconite lithofacies was mapped in detail in the Roosevelt (Minard, 1964), Allentown (Owens and Minard, 1966), and New Egypt (Minard and Owens, 1962) quadrangles on the central sheet. The Red Bank, like the overlying Tinton, crops out only in the northern part of the central sheet from Sandy Hook, Monmouth County, to near New Egypt, Ocean County. The scale of the map permits showing only the thicker Sandy Hook and Shrewsbury Members. The contact with the underlying Navesink Formation is gradational over several feet. The Sandy Hook Member and the unnamed glauconite member near New Egypt have similar sand and clay mineral compositions.

Smith (*in* Owens and others, 1977) determined that the Red Bank Formation is of late middle and late Maastrichtian age based primarily on the presence of the ammonite *Sphenodiscus lobatus* and the planktic foraminifera in the Sandy Hook Member from the Poricy Brook locality, Monmouth County. The concurrence of *Rugoglobigerina scotti* and *Globotruncana contusa* place this member well above the base of the *Gansserina gansseri* Subzone in the upper Maastrichtian. Sugarman and others (1995) assigned a late Maastrichtian CC26 Zone to the unit. Wolfe (1976) assigned pollen from the Sandy Hook Member to the Maastrichtian CA6/MA-1 Zone. Strontium-isotope age estimates for the Red Bank average 65.8 Ma (Sugarman and others, 1995). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Krs - Red Bank Formation, Shrewsbury Member (Late Cretaceous (Maestrichtian))

Krs - Red Bank Sand, Shrewsbury Member (Late Cretaceous)
The Shrewsbury Member is the upper member of the Red Bank Sand. It is composed of massive-bedded silty fine to medium (table 1) feldspathic quartz sand. The sand ranges in color from yellowish gray and grayish orange pink to light moderate and moderate reddish brown. The member is about 100 feet thick in the quadrangle. Many (10 percent) coarse grains and some (2 percent) very coarse grains are present, particularly in the upper half of the formation (table 1). Glauconite is sparse and rock fragments—shale, sandstone, and schist—are abundant. Muscovite is common in the lower part. Grains are mainly subangular to subrounded, but many angular grains are present. This member characteristically is oxidized to shades of reddish brown; but where it is not oxidized, it is generally gray. Ledges and masses of ironoxide-cemented sand occur locally; some of the masses have bizarre shapes, such as pipe and honeycomb structures, whereas other oxidized and cemented zones impart a bedded appearance to the sand.

In the clay-sized fraction, quartz and kaolinite are the major minerals. Characteristic detrital heavy minerals are tourmaline, sillimanite, and staurolite.

The contact with the underlying Sandy Hook Member is gradational over a vertical distance of several feet. Locally, the two members appear to interfinger, but this is generally a weathering. feature. The conspicuous difference between the two members is the color, a reddish-brown sand lying on a dark-gray sand. it may seem that the upper member is merely a deeply weathered and eluviated phase of the formation; but sand size is finer, and clay, silt, and mica are much more abundant in the lower than in the upper member. The high silt-clay content of the lower member probably is responsible for its being oxidized less than the upper member.

Fossils in the Shrewsbury Member are. sparse, and none were found in the quadrangle. Weller (1907, p. 140) reports several species of poorly preserved` pelecypods from the town of Red Bank, N.J., in the Long Branch quadrangle just to the south.

Soil developed on the member is loose and sandy. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Krs - Red Bank Formation, Shrewsbury Member (Late Cretaceous?)
Fine-to-medium quartz sand, minor medium-to-coarse sand, slightly silty, glauconitic (<5%), and micaceous; reddishyellow, yellow where weathered, light gray and gray where unweathered; unstratified to weakly horizontally bedded; locally iron-cemented. As much as 100 feet thick. Late Cretaceous (late Maestrichtian) in age based on fossils in the underlying Sandy Hook Member; the Shrewsbury Member is unfossiliferous. Grades downward within 2-3 feet to the Red Bank Formation, Sandy Hook Member. On geophysical well logs, transition to Sandy Hook Member is marked by increased gamma-ray intensity and decreased resistance. (*GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Krbs - Shrewsbury Member
Sand, quartz, fine- to coarse-grained, somewhat clayey and micaceous, mostly massive with local small-scale crossbedding, light-yellow to red or dark-brown, slightly glauconitic at the base. Feldspar is a minor sand constituent. The Shrewsbury is extensively burrowed but is otherwise unfossiliferous. Locally, small *"Callianassa"*-type burrows are present. Maximum thickness is over 30 m (98 ft) in the highlands near Matawan. Unit thins southwestward and pinches out near Arneytown, Ocean County. The transition to the underlying Sandy Hook Member occurs within several feet and is characterized by an increase in clay, quartz, silt, mica, and fine pieces of wood downward. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Krsh - Red Bank Formation, Sandy Hook Member (Late Cretaceous (Maestrichtian))

Krsh - Red Bank Sand, Sandy Hook Member (Late Cretaceous)
The Sandy Hook Member is the lower member of the Red Bank Sand. It is typically a compact dark-grayish and brownish-black massive-bedded feldspathic quartz sand. The sand is clayey and silty, fine to very fine (table 1), arid very micaceous. Mica is chiefly colorless muscovite, but green chloritized mica is abundant. Sand-sized lignite and clusters of pyrite crystals are present, and glauconite is abundant (10-15 percent) within the basal few feet. Although the glauconite is chiefly in medium to coarse botryoidal grains similar to those in the underlying Navesink, accordion and tabular forms are also present. The Sandy Hook Member ranges in thickness from about 15 to 30 feet. In some outcrops there are many siderite concretions that are typically light brown to moderate or grayish brown on a weathered surface and light olive to medium gray on a fresh surface. The siderite concretions range in shape from spherical concretionary masses to conical-pointed cylinders, and are from several inches to several feet in diameter and length. Some concretions contain unweathered material in the center.

In the clay-sized fraction, quartz, kaolinite, montmorillonite, muscovite, pyrite, and carbonaceous matter are common to major constituents. Characteristic detrital heavy minerals are garnet, staurolite, and tourmaline.

The contact with the underlying Navesink Formation is lithologically distinct, although the colors are similar. The basal part of the Sandy Hook Member is a clayey very micaceous glauconitic quartz sand, whereas the Navesink is a clayey glauconite sand.

Both microfossils and megafossils are abundant in several outcrops. The magafossils occur as both molds and calcareous shells within the basal 10 feet; the microfossils (largely Foraminifera) occur as well-preserved tests. Good fossil locations are in the bases of the bluffs at Waterwitch and west of Locust Point, in the cutbank behind the church school at the northwest edge of Middletown, and in a roadcut along the southeast side of the railroad on the Naval Reservation, about 0.6 mile north of Highland Road. A few of the typical megafossils are *Trigonia sp., 0 strea sp., Turritella vertebroides* Morton, and *Eutrephoceras dekayi* (Morton). For a detailed listing of megafossils, refer to Weller (1907, p. 138-141), and for microfossils, refer to Olsson (1960, p. 5—field location NJK-103—and p. 6-44, 47-55).

Soil developed on the member is a clayey sand which usually is not very well drained. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Krsh - Red Bank Sand, Sandy Hook Member (Late Cretaceous?)
Fine-sandy clayey silt, micaceous, slightly glauconitic (<5%); brown to yellowish-brown where weathered, dark gray, olive-gray where unweathered; unstratified. Calcareous brachiopod, pelecypod, and gastropod fossils are common. As much as 20 feet thick. Late Cretaceous (late Maestrichtian) in age based on calcareous nannofossils (Sugarman and Owens, 1996), foraminifera (Olsson, 1964; Olsson and Wise, 1987; Owens and others, 1977), and strontium-isotope ratios (Sugarman and others, 1995). Grades downward within 2-3 feet into the Navesink Formation. On geophysical well logs, transition to Navesink is marked by increased gamma-ray intensity and slightly decreased resistance. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Krbsh - Sandy Hook Member
Sand, quartz, fine-grained, clayey, very micaceous, massive, dark-gray, fossiliferous. Feldspar, muscovite, chlorite, and biotite are minor sand constituents. Well exposed at Poricy Brook in the Long Branch quadrangle. The Sandy Hook is much thinner than the overlying Shrewsbury Member and is a maximum of 10 m (33 ft) thick. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kns - Navesink Formation (Late Cretaceous (Maestrichtian))

Kns - Navesink Formation (Late Cretaceous)
The unweathered Navesink Formation typically is a massive- to thick-bedded clayey glauconite sand. Clay and silt constitute about 30 percent of the formation (table 1). The remaining 70 percent consists almost entirely of very fine to coarse glauconite sand, most of which consists of medium to coarse dusky-green to greenish-black and olive-black botryoidal grains. A small amount of quartz occurs mainly as coarse grains and granules in the basal few feet, but also as a trace of fine grains throughout. Sand-sized clusters of pyrite crystals are common in the unweathered rock. Phosphatic fragments also are locally present, mainly near the base. In weathered outcrop the formation is dark greenish gray to brownish gray and grayish brown.

In the clay-sized fraction, kaolinite, montmorillonite, chlorite, muscovite, and quartz are common to major minerals. Detrital heavy minerals are sparse and are represented by tourmaline and staurolite.

The contact with the underlying Mount Laurel Sand is distinct and unconformable; the Navesink basically consists of a clayey glauconite sand lying on a clayey quartz sand. It contains reworked phosphatized fossil fragments in the basal foot or two.

Fossils are abundant in some outcrops (in the bluffs along Sandy Hook Bay), both in the base and near the middle of the formation. *Choristothyris plicata (Say), Gryphaea convexa (Say),* and *Gryphaea mutabilis* Morton are typical. Other fossils noted include *Pecten venustus Morton, Ecoypu costata Say, Ostrea falcata* Morton, and *Belemnitella americana* (Morton). The better preserved fossils (including calcareous shells) are located several feet above the base of the formation. For a detailed listing of fossils refer to Weller (1907, p. 105-130).

Soil developed on the Navesink is very fertile and friable, and where it is present on broad, flat areas, the land is highly prized and utilized.

The Navesink Formation is a distinctive glauconite unit that is about 25 feet thick here. Clark (1894, p. 336-337) had reported a thickness of 40-60 feet for the formation, but he included the underlying Mount Laurel Sand and part of the overlying Red Bank Sand with the Navesink. Later, Clark (1898, p. 183-184) separated the Navesink and Mount Laurel and assigned a thickness of 12-50 feet to the Navesink. He probably included some of the basal Red Bank Sand with the Navesink, as did Miller in 1956 (p. 726-727). The Navesink mapped in the Sandy Hook quadrangle is the glauconite unit as defined in the Columbus quadrangle report (Owens and Minard, 1962) and in the New Egypt quadrangle report (Minard and Owens, 1962), and as mapped in the other quadrangles in the lower Delaware basin (fig. 2). The formation has a nearly continuous outcrop in New Jersey, from Sandy Hook southwest to the Woodstown quadrangle. It is only a few feet thick in Woodstown and thins to zero a short distance to the southwest. The Navesink is not present in outcrop in Delaware or eastern Maryland.

The type section of the formation is described (Clark, 1894, p. 336-337) from outcrops near the village of Navesink in the Sandy Hook quadrangle and from outcrops along the north bank of the Navesink River in both the Sandy Hook and Long Branch quadrangles. The formation underlies lower and middle slopes of hills in most of the area and is exposed in many places. Several outcrops can be seen in pits along the south side of Route 35 between Middletown and Tindall Roads, in revetments for railroad cars east of Garrett Hill on the Naval Reservation, in the west side of the hill on Mountain Hill Road, in the railroad cut at the northwest edge of Middletown, and in roadcuts and pits elsewhere in the southwestern part of the quadrangle. The best exposures are in the bluffs along Sandy Hook Bay east of Atlantic Highlands where the entire thickness of the formation is exposed and the basal contact with the Mount Laurel can be seen. The basal contact can also be seen in a pit on the east side of Route 35 just south of Mountain Hill Road, but the rocks are weathered there. The basal contact also was penetrated in several auger holes. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kns - Navesink Formation (Late Cretaceous)
Glauconitic (20-50%) clayey-silty fine-to-medium quartz sand to fine-sandy clayey silt; dark gray, gray, grayish-brown, olive-gray where unweathered, brown to yellowish-brown where weathered; unstratified. Glauconite occurs chiefly in soft grains of fine-to-medium sand size. Calcareous brachiopod, pelecypod, and gastropod fossils are common. Late Cretaceous (late Maestrichtian) in age based on calcareous nannofossils and foraminifera (Olsson, 1964; Miller and others, 2006), macrofossils (Sohl, 1977), and strontium-isotope ratios (Sugarman and others, 1995). Unconformably overlies the Mount Laurel Formation. Contact with Mount Laurel is commonly marked by a sharp peak in gamma-ray intensity on geophysical well logs, with reduced intensity in the Mount Laurel. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kns - Navesink Formation (Upper Cretaceous, Maastrichtian)
Sand, glauconite, medium-grained, clayey and silty, massive, dark-gray to dark-gray-green, extensively bioturbated, locally contains large calcareous shells; sand-size mica, locally abundant; weathers light brown or red brown. Basal quartz sand is fine- to coarse-grained, pebbly, massive, light-yellow, and somewhat glauconitic, as much as 2 m (7 ft) thick and formed by the reworking of the underlying Mount

Laurel Formation (Owens and others, 1977). *Exogyra costata* and the belemnite *Belemnitella americana* occur in the basal quartz sand. Crops out in a narrow belt throughout map area. Fresh exposures occur along tributaries of Raccoon Creek near Mullica Hill, Gloucester County. The Navesink is 3 to 7.5 m (10-25 ft) thick. The Navesink and Red Bank deposits represent a transgressive (Navesink)-regressive (Red Bank) cycle of sedimentation (Owens and Sohl, 1969). The cycle is unconformity-bounded at top and bottom. Within the cycle, the formational contact is gradational. The age of the Navesink was determined from both the macrofauna and microfauna. Planktic foraminifera from the lower part of the Navesink are indicative of the *Rugotruncana subcircumnodifera* subzone of early Maastrichtian age (Smith, *in* Owens and others, 1977). The upper part contains the mollusks *Exogyra costata, Sphenodiscus lobatus*, and *Pycnodonte vesicularis* indicating a middle to late Maastrichtian age. Planktic foraminifera from the upper part represent the *Gansserina gansseri* Subzone of middle Maastrichtian age (Smith, *in* Owens and others, 1977). Pollen in the Navesink and Sandy Hook Member of the Red Bank are similar; the Navesink microflora is a CA6/MA-1 Zone in Wolfe's (1976) classification. The Navesink, therefore, ranges from early to late Maastrichtian. Sugarman and others (1995) assigned a middle Maastrichtian Zone CC 25 to the Navesink. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kml - Mount Laurel Formation (Late Cretaceous (Campanian))

Kml - Mount Laurel Sand (Late Cretaceous)
The basal 15-20 feet of the formation consists of thin-bedded very fine to medium glauconitic quartz sand, interbedded with thin layers of clay and silt. A few coarse and very coarse grains are present (table 1). The sand is yellowish gray, dark yellowish orange, and light gray where weathered and greenish gray to dark greenish gray where fresh. The clay and silt are pale red where weathered and dark gray where fresh. Both horizontal beds and crossbeds are present in the sand, whereas the clay and silt beds are virtually horizontal. The clay and silt beds locally constitute as much as half the sequence. Some thin layers of sand and clay contain abundant lignite and are very micaceous. The mica is mainly colorless muscovite, but some green chloritized mica is present. Glauconite occurs chiefly as smooth rounded sand-sized grains and constitutes several percent of the sand fraction. Locally, many ellipsoidal and tubelike siderite concretions, as much as several inches in diameter or length, are present.

The basal contact is gradational, but it can be determined in outcrop on the basis of internal structures; the Mount Laurel consists of alternate thin beds of sand and clay, whereas the Wenonah is massive-bedded uniform silt and sand. The contact is placed at the base of the thin-bedded sequence.

Many fossils are present in the upper part of the sand and in the contact zone with the overlying Navesink Formation. Most of these fossils are rounded or broken reworked pieces of internal molds. *Belemnitella americana* and *Exogyra costata* are present in the upper zone here, as they are in the Trenton area and as far southwest as eastern Maryland. Other fossils include shark and crocodilian teeth, gastropods, *Cucullaea* sp., *Cardium* sp., and *Longoconcha* sp. For a comprehensive listing of the fossils, refer to Weller (1907, p. 103-136).

Soil developed on the formation is similar to that on the Wenonah.

The Mount Laurel Sand was redefined in the New Egypt quadrangle by Minard, Owens, and Todd (1961) and was both mapped and described as a separate unit by Owens and Minard (1962) in the Columbus quadrangle. Weller (1907, p. 103) assigned a thickness of 3-5 feet to the Mount Laurel in the bluff outcrops along Sandy Hook Bay. Kümmel (1940, p. 52) assigned a thickness of 5 feet to the unit in the Sandy Hook area, but as much as 60 feet in the area to the southwest (1940, p. 118). Most subsequent workers assigned only a few feet to the Mount Laurel in the Sandy Hook area. The unit is actually about 25 feet thick in the quadrangle.

Because no previous workers gave lithologic descriptions detailed enough to separate the Mount Laurel from the Wenonah placement of the contact between them was not attempted. Present mapping has shown that the bulk of the Mount Laurel in the Sandy Hook quadrangle resembles the underlying Wenonah in grain size and mineralogy. The previous generalized description of the Mount Laurel as a coarse glauconitic quartz sand and the Wenonah as a fine micaceous sand is not always adequate for separating them northeast of Trenton. Typically, the Mount Laurel is a massive-bedded medium to coarse sand in southwestern New Jersey; whereas a fine-grained thin-bedded sequence is present in the lower part of the sand east and northeast of Trenton. These lower thin-bedded layers constitute the bulk of the unit in the Sandy Hook quadrangle; they formerly were placed in the Wenonah Formation, largely because of their fine-grained micaceous nature. Probably the best way to distinguish the two formations in outcrops where they appear to be similar in mineralogy and grain size is by their internal structures. The Wenonah is characteristically massive to thick bedded whereas the Mount Laurel is thin bedded, except in the upper several feet where it also is thick bedded. The formation has a nearly continuous outcrop in New Jersey, from Sandy Hook southwest to the Delaware River, and extends as a thick unit across Delaware to at least the east shore of Chesapeake Bay.

The Mount Laurel Sand underlies lower slopes of hills and, locally, valley bottoms. A nearly complete section is exposed in the bluff between Atlantic Highlands and Hilton. The upper part is exposed in pits and cutbanks along the south side of Route 35 near Middletown Road and on the east side, south of Mountain Hill Road. The bedded sequence was well exposed beneath surficial deposits in a storm drain ditch in the housing development between Sleepy Hollow and Chapel Hill Roads just south of Highland Road. Both the horizontally and cross-stratified sequence were exposed in the embankment next to the parking lot of the supermarket at the southwest corner of the intersection of Route 35 and Middletown Road (fig. 4). Exposures also were seen in the banks of the small creek behind the supermarket. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kml - Mount Laurel Formation (Late Cretaceous)
Glauconitic (3-15%) fine-to-medium quartz sand, minor medium-to-coarse sand, with thin interbeds of clay and silt; yellowish-brown where weathered, olive-gray to olive-brown where unweathered. Sand is unstratified to horizontally bedded to cross-bedded. As much as 50 feet thick in the southern part of the quadrangle; thins to 20 feet to the north. In subsurface only, covered by surficial deposits in the Navesink River estuary and by overlying Coastal Plain formations elsewhere. Late Cretaceous (late Campanian) in age, based on calcareous nannofossils and strontium-isotope ratios (Sugarman and others, 1991; Miller and others, 2006). Grades downward into the Wenonah Formation. On geophysical well logs, transition to Wenonah is generally marked by slightly decreased resistance and increased gamma-ray intensity. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kml - Mount Laurel Formation (Upper Cretaceous, upper Campanian)
Sand, quartz, massive to crudely bedded, typically coarsens upward, interbedded with thin clay beds. Glauconite and feldspar are minor sand constituents. Muscovite and biotite are abundant near the base. Lower part of formation is a fine- to medium-grained, clayey, dark-gray, glauconitic (maximum 25 percent) quartz sand. Typically weathers to white or light yellow and locally stained orange brown by iron oxides. Small pebbles scattered throughout, especially in the west-central area. Locally, has small, rounded siderite concretions in the interbedded clay-sand sequence. Granules and gravel are abundant in the upper 1.5 m (5 ft). Upper beds are light gray and weather light brown to reddish brown. The Mount Laurel is 10 m (33 ft) thick from the Roosevelt quadrangle to the Runnemede quadrangle in the central sheet. Thickness varies in the northern part of the map area due, in part, to extensive interfingering of this formation with the underlying Wenonah Formation. Weller (1907) and Kümmel (1940) recognized only about 1.5 m (5 ft) of the Mount Laurel in the north. In this report those beds are assigned to the overlying Navesink Formation. The interbedded sequence, the major facies in the north, ranges to about 4.5 m (15 ft) thick. These interbeds have well-developed large burrows (Martino and Curran, 1990), mainly *Ophiomorpha nodosa*, and less commonly *Rosselia socialis*. The Mount Laurel is gradational into

the underlying Wenonah Formation. A transition zone of 1.5 m (5 ft) is marked by an increase in clay, silt, and mica into the Wenonah, especially in the west-central area of the central sheet.

The oyster *Agerostrea falcata* occurs in the lower part of the formation. *Exogyra cancellata* and *Belemnitella americana* are abundant in upper beds in the west-central area of the central sheet (New Egypt quadrangle). The Mount Laurel Formation is of late Campanian age based on the assignment of Zone CC 22b to the formation by Sugarman and others (1995) and the occurrence of *Exogyra cancellata* near Mullica Hill, Gloucester County. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kw - Wenonah Formation (Late Cretaceous (Campanian))

Kw - Wenonah Formation (Late Cretaceous)
Most of the Wenonah Formation is remarkably uniform in texture, color, and mineralogy. The unweathered deposit is typically thick- to massive-bedded medium-dark-gray to dark-gray, fine to very fine sub-angular to angular quartz sand and silt. The formation contains a few small pieces of lignite and abundant colorless muscovite and green chloritized mica. Small grains and clusters of pyrite crystals are common where the formation is unweathered. Unweathered material was seen only in cuttings from auger holes. A trace to a few percent of fine-grained to very fine grained glauconite is present. The glauconite is of two types; smooth-surfaced light-olive to moderate-green grains and botryoidal dusky-green to greenish-black grains. Clay and silt constitute from one-third to as much as three-fourths of the rock (table 1). The sand-sized fraction is chiefly fine to very fine.

In the clay-sized fraction quartz, kaolinite, muscovite, chlorite, and carbonaceous matter are common to major constituents. Detrital heavy minerals are abundant and are characterized by both stable and unstable types; zircon, tourmaline, staurolite, garnet, and epidote are particularly representative. At the basal contact the micaceous clayey glauconitic silt and sand of the Wenonah grades down into the non-micaceous glauconite-rich clayey silt and sand of the Marshalltown.

Although the formation is fossiliferous elsewhere (Weller, 1907, p. 91-101), only phosphatic fragments, such as shark teeth, were found here. This fossil deficiency may be attributed partly to the lack of unweathered outcrop.

The soil developed on the formation is brown and loamy, and supports a fairly dense and varied vegetative cover.

Before mapping under the present project, the Wenonah was not a clearly defined unit. The Wenonah and the overlying Mount Laurel Sand were previously mapped as a single unit, despite the fact that they had different names, fauna, and group assignments. The Wenonah and Mount Laurel were first mapped separately by Owens and Minard (1962) in the Columbus quadrangle (fig. 2). They have been mapped separately, where present, in all the subsequent quadrangles completed in the present mapping program (fig. 2).

The thickness of the Wenonah in the Sandy Hook quadrangle and vicinity was previously reported as 50 or 55 feet (Weller, 1907, p. 91) and about 35 feet (Kümmel, 1940, p. 118). The actual thickness in the quadrangle is 25-30 feet. The greater thickness assigned to the unit by earlier workers can probably be attributed to their including most of the Mount Laurel with the Wenonah. The formation has a nearly continuous outcrop in New Jersey, from Sandy Hook southwest to about the Delaware River. The Wenonah progressively thins from the central part of the Coastal Plain southwestward and is not present in Delaware.

The formation underlies lower slopes of the hills in the middle part of the land area of the quadrangle. Weathered parts of the formation were seen only in a few temporary excavations and cut-banks. Exposures were present in a 10-foot-high bank near the junction of Thompson and Hamilton Streets in Leonardo and in a roadcut in the small outlier on Middletown Road. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kw - Wenonah Formation (Late Cretaceous)
Silty fine-to-very-fine quartz sand to fine-sandy clayey silt, micaceous, slightly glauconitic (<5%); yellow, very pale brown where weathered, gray to pale-olive where unweathered; unstratified. As much as 40 feet thick. In subsurface only, covered by surficial deposits in the Navesink River estuary and by overlying Coastal Plain formations elsewhere. Late Cretaceous (late Campanian) in age based on pollen (Wolfe, 1976) and ammonites (Kennedy and Cobban, 1994). Grades downward into the Marshalltown Formation. On geophysical well logs, transition to Marshalltown is marked by increased gamma-ray intensity. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kw Wenonah Formation (Upper Cretaceous, upper Campanian)
Sand, quartz and mica, finegrained, silty and clayey, massive to thick-bedded, dark-gray to medium-gray; weathers light brown to white, extensively bioturbated, very micaceous, locally contains high concentrations of sand-sized lignitized wood and has large burrows of *Ophiomorpha nodosa*. Feldspar (5-10 percent) is a minor sand constituent. Unit crops out in a narrow belt from Sandy Hook Bay on the central sheet and pinches out southwest of Oldmans Creek, Salem County, on the southern sheet. Isolated outliers of the Wenonah are detached from the main belt in the central sheet area. Thickness is about 10 m (33 ft) in the northern part of the central sheet, 20 m (66 ft) in the southwestern part of the central sheet, and 7.5 m (25 ft) in the southern sheet. The Wenonah is gradational into the underlying Marshalltown Formation. A transition zone of several meters is marked by a decrease in mica and an increase in glauconite sand into the Marshalltown.

Fossil casts are abundant in the Wenonah. Weller (1907) reported *Flemingostrea subpatulata* Hop Brook in the Marlboro quadrangle indicating a late Campanian age. Wolfe (1976) placed the Wenonah microflora in his CA5A assemblage, considered to be of late Campanian age. Kennedy and Cobban (1994) identified ammonites including *Baculites* cf. *B. scotti, Didymoceras* n. sp., *Menuites portlocki, Nostoceras (Nostoceras) puzosiforme* n. sp., *Nostoceras (Nostoceras)* aff. *N. colubriformus, Parasolenoceras* sp., *Placenticeras placenta, P. minor* n. sp., and *Trachyscaphites pulcherrimus*. The presence of *M. portlocki* and *T. pulcherrimus* indicates late, but not latest, Campanian. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kmt - Marshalltown Formation (Late Cretaceous (Campanian))

Kmt - Marshalltown Formation (Late Cretaceous (Campanian))
The Marshalltown Formation is typically a greenish-black massive-bedded clayey quartz-glauconite sand and silt (table 1) where unweathered. In weathered outcrops the sand- and silt-sized fraction is greenish gray to dark greenish gray, and the clay is pale red to grayish red. The glauconite grains are mostly botryoidal silt to fine sand and constitute 20-60 percent of the formation; a few accordion-shaped grains (Galliher, 1935, p. 1587; Owens and Minard, 1960, p. B430) are present. Quartz grains are subangular to subrounded and range in size from silt to medium sand.

The major clay-sized minerals are quartz, kaolinite, muscovite, chlorite, and montmorillonite. Characteristic detrital heavy minerals are tourmaline and staurolite.

The contact with the underlying Englishtown Formation is distinct and is placed where quartz-glauconite silt-sand of the Marshalltown lies on lignitic quartz sand of the Englishtown. The basal 1 or 2 feet of the Marshalltown, which can be seen in the railroad cut at Leonardo, contains mica, lignite, and animal borings filled by quartz sand from the underlying Englishtown. Pyrite and siderite concretions are common in the basal part of the unweathered deposits.

The formation is very fossiliferous in the southwestern part of the State (Weller, 1907, p. 81-89; Mello and others, 1964; Millard, 1965), but only a few shell fragments in cuttings from an auger hole were found in the Sandy Hook quadrangle. The soil developed on the formation is brown, loamy, and fertile and supports a varied dense vegetative cover.

Within the quadrangle, the Marshalltown is a thin conspicuous marker unit, having a fairly constant thickness ranging between 10 and 12 feet. Most previous workers reported a greater thickness in this vicinity and elsewhere in New Jersey. Clark (in Bascom and others, 1909, p. 12) reported a thickness of 30-35 feet, and Weller (1907, p. 81) and Kümmel (1940, p. 53) reported a thickness of 30-40 feet. These workers were possibly including some of the overlying Wenonah and underlying Englishtown Formations in the Marshalltown. The formation has a nearly continuous outcrop in New Jersey, from Sandy Hook southwest to the Delaware River, and extends across Delaware to at least the east shore of Chesapeake Bay. The Marshalltown underlies the lower slopes of the low hills lying inland from the flat plain bounding Sandy Hook Bay on the south. It is exposed only in the southwestern part of Leonardo, in the railroad cut just west of BM 29 and in a low bank on the south side of Route 36. The contact with the underlying Englishtown can be seen in the railroad cut. The areal distribution of the Marshalltown was determined by augering through the alluvium and slope wash which mantle most of the formation. *(GRI Source Map ID 2584)* (Surficial Geology of the Sandy Hook Quadrangle (OFM 39)).

Kmt - Marshalltown Formation (Late Cretaceous (Campanian))
Glauconititc (20-50%), slightly micaceous, silty-clayey fine-to medium quartz sand, to fine-sandy clayey silt; olive-gray to olive-brown; unstratified. Thickness is 15 to 20 feet. In subsurface only. Late Cretaceous (middle Campanian) in age based on calcareous nannofossils, foraminifera, mollusks, and strontium-isotope ratios (Sugarman and others, 1995). Unconformably overlies the Englishtown Formation. On geophysical well logs, contact with Englishtown is marked by decreased gamma-ray intensity and slightly increased resistance. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kmt - Marshalltown Formation (Upper Cretaceous, upper and middle Campanian)
Sand, quartz and glauconite, fine- to medium-grained, silty and clayey, massive, dark-gray; weathers light brown or pale red, extensively bioturbated. Very glauconitic in basal few meters; glauconite concentration decreases upward so that in upper part of unit, quartz and glauconite are nearly equal. Feldspar, mica, pyrite, and phosphatic fragments are minor sand constituents. Locally, very micaceous (mostly green chlorite) with sparse carbonized wood fragments. Fine-grained pyrite abundant throughout formation. Local thin, pebbly zones with large fossil impressions occur in the middle of the formation. In the upper part of the formation, quartz increases to about 40 percent. Unit crops out in a narrow belt throughout the map area and forms isolated outliers in the central sheet. Best exposures are along Crosswicks Creek in the Allentown quadrangle. In the southern sheet, the Marshalltown underlies a narrow belt in the uplands and broadens to the southwest. Many Marshalltown exposures occur along Oldmans Creek and its tributaries near Auburn, Gloucester County. The contact with the underlying Englishtown Formation is sharp and unconformable. The basal few centimeters of the Marshalltown contain siderite concentrations, clay balls, and wood fragments reworked from the underlying Englishtown. Many burrows, some filled with glauconite, project downward into the Englishtown for about one meter (3 ft) giving a spotted appearance to the upper part of the Englishtown (Owens and others, 1970). The Marshalltown is the basal transgressive unit of a sedimentation cycle that includes the regressive deposits of the overlying Wenonah and Mount Laurel Formations resembling the overlying Red Bank Formation to Navesink Formation cycle in its asymmetry.

Within the map area, only a few long-ranging megafossils occur in the Moorestown quadrangle (Richards, 1967). To the south, in the type area, Weller (1907) reported diverse molluskan assemblages indicating a Campanian age. More importantly, Olsson (1964) reported the late Campanian foraminifera *Globotruncana calcarata* Cushman from the upper part of the formation. No *G. calcarata* were found during our investigations. Wolfe (1976) assigned the pollen assemblage of the Marshalltown to the CA5A Zone considered to be Campanian. The Marshalltown has most recently been assigned to Zone CC 20-21 (Sugarman and others, 1995) of middle and late Campanian age (Perch-Nielsen, 1985). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Ket - Englishtown Formation (Late Cretaceous (Campanian))

Ket - Englishtown Formation - (Late Cretaceous (Campanian))
The Englishtown Formation consists of laminated and thin- to thick-bedded horizontally and cross-stratified clay, silt, and sand. The basal part of the formation is typically dark-gray to medium-dark-gray sandy silty clay. The silt-clay beds are characterized by laminae of fine to very fine light-gray angular to subangular quartz sand and by abundant mica, lignite, and pyrite. The mica is mainly colorless muscovite, but a small percentage of green chloritized mica is present. Lignite fragments range from sand size to several inches in length. The larger pieces generally are flat, and many are as much as 1/4 inch thick, 1/2-1 inch wide, and 2-4 inches long. Abundant sand-sized crystals and crystal clusters of pyrite, and about 1 percent smooth rounded fine to very fine light-olive to moderate-green grains of glauconite are present in the unweathered material. Rounded to nodular oolites and concretions of yellowish-gray siderite, as much as 2 inches in length or width, occur locally near the base.

Within the quadrangle, the formation consists chiefly of very fine to medium quartz sand, containing as much as several percent feldspar. Coarse to very coarse subrounded to rounded sand beds are locally present (table 1). Minor amounts of rose quartz are generally present in the sand. Except near the base, clay layers are thin, generally 2 inches or less in thickness. Much of the sand is weathered and varies in color from pale yellowish brown to yellowish gray or grayish yellow and yellowish orange. Locally, the sand is cemented into massive beds of ironstone. One hill along Harmony Avenue, in the western part of the quadrangle, was capped by ironstone; but most of the hill was bulldozed away, and houses were built on the site. Another hill, just to the west along Laurel Avenue in the Keyport quadrangle, is capped by 8 feet of ironstone. Cavities in the rock have formed where lignite has weathered out. Conspicuous trough and festoon cross-stratification (McKee, and Weir, 1953, p. 387) or flow-and-plunge structure types (Salisbury, 1894, p. 198), as well as horizontally stratified sand that contains interbedded clay layers, are characteristic features (fig. 3). These internal structures and the abundance of lignite suggest a shallow-water to beach-complex depositional environment. In the clay-sized fraction, quartz, kaolinite, muscovite, and chlorite are common to major constituents. Characteristic detrital heavy minerals are zircon, tourmaline, and staurolite. Where overlain by the Marshalltown Formation, the top of the Englishtown usually contains small animal borings (1 in. across by several inches long) that are filled by quartz and glauconite sand from the Marshalltown. These filled borings give the beds a mottled appearance.

The formation generally has been reported as unfossiliferous, but recently, several fossil occurrences have been noted (Johnson and Richards, 1952, p. 2155-2156; Owens and Minard, 1964; Minard, 1965).

The soil developed on the formation is light gray, loose, and sandy, and has a fairly open vegetative cover.

The Englishtown is the oldest exposed formation within the quadrangle. Most of its entire thickness of 140 feet is exposed; only a few feet of the basal part extend into the Keyport quadrangle to the west, where it overlies the Woodbury Clay. The formation has a nearly continuous outcrop in New Jersey from Sandy Hook southwest to the Delaware River. It extends across Delaware to at least the east shore of Chesapeake Bay, where it is only about 20 feet thick.

The Englishtown Formation underlies the flat area bordering Sandy Hook Bay in the west half of the quadrangle, and the low hills and slopes a short distance inland. It is poorly exposed, being largely covered by alluvium and marshes. Exposures of the unit were present in the hill just east of Harmony, but a housing development now covers the outcrop. A few feet of the upper part of the unit are exposed in a small bank on the beach between the Atlantic Highlands Yacht Harbor pier and. he tank farm at the mouth of Wagner Branch, and also in the railroad cut at the southwestern part of Leonardo, just west of BM 29. There are also good exposures a short distance west of Harmony in the adjacent Keyport quadrangle. The exposures are in pits in the small hill along the west side of Laurel Avenue slightly more than 0.3 mile south of Route 36. Except for these few exposures, most information was obtained by angering. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Ket - Englishtown Formation - (Late Cretaceous (Campanian))
Fine-to-medium quartz sand, minor medium-to-coarse sand, with thin interbeds of clay and silt; micaceous and lignitic, with a trace (<1%) of glauconite; white and light gray where weathered, dark gray where unweathered. Sand is unstratified to horizontally bedded to cross-bedded. In subsurface only. As much as 140 feet thick in the eastern part of the quadrangle, thins to 110 feet thick in the west. In the Asbury Park quadrangle to the south of the Long Branch quadrangle, and farther southwest in northern Ocean County, the Englishtown is divided into an upper and lower member based on the presence of a clay-silt facies in the middle of the formation that is distinctive on gamma-ray logs (Nichols, 1977; Sugarman and Owens, 1994; Miller and others, 2006). This facies is not well marked on gamma-ray logs in the Long Branch quadrangle (wells 29-9335, 29-7941, 29-9465, 29-6173, 29-23948, and 29-48307) and so the members are not mapped here. Late Cretaceous (middle to late Campanian) in age, based, based on pollen (Wolfe, 1976), ostracodes (Gohn, 1992), calcareous nannofossils, and strontium-isotope ratios (Miller and others, 2006). Grades downward into the Woodbury Formation. On geophysical well logs, transition to Woodbury is marked by increased gamma-ray intensity and decreased resistance. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Ket - Englishtown Formation (Upper Cretaceous, lower Campanian)
Sand, quartz, fine- to coarsegrained, gravelly, massive, bioturbated, medium- to dark-gray; weathers light brown, yellow, or reddish brown, locally interbedded with thin to thick beds of dark clay. Abundant carbonaceous matter, with large lignitized logs occur locally, especially in clay strata. Feldspar, glauconite, and muscovite are minor sand constituents. Sand is extensively trough crossbedded particularly west of Mount Holly, Burlington County. In a few places in the western outcrop belt, trace fossils are abundant, typically the burrow *Ophiomorpha nodosa*. Unit is pyritic, especially in the carbonaceous-rich beds where pyrite is finely disseminated grains or pyritic masses as much as 0.6 m (2 ft) in diameter. Lowest part of unit is a massive sand that contains small to large, soft, light-gray siderite concretions. The Englishtown underlies a broad belt throughout the map area and ranges from about 45 m (148 ft) thick in the northern part of the central sheet to 30 m (98 ft) thick in the western part of the central sheet to 15 m (49 ft) in the southern sheet. Best exposures occur along Crosswicks Creek in the Allentown quadrangle and along Oldmans Creek. The basal contact with the underlying Woodbury Formation or Merchantville Formation is transitional over several meters. The age of the Englishtown in outcrop could not be determined directly but was inferred from stratigraphic position and pollen content. Wolfe (1976) designated the microflora of the unit as Zone CA4 and assigned it to the lower Campanian. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kwb - Woodbury Formation (Late Cretaceous (Campanian))

Kwb - Woodbury Clay (Upper Cretaceous)
Dark-gray micaceous silty clay. Shown in section only. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kwb - Woodbury Formation (Late Cretaceous (Campanian))
Clay, silty clay, with minor thin beds of very fine quartz sand, slightly micaceous and lignitic; dark gray and black where unweathered, yellowish-brown to brown where weathered; unstratified. In subsurface only. As much as 240 feet thick in the eastern part of the quadrangle, thins to 160 feet thick in the central and western parts of the quadrangle. Late Cretaceous (early to middle Campanian) based on pollen (Wolfe, 1976), ostracodes (Gohn, 1992), and calcareous nannofossils (Miller and others, 2006). Grades downward into the Merchantville Formation. On geophysical well logs, transition to the Merchantville is marked by slightly increased gamma-ray intensity. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kwb Woodbury Formation (Cretaceous)
Clay-silt. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kmv - Merchantville Formation (Late Cretaceous (Campanian))

Kmv - Merchantville Formation (Cretaceous)
Dark-gray, silty, glauconitic quartz sand. Shown in section only. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kmv - Merchantville Formation (Late Cretaceous (Campanian))
Glauconitic (20-50%) clayey silt to sandy clayey silt, slightly micaceous; olive, dark gray, black where unweathered, olive-brown to yellowish-brown where weathered; unstratified. Thickness is 40 to 60 feet. In subsurface only. Late Cretaceous (early Campanian to Santonian) in age based on ammonites (Owens and others, 1977) and calcareous nannofossils (Miller and others, 2006). The Cheesequake Formation, a glauconitic clayey silt underlying the Merchantville, is mapped in outcrop in northern Monmouth and eastern Middlesex counties (Sugarman and Owens, 1996; Sugarman and others, 2005; Stanford and Sugarman, 2008) and in the subsurface both west and south of the Long Branch quadrangle (Sugarman and Owens, 1994, 1996). Because it is lithically similar to the Merchantville and cannot be easily distinguished from it on geophysical logs, it is not mapped separately here. If present, it is included here within the Merchantville, or uppermost Magothy Formation. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kmv - Merchantville Formation (Cretaceous)
Glauconite sand to quartz-glauconite sand, clayey and silty. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kcq - Cheesequake Formation (Late Cretaceous (Santonian to Campanian))

Clay and clay-silt, micaceous, thin-bedded to laminated, dark-gray; weathers light tan. Contains abundant wood fragments intercalated with light-colored, fine-grained micaceous quartz sand and is rarely crossbedded. Rock fragments and feldspar are minor sand constituents. Small cylindrical burrows occur in the updip area. Abundant, rounded, pale-gray siderite concretions (about 8 cm (3 in) in diameter) occur in thin discontinuous beds. Sand interfingers rapidly within a short distance with extensively bioturbated, dark-gray, very micaceous, somewhat woody clay-silt. The basal clay-silt has extensive cylindrical burrows filled with fine-grained, light- to medium-green botryoidal glauconite. The basal contact with the underlying Magothy Formation is sharp. Reworked siderite concretions and some glauconite and coarse-grained quartz sand are found along the contact within the Cheesequake. Unit exposed only in the South Amboy and Keyport quadrangles. The unit is about 14 m (46 ft) thick. The age of the Cheesequake was determined from pollen (Litwin and others, 1993), which indicates the unit is between the Merchantville Formation microflora (CA2 Zone of Wolfe, 1976, lower Campanian) and the uppermost Magothy microflora (?*Pseudoplicapollis cunceata-Semioculopollis* verrucosa Zone of Christopher, 1979, upper Santonian). It is probable that the Cheesequake Formation contains the Santonian-Campanian boundary. This unit was not recognized by Petters (1976) who concluded that the Magothy and Merchantville interfingered in the subsurface and the Merchantville was, in part, Santonian. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kmg - Magothy Formation (Late Cretaceous (Santonian))

Km - Magothy Formation (Cretaceous)
Dark-and light-gray intercalated clay and quartz sand. Shown in section only. *(GRI Source Map ID 2583)* (Geology of the Sandy Hook Quadrangle (Bulletin 1276)).

Kmg - Magothy Formation (Santonian-Conlaclan-Turonlan (late Cretaceous))
Fine-to-medium quartz sand, some very-fine-to-fine sand and minor medium-to-coarse sand, micaceous, lignitic, and pyrite-bearing in places, with thin interbeds of silt and clay; white to yellow where weathered, light gray to gray where unweathered. Sand is cross-bedded to laminated. As much as 220 feet thick. In subsurface only. Late Cretaceous (Turonian-Santonian) in age, based on pollen (Christopher, 1979, 1982; Miller and others, 2006). Unconformably overlies the Raritan Formation, Woodbridge Clay member. On geophysical well logs, contact with the Woodbridge is marked by increased gamma-ray intensity.

In its outcrop area in eastern Middlesex County the Magothy is divided into 5 members. From bottom to top they include; South Amboy Fire Clay, Old Bridge Sand, Amboy Stoneware Clay, Morgan beds, and Cliffwood beds (Sugarman and others, 2005). The Old Bridge is a thick sand, the other members are interbedded clay-silt and fine sand. These members may extend downdip in the subsurface (Miller and others, 2006). Geophysical well logs in the Long Branch quadrangle (wells 29-21612, 29-23948, 29-21510, 29-9335, 29-7941, 29-9465, and 29-6173) show generally higher gamma-ray intensity and lower resistivity in the uppermost 50 feet of the formation, and again in the lowermost 30-40 feet, than in the middle 100-120 feet. The upper fine-grained beds may correspond to the Amboy Stoneware Clay and Morgan and Cliffwood beds, and the lower fine-grained beds may correspond to the South Amboy Fire Clay. The middle sand may correspond to the Old Bridge Sand. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kmg - Magothy Formation (Upper Cretaceous, middle and lower Santonian) - Sand, quartz, fine- to coarse-grained, locally gravelly (especially at the base), white; weathers yellow brown or orange brown, interbedded with thin-bedded clay or dark-gray clay-silt mainly at the top of the formation. Muscovite and feldspar are minor sand constituents. Large wood fragments occur in many clay layers. Clay weathers to gray brown or white. Formation characterized by local vertical and lateral facies changes. The Magothy is best exposed and thickest (about 80 m (262 ft)) in the Raritan Bay area. The outcrop belt is widest in the north and narrows to the southwest. The formation is about 25 m (82 ft) thick or less in the southern sheet. The formation is poorly exposed because of its sandy nature and its widespread cover by younger sediments.

The old geologic map of New Jersey (Lewis and Kümmel, 1910-1912, revised 1950) showed the Magothy to consist of only one lithology (Cliffwood beds at Cliffwood Beach, Monmouth County). Subsequent pollen studies of the Magothy and the underlying Raritan Formation showed most of the Raritan to be the same age as the Magothy. Wolfe and Pakiser (1971) redefined and considerably expanded the Magothy. Kümmel and Knapp (1904) had already recognized that the Magothy, as used here, contained a large number of lithologies. At the time of their study, the Magothy was extensively mined for clay and sand and was well exposed. Their subdivisions had economic designations (for example, Amboy stoneware clay). Barksdale and others (1943) later gave geographic names to these subdivisions, discussed individually below.

The lower contact of the Magothy in the Delaware River valley is difficult to place because the lower part of the Magothy is lithically similar to the underlying Potomac Formation. The contact is placed at the base of the lowest dark-gray clay in the Magothy. The best faunas from the Magothy were obtained from siderite concretions and slabs in and near Cliffwood Beach representing only the top of the formation. These faunas were discussed in detail by Weller (1904, 1907) and supplemented by Sohl (*in* Owens and others, 1977). The presence of *Ostrea cretacea* in the Cliffwood Beach fauna suggests that the upper part of the Magothy is late Santonian in age. Wolfe and Pakiser (1971) and Christopher (1979, 1982) discussed the microfloral assemblage in the Magothy. Christopher subdivided the Magothy into three zones: *Complexipollis exigua-Santalacites minor* (oldest), ?*Pseudoplicapollis longiannulata-Plicapollis incisa* (middle), and ?*Pseudoplicapollis cuneata-Semioculopollis verrucosa* (youngest). The oldest zone, originally considered to be as old as Turonian, was subsequently considered to be post-Coniacian Christopher, 1982). The middle and upper zones are also probably Santonian. Christopher (1979) followed the nomenclature for the subdivisions elaborated upon earlier. The Cliffwood and Morgan beds, and, presumably the upper thin-bedded sequence, would include the youngest pollen zone; the Amboy Stoneware Clay Member and perhaps the uppermost part of the Old Bridge Sand Member, the middle pollen zone; and the lower part of the Old Bridge Sand Member and South Amboy Fire Clay Member, the oldest pollen zone. The Magothy is considered herein to be of Santonian age.

Cliffwood beds - Typically very sandy, horizontally bedded to crossbedded, mainly small-scale trough crossbeds. Thin layers of dark, fine, carbonaceous matter are interbedded with sand. Carbonaceous units are conspicuously micaceous; the sand is less so. Sand is typically fine to medium grained and locally burrowed. Burrows include the small-diameter *Ophiomorpha nodosa* and some that are not clay lined. Slabs of dark-reddish-brown siderite were common at the base of the bluff at Cliffwood Beach before the outcrop was covered. Some of these slabs had many fossil molds, typically a large number of pelecypods. Lower in the section, between high and low tide level, there is a pale-gray clay-silt about 1.5 m (5 ft) thick with many small reddish-brown siderite concretions. These concretions have many fossils that were described in detail by Weller (1904). The Cliffwood beds are about 7.5 m (25 ft) thick in outcrop. Equivalents of the Cliffwood beds are exposed near the Delaware River between Trenton and Florence, Burlington County. These beds are mainly sand, as are those at Cliffwood Beach, but they tend to have more crossbedding than the typical Cliffwood strata and no burrows or marine fossils. In addition, beds of quartz gravel are present in the Cliffwood near Riverside, Burlington County.

Morgan beds - Occur only in the northern part of the central sheet. They consist of interbedded, thin, dark-colored clay and fine-grained, light-colored, micaceous sand. Clay is locally more abundant in the Morgan than in the Cliffwood beds. Sand ranges from massive to locally crossbedded and locally has fine organic matter. This unit is exposed only in the South Amboy quadrangle where it is as much as 12 m (39 ft) thick. It grades downward into underlying clay.

Amboy Stoneware Clay Member - Crops out only in the South Amboy quadrangle in the central sheet and is mainly dark-gray, white-weathering, interbedded clay and silt to fine-grained quartz sand. Clay has abundant, fine, carbonaceous matter and fine mica flakes. Small cylindrical burrows are abundant in this unit. Locally, the clay is interbedded with sand and contains large pieces of lignitized, bored (*Teredolites*) logs. Large slabs of pyrite-cemented sand are associated with the woody beds. Amber occurs in some of the wood. Unit is approximately 7.5 m (25 ft) thick, but pinches out along strike. The Amboy Stoneware is disconformable on the underlying sand.

Old Bridge Sand Member - Predominantly a light-colored sand, extensively crossbedded and locally interbedded with dark-gray laminae; clay is highly carbonaceous, woody, in discontinuous beds, especially near the base. The scale of crossbedding varies from small to large. Locally, small burrows are present. Unit is as much as 12 m (39 ft) thick and rests disconformably on the underlying unit.

South Amboy Fire Clay Member - Basal member of the Magothy Formation. Unit resembles the Amboy Stoneware Clay Member, particularly in its lensing character. Unit is best exposed in the central sheet in the South Amboy quadrangle and in the Delaware River valley at the base of the bluffs at Florence. The South Amboy is a dark, massive to finely laminated clay, locally oxidized to white or red. Unit fills large channels and has local concentrations of large, pyrite-encrusted, lignitized logs. Some of the clay is slumped, suggesting post-depositional undercutting during channel migration. The clay is interbedded with fine- to medium-grained, crossbedded sand. The basal contact with the underlying Raritan is well exposed in the Sayre and Fisher Pit in Sayreville, Middlesex County, where the contact is marked by a deeply weathered gravel zone. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Kr - Raritan Formation, undivided (Late Cretaceous (Cenomanian))

Kr - Raritan Formation (Upper Cretaceous)
Clay, silty clay, sand, gravel. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

Kr - Raritan Formation (Upper Cretaceous, upper Cenomanian)
Consists of an upper clayey silt (Woodbridge Clay Member) and a lower sand (Farrington Sand Member). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Krw - Raritan Formation, Woodbridge Clay Member (Late Cretaceous (Cenomanian))

Clay and silt, micaceous, lignitic, and pyrite-bearing; gray and black where unweathered, white to brown where weathered; with minor thin interbeds and laminas of white, yellow, and light gray very-fine-to-fine quartz sand. As much as 110 feet thick. In subsurface only, penetrated by wells 29-9465 and 29-1921. The driller's log for well 29-2366 in Eatontown reports "weathered bedrock", with no further information, beneath the Magothy Formation, at a depth of 875-891 feet. This depth is anomalously shallow for the basement surface, suggesting that the material may be weathered clay of either the Woodbridge of South Amboy Fire Clay member of the Magothy. The Woodbridge is Late Cretaceous (late Cenomanian) in age based on pollen (Christopher, 1979) and ammonites (Cobban and Kennedy, 1990). Grades downward into the Raritan Formation, Farrington Sand member. Transition to the Farrington is marked by decreased gamma-ray intensity on geophysical well logs. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Krf - Raritan Formation, Farrington Sand Member (Late Cretaceous (Cenomanian))

Fine-to-coarse quartz sand, some coarse-to-very-coarse sand, minor beds of clay and silt; white and yellow where weathered, gray where unweathered. Sands are horizontally bedded to cross-bedded. As much as 60 feet thick. In subsurface only, penetrated in well 29-9465. Late Cretaceous (Cenomanian) in age based on pollen (Christopher, 1979). Unconformably overlies the Potamac Formation. Contact with Potomac is marked by increased gamma-ray intensity on geophysical well logs. *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Kp - Potomac Formation (Late Cretaceous (Cenomanian-Albian))

Fine-to-medium quartz sand, some coarse-to-very-coarse sand, with beds of clay and silt; white, red, yellow where weathered, gray where unweathered. Sands are horizontally bedded to cross-bedded, clays are in beds as much as 8 feet thick. More than 90 feet thick, full thickness not penetrated in the Long Branch quadrangle. In subsurface only, partially penetrated in well 29-9465. Late Cretaceous (Albian-Cenomanian) based on pollen (Sugarman and Owens, 1996; Miller and others, 2006), which indicates that the Potomac in this area corresponds to the Potomac Formation, unit 3, of Doyle and Robbins (1977). *(GRI Source Map ID 75557)* (Bedrock Geology of the Long Branch Quadrangle (OFM 78)).

Jd - Jurassic Diabase (Jurassic)

Concordant to discordant, predominantly sheet-like intrusions of medium- to fine-grained diabase and dikes of fine-grained diabase; dark-greenish-gray to black; subophitic texture. Dense, hard, sparsely fractured rock composed mostly of plagioclase (An_{50-70}), clinopyroxene (mostly augite), and magnetite-ilmenite. Orthopyroxene (En_{75-80}) is locally abundant in the lower part of the sheets. Accessory minerals include apatite, quartz, alkali feldspar, hornblende, sphene, zircon, and rare olivine. Diabase in the map area was derived primarily from high-titanium, quartz-tholeiite magma. Sedimentary rocks within about 300 m (984 ft) above and 200 m (656 ft) below major diabase sheets are thermally metamorphosed. Red mudstone is typically altered to indurated, bluish-gray hornfels with clots or crystals of tourmaline or cordierite. Gray argillitic siltstone is typically altered to brittle, black, very fine grained hornfels. Sills are 365 to 400 m (1,197-1,312 ft) thick. Dikes range in thickness from 3 to 10 m (10-33 ft) and are many kilometers long. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

JTRp - Passaic Formation, undivided (Jurassic and Triassic)

Predominantly red beds consisting of argillaceous siltstone; silty mudstone; argillaceous, very fine grained sandstone; and shale; mostly reddish-brown to brownish-purple, and grayish-red. Upper Triassic gray lake deposits (Trpg) consist of gray to black silty mudstone, gray and greenish- to purplish-gray argillaceous siltstone, black shale, and medium- to dark-gray, argillaceous, fine-grained sandstone and are abundant in the lower half of the Passaic Formation. Red beds occur typically in 3- to 7-m (10- to 23-ft-)-thick, cyclic playa-lake-mudflat sequences and fining-upward fluvial sequences. Lamination is commonly indistinct due to burrowing, desiccation, and paleosol formation. Where layering is preserved, most bedforms are wavy parallel lamination and trough and climbing-ripple cross lamination. Calcite- or dolomite-filled vugs and flattened cavities, mostly 0.5 to 0.2 mm (0.02-0.08 in) across, occur mostly in the lower half. Sand-filled burrows, 2 to 5 mm (0.08-0.2 in) in diameter, are prevalent in the upper two-thirds of the unit. Desiccation cracks, intraformational breccias, and curled silt laminae are abundant in the lower half. Lake cycles, mostly 2 to 5 m (7-16 ft) thick, have a basal, greenish-gray, argillaceous siltstone; a medial, dark-gray to black, pyritic, carbonaceous, fossiliferous, and, in places, calcareous lake-bottom fissile mudstone or siltstone; and an upper thick-bedded, gray to reddish and purplish-gray argillaceous siltstone with desiccation cracks, intraformational breccias, burrows, and mineralized vugs. Gray lakebeds occur in groups of two to five cycles although they also occur as single cycles in some parts of the formation. Several lakebed sequences consisting of one or two thick groups of drab-colored beds as much as 30 m (98 ft) thick or more can be traced over tens of kilometers. Many gray-bed sequences are locally correlated within fault blocks; some can be correlated across major faults or intrusive rock units. Thickness of the formation between Sourland Mountain and Sand Brook syncline is about 3,500 m (11,483 ft). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

JTRpms - Passaic Formation, mudstone facies (Jurassic and Triassic)

Sandy mudstone. Only in cross section. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

JTRps - Passaic Formation, sandstone and siltstone facies (Jurassic and Triassic)

Sandstone and siltstone. Only in cross section. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

TRpg - Passaic Formation, gray bed (Triassic)

Sandstone, siltstone and shale. Only in cross section. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

TRb - Brunswick Formation (Triassic)

Sandstone and conglomerate. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

TRp - Palisade Diabase sill (Triassic)

No unit description available. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

TRl - Lockatong Formation (Triassic)

Predominantly cyclic lacustrine sequences of silty, dolomitic or analcime-bearing argillite; laminated mudstone; silty to calcareous, argillaceous very fine grained sandstone and pyritic siltstone; and minor silty limestone, mostly light- to dark-gray, greenishgray, and black. Grayish-red, grayish-purple, and dark-brownish-red sequences (Trla) occur in some places, especially in upper half. Two types of cycles are recognized: freshwater-lake (detrital) and alkaline-lake (chemical) cycles. Freshwater-lake cycles average 5.2 m (17 ft) thick. They consist of basal, transgressive, fluvial to lake-margin deposits that are argillaceous, very fine grained sandstone to coarse siltstone with indistinct lamination, planar or cross lamination, or are disrupted by convolute bedding, desiccation cracks, root casts, soil-ped casts, and tubes. Medial lake-bottom deposits are laminated siltstones, silty mudstones, or silty limestones that are dark gray to black with calcite laminae and grains and lenses, or streaks of pyrite; fossils are common, including fish scales and articulated fish, conchostracans, plants, spores, and pollen. Upper regressive lake margin, playa lake, and mudflat deposits are light- to dark-gray silty mudstone to argillitic siltstone or very fine grained sandstone, mostly thick bedded to massive, with desiccation cracks, intraformational breccias, faint wavy laminations, burrows, euhedral pyrite grains, and dolomite or calcite specks. Alkaline-lake cycles are similar to freshwater-lake cycles, but are thinner, averaging 3 m (10 ft), have fewer fossils (mainly conchostracans), and commonly have red beds, extensive desiccation features, and abundant analcime and dolomite specks in the upper parts of cycles. Thickness near Byram is about 1,070 m (3,510 ft). The formation thins to the southeast and northeast; thickness near

Princeton is less than 700 m (2,297 ft). *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

TRla - Lockatong Formation, arkosic sandstone facies (Triassic)

Coarse to fine-grained arkosic sandstone. Only in cross section. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

TRs - Stockton Formation (Triassic)

Trs - Stockton Formation (Late Triassic)
Sandstone, mudstone, silty mudstone, argillaceous siltstone, and shale. Only in cross section. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

Trs - Stockton Formation (Upper Triassic)
Arkose, conglomerate, and mudstone. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

Ohr - Harrison Gneiss (Ordovician)

Biotite hornblende quartz plagioclase gneiss with accessory garnet and sphene; plagioclase commonly occurs as augen. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

OCi - Inwood Marble (Cambrian to Ordovician)

Dolomite marble, calc-schist, granulite, and quartzite, overlain by calcite marble; grades into underlying patchy Lowerre Quartzite of Early Cambrian age. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

OZs - Serpentinite (Neoproterozoic to Ordovician)

Os - Serpentinite (Lower Ordovician)
No unit description available. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

CZs - Serpentinite (Neoproterozoic to Cambrian)
Fine-grained. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

OZm - Manhattan Schist (Neoproterozoic to Ordovician)

Om - Manhattan Formation, undivided (middle Ordovician)
Pelitic schists, amphibolite. *(GRI Source Map ID 7288)* (Geologic Map of New York, Lower Hudson Sheet).

CZm - Schist and Gneiss (Neoproterozoic to Cambrian)
Medium- to coarse-grained. *(GRI Source Map ID 7285)* (Bedrock Geology of New Jersey (DGS 04-6)).

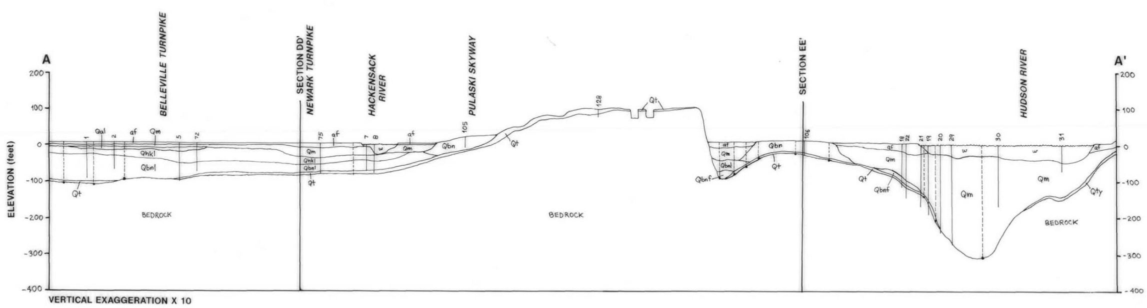
Geologic Cross Sections

The geologic cross sections present in the GRI digital geologic-GIS data produced for Gateway National Recreation Area, New York and New Jersey (GATE) are presented below. Note that some cross section abbreviations (e.g., A-A') may have been changed from their source map abbreviation in the GRI data so that each cross section abbreviation in the GRI data is unique. Cross section graphics were scanned at a high resolution and can be viewed in more detail by zooming in (if viewing the digital format of this document).

Large Scale Maps (1:24,000)

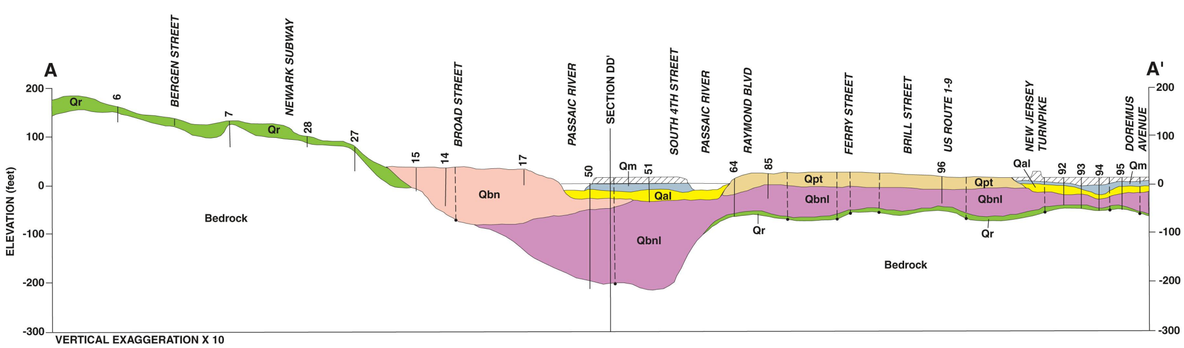
Surficial Sections

Cross Section A-A'



Extracted from: [Surficial Geology of the Jersey City Quadrangle (OFM20)]

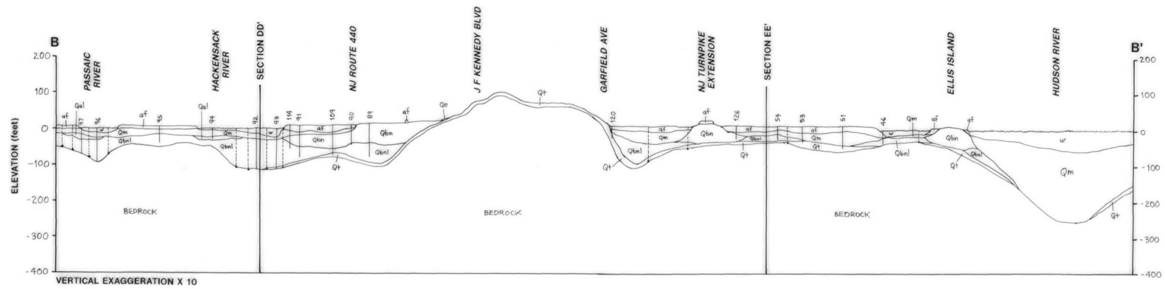
Cross Section B-B'



Extracted from: [Surficial Geology of the Elizabeth Quadrangle (OFM 42)]

Note: this cross section is labeled A-A' on the source map.

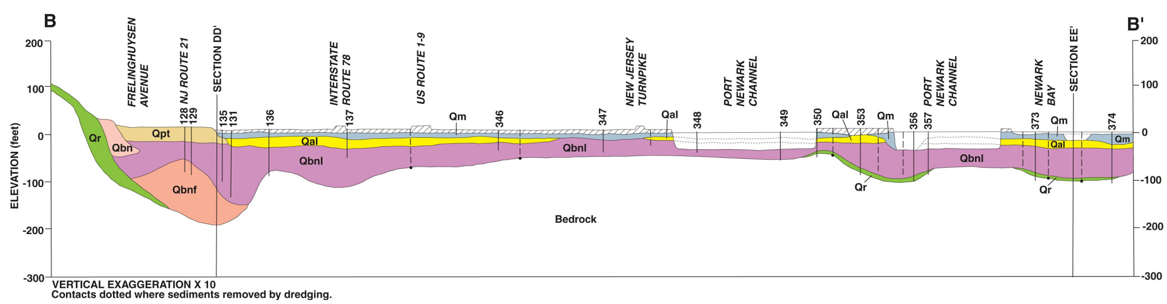
Cross Section C-C'



Extracted from: [Surficial Geology of the Jersey City Quadrangle (OFM20)]

Note: this cross section is labeled B-B' on the source map.

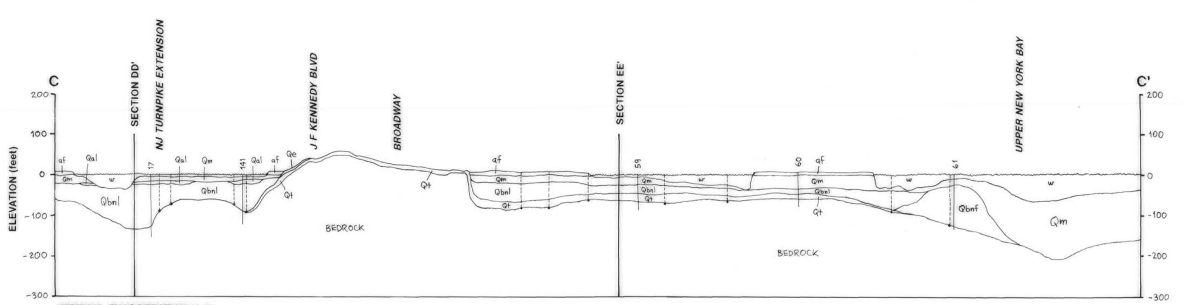
Cross Section D-D'



Extracted from: [Surficial Geology of the Elizabeth Quadrangle (OFM 42)]

Note: this cross section is labeled B-B' on the source map.

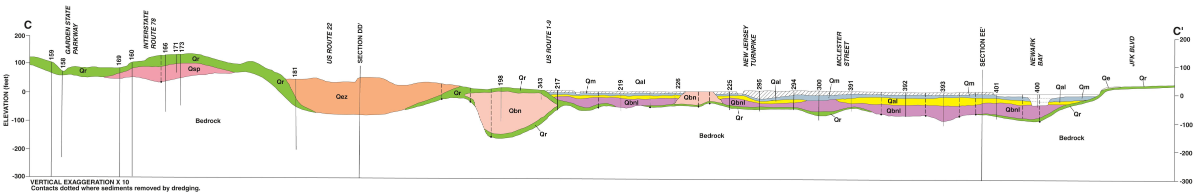
Cross Section E-E'



Extracted from: [Surficial Geology of the Jersey City Quadrangle (OFM20)]

Note: this cross section is labeled C-C' on the source map.

Cross Section F-F'



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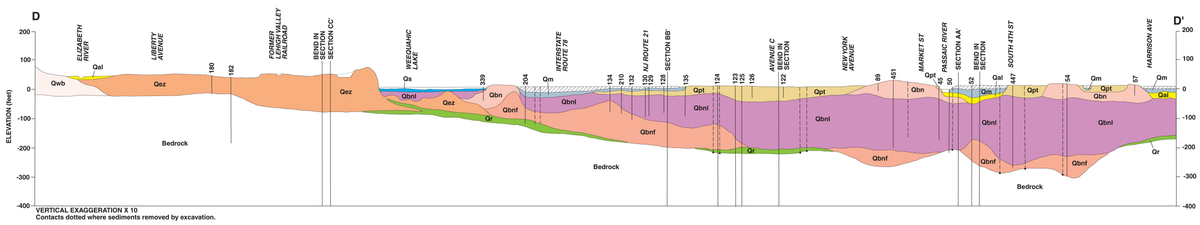
Note: this cross section is labeled C-C' on the source map.

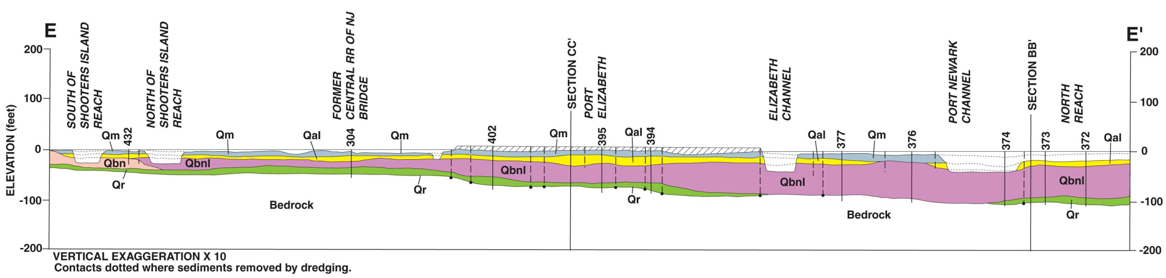
Cross Section G-G'



Extracted from: [Surficial Geology of the Elizabeth Quadrangle (OFM 42)]

Note: this cross section is labeled D-D' on the source map.

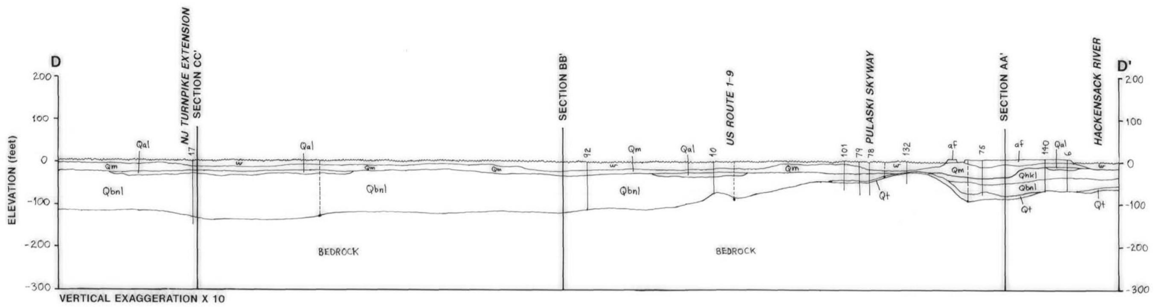
Cross Section H-H'



Extracted from: [Surficial Geology of the Elizabeth Quadrangle (OFM 42)]

Note: this cross section is labeled E-E' on the source map.

Cross Section I-I'



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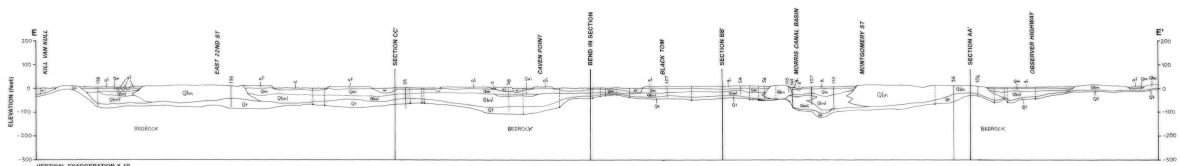
Note: this cross section is labeled D-D' on the source map.

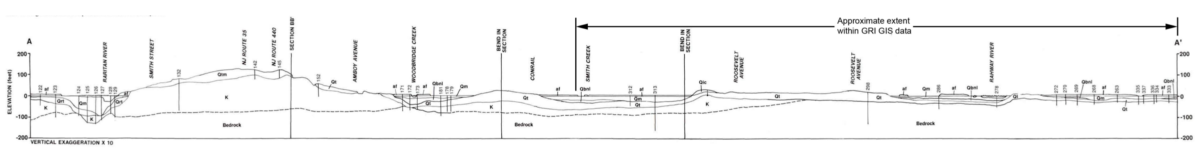
Cross Section J-J'



Extracted from: [Surficial Geology of the Jersey City Quadrangle (OFM20)]

Note: this cross section is labeled E-E' on the source map.

Cross Section K-K'

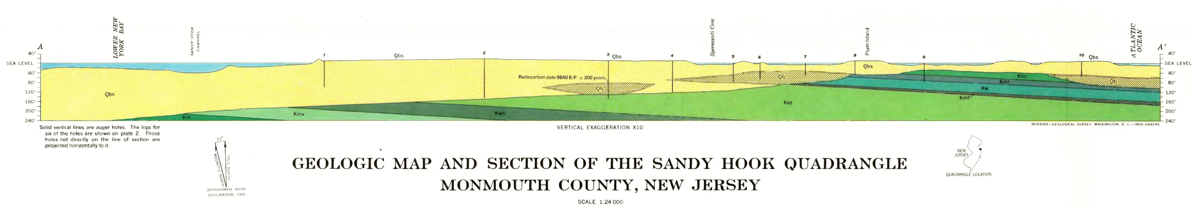


Extracted from: [Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)]

Note: this cross section is labeled A-A' on the source map.

Bedrock Sections

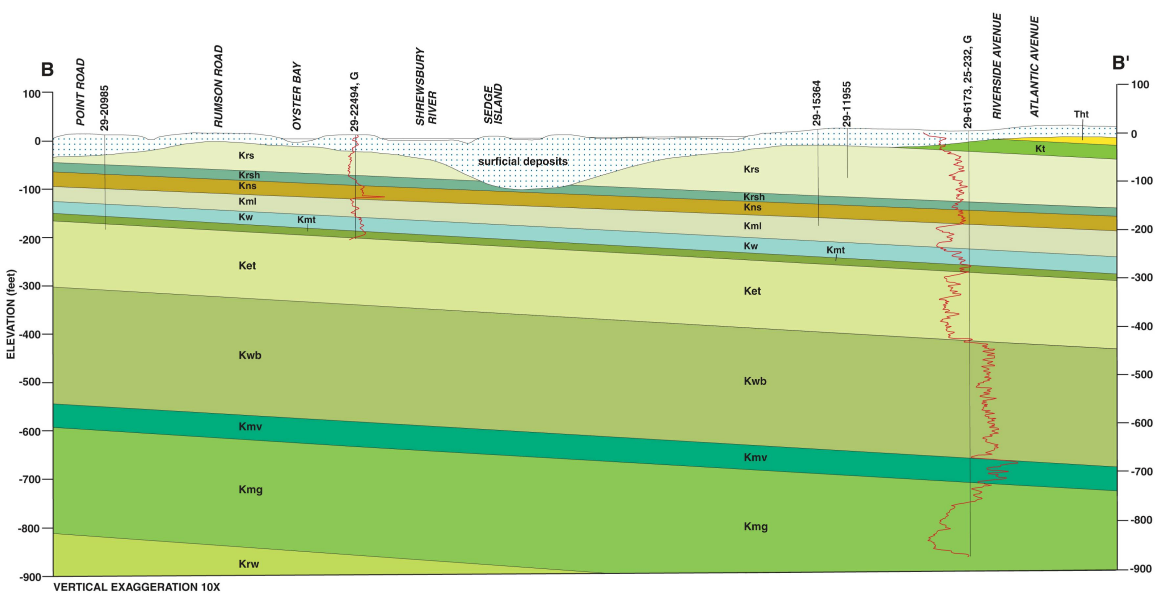
Cross Section L-L'



Extracted from: [Geology of the Sandy Hook Quadrangle (Bulletin 1276)]()

Note: this cross section is labeled A-A' on the source map.

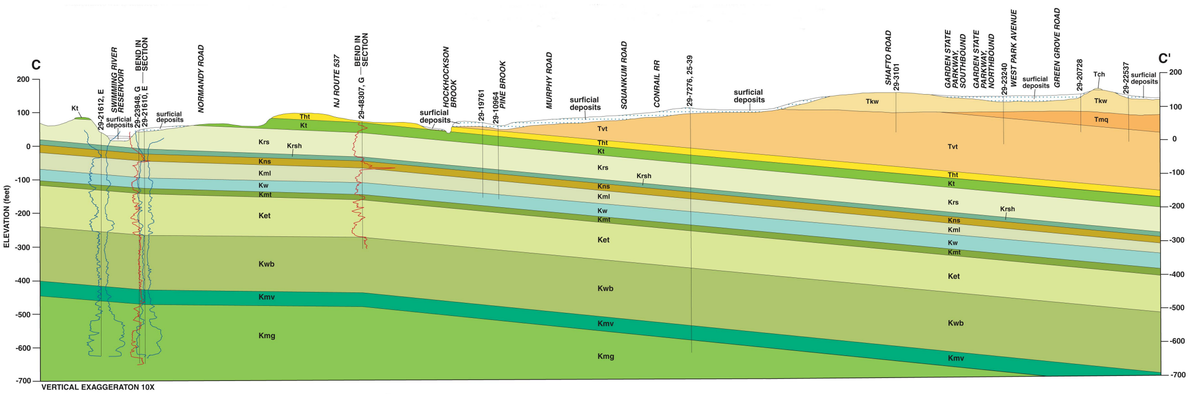
Cross Section M-M'



Extracted from: [Bedrock Geology of the Long Branch Quadrangle (OFM 78)]()

Note: this cross section is labeled B-B' on the source map.

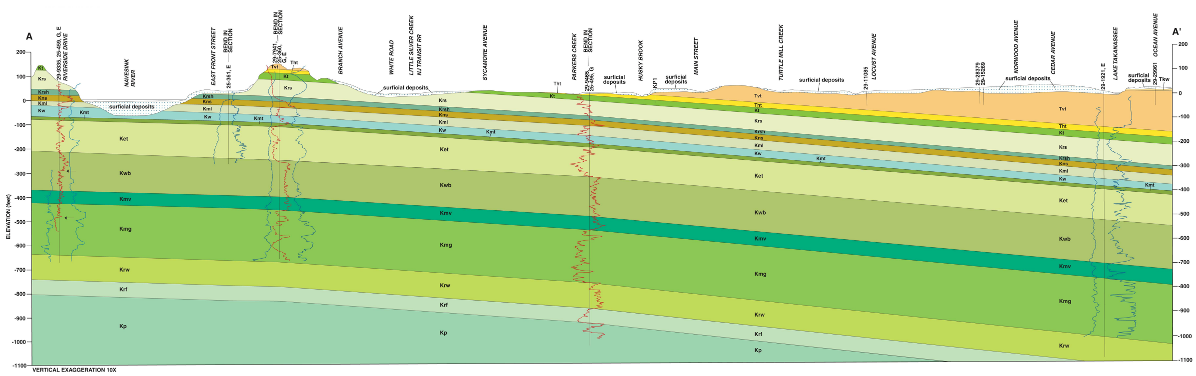
Cross Section N-N'



Extracted from: [Bedrock Geology of the Long Branch Quadrangle (OFM 78)]

Note: this cross section is labeled C-C' on the source map.

Cross Section O-O'



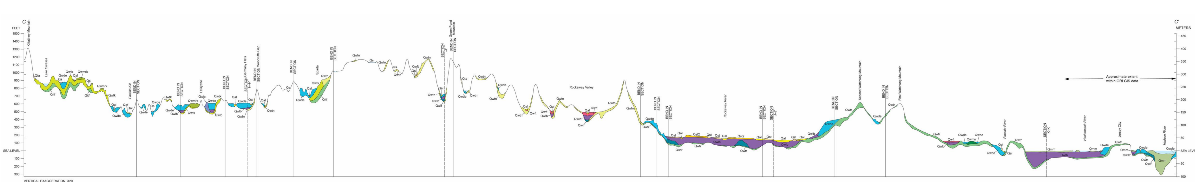
Extracted from: [Bedrock Geology of the Long Branch Quadrangle (OFM 78)]

Note: this cross section is labeled A-A' on the source map.

Small Scale Maps (1:100,000 and 1:250,000)

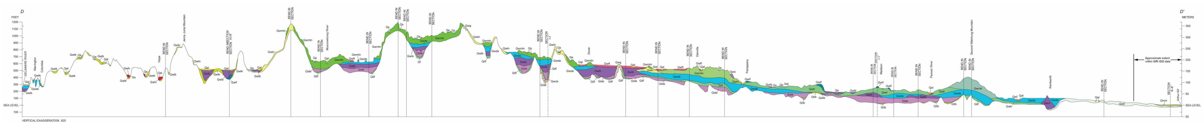
Surficial Sections

Cross Section C-C'



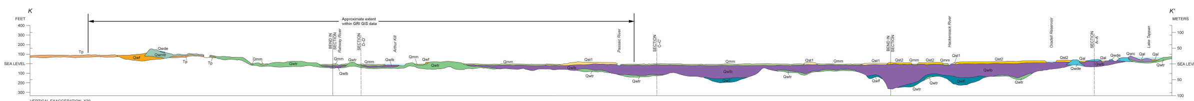
Extracted from: [Surficial Geology of New Jersey (DGS 07-2)]

Cross Section D-D'



Extracted from: Surficial Geology of New Jersey (DGS 07-2)

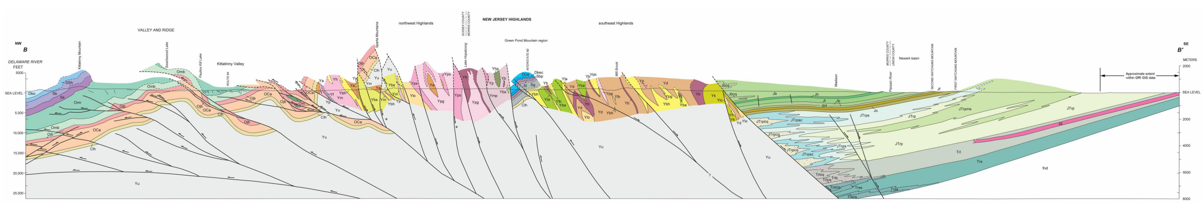
Cross Section K-K'



Extracted from: Surficial Geology of New Jersey (DGS 07-2)

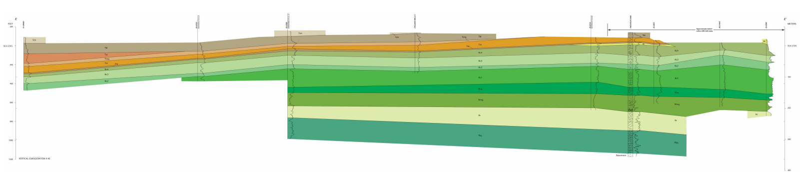
Bedrock Sections

Cross Section NB-B'



Extracted from: Bedrock Geology of New Jersey (DGS 04-6)

Cross Section CSE-E'



Extracted from: Bedrock Geology of New Jersey (DGS 04-6)

GRI Source Map Information

Large Scale Sources

Geomorphologic Maps of Gateway National Recreation Area

Psuty, N.P., McLoughlin, S.M., Schmelz, W., Spahn, A., 2014, Geomorphologic Maps of Gateway National Recreation Area, New York and New Jersey: Institute of Coastal and Marine Sciences, Rutgers University, Sandy Hook, New Jersey, 3 maps, scale 1:6,000. (*GRI Source Map ID 75949*)

Geomorphologic Report

Geomorphologic report for Gateway NRA

Double-click link to view report

Jamaica Bay Unit Legend

Active Coastal Features

- Beach
- Foredune
- Pond
- Wetland

Abandoned Coastal Features

- Major abandoned foredune
- Minor abandoned foredune
- Inter-ridge swale
- Back dune slope

Anthropogenic Features

- Artificial planar surface
- Elevated surface/ridge
- Bulkhead/Riprap
- Pier/Dock
- Jetty/Groin
- Major road
- Street
- Path

Extracted from: (Geomorphologic Maps of Gateway National Recreation Area)

Sandy Hook Unit Legend

Active Coastal Features
- Beach
- Foredune
- Sand flat
- Pond
- Wetland

Abandoned Coastal Features
- Major abandoned foredune
- Minor abandoned foredune
- Inter-ridge swale
- Back dune slope

Anthropogenic Features
- Artificial planar surface
- Elevated surface/ridge
- Bulkhead/Riprap
- Pier/Dock
- Jetty/Groin
- Seawall
- Major road
- Street
- Path

Extracted from: (Geomorphologic Maps of Gateway National Recreation Area)

Staten Island Unit Legend

Glacial Features
- Terminal moraine
- Outwash plain

Coastal Features
- Beach
- Foredune
- Major abandoned foredune
- Minor abandoned foredune
- Inter-ridge swale
- Cliff/Bluff/Scarp
- Pond
- Wetland

Anthropogenic Features
- Artificial planar surface
- Elevated surface/ridge
- Bulkhead/Riprap
- Pier/Dock
- Jetty/Groin
- Major road
- Street
- Path

Extracted from: (Geomorphologic Maps of Gateway National Recreation Area)

Geology of the Sandy Hook Quadrangle

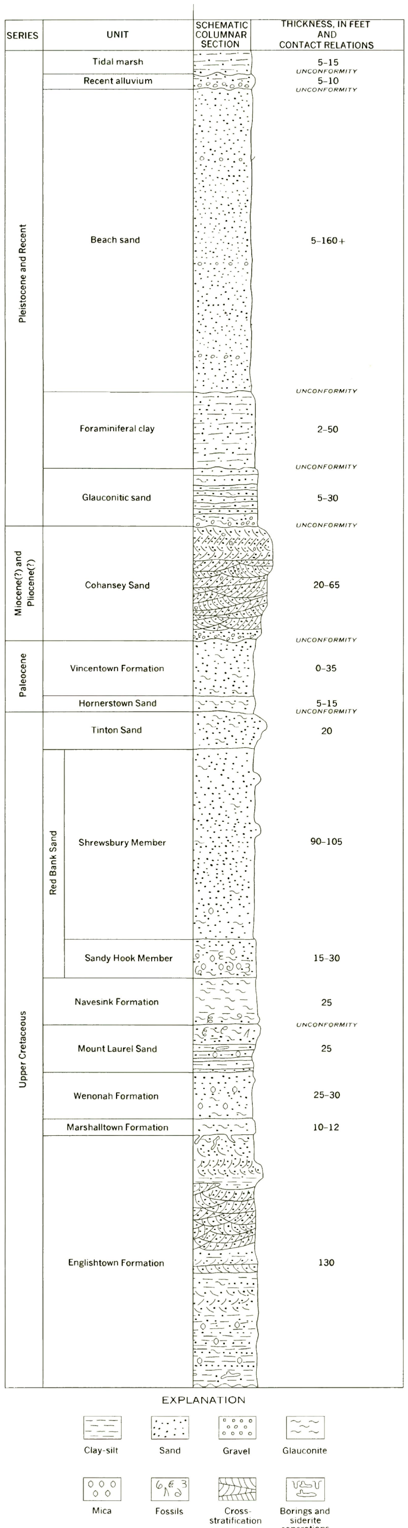
Geology of Sandy Hook Quadrangle (Bulletin 1276)

Minard, J.P., 1969, Geology of the Sandy Hook Quadrangle in Monmouth County, New Jersey: U.S. Geological Survey, Bulletin 1276, scale 1:24,000. (*GRI Source Map ID 2583*)

Map Location

Extracted from: Geology of the Sandy Hook Quadrangle (Bulletin 1276)

Columnar Cross Section

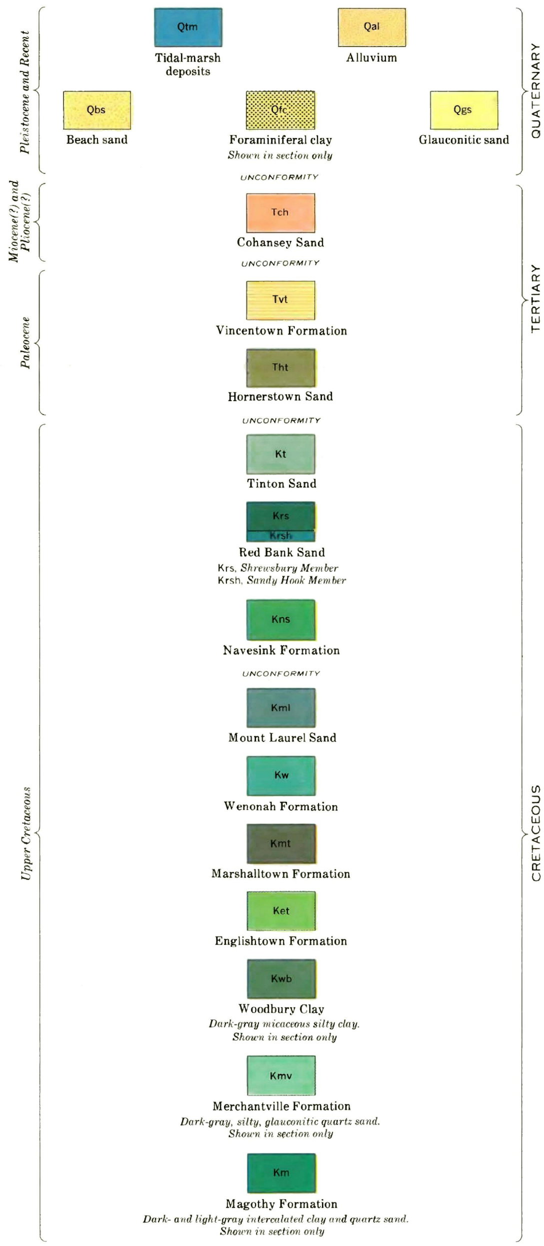


Extracted from: [Geology of the Sandy Hook Quadrangle (Bulletin 1276)]

Report

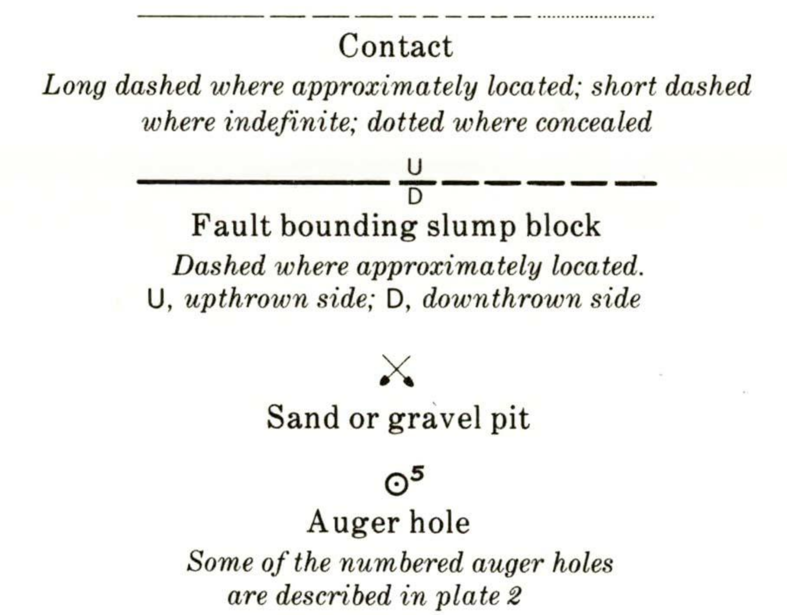
A complete geologic report, including figures and tables, is included with this publication and can be downloaded and viewed through the USGS publications website: http://pubs.er.usgs.gov/publication/b1276.

Correlation of Map Units



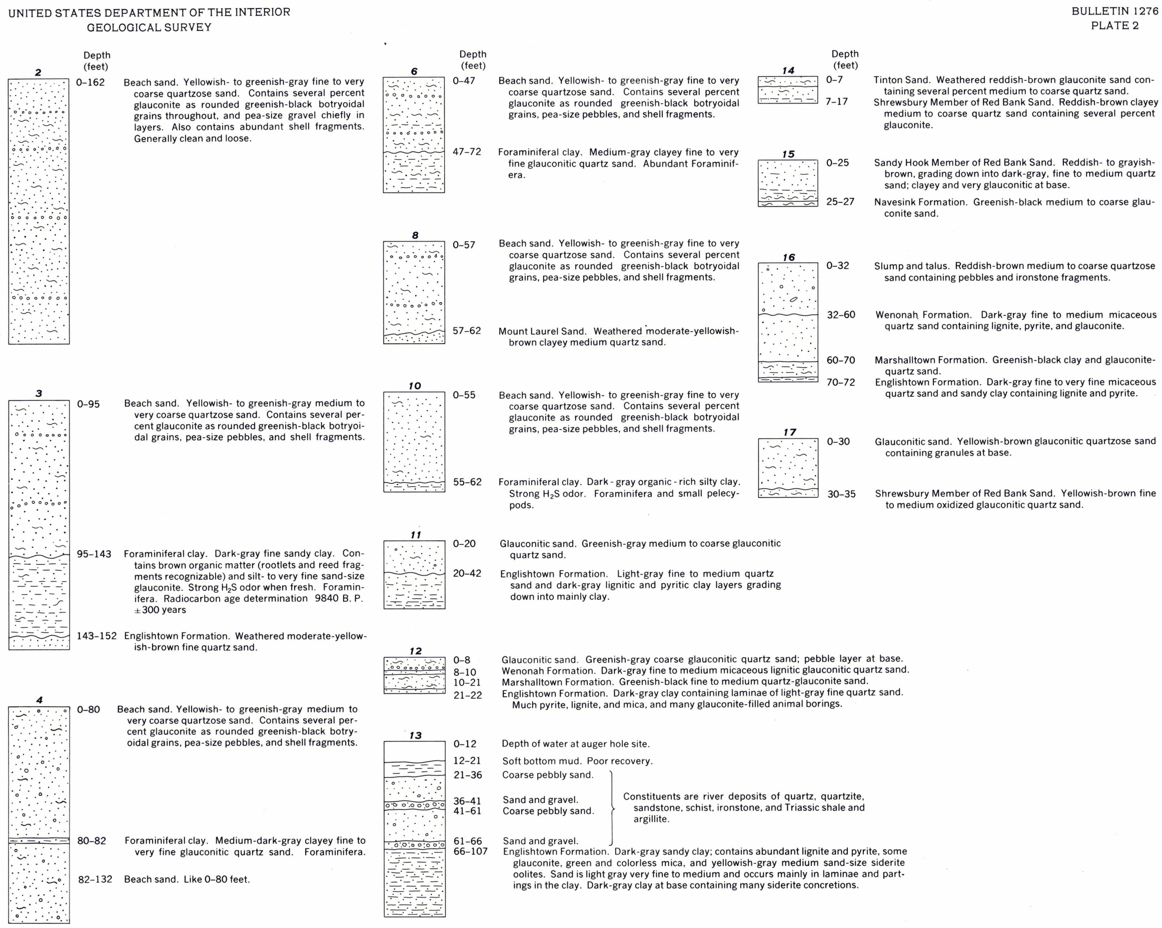
Extracted from: Geology of the Sandy Hook Quadrangle (Bulletin 1276)

Explanation of Map Symbols



Extracted from: Geology of the Sandy Hook Quadrangle (Bulletin 1276)

Logs of Selected Wells (Plate 2)



LOGS OF SELECTED AUGER HOLES
Number at top of column is keyed to a number on the geologic map (pl. 1). See plate 1 for explanation of lithic symbols

Extracted from: Geology of the Sandy Hook Quadrangle (Bulletin 1276)

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Extracted from: Geology of the Sandy Hook Quadrangle (Bulletin 1276)

Surficial Geology of the Sandy Hook Quadrangle (OFM 39)

Stanford, S.D., 2000, Surficial Geology of the Sandy Hook Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map 39, scale 1:24,000. (*GRI Source Map ID 2584*)

Map Location

Extracted from: Surficial Geology of the Sandy Hook Quadrangle (OFM 39)

Explanation of Map Symbols

Contact--Contacts of alluvium, beach deposits, and estuarine deposits are well-defined by landforms and are drawn from 1:12,000-scale aerial stereophotos. Contacts of other units are approximately located based on both landforms and field observation points.

Material observed in hand-auger hole, exposure, or excavation.

Well or boring--Upper number is identifier, lower number is thickness of surficial material. Identifiers of the form 'xxxx' are N. J. Department of Environmental Protection well permit numbers (all carry the prefix '29-'). Identifiers of the form xx-xx-xxx are N. J. Atlas Sheet grid locations of entries in the N. J. Geological Survey permanent note collection. Identifiers of the form 'Bxx' are engineering test borings on file at the N. J. Geological Survey. Identifiers of the form 'Gxx' are from Gaswirth, S. B., 1999, The late Pleistocene to Holocene glacial history of Raritan Bay, New Jersey: M. S. thesis, Rutgers University, New Brunswick, N. J., 157 p. Identifiers of the form '25-xxx' are from Gronberg, J.M., Birkelo, B.A., and Pucci, A.A., 1989, Selected borehole geophysical logs and drillers' logs, northern Coastal Plain of New Jersey: U. S. Geological Survey Open File Report 97-243, 133 p. Identifiers denoted by 'M' are from Minard, J.P., 1969, Geology of the Sandy Hook quadrangle in Monmouth County, New Jersey: U. S. Geological Survey Bulletin 1276, 43 p.

Slump block--Block of Coastal Plain formations detached from outcrop and moved downslope as a result of slope failure. Of Holocene age. From Minard, J.P., 1974, Slump blocks of the Atlantic Highlands of New Jersey: U. S. Geological Survey Professional Paper 898, 24 p.

Extracted from: Surficial Geology of the Sandy Hook Quadrangle (OFM 39)

Geology of the Long Branch Quadrangle

Surficial Geology of the Long Branch Quadrangle (OFM 39)

Stanford, S.D., 2000, Surficial Geology of the Long Branch Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map 38, scale 1:24,000. (*GRI Source Map ID 47707*)

Map Location

Extracted from: Surficial Geology of the Long Branch Quadrangle (OFM 38)

Explanation of Map Symbols

Contact--Contacts of alluvium, beach deposits, and estuarine deposits are well-defined by landforms and are drawn from 1:12,000-scale aerial stereophotos. Contacts of other units are approximately located based on both landforms and field observation points.

Material observed in hand-auger hole, exposure, or excavation.

Well or boring--Upper number is identifier, lower number is thickness of surficial material. Identifers of the form 'xxxx' are N. J. Department of Environmental Protection well permit numbers (all carry the prefix '29-'). Identifiers of the form 'xx-xx-xxx' are N. J. Atlas Sheet grid locations of entries in the N. J. Geological Survey permanent note collection. Identifiers of the form 'Bxx' are miscellaneous borings on file at the N. J. Geological Survey.

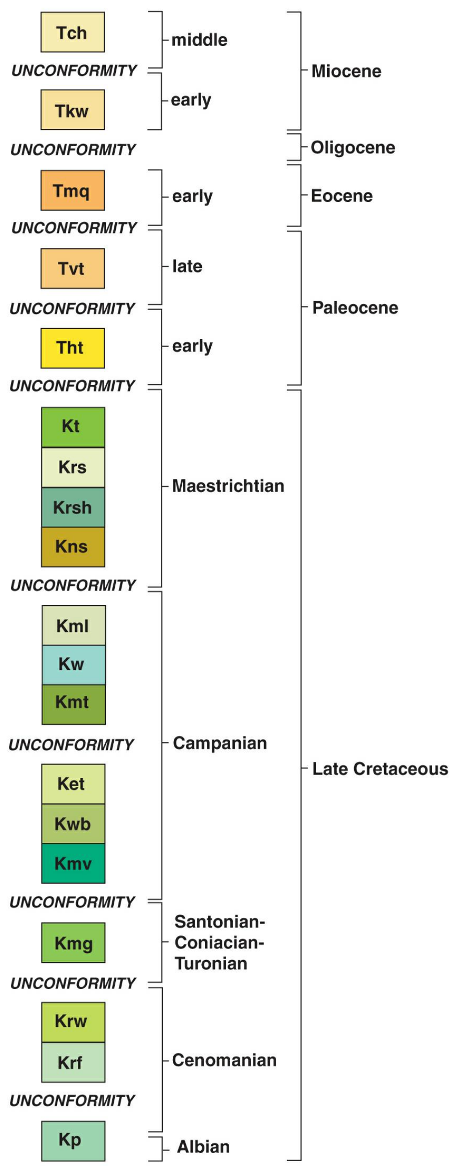
Shallow topographic basin--Of probable periglacial origin. Basins within eolian deposits may be of eolian origin. Drawn from 1:12,000-scale aerial stereophotos taken in 1979.

Extracted from: Surficial Geology of the Long Branch Quadrangle (OFM 38)

Bedrock Geology of the Long Branch Quadrangle (OFM 78)

Stanford, S.D., and Sugarman, P.J., 2010, Bedrock Geology of the Long Branch Quadrangle, Monmouth County, New Jersey: New Jersey Geological Survey, Open-file Map 78, scale 1:24,000. (*GRI Source Map ID 75557*)

Correlation



Extracted from: Bedrock Geology of the Long Branch Quadrangle (OFM 78)

Location Map

LOCATION IN NEW JERSEY

Extracted from: Bedrock Geology of the Long Branch Quadrangle (OFM 78)

Map Symbols

Contact—Approximately located. Solid triangle indicates contact observed in outcrop. Open triangle indicates contact formerly observed, as reported in permanent note collection of the N. J. Geological Survey.

Formation observed in outcrop or excavation, or penetrated in hand-auger hole.

Formation formerly observed in outcrop or excavation—Reported in permanent note collection of the N. J. Geological Survey.

Formation covered by surficial deposits—Surficial deposits of Quaternary, Pliocene, and late Miocene age continuous and generally more than 5 feet thick.

29-31486
14 surficial
37 Krs
39 Krsh

Well showing formations penetrated—Location accurate to within 200 feet. Identifiers of the form 29-xxxx are N. J. Department of Environmental Protection well permit numbers. Identifiers of the form 25-xxx are U. S. Geological Survey Ground Water Site Inventory identification numbers. Lithologic and geophysical logs for most of these wells are provided by Gronberg and others (1989). Identifiers of the form 29-xx-xxx are N. J. Atlas Sheet coordinates of records of wells in the permanent note collection of the N. J. Geological Survey. Identifiers of the form "Healy 3-23-63 B2" provide the date and identification number of test borings drilled by the A. J. Healy Company, with copies on file at the N. J. Geological Survey. Identifier "KP1" indicates a stratigraphic test hole drilled by the U. S. Geological Survey in cooperation with the N. J. Geological Survey and Rutgers University Earth and Planetary Sciences Department in 2008.

Extracted from: Bedrock Geology of the Long Branch Quadrangle (OFM 78)

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Extracted from: Bedrock Geology of the Long Branch Quadrangle (OFM 78)

Surficial Geology of the Jersey City Quadrangle (OFM20)

Stanford, S.D., 1995, Surficial Geology of the Jersey City Quadrangle, Hudson and Essex Counties, New Jersey: New Jersey Geological Survey, Open-file Map 20, scale 1:24,000. (*GRI Source Map ID 2585*)

Ancillary Map Notes

Introduction

Surficial deposits in the Jersey City quadrangle include alluvial, estuarine, and windblown (eolian) deposits of postglacial age, and glacial lacustrine deposits and till of late Wisconsinan age. These deposits are delineated on the accompanying map and sections and are described below. The glacial and postglacial events they record are also discussed below. Well and boring data used to draw bedrock-surface contours and to infer the subsurface distribution of the deposits are provided in table 1. The chronologic relationships of the deposits are shown on the correlation chart.

Postglacial Deposits

These include sediment deposited in estuaries and salt marshes (Qm), stream sediment deposited in former channels and floodplains beneath the salt-marsh sediment (Qal), windblown sediment blanketing parts of the west slope of the Palisades Ridge (Qe), and man-made fill (af). They were all deposited after glacial retreat.

After glacial lakes Hackensack and Bayonne drained (see below), streams cut shallow channels and plains into the exposed lake bottoms in places and deposited sandy alluvium (Qal). At the same time, and before return of vegetation stabilized surfaces, westerly winds entrained fine sand and silt from the former lake bottom in the Newark Bay area and deposited this sediment as a sheet along the base of the west slope of the Palisade Ridge (Qe). Faint dunes are visible in Lincoln Park and Holy Name cemetery, but urbanization has destroyed any evidence of dunes elsewhere. Merrill and others (1902) mapped several areas of dunes along the west base of the Palisades Ridge in Jersey City of Bayonne, and Russell (1880) described eolian sand deposits at several locations on the east side of the Palisades Ridge from Constable Hook to Hoboken. No evidence of these deposits remains. Most of those described by Russell (1880) were outcrop areas of glacial-lake sand (unit Qbn, see below), and may have been largely wind-shaped glacial sand deposits rather than transported eolian sediment. Some of the sand beneath the salt-marsh deposits, mapped as alluvium, may also be windblown.

Deposition of the alluvial and windblown sediments gradually ended as seal level rose and marshes covered the former lake plains. The bedrock surface beneath the Hudson valley is lower than that beneath the Newark Bay-Kearny area, and the glacial sediment is not as thick, so the rising sea flooded the Hudson valley long before it flooded the Newark Bay-Kearny lowland. Newman and others (1969) indicate estuarine conditions were present in the Hudson valley as long ago as 12,000 yrs B.P (years before present). In the Hackensack valley just north of the quadrangle, salt-marsh deposition did not begin until about 2000 yrs B.P (Heusser, 1963). Estuarine deposits are as much as 300 feet thick beneath the Hudson (sections A-A’, B-B’, C-C’) but are less than 40 feet thick in the Newark Bay-Kearny area. This marked difference in thickness is attributable to the greater depth of the Hudson valley, and the longer period of estuarine deposition there. Estuarine deposition continues today.
Landfilling on the marsh deposits began shortly after permanent European settlement in the 1600s. The earliest areas of fill were likely along the Hudson in Hoboken and adjacent parts of Jersey City. The latter part of the nineteenth century, and early twentieth century, saw large-scale landfilling for railroad and shipping terminals and industrial development. By the 1920s almost all of the salt marsh, and some areas of open water, had been covered by fill. Some filling continues today.

Glacial Deposits

These include till—a poorly-sorted, nonstratified sediment containing gravel clasts and boulders, deposited directly from glacial ice (Qt, Qty), and well-sorted, stratified sediments. The stratified sediments include sand and gravel laid down by glacial meltwater in glacial-lake deltas (Qbn) and fans (Qbnf) and varved silt, clay, and fine sand deposited on the bottoms of glacial lakes (Qbnl, Qhkl). All of these deposits are of late Wisconsinan age.

Before these deposits were laid down the underlying bedrock surface was shaped by glacial erosion. The topography of the bedrock surface (plotted at 50-foot contour intervals on the map) shows elongate glacially-scoured troughs that extend to more than 200 feet below sea level in the Newark Bay area and more than 300 feet below sea level beneath the Hudson River. To the south and to the north the bedrock surface in these troughs rises, and the trough forms die out (Parrillo, 1959; Stanford and others, 1990), indicating that they are true glacial-scour features rather than buried fluvial valleys, They are eroded into outcrop belts of weak rock, including shale and arkosic sandstone of the Passaic and Lockatong Formations west of the Palisades ridge, arkosic sandstone of the Stockton Formation along the east base of the Palisades ridge, and schist beneath the Hudson River. Resistant diabase makes up the Palisades Ridge. Parrillo (1959) and Lovegreen (1974) show a buried valley crossing the Palisades Ridge at the Bayonne-Jersey City boundary, but no test boring data verify this valley, and outcrops in the area suggest that no valley is present. The series of bedrock highs along the west bank of the Hudson from Castle Point in Hoboken southward to Bayonne is formed on serpentinite and schist.

During the late Wisconsinan advance, the Jersey City area was on the east side of an ice lobe that was channeled between the Watchung Mountains to the west and the Palisades Ridge to the east, and centered on the Hackensack valley (Salisbury, 1902; Standford and Harper, 1991). The orientation of striation, and the composition and distribution of till in the quadrangle, indicate that ice flowed southeasterly here. Reddish-brown silty sand to sandy silt till (“Rahway till”, Qt), is derived from mudstone and sandstone bedrock. It forms a nearly continuous blanket on the bedrock surface except in places on the steep east slope of the Palisades Ridge, where it likely was never deposited, and in the glacially-scoured troughs in the Hudson and Newark Bay-Kearny lowlands, where it either was never deposited or was later eroded by subglacial meltwater. In the Hoboken-Jersey City area, east of the Palisades Ridge, the reddish-brown till grades into a more yellowish, siltier till ("Rahway till, yellow phase", Qty) that reflects incorporation of weathered serpentinite and diabase. This yellow till likely underlies unit Qt in places on the Palisades Ridge, and may be present in the subsurface elsewhere east of Palisades.

Late Wisconsinan ice reached its southernmost position at Perth Amboy, about 16 miles southwest of Bayonne, earlier than 20,000 yrs B.P., based on radiocarbon dates of organic material at the bottom of postglacial bogs in western New Jersey (Harmon, 1968; Cotter and others, 1986), on concretions in glacial Lake Passaic sediments west of the Watchung Mountains (Stone and others, 1989), and on organic sediments beneath till on Long Island (Sirkin, 1986), A continuous terminal moraine was deposited at the position of maximum advance (fig. 1). As the ice front retreated, a series of glacial lakes formed, damned to the south by the moraine (Stanford and Harper, 1991). One of these, Lake Bayonne, occupied the Arthur Kill, Newark Bay, and upper New York Bay Lowlands, and had an outlet over the moraine at Perth Amboy (fig. 1). This outlet was gradually lowered by erosion, and therefore the level of Lake Bayonne steadily declined. In the Jersey City quadrangle, deltas deposited in Lake Bayonne have top elevations 20 to 30 feet above sea level. Adjusting for postglacial rebound of Earth's surface in response to release of the weight of the glacier, these altitudes indicate the spillway at Perth Amboy had been eroded to between 0 to 20 feet below sea level (using the rebound rate of 3.5 feet/mile to the north from Standford and Harper, 1991). Deposits in Lake Bayonne include deltaic sand and gravel (Qbn), lacustrine-fan sand and gravel (Qbnf), and lake-bottom silt, clay, and fine sand (Qbnl).

Continued erosion of the outlet at Perth Amboy, and along the Arthur Kill to the north, uncovered diabase bedrock at an elevation of 30 feet below sea level in the Arthur Kill about 7 miles north of Perth Amboy. The diabase halted further downcutting and formed the stable spillway for Lake Hackensack (fig. 1). An auxiliary spillway was also established across diabase in the Kill van Kull, just west of the quadrangle boundary (fig. 1). In the Jersey City Quadrangle, Lake Hackensack occupied the lowest parts of the Newark Bay-Kearny lowland. Some lake-bottom silt and clay (Qhkl) in the northeastern corner of the map area were deposited in Lake Hackensack. The lake drained eastward into the Hudson Valley when the retreating ice front uncovered Sparkill Gap, a deep gap through the Palisades Ridge, about 22 miles north of Hoboken.

In the Hudson Valley, Lake Bayonne lowered to form Lake Hudson when the retreating ice front uncovered the Hell Gate area in the East River between Manhattan and Queens, about 5 miles east of Hoboken (fig. 1). This event likely occurred when the ice front was just north of the Hoboken area, because deltaic sand at the Lake Bayonne level occurs in Hoboken but not north of there. Gneiss bedrock at Hell Gate formed a stable spillway for Lake Hudson at an elevation of 30 feet below sea level. In the Jersey City quadrangle the level of Lake Hudson, corrected for rebound, was between 40 and 60 feet below sea level (Newman and others, 1969; Stanford and Harper, 1991). Test borings for the Holland Tunnel (borings 29-32 in table 1) did not encounter any Lake Hudson deposits, and none are mapped in the quadrangle. This absence is due to either nondeposition or removal of deposits by lake meltwater floods in the Hudson Valley (Newman and others, 1969; Stanford and Harper, 1991). However, remnants of lake-bottom sediment deposited in Lake Hudson may be present locally beneath the estuarine deposits under the Hudson River and Upper New York Bay. Lake Hudson persisted until the moraine dam at the Narrows, about 6 miles south of Bayonne (fig. 1), was breached. The timing of this event is uncertain, but breaching may have occurred as long ago as about 15,500 yrs B.P., when large volumes of meltwater, sourced from glacial lakes in the Great Lakes basin, discharged through the Hudson Valley (Ridge, 1991).

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Figure 1 - Glacial Extents

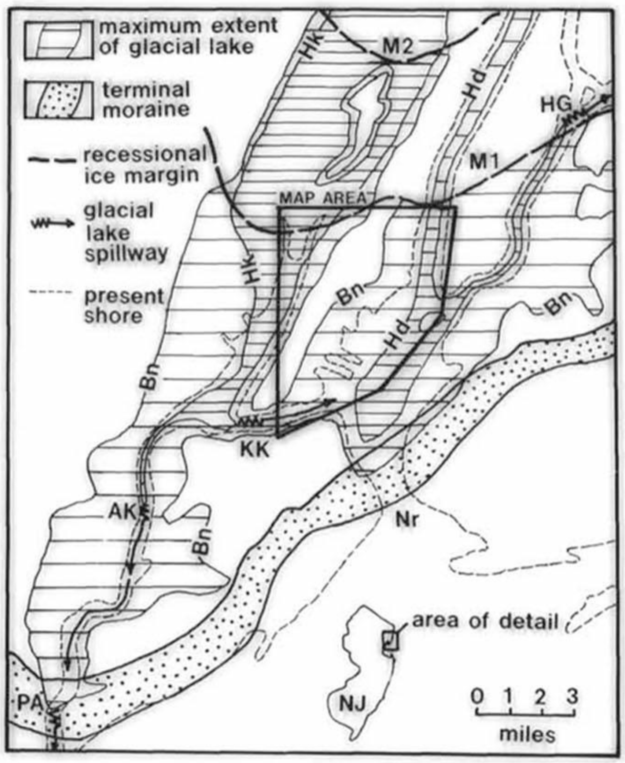
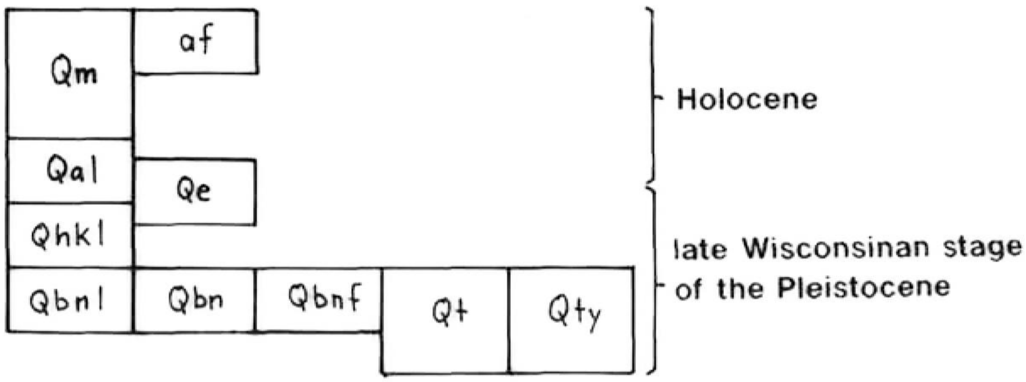


Figure 1.--Ice margins, glacial-lake spillways, and maximum extent of glacial lakes. Lakes are identified by the following abbreviations on their shorelines: Bn=Bayonne, Hk=Hackensack, Hd=Hudson. Placename abbreviations are: PA=Perth Amboy, AK=Arthur Kill, KK=Kill van Kull, Nr=Narrows, HG=Hell Gate. Recessional ice margins include: M1=last ice margin before Lake Bayonne lowered to the Lake Hudson level in the Hudson valley. Deltas in Lake Bayonne were deposited at Hoboken and on the west side of Jersey City. M2=approximate position of ice margins at maximum extent of Lake Bayonne, before the stable Lake Hackensack level was established.

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Correlation of Map Units



Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Map Location

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Explanation of Map Symbols

Contact--Solid where well-defined by landforms; dashed where approximate, gradational, or featheredged; dotted where concealed by fill. Some contacts are modified from Merrill and others (1902), and unpublished manuscript maps of C. E. Peet and R. D. Salisbury on file at the N. J. Geological Survey.

Striation--Observation at dot. Flag indicates data from Salisbury and Peet (1895).

(-47) **Elevation of bedrock surface in well or boring**--Data from Parrillo (1959). "Less-than" sign (<) indicates elevation of bottom of boring that did not reach bedrock.

(-40) **Elevation of bedrock surface in well or boring**--Data from Lovegreen (1974). Values are inferred from a bedrock topography map with a contour interval of 20 feet.

(-5) **Elevation of bedrock surface in well or boring**--Data from files of the N. J. Geological Survey.

47 (-45) **Well with log in table 1**--Location judged to be accurate within 100 feet. Elevation of bedrock surface in parentheses.

74 (-74) **Well with log in table 1**--Location judged to be accurate within 500 feet. Elevation of bedrock surface in parentheses.

50 **Elevation of bedrock surface**--Contour interval 50 feet. Shown only where depth to bedrock generally exceeds 50 feet.

r **Large bedrock outcrop**--May be partly covered by fill or structures.

(r) **Former bedrock outcrop**--Outcrop noted on unpublished manuscript maps by C. E. Peet, R. D. Salisbury, and H. B. Kummel (on file at the N. J. Geological Survey) but no longer exposed.

47 **Well with log in table 1**--On sections, projected to line of section.

Depth to bedrock in well or boring--On sections, projected to line of section. Dot indicates bedrock surface penetrated, no dot indicates bedrock not reached.

af/Qm **Unit to left of slash overlies unit to right**--Shows extent of unit underlying large areas of artificial fill and eolian deposits.

w **Surface water**--On sections only.

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Table 1 - Selected Well and Boring Logs

Selected Well and Boring Logs 1-20

Well No.	Identifier[1]	Lithologic Log: Depth (feet below land or water surface)	Lithologic Log: Description[2]
1	N 26-13-764	0-6	mud (Qm)
		6-9	fine sand and clay (Qal)
		9-15	gray sand (Qal)
		15-23	light yellow clay and sand (Qal)
		23-54	hard blue clay (Qhkl over Qbnl)
		54-100	light brown clay (Qbnl)
2	N 26-13-765	0-6	muck (Qm)
		6-11	gray sand (Qal)
		11-29	gray sand and clay (Qal)
		29-53	light brown very soft clay (Qhkl over Qbnl)
		53-74	red clay (Qbnl)
		74-76	soft shale
		at 76	rock
3	N 26-13-759	0-4	muck (Qm)
		4-16	gray sand (Qal)
		16-41	blue clay and sand (Qhkl)
		41-81	light brown clay (Qbnl)
		81-84	fine brown sand (Qt?)
		at 84	rock
4	N 26-13-773	0-9	muck (Qm)
		9-13	sand and gravel (Qal)
		13-20	coarse sand and gravel (Qal)
		20-26	fine sand (Qal)
		26-31	blue clay and sand (Qhkl)
		31-35	brown clay and sand (Qbnl)
		35-61	fine brown sand (Qbnf)
		at 61	shale
5	Well 3 from Russell, 1880	0-10	marsh mat (Qm)
		10-22	fine quicksand (Qal)
		22-58	bluish-gray clay (Qhkl)
		58-64	sand (Qhkl?)
		64-84	ash-colored clay (Qbnl)
		84-104	stiff clay (Qbnl)
		at 104	rock
6	N 26-13-858	0-5	ash fill (af)
		5-16	mud (Qm)
		16-19	fine sand, clay (Qal)
		19-22	medium sand and clay (Qal)
		22-58	soft sand and clay (Qal over Qhkl)
		58-77	compact clay (Qbnl)
		at 77	rock
7	N 26-13-882 boring 1	0-32	mud (Qm)
		32-40	blue clay (Qhkl)
		40-50	blue and red clay (Qbnl)
		50-60	red clay (Qbnl)
		60-64	red clay with some fine sand (Qbnl)
		64-68	hard red clay mixed with small pebbles and stones (Qt)
8	N 26-13-882 boring 2	0-37	water
		37-50	blue clay (Qhkl)
		50-64	red clay (Qbnl)
		64-68	hard red clay mixed with pebbles and sandstone (Qt)
9	N 26-13-797	0-4	cinder fill (af)
		4-14	swamp mud (Qm)
		14-34	gray sand (Qal)
		34-114	red clay (Qbnl)
		114-126	red shale
		126-127	gray sandstone
		127-141	red shale
10	N 26-12-121 boring 2	0-14	water
		14-20	mud (Qm)
		20-32	sand and gravel (Qal)
		32-65	red sand and clay (Qbnl)
		65-66	disintegrated rock
		66-76	red shale
11	N 26-23-138	0-11	sand and fill (af)
		11-25	meadow mud (Qm)
		25-33	sand (Qal)
		33-54	mud and clay (Qbnl)
		54-95	fine sand (Qbnf)
		at 95	probable rock
12	N 26-23-435	0-1	water (boring made before filling)
		1-11	mud (Qm)
		11-23	sand (Qal)
		23-43	sand and clay (Qbnl)
		43-73	gravelly clay (Qbnl over Qt)
		at 73	trap rock
13	Well 16 from Russell, 1880	0-8	dune sand (Qe or Qbn)
		8-14	sand and gravel (Qbn)
		14-15	bluish sandy clay (Qbn)
		15-31	sand and gravel, quicksand at bottom (Qbn)
		31-49	reddish sandy clay, including some gravel (Qt)
		at 49	trap rock
14	NJGS files	0-34	fill (af)
		34-49	gray organic silty clay (Qm)
		49-74	brown-to-gray fine-to-medium sand and silty sand (Qbnf)
		74-81	red-brown silty sand, trace rock fragments (Qt)
		81-96	arkosic sandstone
15	NJGS files	0-22	fill (af)
		22-56	gray organic silty clay (Qm)
		56-68	fine-to-medium gray to red-brown sand, some silt; to silty fine sand (Qbnf)
		68-78	red-brown silty sand, gravel, trace clay (Qt)
		78-85	arkosic sandstone
16	NJGS files	0-9	cinder fill (af)
		9-127	gray organic silty clay, trace fine sand; shells (Qm)
		127-140	coarse-to-fine sand, some silt and gravel (Qbnf)
		140-150	serpentinite and conglomerate
17	Figure 17 from Lovegreen, 1974	0-10	water
		10-14	gray organic silt, clay, meadow material, shells (Qm)
		14-25	brown sand (Qal)
		25-128	reddish-brown varved clay and silt (Qbnl)
		128-150	shale
18	NJGS files	0-22	fill (af)
		22-90	gray organic silty clay (Qm)
		90-113	gray to red-brown fine-to-medium sand and silt (Qbnf)
		113-115	till (Qt)
		115-120	cemented till (probable conglomerate bedrock)
19	NJGS files	0-4	fill (af)
		4-184	gray organic silty clay (Qm)
		184-195	gray to red-brown fine-to-coarse sand and gravel, trace clay, occasional boulders from 189-195 (Qbnf or Qt)
20	NJGS files	0-10	fill (af)
		10-241	gray organic silty clay, trace fine sand; shells (Qm)
		241-245	gray clayey coarse-to-fine sand, trace gravel (Qt or Qbnf)
		245-246	gray gravel, some fine-to-coarse sand, silt (Qt or Qbnf)
		at 246	refusal (bedrock)

Extracted from: (Surficial Geology of the Jersey City Quadrangle (OFM20)

Selected Well and Boring Logs 21-40

21	NJGS files	0-24	fill (af)
		24-158	gray organic silty clay (Qm)
		158-165	gray silty medium-to-fine sand, some gravel and boulders (Qt)
		165-175	cemented till (probable conglomerate bedrock)
22	NJGS files	0-28	fill (af)
		28-108	gray organic silty clay (Qm)
		108-130	gray fine-to-medium sand, trace silt and gravel (Qbnf)
		130-138	gray medium-to-fine sand, some gravel and boulders, trace silt (Qt)
		138-148	serpentinite
23	NJGS files	0-30	fill (af)
		30-36	gray organic silty clay (Qm)
		36-78	red-brown to brown-gray fine-to-medium sand, some silt (Qbnf)
		78-85	brown-gray, red-brown, black coarse-to-fine sand, some silt, gravel (Qt)
		85-91	serpentinite
24	NJGS files	0-18	fill (af)
		18-41	gray organic silty clay (Qm)
		41-45	dark gray fine-to-coarse sand, some gravel and organic silty clay (Qm over Qbnf or Qt)
		45-51	boulders and cemented till (Qt or Qbnf on conglomerate bedrock?)
25	NJGS files	0-24	water
		24-85	gray organic silty clay (Qm)
		85-118	gray and brown silty fine sand (Qbnf)
		118-130	cemented till (probable conglomerate bedrock)
26	NJGS files	0-19	fill (af)
		19-48	gray organic silty clay (Qm)
		48-61	red-brown clayey fine-to-coarse sand, some gravel and boulders (Qt)
		61-74	serpentinite
27	NJGS files	0-4	fill (af)
		4-78	gray organic silty clay (Qm)
		78-113	gray fine sand, some silt, becoming black and silty with trace wood below 105 feet (Qm)
		113-124	till (Qt)
		124-150	cemented till (probable conglomerate bedrock)
		150-153	serpentinite
28	NJGS files	0-25	fill (af)
		25-220	gray organic silty clay (Qm)
		220-228	gray sand and gravel (Qbnf)
29	N 26-24-124 boring XXVIII	0-35	water
		35-277	river silt (Qm)
		at 277	rock
30	N 26-24-124 boring XXVII	0-33	water
		33-171	river silt (Qm)
		at 171	rock
31	N 26-24-124 boring XXII	0-53	water
		53-59	black river mud (Qm)
		59-64	river silt (Qm)
		64-66	sand and gravel (Qbnf or Qt)
		66-78	mica schist
32	N 26-24-124 boring XXXI	0-16	water
		16-51	black river mud (Qm)
		51-123	river silt (Qm)
		123-128	sand and gravel (Qbnf or Qt)
		128-142	serpentine (serpentinite bedrock)
33	N 26-24-117	0-5	from dock to water
		5-11	water
		11-14	ashes
		14-30	soft mud (Qm)
		30-202	silt (Qm)
		202-222	gravel, white sand, boulders (Qbnf)
		222-224	hard brown shale (Qt or bedrock)
		224-242	green sand and clay (weathered serpentinite)
		242-720	rock
34	N 26-23-339	0-70	boulder clay (af?/Qm?/Qt?)
		70-142	sandstone
		142-215	red sandstone
		215-455	micaceous gneiss
35	Well 24 from Russell, 1880	0-30	surface sand (Qbn)
		30-70	boulder clay (Qt)
		70-846	red sandstone
36	Well from Russell, 1880	0-12	fill (af)
		12-14	turf (Qm)
		14-28	bluish river mud with organic matter (Qm)
		28-29	quicksand (Qbn)
		29-47	reddish mud (Qbn)
		47-52	gravel (Qbn)
37	Well 18 from Russell, 1880	0-24	drift material (af/Qm/Qbn)
		24-250	gneiss
38	N 26-23-368	0-17	black fill (af)
		17-22	black silt (Qm)
		22-28	coarse sand (Qbn)
		28-29	mica sand (weathered schist)
		29-60	mica rock (schist)
39	N 29-23-393	0-26	black silt (Qm)
		26-32	soft mica rock (weathered schist)
		32-35	quartz rock
		35-45	soft mica rock (weathered schist)
40	Figure 13a from Lovegreen, 1974	0-20	fill (af)
		20-60	gray organic silt and clay with shells (Qm)
		60-70	gray and brown sand, some gravel (Qbn)
		70-100	varved reddish-brown clay and silt (Qbnl)
		100-110	sand, gravel, cobbles, and rock fragments (Qt)
		110-125	schist

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Selected Well and Boring Logs 41-60

50	NJGS files	0-17	water
		17-24	black organic silty clay (Qm)
		24-25	mica schist
51	NJGS files	0-10	fill (af)
		10-50	gray organic silty clay, trace shells (Qm)
		50-60	gray sand, trace gravel, trace silt (Qbnf or Qt)
		60-61	red-brown clayey silt (Qbnl or Qt)
52	NJGS files	0-7	cinder fill (af)
		7-55	dark gray organic clay and silt, trace shells (Qm)
		55-60	medium-to-fine gray sand, gray silt and clay, trace gravel (Qbnf or Qt)
		60-61	brown clayey silt (Qt or Qbnl)
53	NJGS files	0-17	fill (af)
		17-30	gray organic silty clay (Qm)
		30-41	gray sand, trace gravel, trace silt (Qbnf or Qt)
54	NJGS files	0-5	fill (af)
		5-20	organic silty clay, trace shells (Qm)
		20-22	dark brown peat (Qm)
		22-36	gray-brown silt and clay and fine sand, little gravel (Qbnl)
55	NJGS files	0-15	fill (af)
		15-62	gray organic silty clay, shells (Qm)
		62-71	varved gray and brown silt and clay (Qbnl)
56	NJGS files	0-15	cinder fill (af)
		15-25	organic clay and dark brown peat (Qm)
		25-30	fine gray sand, trace silt (Qbn)
		30-40	gravel and coarse-to-fine sand, some silt and clay (Qbn)
		40-41	varved brown silt and clay, fine sand partings (Qbnl)
57	NJGS files	0-15	fill (af)
		15-30	gray organic silty clay, shells (Qm)
		30-40	sand, trace silt (Qbn)
		40-41	brown silt and clay, seams of fine-to-medium sand (Qbnl)
58	Figure 13b from Lovegreen, 1974	0-20	fill (af)
		20-25	gray organic silt and clay with shells (Qm)
		25-35	gray and brown sand, some gravel (Qal)
		35-80	varved reddish-brown clay and silt (Qbnl)
		80-100	sand, gravel, cobbles, rock fragments (Qbnf or Qt)
59	N 26-23-582	0-6	water
		6-13	mud (Qm)
		13-21	mud and black sand (Qm)
		21-25	sand with a little clay (Qbnl)
		25-39	fine sand and clay (Qbnl)
		39-46	coarse, compact sand (Qbnf or Qt)
		46-49	clay and hardpan (Qt)
		49-50	fine sand (Qt)
		50-59	boulders (Qt)
		59-61	clay and gravel (Qt)
		61-82	red sandstone
60	N 26-23-831	0-10	water (boring made before filling)
		10-40	sand and mud (Qm)
		40-47	clay and boulders (Qbnl or Qt)
		47-48	sand (Qbnl or Qt)
		48-49	clay (Qbnl or Qt)
		49-52	sand (Qbnf or Qt)
		52-53	gravel (Qbnf or Qt)
		53-60	clay (Qbnl or Qt)
		60-61	coarse gravel and sand (Qbnf or Qt)
		61-80	Hudson schist

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Selected Well and Boring Logs 61-80

61	N 26-23-917	0-16	water
		16-21	mud (Qm)
		21-30	gray sand (Qm or Qbnf)
		30-115	red sand gradually hardening (Qbnf)
		115-128	gray sand (Qbnf)
		128-132	mica schist
62	Kummel, 1905, p. 264	0-100	sand and clay (Qbn and Qbnl)
		100-1060	sandstone and shale
		1060-1397	pre-Triassic crystalline rocks
63	N 26-23-292	0-22	no report (possible Qt deposited during a short readvance)
		22-60	fine-to-medium pink sand (Qbn)
		60-72	medium-to-coarse sand and gravel (Qbn)
		at 72	trap rock
64	NJGS files	0-157	drift (Qbn over Qt)
		157-290	slate
		260-593	trap
		593-659	gray sandstone
		659-679	gneiss
65	NJGS files	0-91	drift (Qbn over Qt)
		91-127	red shale
		127-227	black shale
		227-235	blue clay (weathered rock)
		235-402	black rock
		402-440	trap
66	26-6539	0-25	fill (af)
		25-30	gray organic silty clay, trace shells (Qm)
		30-35	gray silty coarse to fine sand, boulder at 35 (Qt or Qbn)
		35-40	red-brown silty clay (Qt or Qbnl)
67	26-6541	0-8	fill (af)
		8-20	gray-to-brown silty sand (Qm)
		20-35	decomposed serpentine
		35-50	bedrock--serpentine
68	26-5739	0-7	fill (af)
		7-14	fill and peat (Qm)
		14-27	sand (Qal)
		27-32	varved clay (Qhkl)
69	26-5740	0-9	fill (af)
		9-15	peat (Qm)
		15-25	sand (Qal)
		25-27	varved clay (Qhkl)
70	26-5741	0-8	fill (af)
		8-13	peat (Qm)
		13-19	sand (Qal)
		19-32	varved clay (Qhkl)
71	26-5743	0-10	fill (af)
		10-13	peat (Qm)
		13-20	sand (Qal)
		20-111	varved clay (Qhkl over Qbnl)
		111-112	shale
72	26-5744	0-11	fill (af)
		11-18	sand (Qal)
		18-68	varved clay (Qhkl over Qbnl)
		68-75	till (Qt)
73	26-4687	0-20	gray silty sand (af/Qm)
		20-27	silty fine-to-coarse sand, fine gravel (Qal)
		27-43	gray soft silty clay (Qhkl)
		43-54	brown soft silty clay (Qbnl)
		54-57	brown shaly clay (Qt)
		160-403	red shale
74	26-2111	0-20	fill and gray clay (af/Qm)
		20-60	sand (Qbn)
		60-98	sand and gravel (Qbnf)
		98-108	sandy clay (Qbnl)
		108-113	clay (Qbnl)
		113-505	red sandstone
75	26-11624	0-7	fill (af)
		7-19	brown fine-to-coarse sand, little fine-to-medium gravel, trace silt (af)
		19-43	gray organic silt, trace peat and fine sand (Qm)
		43-76	red silt and clay (Qhkl over Qbnl)
		76-80	red dense fine-to-coarse gravel and fine-to-coarse sand, little silt (Qt)
76	26-12054	0-14	fill (af)
		14-17	peat (Qm)
		17-29	brown fine-to-coarse sand (Qal)
		29-65	brown-to-gray varved silt and clay, trace fine sand (Qhkl over Qbnl)
		65-100	brown-red clay and silt (Qbnl)
		100-117	red clay and silt, some sand and fine-to-coarse gravel (Qt)
77	26-7005	0-15	fill (af)
		15-28	gray silt, trace peat and vegetation (Qm)
		28-33	gray fine-to-medium sand, trace silt (Qm or Qal)
		33-43	gray fine-to-coarse sand, trace fine gravel (Qal)
		43-54	fine red-brown sand, some silt (Qbnl)
78	Well 45e, Parrillo, 1959	0-30	swamp mud (Qm)
		30-45	red sand (Qbnf or Qbnl)
		45-79	red shale
79	Well 43e, Parrillo, 1959	0-27	water
		27-78	red shale
80	Well 40e, Parrillo, 1959	0-15	swamp mud (Qm)
		15-25	gray sand (Qal)
		25-55	gray clay (Qhkl over Qbnl)
		55-81	red clay and sand (Qbnl)
		81-102	red shale

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Selected Well and Boring Logs 81-100

81	Well 33e, Parrillo, 1959	0-14	swamp mud (Qm)
		14-34	gray sand (Qal)
		34-114	red clay (Qhkl over Qbnl)
		114-126	red shale
		126-127	gray sandstone
		127-142	red shale
82	Well 35e, Parrillo, 1959	0-4	swamp mud (Qm)
		4-38	gray sand (Qal)
		38-110	soft red clay (Qhkl over Qbnl)
		110-113	boulders (Qt)
		113-132	broken and seamy red shale
83	Well 34e, Parrillo, 1959	0-34	swamp mud (Qm)
		34-44	gray sand (Qal)
		44-98	gray clay (Qhkl over Qbnl)
		98-114	red clay (Qbnl)
		114-130	red sand (Qbnf or Qt)
		at 130	red shale
84	Well 31e, Parrillo, 1959	0-12	swamp mud (Qm)
		12-42	gray sand (Qal)
		42-82	red clay (Qhkl over Qbnl)
		82-92	sand and clay (Qbnl)
		92-117	red clay (Qbnl)
		117-140	red shale
85	Well 28e, Parrillo, 1959	0-33	brown sand (Qm)
		33-43	gravel (Qal)
		43-53	red clay (Qhkl over Qbnl)
		53-63	red sand and clay (Qbnl)
		63-85	red shale
86	Well 26e, Parrillo, 1959	0-20	water
		20-39	river mud, sand, gravel (Qm)
		39-49	gray sand, gravel, clay (Qbnl and Qbnf)
		49-55	red clay and gravel (Qt)
		55-100	red shale
87	Well 22e, Parrillo, 1959	0-25	marsh (Qm)
		25-37	gray sand (Qal)
		37-42	red sand and gravel (Qbnf or Qt)
		42-65	red shale
88	Well 11d, Parrillo, 1959	0-12	marsh (Qm)
		12-24	fine red sand (Qal or Qbn)
		24-39	red sand and gravel (Qbn)
		39-49	medium sand (Qbn)
		49-64	fine red sand (Qbn)
		64-69	medium-to-coarse sand (Qbn)
		69-82	fine red sand (Qbn)
		82-91	fine red sand, clay, gravel (Qt)
		at 91	decomposed diabase
89	Well 24f, Parrillo, 1959	0-15	red sand (Qbn)
		15-65	red clay and gravel (Qbnl and Qbn)
		65-91	red sand and clay (Qbnl)
90	Well 22f, Parrillo, 1959	0-36	sand, gravel, boulders (Qbn)
		36-50	fine red sand, some clay (Qbn and Qbnl)
		at 50	rock
91	Well 21f, Parrillo, 1959	0-22	fill (af over Qm)
		22-52	red sand (Qbn)
		52-62	red sand and boulders (Qbn)
		62-87	red sand and clay (Qbnl)
92	Well 17f, Parrillo, 1959	0-16	water
		16-23	sand (Qm)
		23-45	clay (Qbnl)
		45-95	red clay (Qbnl)
		95-107	very fine red sand and clay (Qbnl)
		at 107	rock
93	Well 19f, Parrillo, 1959	0-21	water
		21-24	silt (Qm)
		24-32	fine sand (Qbnl)
		32-82	fine red sand and clay (Qbnl)
		82-92	fine red sand (Qbnl)
		92-103	fine red sand and clay (Qbnl)
		103-109	hardpan (Qt)
		at 109	red and gray sandstone
94	Well 14f, Parrillo, 1959	0-8	fill (af)
		8-28	gray sand and clay (Qm)
		28-35	gray sand (Qbnl or Qal)
95	Well 13f, Parrillo, 1959	0-7	fill (af)
		7-17	gray sand and clay (Qm)
		17-37	red sand and clay (Qbnl)
		37-44	red sand, some clay (Qbnl)
96	Well 11f, Parrillo, 1959	0-12	water
		12-24	silt (Qm)
		24-34	fine red sand (Qal)
		34-54	gray sand and clay (Qbnl)
		54-104	fine sand and clay (Qbnl)
		at 104	rock
97	Well 9f, Parrillo, 1959	0-10	water
		10-15	silt (Qm)
		15-36	fine sand Qal)
		36-40	gravel (Qal)
		40-70	fine red sand and clay (Qbnl)
		at 70	rock
98	NJGS files	0-4	clay, sand, gravel fill (af)
		4-11	sand, mud (Qm)
		11-23	mud (Qm)
		23-31	red sand (Qal or Qbnl)
		31-41	red sand, clay (Qbnl)
		41-51	red clay (Qbnl)
		51-117	red clay, sand, and gravel (Qbnf or Qt)
		117-128	red sand and clay (Qbnl or Qt)
99	NJGS files	0-12	sand, gravel, ash, cinder fill (af)
		12-23	peat and vegetation (Qm)
		23-36	fine gray silty sand (Qbnl)
		36-39	medium gray sand and gravel (Qbnf)
		at 39	refusal (boulder or bedrock)
100	NJGS files	0-27	cinder, slag, brick, ash fill (af)
		27-32	peat and vegetation (Qm)
		32-33	gray silty sand (Qm)
		33-38	red silty sand and some gravel (Qbn)

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Selected Well and Boring Logs 101-120

101	NJGS files	0-11	cinders, brick, ash, wood (af)
		11-26	organic silt and layers of gray sand (Qm)
		26-31	red silt and thin layers of fine sand (Qbnl)
		31-39	red silt (Qbnl)
		39-70	medium red sand, clay, and coarse gravel (Qt)
		at 70	refusal (bedrock)
102	NJGS files	0-11	cinders, wood, glass, brick fill (af)
		11-22	peat and vegetation (Qm)
		22-27	fine brown sand and gray silty sand (Qbnl)
		27-32	very fine gray silty sand (Qbnl)
		32-44	fine red silty sand (Qbnl)
		44-50	red clay and gravel (Qt)
103	NJGS files	0-10	fill, cinders, wood, brick (af)
		10-19	peat (Qm)
		19-48	gray clay (Qbnl)
		48-50	fine reddish brown sand with a trace of clay (Qbnl)
104	NJGS files	0-15	concrete and cinder fill (af)
		15-36	organic silt and peat (Qm)
		36-47	organic silt and shells (Qm)
		47-51	gray sand and coarse gravel (Qbnf)
		51-85	red silty sand (Qbnf)
		85-95	red sand and coarse gravel (Qbnf)
105	NJGS files	0-4	fill
		4-25	medium-to-fine reddish brown sand with trace of silt (Qbn)
106	NJGS files	0-3	fill
		3-10	coarse-to-fine brown sand with trace of gravel (Qbn)
		10-24	fine reddish-brown silty sand with layers of clay (Qbn)
		24-32	medium-to-fine brown sand and silt (Qbn)
		32-40	coarse-to-fine gray-brown sand, silt, some gravel (Qt)
		at 40	refusal (bedrock)
107	NJGS files	0-12	fill (af)
		12-24	organic silt and shells (Qm)
		24-37	fine gray silty sand (Qbnl)
		37-52	medium-to-coarse brown sand (Qbn)
		52-61	red silt and traces of clay (Qbnl)
		61-71	red clay, sand, and gravel (Qbnl over Qbnf)
108	NJGS files	0-12	sand, clay, gravel fill (af)
		12-16	sand, mud (Qm)
		16-19	mud (Qm)
		19-27	gray sand (Qal or Qbnl)
		27-33	medium red sand (Qbn)
		33-53	red sand and clay (Qbnl)
		53-55	red clay (Qbnl)
109	NJGS files	0-21	cinder fill (af)
		21-29	brown sand, fine gravel (Qbn)
		29-36	fine red sand (Qbn)
		36-47	fine red silty sand (Qbn)
		47-52	fine-to-medium red sand, gravel (Qbn)
		52-67	red silty sand, clay, and gravel (Qbn)
		67-72	medium-to-coarse red sand, gravel (Qbn)
		72-76	red clay, sand, gravel, boulders (Qt)
110	NJGS files	0-16	cinder, wood, brick, glass fill (af)
		16-26	mud bog (Qm)
		26-37	fine gray sand, clay, trace of gravel (Qbn)
		37-46	fine red sand, clay, trace of gravel (Qbn)
		46-51	red sand, gravel, clay, boulders (Qt)
111	NJGS files	0-4	cinder and ash fill
		4-10	brown and gray clay, some sand and gravel (Qt)
		10-13	red and brown sand and coarse gravel (Qt)
		13-18	rock
112	NJGS files	0-5	cinders and ashes (af)
		5-10	gray silt with trace of peat (Qm)
		10-16	black silt and shells (Qm)
		16-34	gray silt with some shells and peat (Qm)
		34-35	red and brown silty sand and gravel (Qbn)
113	NJGS files	0-15	cinders, boulders, sand, wood (af)
		15-23	peat (Qm)
		23-38	gray clay (Qhkl)
		38-50	brown clay, layers of fine sand (Qbnl)
		50-55	red clay, silty sand (Qbnl)
		55-56	red clay, sand, gravel (Qt)
114	NJGS files	0-17	cinders, wood, glass, concrete fill (af)
		17-21	mud (Qm)
		21-42	gray sand and fine gravel (Qbn)
		42-53	red silty sand (Qnbl)
		53-61	red silty sand and layers of clay (Qbnl)
115	NJGS files	0-10	cinders, brick, wood, black silty sand (af)
		10-19	soft black and gray organic clayey silt, meadow mat (Qm)
		19-25	stiff red-brown and gray varved silty clay, trace fine sand seams (Qhkl)
		25-42	same as 19-25, but soft (Qhkl over Qbnl)
		42-50	stiff red-brown silt, small gravel, trace clay (Qt)
		50-55	light gray arkosic sandstone
116	NJGS files	0-15	cinders and brick fill (af)
		15-19	black organic clayey silt and meadow mat (Qm)
		19-42	red-brown and gray varved silty clay, trace fine sand seams (Qhkl over Qbnl)
		42-58	red-brown silty fine-to-coarse sand and gravel (Qt or Qbnf)
		58-63	light gray arkosic sandstone
117	NJGS files	0-9	dark gray silt, trace cinders and vegetation (af)
		9-17	soft dark brown organic clayey silt and meadow mat (Qm)
		17-30	stiff to medium-stiff red-brown and gray varved silty clay, trace fine sand seams (Qhkl over Qbnl)
		30-43	soft red-brown and gray varved silty clay, trace fine sand (Qbnl)
		43-50	sand, silt, clay, and gravel (Qt)
		50-55	light gray arkosic sandstone
118	NJGS files	0-2	sand, gravel, trap rock fill
		2-5	medium-to-fine reddish brown sand with some gravel (Qt)
		5-23	fine reddish brown sand with shale fragments, some gravel, and trace of clay (Qt)
119	NJGS files	0-11	cinder and ash fill (af)
		11-18	peat (Qm)
		18-27	gray silt (Qm)
		27-37	gray silt and trace of gravel (Qm)
		37-53	very fine red silty sand (Qbnl)
		53-75	red silt (Qbnl)
		75-90	red clay (Qbnl)
		90-100	red silt (Qbnl)
120	NJGS files	0-8	cinders, ash, coal fill (af)
		8-14	peat (Qm)
		14-22	gray clay and sand (Qm or Qbnl)
		22-32	red sand and coarse gravel (Qt)

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Selected Well and Boring Logs 121-140

121	NJGS files	0-4	brown clay and cinder fill (af)
		4-25	red clay, sand, gravel, and sandstone fragments (Qt)
122	NJGS files	0-7	meadow bog and gray-brown clay (Qm)
		7-17	stiff brown clay (Qhkl)
		17-26	soft brown clay with layers of fine red silty sand (Qbnl)
		26-37	red clay, sand, fine-to-coarse gravel (Qt)
		37-42	hard fine-grained red rock
123	NJGS files	0-7	cinder, brick, sand, ash fill (af)
		7-24	river mud (Qm)
		24-39	organic silt and some shells (Qm)
		39-43	rock, cored
124	NJGS files	0-7	medium-to-fine brown sand (Qe)
		7-11	medium-to-fine brown sand with some gravel, trace silt (Qt)
		11-27	medium-to-fine brown sand with some gravel and a trace of silt and boulders (Qt)
		27-34	rock
125	NJGS files	0-5	fine brown sand (Qe)
		5-11	fine gray and brown sand, trace silt (Qe)
		11-27	fine-to-medium red sand, gravel, trace of silt and clay (Qt)
		27-32	rock
126	NJGS files	0-14	sand, gravel, cinders, ash, tin, wood, glass fill (af)
		14-19	gray silt, sand, clay (Qm)
		19-24	gray and red sand, silt (Qbn)
		24-35	red sand, clay, gravel (Qt or Qbn)
127	NJGS files	0-12	cinder, coal, sand, gravel, clay fill (af)
		12-22	mud--bog (Qm)
		22-33	gray silty sand, trace of clay (Qbnl)
		33-39	red silty sand (Qbnl)
		39-46	red sand, clay, gravel (Qt)
128	NJGS files	0-7	cinders, brick, wood, sand, gravel fill
		7-11	red silty sand, clay, gravel (Qt)
		11-13	brown and red sand, clay, and gravel (Qt)
		13-18	rock
129	NJGS files	0-9	sand, gravel, cinder, wood fill (af)
		9-15	meadow bog (Qm)
		15-21	fine-to-medium gray sand (Qal)
		21-59	gray clay, fine layers of silty sand (Qhkl over Qbnl)
		59-89	red clay, layers of silty sand (Qbnl)
		89-94	red clay, sand, and gravel (Qt)
		at 94	refusal (probable bedrock)
130	NJGS files	0-12	cinders, brick, wood, glass, riprap fill (af)
		12-42	organic silt, shells, shells, rip-rap fill (af over Qm)
		42-48	gray sand, trace clay (Qe or Qbnl)
		48-53	brown sand, gravel, clay, boulders (Qt)
131	NJGS files	0-10	cinder fill (af)
		10-18	meadow mat and silt (Qm)
		18-60	plastic silty clay with thin layers of fine sand (Qhkl over Qbnl)
		60-76	stiff clay, sand, gravel (Qt)
		76-86	red shale
132	NJGS files	0-5	river mud (Qm)
		5-17	stiff clay, sand, gravel (Qt)
		17-47	red shale
133	26-4654	0-5	fill
		5-6	wood
		6-23	hard-packed gravel, weathered rock (Qbn)
		23-25	boulders (Qbn)
		25-43	weathered rock, hard-packed gravel (Qbn)
		43-67	brown clay, tough (Qbnl or Qt)
		67-85	red clay, tough (Qbnl or Qt)
134	26-12662	0-26	sand and shells (af over Qm)
		26-53	fine sand (Qm over Qbnl)
		53-95	red clay (Qbnl)
		95-98	gravel (Qt)
		98-160	red sandstone
135	26-16811	0-12	sand, gravel, cinders, brick fill (af)
		12-17	fine sand (af or Qm)
		17-45	gray silt with some clay and fine sand (Qbnl)
		45-77	red-brown silt with fine sand (Qbnl)
		77-95	rock core
136	26-19496	0-11	fill (af)
		11-23	brown organic silt and peat (Qm)
		23-34	green-gray silt, fine sand (Qm)
		34-51	red-brown fine sand, trace silt (Qbnl)
		51-79	red-brown varved silt to fine sand (Qbnl)
		79-89	red-brown silt, some gravel (Qt)
		89-90	shale bedrock
137	26-21998	0-13	miscellaneous fill (af)
		13-26	gray organic clay (Qm)
		26-30	gray silty sand (Qm or Qbnl)
		30-50	gray fine-to-medium sand, trace silt (Qbn)
		50-52	red-brown silt, trace fine sand (Qbn or Qbnl)
138	26-22152	0-3	brown silt, medium-to-fine sand (af)
		3-17	gray clay, peat (Qm)
		17-18	gray sand (Qm)
		18-68	red sand and gravel (**Qbnf**)
		68-76	coarse-to-medium sand, trace silt and gravel (Qt)
139	26-25210	0-8	red silt, trace gravel and rock fragments (Qt or fill)
		8-10	gray fine-to-medium sand (Qt)
		10-12	gray medium sand, red silt, rock fragments (Qt)
		12-18	red silt and rock fragments (Qt)
140	N 26-13-858, well 2	0-7	bog and mud (Qm, boring made before landfilling)
		7-11	fine sand and clay (Qal)
		11-13	medium sand and clay (Qal)
		13-60	compact clay (Qhkl over Qbnl)
		60-63	soft to hard shale rock

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Selected Well and Boring Logs 141-145

141	Figure 17 from Lovegreen, 1974	0-5	water
		5-12	gray organic silt, clay, meadow material, shells (Qm)
		12-20	brown sand (Qal)
		20-95	reddish-brown varved clay and silt (Qbnl)
		95-120	shale
142	boring B203, Lippincott, Jacobs, and Gouda, 1995a	0-8	fill (af)
		8-42	dark-gray organic silty clay, trace shells, and fine sand (Qm)
		42-62	gray to grayish-red gravel, some coarse-to-fine sand, trace silt (Qbn)
		62-103	grayish-red fine-to-medium sand, trace silt (Qbn over Qbnl)
		103-116	grayish-red clayey silt (Qbnl)
		116-145	grayish-red medium-to-fine sand, trace silt (Qbnl over Qbnf)
		145-155	gravel (Qbnf)
		155-170	cobbles and boulders with clayey sand matrix (Qt)
		170-174	decomposed rock
		174-179	red sandstone and conglomerate
143	boring B216, Lippincott, Jacobs, and Gouda, 1995a	0-13	dark-gray sand and silt fill (af)
		13-23	dark-gray to black organic silt and clay with plant roots (Qm)
		23-32	dark-gray fine sand (Qm)
		32-47	brown clayey silt (Qbnl)
		47-57	dark-brown fine-to-medium sand, little silt (Qbnl)
		57-87	dark reddish-brown silt to clayey silt, trace fine sand (Qbnl)
		87-98	brown cobbles and boulders (Qt)
		at 98	refusal on rock
144	boring B7, Lippincott, Jacobs, and Gouda, 1995b	0-13	fill (af)
		13-53	gray organic silty clay, trace fine sand and shells (Qm)
		53-58	gray fine-to-medium sand, trace silt and fine gravel (Qal or Qm)
		58-68	red clayey silt (Qbnl)
		68-89	red to grayish-red fine-to-medium sand, some clay and silt (Qbnf)
		at 89	refusal
145	boring B1, Lippincott, Jacobs, and Gouda, 1995b	0-8	fill (af)
		8-21	red-brown sand, some clayey silt, a little fine gravel (Qbn)
		21-22	red-brown rock fragments

[1]Numbers of the form 26-xxxx are well permit numbers issued by the N. J. Department of Environmental Protection, Bureau of Water Allocation. Numbers of the form N 26-xx-xxx are N. J. Atlas Sheet grid locations of entries in the N. J. Geological Survey permanent note collection. The notation "NJGS files" indicates borings from various construction projects that are on file at the N. J. Geological Survey, but that are not entered into the permanent note collection. Notations of the form "Well 24c, Parrillo, 1959" refer to logs provided in the cited publications.

[2]Inferred map units and comments by author in parentheses. All descriptions are reproduced as they appear in the original source, except for minor format, spelling, and punctuation changes. Many logs have been condensed for brevity. Map units are inferred from the known extent of materials at the surface and from known depositional settings, in addition to the driller's descriptions.

Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

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Extracted from: Surficial Geology of the Jersey City Quadrangle (OFM20)

Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Stanford, S.D., 1999, Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles, Middlesex and Union Counties, New Jersey: New Jersey Geological Survey, Open-file Map 28, scale 1:24,000. (*GRI Source Map ID 47711*)

Ancillary Map Notes

Introduction

Surficial materials in the Perth Amboy and Arthur Kill quadrangles consist of glacial, stream, wetland, and weathered bedrock sediment. The glacial sediment includes sand, gravel, silt, and clay laid down by meltwater in glacial ice as a sheet on the bedrock surface and in the terminal moraine. The sand, gravel, silt, and clay, known collectively as stratified drift, are as much as 70 feet thick. Till is as much as 130 feet thick. The stream sediment included sand, gravel, and silt deposited in floodplains, stream terraces, and former river plains. It is as much as 40 feet thick. The wetland sediment included peat and organic silt and clay deposited in freshwater swamps and saltwater marshes and estuaries. It is as much as 100 feet thick. The weathered bedrock consists of silty clay and shale fragments formed by chemical and mechanical decomposition of shale bedrock of Triassic and Jurassic age. It is generally less than 10 feet thick.

The accompanying map and sections show the surface extent and subsurface relations of these deposits. Figure 1 shows the extent of glacial lakes and river plains, the terminal moraine, and recessional ice margins. Table 1 lists water-well and test-boring logs used to plot bedrock-surface topography and to infer the subsurface distribution of deposits. Table 2 lists the composition of pebbles in the glacial deposits. The correlation chart shows the temporal relationships and age of deposits.

Postglacial Deposits

These include artificial fill, stream, wetland, and beach sediment deposited since retreat of the late Wisconsinan glacier. Alluvial and swamp deposits began to accumulate shortly after deglaciation. Estuarine and salt-marsh deposits began to accumulate as rising sea level entered the Raritan Valley. This occurred as early as 11,500 radiocarbon years before present (yrs B. P.) as indicated by a radiocarbon date of 11,420±560 yrs B. P. (GX-21687) on organic clay at the base of the estuarine deposit at a depth of 98-100 feet in a boring adjacent to boring 139 (Table 1) (Lippincou. Jacobs, and Gouda. Inc., 1995. boring B2).

Glacial Deposits

These include till and stratified drift deposited by ice and meltwater during the [late Wisconsinan glaciation. The till is a reddish-brown, nonstratified poorly-sorted sediment consist of pebbles, cobbles, and a few boulders scattered in a compact matrix of mixed silt, sand. and clay. It is deposited by glacial ice. Stratified drift includes reddish-brown, to gray, moderately- to well-sorted, cross- to plane-bedded sand and, gravel deposited in deltas and fans in glacial lakes and in glacial river plains; and reddish-brown to gray, well-sorted, laminated to varved silt, clay, and fine sand deposited on the bottoms of glacial lakes. The sand fraction in both till and stratified drift is predominantly quartz and red and gray shale fragments. The composition of pebbles in these deposits is provided in Table 2.

Late Wisconsinan ice advanced southerly to southwesterly across the map area to the southern edge of the terminal moraine. As the glacier advanced, it overrode sand and gravel laid down in lakes and river plains in valleys in front of the ice margin. Records of wells and borings indicate that these deposits are preserved beneath till in a few places, chiefly where valleys drained toward the advancing glacier. These include the preglacial valley in the northwestern pan of the map area (units Qpf and Qsu in wells 4-7. 80, 82, 83, 85), the preglacial valley extending from Metuchen to the Rahway area (units Qpf and Qsu, section C-C'; wells 42, 47, 93, 203, 208-210, 221, 331),and in the lowland between the Arthur Kill and Woodbridge Creek (wells 179-182, 237-239, 241, 242, 244-246, 249, 256, 305, 309, 311}. Ice also overrode fluvial sand and gravel at Perth Amboy (unit Qpa, section B-B'; wells 134-137, 151, 158, 159, 343).

Ice also overrode,eroded, and deformed unconsolidated Cretaceous deposits and Pensauken Formation sediment at and south of Carteret, Woodbridge, and Metuchen (K and Tp on sections A-A', B-B'). Folded Cretaceous sand and clay, and, in places, Pensauken sand and gravel, were formerly well exposed in the clay pits at Woodbridge, Perth Amboy, and Fords (Ries and others, 1904) and were also observed in several excavations between 1987 and 1995. The two hills mapped as ice-contact deposits (Qic) in Woodbridge and Carteret may contain, or consist largely of, deformed Cretaceous sediment.

North of the Cretaceous outcrop belt the ice advanced across red shale bedrock. Glacial erosion of bedrock in the preglacial valleys was minimal because the valleys were sediment-filled. On low uplands between the valleys, though, ice eroded rock and deposited till to form low, smoothed ridges with a rough northeast-southwest trend parallel to both ice now and rock strike.

The terminal moraine (Qtm) was deposited while the ice margin stood at and melted back from its maximum position. The moraine is a broad belt of knolls, ridges, and basins, composed mostly of till extending in an are from Perth Amboy to Scotch Plains. A prominent frontal ridge as much as 100 feet high marks the south edge of the moraine between Metuchen and Fords, but elsewhere it generally has less than 50 feet of relief. The back edge of the moraine is a gradual transition from constructional moraine landforms to nonmorainic till. As ice stood at the moraine, meltwater deposited sand and gravel in three glacial river plains (Qpf, Qmt, Qpa).

The ice margin was probably in retreat from the moraine by 20,000 years ago (Stanford and Harper. 1991). The retreating ice margin had roughly the same arc-like orientation as the terminal moraine, and three glacial lakes fanned in basins between the retreating ice front and the moraine (fig. 1).

Lake Ashbrook occupied the Robinsons Branch valley. It was controlled first by a spillway at an elevation of about 90 feet across the terminal moraine at Oak Tree, about half-a-mile west of Oak Tree School, just west of the map boundary (spillway AB1 on fig. 1). Most of the Lake Ashbrook deposits in the map area (Qab. Qabl) were probably deposited in this higher lake stage. As the ice margin retreated a lower spillway at an elevation of about 80 feet was uncovered on the divide between the Robinsons Branch and South Branch of the Rahway valleys, just north of Shore View (spillway AB2 on fig. 1). Lake Ashbrook lowered to the level of Lake Woodbridge when the retreating ice front uncovered the Robinsons

Branch valley in the vicinity of the present Middlesex Reservoir.

Lake Woodbridge occupied the South Branch valley and, later, the Robinsons Branch valley and main Rahway valley upstream of Rahway. It was controlled by a spillway at an elevation of about 60 feet on the Rahway-Woodbridge Creek divide near Colonia (WB on fig. 1), and drained when the ice front retreated north of the low upland between the South Branch and Woodbridge Creek valleys between Avenel and Rahway. Deposits in this lake in the map area include deltaic sediment near Iselin (Qwb).

Lake Bayonne occupied the lowland along the Arthur Kill, Woodbridge Creek, and lower Rahway River. It was controlled at first by a spillway across the terminal moraine at Richmond Valley on Staten Island at an elevation of 25-30 feet. This spillway was succeeded by one across the terminal moraine between Perth Amboy and Staten Island (BN on fig. 1), which gradually lowered as the overflow eroded the moraine. Deposits in Lake Bayonne in the map area are primarily lake-bottom silt and clay (Qbnl) and scant deltaic or fan sand and gravel (Qbn). With continued erosion the spillway migrated northward along the present Arthur Kill and stabilized when it uncovered diabase bedrock near Tremley Point at an elevation of -30 feet. This formed the spillway for Lake Hackensack (HK on fig. 1). Only the southern most tip of Lake Hackensack extended into the map area, as shallow water along the Arthur Kill north of Tremley Point. Because the ice margin at this time was about 15 miles northeast of Tremley Point, there was little or no glacial sediment deposited in this lake in the map area.

Lakes in the map area had drained by 18,000 years ago (Stanford and Harper, 1991), although meltwater continued to drain down the Rahway, Raritan, and Arthur Kill valleys for a period after lake drainage. In the Rahway valley this meltwater deposited sand and gravel (Qrw). In the Raritan valley the meltwater, sourced mostly from glacial lake overflows in headwater areas, was combined with nonglacial drainage and deposited nonglacial and reworked glacial sediment (Qrt). This deposition likely spanned most of the period when ice was in the Raritan basin. In the Arthur Kill the meltwater was glacial lake overflow from Lake Hackensack. This drainage carried little sediment and so deepened the channel through the moraine at Perth Amboy and the till plain to the north.

Preglacial Deposits

These include sand and gravel deposited by a preglacial river (Tp), weathered shale bedrock (Qsw), and outcropping sand and clay of Cretaceous age (K). The preglacial river, which may have included drainage from the Hudson valley and southern New England, flowed across the region from northeast to southwest between about 5 and 2 million years ago and deposited a broad plain of sand and gravel that covered the entire map area. This river was diverted, possibly by glacial blockage, about 2 million years ago. Local drainage then eroded valleys into and through the former river plain, leaving remnants of the deposit on uplands. These remnants, except for a small area in the southwest corner of the map area, beyond the glacial limit, were then overridden by the late Wisconsinan glacier.

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Figure 1 - Glacial Extents

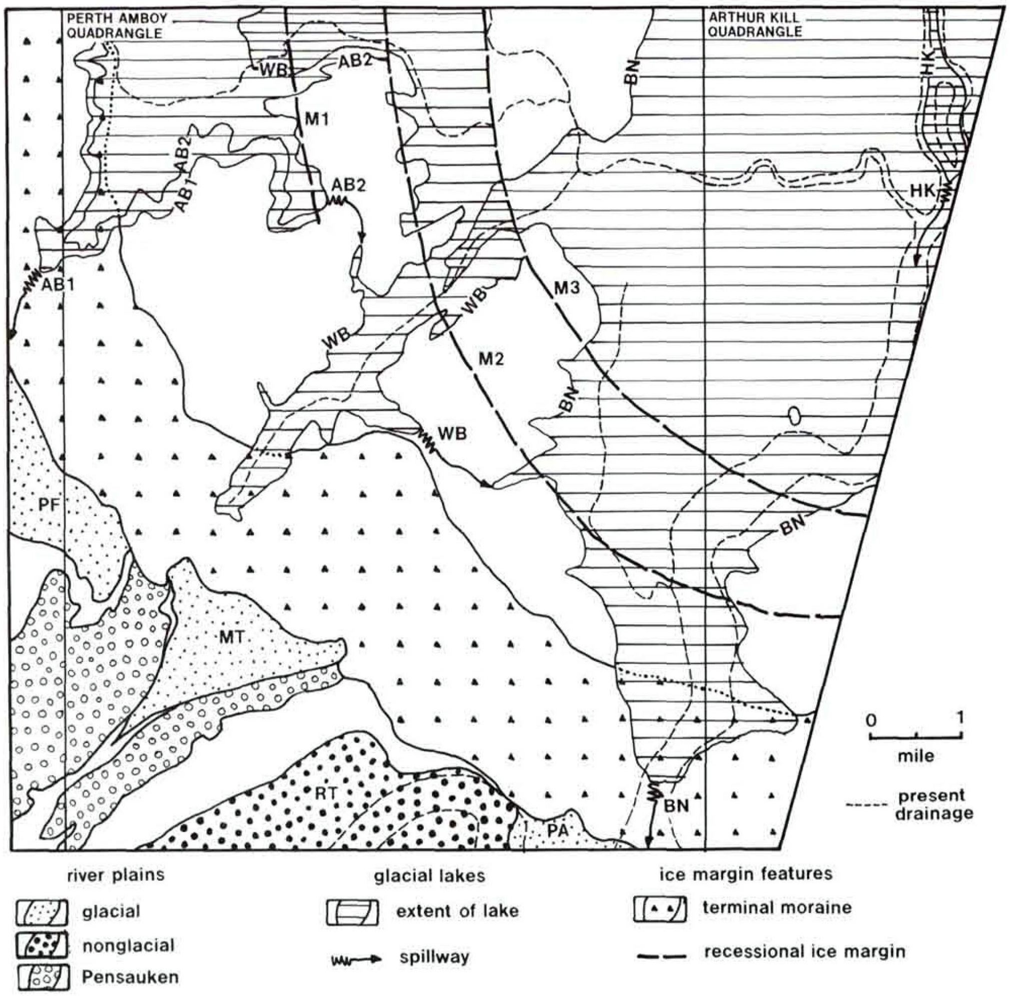


Figure 1.--Glacial lakes, river plains, terminal moraine, and recessional ice margins in the map area. Glacial lakes are identified by the following abbreviations on their shorelines and next to their spillways:

- BN=Bayonne
- WB=Woodbridge
- HK=Hackensack
- AB1=high stage of Ashbrook
- AB2=low stage of Ashbrook.

River-plain abbreviations are:

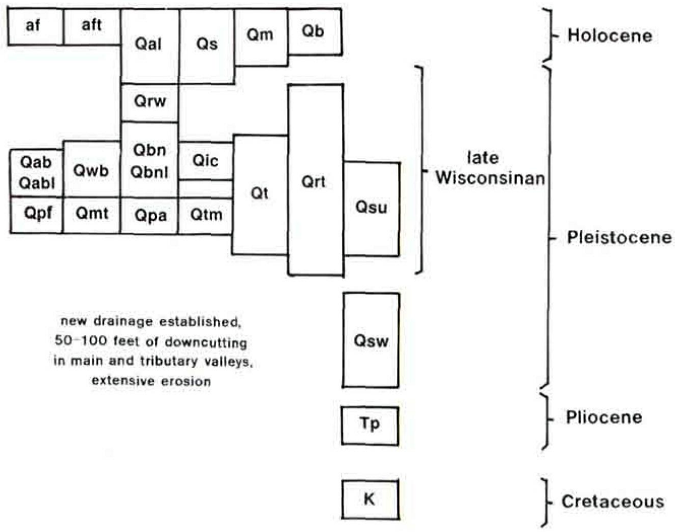
- PF=Plainfield
- MT=Metuchen
- PA=Perth Amboy
- RT=Raritan.

Recessional ice margins are:

- M1=last ice margin before lowering of Lake Ashbrook to lower stage
- M2=last ice margin before Lake Ashbrook lowers to Lake Woodbridge
- M3=last ice margin before Lake Woodbridge drains eastward into Lake Bayonne.

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Correlation of Map Units



Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Explanation of Map Symbols

Contact--Solid where well-defined by landforms, long-dashed where approximate, short-dashed where gradational or feather-edged, dotted where excavated or projected under fill.

Limit of excavation--Ticks point into excavation. Dashed where obscured by regrading or filling. Marks extent of former clay, sand, and gravel pits. These areas have a discontinuous layer of artificial fill and displaced and regraded surficial and bedrock materials as much as 20 feet thick. Contacts within these areas show the approximate extent of natural material beneath this man-made layer. Fill is mapped separately only where it has a distinct landform . Extent of pits based, in part, on Ries and others (1904). In places, the base map topography within the excavation has been significantly altered since the date of the topographic survey (1934). Contacts within excavated areas show the location of materials at the time of mapping rather than with respect to the base topography.

af/Qm **Unit to left of slash overlies unit to right**--Shows extent of natural material beneath large areas of fill. Extent of natural materials is based, in part, on Ries and others (1904) and Darton and others (1908).

(Qbn) **Unit formerly present**--Unit in parentheses removed by excavation. Shows location of Maurer delta deposited in Lake Bayonne, based on Darton and others (1908).

47 *-47* **Well or boring with log in table 1**--Location accurate to within 100 feet. Elevation of bedrock surface in italics.

74 *-47* **Well or boring with log in table 1**--Location accurate to within 500 feet. Elevation of bedrock surface in italics.

-47 **Elevation of bedrock surface in well or boring**--Data from Nemickas (1974).

-47 **Elevation of bedrock surface in well or boring**--Data from N. J. Geological Survey files.

8 **Site of pebble count**--Data in table 2.

r **Bedrock outcrop**--Some outcrop locations from R. A. Volkert and D. H. Monteverde, N. J. Geological Survey (personal communication, 1996).

(r) **Former bedrock outcrop**--No longer exposed. From field maps of H. B. Kummel, N. J. Geological Survey (undated).

50 **Elevation of bedrock surface**--Contour interval 50 feet. Includes surface of Cretaceous deposits.

Qwb **Spillway for glacial lake**--Symbol in spillway area, arrow shows direction of drainage, lettering indicates associated deposit.

47 **Well or boring**--On section, projected to line of section.

Depth to bedrock in well or boring--On section, projected to line of section.

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Table 1 - Selected Well and Boring Logs

Selected Well and Boring Logs 1-70

Well no.	Identifier[1]	Driller's Log[2]	
		Depth[3]	Description
1	25-21337	0-68	clay and gravel overburden (Qtm)
		68-125	red slate
2	25-1203	0-14	red sand clay (Qtm)
		14-30	boulders and heavy gravel (Qtm)
		30-45	hard red clay (Qtm)
		45-60	red hardpan (Qtm)
		60-65	red muddy sand (Qtm)
		65-67	red hard clay (Qtm or Qsw)
		67-132	hard red sand rock
3	25-627	0-5	red sandy clay (Qt)
		5-15	hard pan with streak of red sand (Qt)
		15-33	hard red clay, heavy gravel (Qt)
		33-150	red hard sand rock and streaks of red shale
4	25-1298	0-25	red sand and gravel mixed with red clay (Qtn
		25-75	red hard pan with streaks of yellow dry sand (Qtm)
		75-100	red muddy sand (Qpf?)
		100-110	hard red clay (Qsw)
		110-170	red sand rock
5	25-28739	0-12	brown coarse-to-fine sand; trace silt, clay, cobbles,and boulders (Qtm)
		12-40	red-brown coarse-to-fine sand, trace silt (Qpf
		40-60	red-brown fine sand, trace silt (Qpf?)
		60-76	red-brown coarse-to-fine sand, little coarse-tc fine gravel, trace silt (Qpf?)
		76-170	red shale
6	25-8379	0-70	sand (Qtm over Qpf)
		70-127	shale
7	25-408	0-50	dirt, red sand, some clay (Qtm over Qpf)
		50-402	red shale
8	25-5432	0-41	brown clay and stone (Qtm)
		41-608	red shale, some brownstone and clay seams
9	25-5637	0-26	fine red sand, few streaks of gravel (Qtm)
		26-629	red shale, some brownstone
10	25-27174	0-30	sand and gravel, stones (Qt)
		30-110	red shale
11	25-24853	0-41	overburden (Qt)
		41-300	red rock
12	25-1073	0-25	sand and clay (Qt)
		25-130	shale
13	25-1256	0-23	sand and clay (Qt)
		23-90	shale
14	25-13392	0-30	sand and gravel (Qt)
		30-120	red shale
15	25-12799	0-28	sand and gravel (Qt)
		28-130	red shale
16	25-15987	0-20	sand and gravel (Qt)
		20-145	shale
17	25-13060	0-30	sand and gravel (Qt)
		30-150	red shale
18	25-28407	0-30	overburden (Qt)
		30-300	shale
19	26-577	0-42	sand and gravel (Qt)
		42-90	rock
20	26-356	0-32	sand and clay (Qt)
		32-85	shale
21	26-329	0-23	sand, clay, gravel (Qt)
		23-80	rock
22	25-12610	0-25	sand and gravel (Qt)
		25-110	red shale
23	26-330	0-10	sand (Qt)
		10-16	clay (Qt)
		16-82	shale
24	26-673	0-42	sand and clay (Qt)
		42-90	rock
25	26-423	0-26	sand and clay (Qt)
		26-80	rock
26	26-477	0-28	sand and clay (Qt)
		28-89	rock
27	26-474	0-25	clay and sand (Qt)
		25-78	rock
28	26-478	0-17	sand and clay (Qt)
		17-85	rock
29	26-554	0-24	sand and clay (Qt)
		24-82	rock
30	26-291	0-18	clay and sand (Qt)
		18-86	shale
31	26-469	0-10	red hard pan (Qt)
		10-20	red muddy sand (Qt)
		20-27	red hard clay (Qt or Qsw)
		27-100	red sand rock
32	26-275	0-5	red hard pan (Qt)
		5-145	red shale and red sand rock
33	26-341	0-10	red sandy clay, hard, mixed with some fine gravel (Qt)
		10-30	tough hard red clay (Qt)
		30-43	red hard pan (Qt)
		43-150	red sand rock
34	26-460	0-22	sand and clay (Qt)
		22-99	rock
35	26-8535	0-18	red-brown clayey silt till (Qt)
		18-19	soft shale (Qsw)
		19-28	red shale
36	25-21970	0-10	topsoil and clay (Qt)
		10-200	shale
37	25-1104	0-26	sand and clay (Qt)
		26-80	shale
38	26-1155	0-30	clay (Qt)
		30-320	red shale
39	25-10489	0-NR	sand (Qt, 53 feet of casing)
		NR-NR	shale
40	25-6566-8	0-5	red-brown silty clay, trace medium-to-fine gravel (Qt)
		5-12	red-brown silty clay (Qt or Qsw)
		12-13	soft red shale
41	25-62	0-49	red dirt (Qtm)
		49-102	red shale
42	25-21996	0-20	sand and gravel (thin Qtm over Qpf)
		20-200	shale
43	25-14787A	0-50	sand and gravel (Qtm over Qpf?)
		50-180	red shale
44	25-21969	0-70	sand and gravel (Qtm)
		70-250	red shale
45	25-13343	0-40	sand and gravel (Qtm)
		40-50	red clay (Qsw or Qtm)
		50-100	red shale
46	25-13204	0-42	sand and gravel (Qtm)
		42-52	red clay (Qsw or Qtm)
		52-110	red shale
47	25-233	0-105	clay and sand (Qtm over Qpf)
		105-126	sand and gravel (Qpf)
		126-143	shale
48	25-27254	0-20	red silt and clay with sandstone, shale, and siltstone fragments (Qtm)
		20-29	red shale
49	25-13009	0-55	sand and clay (Qtm)
		55-150	red shale
50	25-6989	0-50	clay (Qpf)
		50-403	red shale
51	25-10771	0-85	soft red shale and sandstone (Qpf over Qsw)
		85-296	red shale
52	25-5278	0-28	earth, sand, clay (Qpf)
		28-35	soft red shale rock (Qsw)
		35-231	red shale rock
53	25-6877	0-28	red clay (Tp over Qsw)
		28-170	red shale
54	N 25-44-363	0-15	brown, gray, yellow clayey sand and gravel (Tp)
		15-27	red clay (Qsw)
55	25-42	0-36	clay, stones, and hardpan (Tp)
		36-95	red shale
		95-105	gray slate
		105-417	red rock
56	25-58	0-5	stones and sandy clay (Tp)
		5-10	hardpan, stones (Tp)
		10-12	yellow clay (Tp or Qsw)
		12-18	pink clay (Qsw)
		18-32	purple clay (Qsw)
		32-82	brown and red rock
		82-92	red and gray rock
		92-402	red rock
57	26-1026	0-10	earth and clay (Qt)
		10-394	red shale rock
58	26-6661	0-6	red-brown clayey silt, trace gravel (Qt)
		6-14	red-brown coarse-to-fine sand, some fine gravel, little clayey silt (Qt)
59	22-22018	0-7	fill
		7-20	red silty clay, little gravel, fragmented shale and gravel (Qt)
60	25-9026	0-28	coarse brown sand and gravel (Qmt)
		28-40	red and white clay, streaks of red shale (Qsw)
61	26-20207	abbreviated log	
		0-31	red sandy clay, trace pebbles (Qt)
		31-35	red clayey sand and gravel (Qt)
62	26-16079	abbreviated log	
		0-34	reddish-brown sandy silt, little gravel and clay (Qt)
63	25-22689	0-8	red to light-brown clay, trace sand (Qmt or af)
		8-11	brown sand and gravel, some clay, gravel is rounded (Qmt)
		11-21	white, orange, brown fine sand; a little light green clay (K)
64	26-20274	0-16	fill
		16-25	red-brown sand and clay (Qtm over Qmt)
		25-30	red-brown clay (Qsw)
65	26-12460	abbreviated log	
		0-6	brown and gray medium-to-fine sand, a little medium-to-fine gravel (Qmt)
		6-25	dark-gray silt and clay with lignite and pyrite (K)
		25-27	light-gray to buff medium-to-fine quartz sand (K)
66	26-12462	abbreviated log	
		0-4	fill
		4-7	light-gray to light-brown medium-to-fine sand (Qmt)
		7-33	dark-gray clay and silt, lignitic, with sand seams (K)
		33-42	orange-brown to light-gray medium-to-fine quartz sand (K)
67	26-12	0-50	dirt and sand (Qtm over K)
		50-90	clay (K)
		at 90	red rock
68	26-6550	abbreviated log	
		0-12	red-brown clayey silt, trace sand and gravel (Qtm)
69	N 26-31-794	0-75	glacial drift (Qtm)
		75-100	yellow-brown pebbly sand (Tp)
		100-160	clay, sand, clayey sand (K)
		160-235	red shale
70	26-484	0-105	red clay and red hard pan (Qtm)
		105-160	dirty, muddy, fine gray sand (K)
		160-165	yellow hard clay (K)
		165-195	hard black and brown clay (K)
		195-200	gray clay and boulders (shale bedrock?)

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Selected Well and Boring Logs 71-116

117	NJGS files	Route 9 bridge boring 2	
		0-7	water
		7-32	river mud (Qm)
		32-37	reddish sand and gravel (Qrt)
		37-49	brown sand and gravel (Qrt)
		49-52	brown clay and serpentine (weathered diabase)
		52-57	serpentine (weathered diabase)
		57-62	trap rock (diabase)
118	NJGS files	Route 9 bridge boring 26	
		0-9	water
		9-53	black river mud and shells (Qm)
		53-57	clayey brown sand and gravel (Qrt)
		57-71	clay (K over weathered diabase)
		71-77	disintegrated rock (weathered diabase)
		77-81	trap (diabase)
119	NJGS files	Route 9 bridge boring 14	
		0-12	water
		12-58	river mud (Qm)
		58-68	dirty brown sand and gravel (Qrt)
		68-70	serpentine (weathered diabase)
		70-74	trap rock (diabase)
120	NJGS files	Route 9 bridge boring 16	
		0-10	water
		10-40	river mud (Qm)
		40-63	fine-to-coarse light-gray sand (K)
		63-70	decomposed limestone (weathered diabase)
		70-73	trap rock (diabase)
121	NJGS files	Route 9 bridge boring 20	
		0-17	water
		17-21	mud (Qm)
		21-27	reddish-brown clayey sand and gravel (Qrt)
		27-65	very-fine-to-fine light-gray sand and some clay (K)
		65-72	decomposed limestone (weathered diabase)
		72-75	trap rock (diabase)
122	N 26-41-511	0-2	silt (Qm)
		2-8	sand (Qrt)
		8-25	sand and gravel (Qrt)
		25-33	silty clay (K)
		33-42	sand (K)
		42-50	gray black clay (K)
123	N 26-41-512	0-11	sand and silt (af over Qm)
		11-25	sand (Qrt)
		25-39	sand and gravel (Qrt)
		39-51	gray clay (K)
		51-65	sand and clay (K)
		65-75	gray and brown clay (K)
		75-85	red brown clay (K)
		85-107	brown and white clay (K or weathered rock)
124	N 26-41-278	0-59	silt (Qm)
		59-65	sand (Qrt)
		65-75	sandy silt (Qrt)
		75-83	sand and gravel (Qrt)
		83-86	hard clay (weathered diabase)
		at 86	trap rock (diabase)
125	N 26-41-275	0-69	silt (Qm)
		69-92	sand, gravel at base (Qrt)
		92-126	clay and sand (K)
		at 126	trap rock (diabase)
126	N 26-41-276	0-8	water
		8-85	silt (Qm)
		85-88	gravel (Qrt)
		88-132	mixed clay (K)
		at 132	rock (diabase)
127	N 26-41-276	0-8	water
		8-94	silt (Qm)
		94-112	mixed clay (K)
		at 112	rock (diabase)
128	N 26-41-273	0-27	water
		27-45	silt and sand (Qm)
		45-55	sand and gravel (Qrt)
		55-61	silt (Qrt)
		61-64	clay (Qrt)
		64-76	silt and sand (Qrt)
		76-80	boulders (Qrt)
		at 80	rock (diabase)
129	N 26-41-273	0-3	water
		3-20	silt and gravel (Qm over Qrt)
		20-53	sand (Qrt)
		53-56	clay (K)
		56-96	mixed clay (K)
		at 96	rock (diabase)
130	26-9400	0-30	metal, glass, wood, paper, sand, etc. fill (aft)
		30-36	dark-gray silty clay with layers of light-gray medium-to-fine sand (K)
131	26-9068	abbreviated log	
		0-40	cinder, brick, metal, soil fill (aft)
		40-45	red-brown clayey silty gravelly medium-to-fine sand (Qtm)
		45-57	brown, gray, white fine sand and clay (K)
132	26-28814	0-19	yellow sand and gravel with clay lenses (Qtm)
		19-97	soft gray clay (K)
		97-104	medium-to-coarse weathered white coarse sand (K)
		104-118	gray clay (K)
		118-140	medium-to-coarse weathered gray quartz sand with trace clay lense (K)
		140-145	gray clay (K or weathered shale)
133	26-10574	abbreviated log	
		0-20	red-brown sand, little silt and clay, trace gravel (Qtm)
		20-32	dark-gray medium-to-fine sand, little clayey silt, trace fine gravel (K)
134	26-7096	abbreviated log	
		0-30	red-brown silty clayey sand with some gravel (Qtm)
		30-47	brown-yellow sand and gravel (Qpa?)
		47-54	dark-gray plastic silty clay (K)
135	26-30698	0-2	fill material
		2-8	brown silt, sand, gravel (Qtm)
		8-15	brown sand, gravel (Qpa?)
		15-20	white sand (Qpa?)
		20-35	gray sand and gravel (Qpa?)
		35-40	brown medium-to-fine sand and gravel (Qpa?)
		40-45	gray silty clay (K)
		45-52	gray silty clay with mica (K)
136	26-7200	abbreviated log	
		0-5	cinders on gray-green silty clay (af over Qm)
		5-15	red-brown clayey silty sand with gravel (Qtm)
		15-42	red-brown, yellow-orange sand and gravel (Qpa)
		42-45	light-gray silty very micaceous clay (K)
137	26-7267	0-13	fill of cement, cinder, sand, clay, gravel (af)
		13-21	gray clay with peat moss (Qm)
		21-39	brown coarse-to-fine sand and gravel (Qpa)
		39-111	gray silty clay with layers of gray fine sand and some wood (K with lignite)
		111-137	gray coarse-to-medium sand with some wood (K with lignite)
		137-140	gray clay, layer of gray medium-to-fine sand (K)
138	26-12857	abbreviated log	
		0-5	fill dirt
		5-42	gray and red silt, fine sand, and clay (Qtm)
		42-60	brown and gray clay and fine sand (K)
139	NJGS files	boring B4 from Lippincott, Jacobs, and Gouda (1995)	
		0-12	black river mud (Qm)
		12-41	reddish-brown coarse-to-fine sand, trace silt, little gravel (Qm)
		41-105	dark-gray silty clay with organic matter, trace fine sand (Qm)
		105-116	gravel (Qpa)
		at 116	refusal on cobble or bedrock
140	NJGS files	boring B3 from Lippincott, Jacobs, and Gouda (1995)	
		0-11	black river mud (Qm)
		11-22	black, green to reddish-brown coarse-to-fine sand, trace silt and fine gravel (Qm)
		22-41	interbedded black organic silty clay and reddish-brown coarse-to-fine sand (Qm)
		41-110	dark-gray silty clay, some peat and shell fragments (Qm)
		110-120	gravel with alternating layers of sand, silt, clay (Qpa)
		at 120	refusal on cobble or bedrock
141	26-28568	abbreviated log	
		0-51	red-brown fine-to-medium sand, some silt and clay and fine-to-medium gravel (Qtm)
		51-52	gray clayey silt with mica (K)
142	26-16641	abbreviated log	
		0-20	red-brown, brown silty, clayey, gravelly sand (Qtm)
		20-32	yellow-brown silty coarse-to-fine sand (K or Qtm)
		32-38	white-tan sandy silty clay (K)
143	26-11042	abbreviated log	
		0-20	red-brown sandy silty clay, trace medium-to-fine gravel (Qtm)
144	26-18368	0-24	red medium sand (Qtm)
		24-46	red weathered shale (Qtm or K, Qsw unlikely)
145	26-5842	abbreviated log	
		0-8	fill
		8-36	red-brown clayey sandy silt, trace fine gravel (Qtm)
146	26-4071	0-250	sand and clay (Qtm over K)
		250-650	trap (diabase)
147	N 26-41-266	well 1	
		0-50	red clay and coarse gravel (Qtm)
		50-190	black to dark-brown clay, minor sand (K)
		190-523	varicolored rock (possible hornfels rock)
148	26-15929	abbreviated log	
		0-20	red clay, trace medium-to-fine red sand (Qtm)
149	26-22638	0-5	fill
		5-12	sand, fine, silty with clay (Qtm)
		12-20	sand, fine, silty with fractured shale (Qtm)
		20-45	weathered shale (K, Qsw unlikely)
150	26-24632	abbreviated log	
		0-14	gravel, wood, concrete fill
		14-31	red-brown silty sand, some gravel (Qtm)
		31-39	dark-gray micaceous clayey silt (K)
151	26-23061	0-29	reddish-brown silty sand with some gravel and cobbles mixed (Qtm)
		29-40	reddish brown sand and silt (Qpa?)
152	26-5216	0-20	silty clay (Qt)
		20-22	silty clay and gravel (Qt)
		22-48	gray clay (K)
		48-60	gray silty sand and clay (K)
153	26-5213	0-12	clay, sand, gravel (Qt)
		12-19	silty clay, trace of sand (Qt)
		19-23	silty sand, some clay (Qt)
		23-59	gray silty sandy clay (K)
		59-63	clay and sand (K)
		63-99	gray clay (K)
		99-123	gray clay and sand (K)
		123-138	green clay (weathered diabase?)
		138-139	basalt (diabase)
154	NJGS files	Outerbridge Crossing boring 14+28	
		0-15	red clay and sand (Qtm)
		15-75	gray clay and sand (K)
155	NJGS files	Outerbridge Crossing boring 25+00	
		0-5	fill
		5-22	soft mud, clay, and sand (Qtm)
		22-44	blue clay (K)
		44-50	fine sand, stiff gray clay (K)
156	26-4934	0-8	brown silty sand, lttle clay (Qtm)
		8-12	brown and gray silty clay (K)
		12-20	gray-black silty clay with partings of mica and fine sand, some lignite (K)
157	26-19837	abbreviated log	
		0-11	brown silty clayey sand, some gravel (Qtm)
		11-18	brown silty clay, trace fine sand (Qtm)
		18-36	brown fine-to-medium sand, trace fine gravel (Qpa)
		36-50	gray silty clay, trace fine sand and lignite (K)
158	NJGS files	Outerbridge Crossing boring 38+82	
		0-25	yellow clay (Qtm)
		25-39	brown sand and gravel (Qpa)
		39-125	black, gray, red clay, some fine white sand (K)
159	NJGS files	Outerbridge Crossing boring 58+86	
		0-48	silt (Qm)
		48-60	gray sand (Qm over Qbn)
		60-90	coarse brown sand (Qbn)
		90-95	clay, sand, gravel (Qbn)
		95-105	hardpan (Qtm?)
		105-110	brown sand (Qtm or Qpa)
		110-119	gray fine-to-coarse sand and clay, some beach sand (K)
160	26-13984	abbreviated log	
		0-10	water
		10-40	gray soft silt, some sand and shells (Qm)
		40-45	gray sandy silt (Qm)
		45-50	brown firm sand and gravel (Qtm)
		50-70	gray and red silt, clay, and sand, very firm (K)

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Selected Well and Boring Logs 117-160

117	NJGS files		Route 9 bridge boring 2
		0-7	water
		7-32	river mud (Qm)
		32-37	reddish sand and gravel (Qrt)
		37-49	brown sand and gravel (Qrt)
		49-52	brown clay and serpentine (weathered diabase)
		52-57	serpentine (weathered diabase)
		57-62	trap rock (diabase)
118	NJGS files		Route 9 bridge boring 26
		0-9	water
		9-53	black river mud and shells (Qm)
		53-57	clayey brown sand and gravel (Qrt)
		57-71	clay (K over weathered diabase)
		71-77	disintegrated rock (weathered diabase)
		77-81	trap (diabase)
119	NJGS files		Route 9 bridge boring 14
		0-12	water
		12-58	river mud (Qm)
		58-68	dirty brown sand and gravel (Qrt)
		68-70	serpentine (weathered diabase)
		70-74	trap rock (diabase)
120	NJGS files		Route 9 bridge boring 16
		0-10	water
		10-40	river mud (Qm)
		40-63	fine-to-coarse light-gray sand (K)
		63-70	decomposed limestone (weathered diabase)
		70-73	trap rock (diabase)
121	NJGS files		Route 9 bridge boring 20
		0-17	water
		17-21	mud (Qm)
		21-27	reddish-brown clayey sand and gravel (Qrt)
		27-65	very-fine-to-fine light-gray sand and some clay (K)
		65-72	decomposed limestone (weathered diabase)
		72-75	trap rock (diabase)
122	N 26-41-511	0-2	silt (Qm)
		2-8	sand (Qrt)
		8-25	sand and gravel (Qrt)
		25-33	silty clay (K)
		33-42	sand (K)
		42-50	gray black clay (K)
123	N 26-41-512	0-11	sand and silt (af over Qm)
		11-25	sand (Qrt)
		25-39	sand and gravel (Qrt)
		39-51	gray clay (K)
		51-65	sand and clay (K)
		65-75	gray and brown clay (K)
		75-85	red brown clay (K)
		85-107	brown and white clay (K or weathered rock)
124	N 26-41-278	0-59	silt (Qm)
		59-65	sand (Qrt)
		65-75	sandy silt (Qrt)
		75-83	sand and gravel (Qrt)
		83-86	hard clay (weathered diabase)
		at 86	trap rock (diabase)
125	N 26-41-275	0-69	silt (Qm)
		69-92	sand, gravel at base (Qrt)
		92-126	clay and sand (K)
		at 126	trap rock (diabase)
126	N 26-41-276	0-8	water
		8-85	silt (Qm)
		85-88	gravel (Qrt)
		88-132	mixed clay (K)
		at 132	rock (diabase)
127	N 26-41-276	0-8	water
		8-94	silt (Qm)
		94-112	mixed clay (K)
		at 112	rock (diabase)
128	N 26-41-273	0-27	water
		27-45	silt and sand (Qm)
		45-55	sand and gravel (Qrt)
		55-61	silt (Qrt)
		61-64	clay (Qrt)
		64-76	silt and sand (Qrt)
		76-80	boulders (Qrt)
		at 80	rock (diabase)
129	N 26-41-273	0-3	water
		3-20	silt and gravel (Qm over Qrt)
		20-53	sand (Qrt)
		53-56	clay (K)
		56-96	mixed clay (K)
		at 96	rock (diabase)
130	26-9400	0-30	metal, glass, wood, paper, sand, etc. fill (aft)
		30-36	dark-gray silty clay with layers of light-gray medium-to-fine sand (K)
131	26-9068		abbreviated log
		0-40	cinder, brick, metal, soil fill (aft)
		40-45	red-brown clayey silty gravelly medium-to-fine sand (Qtm)
		45-57	brown, gray, white fine sand and clay (K)
132	26-28814	0-19	yellow sand and gravel with clay lenses (Qtm)
		19-97	soft gray clay (K)
		97-104	medium-to-coarse weathered white coarse sand (K)
		104-118	gray clay (K)
		118-140	medium-to-coarse weathered gray quartz sand with trace clay lense (K)
		140-145	gray clay (K or weathered shale)
133	26-10574		abbreviated log
		0-20	red-brown sand, little silt and clay, trace gravel (Qtm)
		20-32	dark-gray medium-to-fine sand, little clayey silt, trace fine gravel (K)
134	26-7096		abbreviated log
		0-30	red-brown silty clayey sand with some gravel (Qtm)
		30-47	brown-yellow sand and gravel (Qpa?)
		47-54	dark-gray plastic silty clay (K)
135	26-30698	0-2	fill material
		2-8	brown silt, sand, gravel (Qtm)
		8-15	brown sand, gravel (Qpa?)
		15-20	white sand (Qpa?)
		20-35	gray sand and gravel (Qpa?)
		35-40	brown medium-to-fine sand and gravel (Qpa?)
		40-45	gray silty clay (K)
		45-52	gray silty clay with mica (K)
136	26-7200		abbreviated log
		0-5	cinders on gray-green silty clay (af over Qm)
		5-15	red-brown clayey silty sand with gravel (Qtm)
		15-42	red-brown, yellow-orange sand and gravel (Qpa)
		42-45	light-gray silty very micaceous clay (K)
137	26-7267	0-13	fill of cement, cinder, sand, clay, gravel (af)
		13-21	gray clay with peat moss (Qm)
		21-39	brown coarse-to-fine sand and gravel (Qpa)
		39-111	gray silty clay with layers of gray fine sand and some wood (K with lignite)
		111-137	gray coarse-to-medium sand with some wood (K with lignite)
		137-140	gray clay, layer of gray medium-to-fine sand (K)
138	26-12857		abbreviated log
		0-5	fill dirt
		5-42	gray and red silt, fine sand, and clay (Qtm)
		42-60	brown and gray clay and fine sand (K)
139	NJGS files		boring B4 from Lippincott, Jacobs, and Gouda (1995)
		0-12	black river mud (Qm)
		12-41	reddish-brown coarse-to-fine sand, trace silt, little gravel (Qm)
		41-105	dark-gray silty clay with organic matter, trace fine sand (Qm)
		105-116	gravel (Qpa)
		at 116	refusal on cobble or bedrock
140	NJGS files		boring B3 from Lippincott, Jacobs, and Gouda (1995)
		0-11	black river mud (Qm)
		11-22	black, green to reddish-brown coarse-to-fine sand, trace silt and fine gravel (Qm)
		22-41	interbedded black organic silty clay and reddish-brown coarse-to-fine sand (Qm)
		41-110	dark-gray silty clay, some peat and shell fragments (Qm)
		110-120	gravel with alternating layers of sand, silt, clay (Qpa)
		at 120	refusal on cobble or bedrock
141	26-28568		abbreviated log
		0-51	red-brown fine-to-medium sand, some silt and clay and fine-to-medium gravel (Qtm)
		51-52	gray clayey silt with mica (K)
142	26-16641		abbreviated log
		0-20	red-brown, brown silty, clayey, gravelly sand (Qtm)
		20-32	yellow-brown silty coarse-to-fine sand (K or Qtm)
		32-38	white-tan sandy silty clay (K)
143	26-11042		abbreviated log
		0-20	red-brown sandy silty clay, trace medium-to-fine gravel (Qtm)
144	26-18368	0-24	red medium sand (Qtm)
		24-46	red weathered shale (Qtm or K, Qsw unlikely)
145	26-5842		abbreviated log
		0-8	fill
		8-36	red-brown clayey sandy silt, trace fine gravel (Qtm)
146	26-4071	0-250	sand and clay (Qtm over K)
		250-650	trap (diabase)
147	N 26-41-266		well 1
		0-50	red clay and coarse gravel (Qtm)
		50-190	black to dark-brown clay, minor sand (K)
		190-523	varicolored rock (possible hornfels rock)
148	26-15929		abbreviated log
		0-20	red clay, trace medium-to-fine red sand (Qtm)
149	26-22638	0-5	fill
		5-12	sand, fine, silty with clay (Qtm)
		12-20	sand, fine, silty with fractured shale (Qtm)
		20-45	weathered shale (K, Qsw unlikely)
150	26-24632		abbreviated log
		0-14	gravel, wood, concrete fill
		14-31	red-brown silty sand, some gravel (Qtm)
		31-39	dark-gray micaceous clayey silt (K)
151	26-23061	0-29	reddish-brown silty sand with some gravel and cobbles mixed (Qtm)
		29-40	reddish brown sand and silt (Qpa?)
152	26-5216	0-20	silty clay (Qt)
		20-22	silty clay and gravel (Qt)
		22-48	gray clay (K)
		48-60	gray silty sand and clay (K)
153	26-5213	0-12	clay, sand, gravel (Qt)
		12-19	silty clay, trace of sand (Qt)
		19-23	silty sand, some clay (Qt)
		23-59	gray silty sandy clay (K)
		59-63	clay and sand (K)
		63-99	gray clay (K)
		99-123	gray clay and sand (K)
		123-138	green clay (weathered diabase?)
		138-139	basalt (diabase)
154	NJGS files		Outerbridge Crossing boring 14+28
		0-15	red clay and sand (Qtm)
		15-75	gray clay and sand (K)
155	NJGS files		Outerbridge Crossing boring 25+00
		0-5	fill
		5-22	soft mud, clay, and sand (Qtm)
		22-44	blue clay (K)
		44-50	fine sand, stiff gray clay (K)
156	26-4934	0-8	brown silty sand, lttle clay (Qtm)
		8-12	brown and gray silty clay (K)
		12-20	gray-black silty clay with partings of mica and fine sand, some lignite (K)
157	26-19837		abbreviated log
		0-11	brown silty clayey sand, some gravel (Qtm)
		11-18	brown silty clay, trace fine sand (Qtm)
		18-36	brown fine-to-medium sand, trace fine gravel (Qpa)
		36-50	gray silty clay, trace fine sand and lignite (K)
158	NJGS files		Outerbridge Crossing boring 38+82
		0-25	yellow clay (Qtm)
		25-39	brown sand and gravel (Qpa)
		39-125	black, gray, red clay, some fine white sand (K)
159	NJGS files		Outerbridge Crossing boring 58+86
		0-48	silt (Qm)
		48-60	gray sand (Qm over Qbn)
		60-90	coarse brown sand (Qbn)
		90-95	clay, sand, gravel (Qbn)
		95-105	hardpan (Qtm?)
		105-110	brown sand (Qtm or Qpa)
		110-119	gray fine-to-coarse sand and clay, some beach sand (K)
160	26-13984		abbreviated log
		0-10	water
		10-40	gray soft silt, some sand and shells (Qm)
		40-45	gray sandy silt (Qm)
		45-50	brown firm sand and gravel (Qtm)
		50-70	gray and red silt, clay, and sand, very firm (K)

Extracted from: [Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)]

Selected Well and Boring Logs 161-215

161	26-7230	0-7	fill (af)
		7-15	organic silt (Qm)
		15-20	gray silty sandy clay (Qtm)
		20-27	gray silty clay with yellow sand seams and lignite (K)
162	26-4688	0-16	dry brown clay (Qt)
		16-78	dark gray clay (K)
		78-98	sand, fine gray clay, streaks of lignite (K)
		98-122	red shale
		122-134	brown soft rock
		134-146	red and gray shale rock
		146-402	gray to black hard rock (diabase)
163	26-9967	abbreviated log	
		0-15	red-brown, gray-brown silty sand (Qt)
		15-46	dark gray silty clay, some medium-to-fine sand layers, some mica and lignite (K)
164	26-10085	abbreviated log	
		0-12	gray to brown sandy silt, trace gravel (Qt)
		12-46	dark gray clay, silt, and medium-to-fine sand, some lignite (K)
165	26-18987	0-7	fill
		7-14	red-brown silty clay, trace sand and gravel (Qt)
		14-24	gray medium-to-fine sand, trace silt (K)
		24-25	black silty clay (K)
166	26-10971	0-38	gray silty clay (K)
		38-45	clay and sand (K)
		45-59	sand (K)
167	N 26-31-891	0-40	red clay, sand, gravel (Qt)
		40-55	pinkish, medium-to-coarse sand, with rounded red shale grains (Qsu)
		55-65	medium-to-coarse white sand and granules (K)
		65-75	light-gray sandy clay over green decomposed trap (K over weathered diabase)
		75-77	dark green trap (diabase)
168	N 26-31-892	0-50	glacial drift (Qt)
		50-73	Raritan formation (K)
		73-80	greenish baked shale
169	26-21745	0-36	glacial till (Qt)
		36-55	fine-to-coarse brown sand, gravel, and cobbles (Qsu)
		55-56	white beach sand (K)
170	26-9604	0-4	silt, sand, clay fill (af)
		4-8	dark-gray silty clay, some sand (af over Qm)
		8-12	brown, gray organic silty clay and meadow mat (Qm)
		12-20	olive-black silty clay (Qm)
		20-27	red silt, trace of clay (Qbnl)
171	26-5356	abbreviated log	
		0-4	sand and gravel fill (af)
		4-16	soft gray, black, brown clay (Qm)
		16-41	red-brown dense fine-to-coarse sand, some gravel and silt (Qt)
		41-53	light-gray medium-to-fine sand, very dense (K)
		53-72	very tough gray-green clay (weathered hornfels)
		72-78	hard gray-black weathered hornfels rock
172	26-5313	abbreviated log	
		0-11	sandy fill (af)
		11-19	dark-brown clayey peat (Qm)
		19-54	very tough red silt, trace clay and fine sand (Qbnl)
		54-64	brown sandy clayey silt, some gravel (Qt)
		64-75	very tough green to gray clay (weathered diabase)
		at 75	diabase fragments, refusal
173	26-5314	abbreviated log	
		0-11	clay and sand fill (af)
		11-20	gray clay and peat (Qm)
		20-59	dense red-brown coarse-to-fine sand and some gravel (Qbn over Qt)
		59-70	very stiff gray clay (K over weathered shale)
		at 70	weathered shale, refusal
174	26-5316	abbreviated log	
		0-14	fill (af)
		14-18	soft brown moist peat (Qm)
		18-31	red sandy silty clay, trace gravel (Qt)
		31-55	red-brown coarse-to-fine sand and gravel (Qsu)
		55-73	very dense light-gray medium-to-fine sand (K)
		73-96	hard gray to green clay; some black, brown veins (weathered diabase)
		at 96	weathered diabase
175	26-9706	0-5	clay and gravel (af)
		5-22	gummy gray clay with interbedded lenses of sand (Qm)
		22-45	decomposed red shale (K over weathered shale)
		45-67	red to gray shale
		67-74	dense hard rock--limestone or granite (diabase)
176	26-25346	abbreviated log	
		0-10	stone and sand fill (af)
		10-18	peat (Qm)
		18-45	red-brown clayey sandy silt, trace gravel (Qt)
		45-52	fine-to-medium gray sand (K)
177	NJGS files	0-21	fill (af)
		21-24	silt (Qm)
		24-58	sand and gravel (Qbn over Qt)
178	26-28361	0-16	dark-reddish-brown fine-to-medium silty sand (Qt)
		16-42	dark-reddish-brown coarse-to-fine sand, trace silt (Qt)
		42-70	light-green-gray clay (K)
179	26-28352	0-16	dark-reddish-brown fine-to-medium silty sand (Qt)
		16-42	dark-reddish-brown coarse-to-fine sand, trace silt (Qt or Qsu)
		42-70	light-gray-green clay (K)
180	26-28359	0-16	dark-reddish-brown fine-to-medium silty sand (Qt)
		16-42	dark-reddish-brown coarse-to-fine sand, trace silt (Qt or Qsu)
		42-70	light-gray-green clay (K)
181	26-17050	abbreviated log	
		0-54	gray to reddish-brown clayey silty sand, little fine-to-coarse gravel; sandier below 27 feet (Qt, possibly over Qsu)
		54-59	white to gray fine-to-medium sand (K)
		59-90	white to gray clay, becoming green and brittle with depth (K over weathered diabase)
182	N 26-31-971	0-20	red clay and sand (Qt)
		20-40	gray sand and gravel (Qsu?)
		40-75	clay and sand (K)
		75-78	red shale
		78-148	trap (diabase)
		148-150	red sandstone
		150-157	trap (diabase)
183	26-30216	0-38	red-brown coarse-to-fine sand, some silt, little gravel (Qt)
		38-65	white coarse-to-fine sand, little silt (K)
		65-69	layered white sand and clay (K)
		at 69	gray silt and clay (K)
184	26-30214	0-35	red-brown coarse-to-fine sand, trace gravel and clayey silt (Qt)
		35-68	brown-white coarse-to-fine sand, trace silt and fine gravel (K)
		at 68	decomposed shale
185	26-28367	0-15	dark-reddish-brown silty fine sand, trace clay (Qt)
		15-35	dark-reddish-brown fine-to-medium sand, trace silt (Qt)
		35-48	dark-reddish-brown medium-to-coarse sand, trace coarse gravel (Qsu?)
		48-70	light-gray-green clay (K)
186	26-5175	0-10	stones, sand fill (af)
		10-12	peat (Qm)
		12-21	black clay and silt (Qm)
		21-24	red clay and sand (Qbnl)
		24-26	red clay (Qbnl)
		26-33	red shale and gravel (Qt)
187	26-15044	0-24	brown medium-to-coarse sand, gravel, cobbles (Qt)
		24-40	brown fine sand (Qsu?)
188	26-14632	abbreviated log	
		0-14	reddish-brown sandy silty clay, some gravel (Qt)
		14-22	reddish-brown clayey sand, trace gravel (Qt)
189	26-21239	abbreviated log	
		0-9	sandy, gravelly fill (af)
		9-10	gray silty clay (Qm)
		10-41	red-brown to light-gray silty clayey sand, some gravel (Qt)
		41-49	light-brown clay and silt, trace fine sand (K)
		49-50	green-gray fractured rock (diabase?)
190	N 26-31-863	0-8	soft gray meadow mat (Qm)
		8-14	yellow and gray clay, sand and gravel (Qal)
		14-40	red clayey sand and gravel (Qt)
		at 40	hard red sandy red shale
191	N 26-31-863	0-10	gray clay and medium-to-coarse sand with shell fragments (Qm)
		10-21	slightly clayey medium-to-coarse red sand (Qt)
		21-31	compact red clay and shale fragments (Qt over Qsw)
192	N 26-31-865	0-43	red sandy clay, some gravel (Qt)
		at 43	stiff bluish-gray micaceous clay (K)
193	26-1269	0-21	silt, clay, and gravel (Qt)
		21-200	shale
194	26-18360	abbreviated log	
		0-17	red silty clay, trace sand and gravel (Qt)
		17-18	red siltstone
195	26-24837	abbreviated log	
		0-14	red to gray silty clayey sand, some gravel (Qt)
		14-18	red siltstone
196	26-28597	0-10	mixed red clay, sand, gravel (Qt)
		10-24	soft red shale
197	26-2266	0-29	red clay (Qt)
		29-350	red shale
198	26-1428	0-30	clay and boulders (Qt)
		30-298	shale
199	26-9469	0-9	brown, reddish-brown, tan clayey sand, trace gravel (Qt)
		9-17	red shale
200	26-2372	0-5	clay (Qt)
		5-359	red shale
201	26-6896	0-16	red-brown sandy clayey silt, trace gravel (Qt)
		16-18	red shale
202	226-27105	0-8	brownish-tan silty clay (Qt)
		8-15	red shale
203	26-564	0-10	red, white, yellow clay (af or Qt)
		10-30	red hard pan (Qt)
		30-50	very muddy fine sand (Qsu? or Qt)
		50-60	hard red clay (Qsw)
		60-115	hard red sand rock
204	26-1201	0-40	clay, sandy clay (Qt)
		40-204	red shale
205	25-11829	0-11	hardpan (Qt)
		11-27	soft shale and clay (Qsw)
		27-505	red shale
206	26-4375	0-12	dirt (Qt)
		12-120	sandstone
207	26-1654	0-53	red clay (Qt)
		53-500	red shale
208	26-4118	0-35	sand and gravel (Qt, possibly over Qsu)
		35-200	red shale
209	26-4944	0-50	sand (Qt, possibly over Qsu)
		50-700	red shale
210	26-11291	abbreviated log	
		0-18	red sandy clayey silt, some gravel (Qt)
		18-24	fine-to-medium sand and gravel (Qsu or Qt)
211	26-10667	0-4	fill
		4-11	red medium sand, some gravel (Qt)
		11-14	weathered shale
212	26-10669	0-4	fill
		4-11	red medium sand, some gravel (Qt)
		11-15	weathered red shale
213	26-11416	0-4	fill
		4-20	silty sand (Qt)
214	26-520	0-25	sand and clay (Qt)
		25-109	rock
215	26-381	0-8	clay and silt (Qal)
		8-20	sand and gravel (Qal over Qrw)
		20-23	silt and clay (Qt or Qsw)
		23-30	soft red shale (Qt or Qsw)
		30-50	red shale

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Selected Well and Boring Logs 216-271

216	26-380	0-8	clay and silty sand (Qal)
		8-18	medium sand and a little clay (Qal)
		18-24	coarse sand and gravel (Qal over Qrw)
		24-28	soft shale (Qt or Qsw)
		28-51	red shale
217	26-724	0-76	sand and gravel (Qic)
		screened 21-38 feet, yield 355 gpm	
218	26-1595	0-45	red sand and gravel (Qrw)
		45-300	red shale rock
219	26-9620	abbreviated log	
		0-18	red-brown silty clay, some sand, trace gravel (Qrw)
		18-26	brown coarse-to-fine sand, little clayey silt, trace fine gravel (Qrw)
220	26-629	0-40	earth (Qrw over Qt)
		40-300	red rock
221	26-6711	0-5	brown silty sand, trace fine gravel (Qt)
		5-13	red-brown silty clay (Qt)
		13-18	dark-gray silty sand, trace gravel (Qsu)
222	26-50	0-21	red dirt (Qt)
		21-349	red shale
223	26-5251	0-25	overburden (Qt)
		25-254	red rock
224	26-4447	0-10	clay and sand (Qt)
		10-359	red shale
225	26-120	0-7	fill
		7-31	red clay (Qt)
		31-37	broken red shale, clay and boulders (Qt)
		37-266	red shale
226	26-1124	0-30	hard clay (Qt)
		30-250	red shale and hard sandstone streaks
		250-285	red and purple shale
		285-308	hard red and purple shale
227	26-530	0-10	red and yellow clay (Qt)
		10-20	red hard pan (Qt)
		20-35	hard red clay (Qt)
		35-96	red sand rock
228	26-5108	abbreviated log	
		0-16	red-brown sandy silt and clay, trace gravel (Qt)
		16-23	angular red-brown shale and siltstone fragments and clay and silt (Qsw)
229	26-5786	0-27	red-brown sandy silt and clay, some weathered shale fragments (Qt)
		27-37	red-brown clay and silt with angular shale fragments (Qsw)
		37-47	red-brown shale
230	26-10560	0-8	brown silty clay (Qt)
		8-10	brown sandy clay with large gravel (Qt)
		10-15	decomposed red-brown shale (Qsw)
231	26-10490	0-14	red sandy-clayey silt with red shale fragments (Qt)
		14-20	decomposed red sandy shale
232	26-9158	0-5	soft, silty clay (Qt)
		5-6	reddish silty sand (Qt)
		6-12	reddish weathered shale
233	26-522	0-5	red and yellow sandy clay (Qt)
		5-25	red hard pan (Qt)
		25-40	hard red clay (Qt)
		40-60	red sand rock
234	NJGS files	0-3	mud (Qal)
		3-20	sand and gravel (Qal or Qrw)
		at 20	rock or boulder
235	26-428	0-42	sand and clay (Qt)
		42-81	rock
236	26-8781	0-10	clay (af over Qm?)
		10-15	clay, sand (Qt or Qbnl)
		15-20	sand (Qt)
		20-25	sand, gravel (Qt)
237	26-14186	0-10	red-brown coarse sand and gravel (Qt)
		10-15	red-brown coarse sand and gravel, trace clay (Qt)
		15-25	red-brown medium-to-coarse sand, trace gravel (Qt)
		25-29	red-brown coarse sand and gravel (Qt or Qsu)
		29-30	weathered shale (Qsw)
238	26-24304	0-21	red clay, silt (Qt)
		21-28	sand, cobbles (Qt or Qsu)
		28-29	red clay (Qt or Qsw)
239	26-14426	0-23	red silty clay (Qt)
		23-35	brown-red sand and gravel (Qt or Qsu)
240	26-82	0-50	red dirt and rock (Qt)
		50-405	red rock
241	26-5547	0-5	red silty clay, trace sand, occasional cobble, very dense (Qt)
		5-10	red silty clay, trace sand, dense (Qt)
		10-15	red silty clay, trace sand (Qt)
		15-20	wet red silty clay (Qt or Qsu)
242	26-7505	0-23	red-brown clayey silt (Qt)
		23-29	red-brown coarse-to-fine sand and coarse-to-fine gravel (Qsu or Qt)
243	26-22308	0-21	red-brown silt and clay (Qal over Qt)
		21-23	red-brown decomposed shale (Qsw)
		23-40	red-brown shale
244	26-26065	0-10	silty clay (Qt)
		10-28	red-brown coarse sand, trace silt (Qsu or Qt)
245	26-26335	0-7	red-brown silt, some clay (Qt)
		7-18	red-brown medium sand (Qsu or Qt)
		18-20	red shale
246	26-23758	0-17	red-brown sandy clay (Qt)
		17-20	coarse sand and gravel (Qsu or Qt)
		20-22	red clay lenses (Qsu or Qt)
247	26-29549	0-20	silty clay (Qt)
		20-25	weathered shale (Qsw)
		25-155	red shale
248	26-14834	0-10	red-brown till with red shale fragments (Qt)
		10-60	Brunswick shale
249	26-29799	abbreviated log	
		0-15	red hard silt with some gravel, little sand (Qt)
		15-24	red very dense fine-to-coarse gravel and fine-to-coarse sand, some silt (Qt or Qsu)
		24-31	red, gray, green moist hard silt and weathered shale (Qsw)
250	26-19868	0-5	red-brown clayey silt with rock fragments (Qt)
		5-12	red-brown clayey silt (Qt)
		12-19	red-brown clayey silt, trace sand (Qt)
		19-32	red-brown clayey silt with fine gravel and rock fragments (Qt)
		32-40	red-brown decomposed shale
251	26-238	0-10	red hardpan (Qt)
		10-30	yellow mud with streaks of fine muddy sand (Qsu or Qt)
		30-60	gray, black, red, green silt (K?)
		60-85	green, white, blue clay (K over weathered shale)
		85-146	mica rock (shale?)
252	26-26108	0-13	red-brown fine sand with gravel, silt, clay (Qt)
		13-33	red-brown medium-to-fine sand and gravel with silt (Qsu or Qt)
		33-37	gray silty clay (K)
253	N 26-31-685	abbreviated log	
		0-31	red-brown sandy gravelly clay (Qt)
254	N 26-31-688	abbreviated log	
		0-6	red sandy clay (Qt)
		6-36	yellow and gray fine-to-medium lignitic sand with some clayey streaks (K)
		36-47	greenish-gray and dull-red clay (K over Qsw)
		at 47	soft, weathered shale
255	26-5052	0-115	clay, sand (Qt over K)
		115-300	shale
256	N 26-31-891	log by M. E. Johnson, NJGS, abbreviated here	
		0-40	red clay, sand, gravel (Qt)
		40-50	pinkish medium-to-coarse sand, with rounded grains of red shale (Qsu)
		50-65	white medium-to-coarse sand and pea gravel (K)
		65-74	light-gray sandy clay (K)
		74-77	green decomposed trap (weathered diabase)
		at 77	dark-green trap (diabase)
257	26-4936	abbreviated log	
		0-14	brown and gray silty clay with fragments of red sandstone (Qtm)
		14-30	black and gray silty clay with partings of fine sand and mica; some lignite (K)
258	26-7714	0-160	sand, clay (Qtm over K)
		160-580	serpentine (probably diabase)
259	26-8679	0-23	reddish-brown medium-to-fine sand, gravel, silt (Qt)
		23-26	reddish-brown coarse sand, gravel, clay, shale fragments (Qt)
260	26-8466	abbreviated log	
		0-7	cinder, gravel, sand, clay fill (af)
		7-15	dark-gray silt, peat, and clay (Qal)
		15-18	gravel and silty sand (Qal or Qt)
		18-55	red-brown shale
261	26-5968	abbreviated log	
		0-8	brown, orange, red silty clay, some sand and gravel (af)
		8-10	meadow mat (Qm)
		10-12	dark-brown silty clay and meadow mat (Qm)
		12-16	olive-gray silty clay trace fine sand (Qbnl)
		16-18	red silty clay and fine sand (Qbnl)
		18-21	red silty clay, gravel, fine sand (Qt)
		21-22	red weathered shale (Qsw)
262	26-5967	0-5	gray, orange silty clay (af)
		5-7	black, brown meadow mat and organic silty clay (Qm)
		7-20	red silt, trace of clay, gravel, and fine sand (Qt)
		20-26	red silt, fine sand, trace clay (Qt)
		26-27	red weathered shale (Qsw)
263	26-22622	0-8	white soda ash (af)
		8-16	brown peat (Qm)
		16-29	red-brown till--silty clay with gravel (Qt)
		29-30	red-brown shale
264	26-22608	0-10	gravel, silty sand, silty clay (af)
		10-24	peat to medium sand and gravel (Qm over Qt)
		24-42	medium silty sand and gravel (Qt)
		at 42	bedrock
265	26-22567	0-13	stone, concrete, gravel fill (af)
		13-24	brown peat Qm)
		24-40	red-brown till (Qt)
266	26-19873	0-12	black silty clay with wood--fill (af)
		12-24	peat grading to organic silt with some sand (Qm)
		24-29	red-brown clayey silt, some fine-to-medium sand and trace of gravel (Qt)
		29-34	red-brown fine-to-medium sand and some clay and fine gravel with shale fragments (Qt)
		34-40	red-brown shale
267	26-19876	0-13	black sand, silt, cinders, gravel, wood (af)
		13-25	dark-brown and gray peat and organic clayey silt and sand (Qm)
		25-42	red-brown clayey silt, some fine-to-coarse gravel and sand (Qt)
		42-45	red-brown shale
268	26-22560	0-14	fill (af)
		14-22	brown peat (Qm)
		22-26	gray silty sand (Qm)
		26-36	red-brown silty till (Qt)
		36-40	red-brown shale
269	26-19749	abbreviated log	
		0-12	clay and silt fill (af over Qm)
		12-22	red-brown silty clay, some sand (Qbnl)
		22-32	red silty clay and shale fragments (Qt)
		32-54	red shale
270	26-15657	abbreviated log	
		0-6	silt and clay fill (af)
		6-10	gray peat, organic silt, shell fragments (Qm)
		10-26	red clay, silt, sand, little gravel (Qt)
		26-28	weathered Brunswick (Qsw)
		28-46	rock
271	26-5293	abbreviated log	
		0-7	slag, cinder, brick fill (af)
		7-14	black-gray organic clay (Qm)
		14-42	red-brown clayey silt with some sand and pebble-to-cobble gravel (Qt)
		at 42	bedrock

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Selected Well and Boring Logs 272-317

272	26-19748	abbreviated log	
		0-8	sand, clay, wood fill (af)
		8-16	black silty clay and peat (Qm)
		16-30	red-brown silty clay, trace gravel and sand (Qt)
		30-51	red shale
273	26-22858	0-8	brown to black medium-to-fine sand and silt (af)
		8-15	organic peat (Qm)
		15-23	gray clayey silt with peat (Qm)
		23-40	red-brown silt (Qbnl)
		40-45	red till (Qt)
		45-50	red decomposed sandstone (Qsw)
274	26-22861	0-10	brown to black sand, wood, cinders (af)
		10-20	gray clayey silt, trace peat (Qm)
		20-25	gray fine sandy silt (Qm)
		25-35	red-brown silt (Qbnl)
		35-40	red till (Qt)
		40-55	decomposed red sandstone (Qsw)
		55-60	red sandstone
275	26-22856	0-5	gray sand, silt, gravel, wood (af)
		5-20	peat and gray silty clay (Qm)
		20-30	red till (Qt)
		30-40	red-brown clay and silt (Qt)
		40-45	red-brown till (Qt)
		45-50	red shale
276	26-28653	abbreviated log	
		0-10	silt, sand, clay fill (af)
		10-16	dark-brown silt and peat, trace clay (Qm)
		16-25	reddish-brown silty clay, some gray organic seams (Qm over Qbnl?)
		25-51	reddish-brown clayey silt with fine sand seams (Qbnl over Qt?)
		51-71	shale rock
277	26-28657	0-8	fill (af)
		8-12	black silt, organic clay (Qm)
		12-15	peat (Qm)
		15-20	gray silty clay (Qm or Qbnl)
		20-40	reddish-brown silty clay with trace fine sand and gravel seams (Qt)
		40-45	reddish-brown decomposed shale rock (Qsw)
		45-50	shale rock
278	26-10390	0-10	fill (af)
		10-27	black organic silt (Qm)
		27-41	red-brown clay (Qbnl over Qt)
		41-57	gray siltstone
279	NJGS files	abbreviated log	
		0-9	cinder, brick, sand, gravel fill (af)
		9-20	peat (Qm)
		20-26	dark-gray river mud and vegetable matter (Qm)
		26-39	gray, reddish-brown silty sand and gravel (Qt or Qbn)
		39-59	reddish-brown clayey silt, numerous shale and sandstone fragments (Qt or Qsw)
		59-72	gray and green shale
280	NJGS files	abbreviated log	
		0-14	cinder, sand, gravel fill (af)
		14-28	black, dark gray soft river mud (Qm)
		28-45	gray medium-to-coarse sand and gravel (Qt or Qbn)
		45-50	hard gray shale
281	NJGS files	abbreviated log	
		0-13	cinders, sand, gravel, sulfer fill (af)
		13-28	soft brown peat and dark gray river mud (Qm)
		28-35	gray silty sand and gravel (Qt or Qbn)
		35-43	light-gray medium sand (Qt or Qbn)
		43-50	reddish-brown decomposed shale (Qt or Qsw)
		50-55	hard gray sandstone
282	NJGS files	0-22	water (drilled from dock)
		22-30	very soft dark gray river mud (Qm)
		30-35	medium-to-coarse brown sand and gravel (Qt or Qbn)
		35-40	hard gray shale
283	26-25830	0-15	gray clay, sand, gravel (af)
		15-25	gray clay (Qm)
		25-40	gray fine-to-medium sand and fine-to-coarse gravel (Qbn)
		40-45	red clayey silt (Qbn or Qt)
		45-55	red till (Qt)
		55-60	gray decomposed shale (Qsw)
		60-65	green marl (Qsw?)
284	NJGS files	0-26	water (drilled from dock)
		26-30	soft river mud and fine sand (Qm)
		30-37	reddish-brown silty sand and gravel (Qt)
		37-47	reddish-brown decomposed shale and clayey silt (Qt or Qsw)
		47-60	soft greenish decomposed shale (Qsw)
		60-72	hard gray shale
285	NJGS files	abbreviated log	
		0-4	cinders, sand, gravel fill (af)
		4-15	very soft dark-gray river mud (Qm)
		15-25	soft sandy river mud with peat and shells (Qm)
		25-35	gray medium-to-coarse silty sand and some small gravel (Qbn or Qt)
		35-49	reddish-brown coarse silty sand and gravel, some large gravel (Qt)
		49-53	soft red sandstone with limey shale nodules and clayey silt (Qsw)
		53-60	greenish soft decomposed shale (Qsw)
		60-65	hard dark-gray shale
286	26-10386	0-11	black organic sand (Qm)
		11-35	red-brown clay (Qbnl over Qt)
		35-60	red siltstone
287	N 26-32-411	0-6	gray clay and roots and red medium sand (Qm)
		6-13	tough red silty clay (Qbnl or Qt)
		13-19	rusty-red fine sand with shale pebbles (Qt)
		19-21	red sandy, micaceous red shale
288	26-26175	0-37	red-brown fine sand with gravel, silt, clay (Qt)
289	N 26-31-636	0-36	sand and small variegated pebbles (Qt)
		36-42	red clay, sand, gravel (Qt)
		42-47	typical glacial material of variegated color and type (Qt)
290	26-15616	abbreviated log	
		0-5	gravelly fill
		5-22	red sandy clay, some gravel (Qt)
291	26-14699	abbreviated log	
		0-17	reddish-brown sandy silty clay, little to some gravel (Qt)
292	26-433	0-39	sand (Qt)
		39-108	rock
293	26-4159	0-45	gravel (Qt)
		45-300	red shale
294	26-26189	0-20	red-brown fine sand, some silt, some gravel (Qt)
		20-27	red-brown fine silty sand with gravel (Qt)
295	N 26-31-662	0-30	red gravelly and sandy clay, some shale fragments (Qt)
296	26-26740	0-33	red-brown silty-clayey fine sand, some gravel (Qt)
		33-36	decomposed rock (Qsw)
297	26-26183	abbreviated log	
		0-30	red-brown silty fine sand, some gravel (Qt)
		30-36	red-brown decomposed rock (Qsw)
298	26-4139	0-40	clay (Qt)
		40-145	diabase
299	26-22031	0-10	miscellaneous fill (af)
		10-21	peat with silt (Qm)
		21-30	fine silty sand, some fine gravel (Qbn or Qt)
		30-33	fine-to-coarse sand and gravel (Qbn or Qt)
		33-46	till (Qt)
		46-50	decomposed rock
300	26-30178	abbreviated log	
		0-10	silty sand fill (af)
		10-14	brown peat (Qm)
		14-18	gray fine-to-medium sand, some silt (Qm)
		18-42	red-brown sandy clayey silt, trace gravel (Qt)
		42-49	gray silt and fine sand (Qt or Qsu or K)
301	N 26-32-456	0-45	yellowish sand (af over Qm over Qt?)
		45-50	bluish sand mixed with black clay (K?)
		50-60	fine white clay (K or weathered diabase)
		at 60	trap rock (diabase)
302	26-5795	0-40	red overburden with roundstones (Qt)
		40-70	gray sand (K)
		70-150	Palisades traprock (diabase)
303	26-30330	abbreviated log	
		0-9	miscellaneous fill (af)
		9-10	gray silt and clay, trace shells (Qm)
		10-25	red sandy, clayey silt, trace gravel and fragmented shale (Qt)
		25-42	gray, orange, red interbedded clay, silt, and sand (K)
304	26-891	0-10	clay and sand (Qt)
		10-20	sand and gravel (Qt)
		20-24	gray clay (K?)
		24-33	gravel (K?)
		33-42	gray sand (K?)
		at 42	clay (K?)
305	26-892	0-3	clay (Qt)
		3-14	red clay and gravel (Qt)
		14-24	fine red sand (Qt or Qsu)
		24-28	fine gray sand (K?)
		28-40	fairly coarse gray sand (K?)
		at 40	gray clay (K?)
306	26-8525	abbreviated log	
		0-8	brown fine-to-coarse sand, trace gravel (Qt)
		8-31	red silty sand, trace clay and fine gravel (Qt)
307	26-29566	0-8	red-brown silty medium-to-fine sand with gravel (Qt)
		8-14	red-brown silty medium-to-fine sand (Qt)
		14-36	red-brown silty clayey sand with gravel (Qt)
		36-38	red-brown silty coarse-to-fine sand (Qt)
		38-39	white and green decomposed rock (weathered diabase)
308	26-29514	0-30	red-brown silty clayey sand with little gravel (Qt)
		30-40	gray silty fine sand (K)
309	N 26-31-689	0-15	red clay with a few sand grains (Qt)
		15-25	red slightly clayey fine-to-coarse sand and gravel including angular quartz, chert, sandstone and trap grains (Qt)
		25-35	reddish-brown sand and gravel (Qt or Qsu)
		35-43	pinkish-buff fine-to-coarse sand (K)
		at 43	white sandy clay with light-green streaks (K or weathered diabase)
310	26-26232	0-40	reddish-brown sand, silt, clay, gravel (Qt)
		at 40	refusal (diabase?)
311	26-19611	0-5	fill (af)
		5-9	reddish clayey gravel (Qt)
		9-40	fine-to-coarse sand with some clay and gravel (Qt or Qsu)
		40-50	reddish-brown fine-to-coarse sand with some clay and gravel (Qt or Qsu)
		50-57	grayish clay (K)
312	26-9305	abbreviated log	
		0-7	reddish-brown to dark-brown sand (af)
		7-30	gray silt and peat (Qm)
		30-50	reddish-brown medium-to-coarse sand (Qt or Qbn)
313	26-1829	0-12	fill (af)
		12-20	muck (Qm)
		20-30	gray clay (Qm)
		30-45	fine sand (Qbnl or Qt)
		45-55	sand and gravel mixed with brown sand (Qt or Qbn)
		55-62	white sand (K)
		62-71	gray clay (K)
		71-106	grayish-green clay (K over weathered diabase)
		106-168	gray rock (diabase)
314	26-23039	abbreviated log	
		0-28	silty clayey sand with some gravel (Qt)
		28-30	saprolite clay (weathered diabase)
		30-38	diabase
315	26-23038	abbreviated log	
		0-37	silty-sandy clay to clayey sand with trace gravel (Qt)
		37-41	saprolite clay (weathered diabase)
		41-42	rock (diabase)
316	26-21918	abbreviated log	
		0-19	concrete and slag fill (af)
		19-20	peat, organic silt (Qm)
		20-27	gray medium sand, trace rounded fine-to-medium gravel (Qbn or Qt)
		27-35	red medium sand, trace gravel (Qbn or Qt)
		35-38	red silty fine sand, trace rounded to subangular gravel (Qt)
		38-42	diorite (diabase)
317	26-21919	abbreviated log	
		0-14	black slag fill (af)
		14-16	gray clay (Qm)
		16-32	red to brown fine-to-medium sand, some silt, little gravel (Qt or Qbn)
		32-38	red fine sand and gravel till (Qt)
		38-40	saprolite (weathered diabase)
		40-44	diorite (diabase)

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Selected Well and Boring Logs 318-343

318	26-5680	0-2	cement fill (af)
		2-8	gray silty clay (Qm)
		8-9	brown coarse-to-medium sand (Qm)
		9-18	gray silty clay (Qm)
		18-28	gray silty clay and peat (Qm)
		28-31	light-gray coarse sand (Qm)
		31-37	red coarse-to-medium sand and gravel (Qt)
		at 37	bedrock
319	26-5679	0-28	slag (af)
		28-33	gray silty clay (Qm)
		33-41	medium gravel mixed with red clay (Qt)
		41-52	fine-to-medium sand with gravel, trace clay (Qt)
320	26-5678	0-19	slag (af)
		19-35	gray clay and brown peat (Qm)
		35-36	gray clay and silt (Qm)
		36-48	fine-to-medium sand and gravel (Qt)
		48-52	decomposed limestone--white clay and trace of fine sand (weathered diabase)
321	26-5677	abbreviated log	
		0-16	sand and slag fill (af)
		16-38	gray clay with organics (Qm)
		38-45	gray clayey fine-to-medium sand with gravel (Qt)
		45-54	red sandy loam with medium gravel (Qt)
		54-57	decomposed rock--white clay (weathered diabase)
322	26-5676	0-14	slag and miscellaneous fill (af)
		14-33	gray clay with organics (Qm)
		33-53	fine-to-medium sand and gravel (Qt)
		at 53	red silty clay (Qt or weathered diabase)
323	26-3009	0-42	red clay (Qt)
		42-55	red shale
		55-75	gray rock
		75-78	trap rock (diabase)
324	Lovegreen, 1974	boring on section 12	
		0-7	water
		7-25	organic silt, clay, meadow material, shells (Qm)
		25-45	brown and gray sand (Qt or Qal)
		45-49	green, gray, yellow clay (weathered diabase)
		49-50	diabase
325	Lovegreen, 1974	boring on section 12	
		0-20	water
		20-35	organic silt, clay, meadow material, shells (Qm)
		35-45	brown and gray sand (Qt or Qal)
		45-72	gray varved silt and clay with lignite (K)
326	Lovegreen, 1974	boring on section 12	
		0-17	fill
		17-21	brown and gray sand, gravel, boulders (af?)
		21-42	brown and gray varved clay (Qbnl)
		42-60	brown and gray sand, gravel, boulders (Qt)
		60-70	red and gray clay (K)
		70-78	gray varved silt and clay with lignite (K)
		78-102	gray sand (K)
		102-155	green, gray, yellow mottled clay (K over weathered shale)
		155-180	red shale and arkosic sandstone
327	NJGS files	Outerbridge Crossing boring 69+95, C2	
		0-37	water
		37-57	silt and sand (Qm)
		57-66	large gravel (Qt)
		66-98	fine gray sand (K)
		98-120	red clay (K or weathered shale)
328	NJGS files	Outerbridge Crossing boring 76+70	
		0-6	water
		6-30	silt (Qm)
		30-50	mud and silt (Qm)
		50-58	gray clay and sand (Qt)
		58-63	sand (Qt)
		63-108	gray clay (K)
		108-120	red clay (K or weathered shale)
329	26-5884	abbreviated log	
		0-20	reddish-brown sandy clay with stones (Qt)
		at 20	red shale
330	26-5885	abbreviated log	
		0-12	reddish-brown sandy clay (Qt)
		at 12	rock
331	N 26-31-725	0-18	red clayey gravel (Qt)
		18-23	boulder (Qt)
		23-46	red clayey gravel (Qt)
		46-59	clean water-bearing red gravel (Qsu?)
		59-63	gray fine sand (Qsu?)
		at 63	red shale
332	NJGS files	Outerbridge Crossing boring 33+00	
		0-5	fill
		5-9	sand and gray clay (Qtm)
		9-18	yellow and gray clay (Qtm)
		18-20	red clay, gray sand and gravel (Qtm)
		20-27	gray clay and sand (K)
		27-42	dark-gray clay (K)
		42-47	gray clay and fine beach sand (K)
333	NJGS files	Linden powerplant boring 11	
		0-7	meadow mat (Qm)
		7-14	brown fine sand, some silt (Qm)
		14-18	red fine sand, some silt and clay (Qbnl)
		18-24	red clay, some gravel (Qt)
		24-26	red soft weathered shale (Qsw)
		26-31	red shale rock
334	NJGS files	Linden powerplant boring 9	
		0-10	meadow mat (Qm)
		10-18	gray fine sand, some organic silt (Qm)
		18-24	red clay and gravel (Qt)
		24-26	red soft weathered shale (Qsw)
		26-31	red shale rock
335	NJGS files	Linden powerplant boring 6	
		0-14	meadow mat (Qm)
		14-16	gray fine sand, some organic silt (Qm)
		16-26	red clay, some gravel, trace sand (Qt)
		26-31	red soft weathered shale (Qsw)
		31-36	red shale rock
336	NJGS files	Linden powerplant boring 20	
		0-15	brown meadow mat (Qm)
		15-18	gray river mud, some peat (Qm)
		18-32	red and brown silty clay, shattered shale, some gravel (Qt)
		32-43	rock
337	NJGS files	Linden powerplant boring 18	
		0-2	fill (af)
		2-19	river mud (Qm)
		19-21	gray sand and river mud (Qm)
		21-27	red clay, some shale and sand (Qt)
		27-34	red clay, some fine gravel, some shale (Qt)
		34-39	rock
338	NJGS files	Linden powerplant boring 29	
		0-12	miscellaneous fill (af)
		12-19	river mud (Qm)
		19-24	gray sand, some clay and vegetable matter (Qm)
		24-29	gray sand and gravel, some clay (Qt)
		29-32	red clay, sand, and gravel (Qt)
		32-36	red clay and shale (Qt)
		36-41	rock
339	NJGS files	Linden powerplant boring 28	
		0-9	meadow mat and river mud (Qm)
		9-14	river mud and vegetable matter (Qm)
		14-19	gray sand and vegetable matter (Qm)
		19-23	gray clay some gravel and red shale (Qt)
		23-32	red clay and shale (Qt over Qsw)
		32-72	red shale rock
340	NJGS files	Linden powerplant boring 47	
		0-9	river mud (Qm)
		9-22	red clay, some gravel (Qt)
		at 22	top of rock
341	NJGS files	Linden powerplant boring 40	
		0-2	river muck and gray sand (Qm)
		2-9	red sandy clay (Qbnl or Qt)
		9-11	red sandy clay, soft shale (Qt over Qsw)
		11-16	rock
342	N 26-41-266	well 2	
		0-20	red clay (Qtm)
		20-55	gray clay mixed with gravel (Qtm)
		55-140	tough gray clay (K)
		140-160	gray clay, sand, and wood (K with lignite)
		160-175	red clay (weathered shale)
		175-463	red shale
343	N 26-41-266	well 3	
		0-10	fill
		10-35	hardpan (Qtm)
		35-55	yellow sand and gravel (Qpa)
		55-132	gray clay (K)
		132-141	fine gray sand, a little black clay (K)

[1]Numbers of the form xx-xxxx (for example, 26-29514) are well permit numbers issued by the N. J. Department of Environmental Protection, Bureau of Water Allocation. Numbers of the form N xx-xx-xxx (for example, N 26-41-266) are New Jersey Atlas Sheet grid locations of entries in the N. J. Geological Survey permanent note collection. The notation "NJGS files" indicates records of borings or wells on file at the N. J. Geological Survey that are not entered in the permanent note collection. These borings were made for various construction projects. Notations of the form "Lovegreen, 1974" refer to logs provided in the cited publication.

[2]All descriptions are as they appear in the original source, except for minor format, punctuation, and spelling changes. Most logs are drillers' reports; a few are reports of geologists or engineers. Inferred map units and comments by author are in parentheses. Logs identified as "abbreviated" have been condensed for brevity. Some descriptions of bedrock and thin surface fill and soil layers have also been omitted or condensed for brevity. "NR" indicates "not reported". For wells completed in surficial material, the screened interval in feet below land surface and yield in gallons per minute (gpm) are provided below the geologic log.

[3]In feet below land surface.

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Table 2 - Pebble Count and Compositions

Table 2.--Composition of pebbles in surficial units.

Site	Unit	Number of Pebbles	Percentage of pebbles					
			red shale and sandstone	gray shale and sandstone	Pensauken Fm.[1]	gneiss	conglom-erate[2]	basalt
1	Qab	116	86	6	3	2	2	1
2	Qtm	138	72	9	4	11	2	0
3	Qtm	146	68	14	4	10	1	2
4	Qtm	121	69	9	11	8	2	2
5	Qtm	128	70	15	8	5	2	0
6	Qmt	143	70	8	11	10	1	0
7	Qmt	136	81	11	1	7	0	0
8	Qmt	185	59	5	23	11	1	0
9	Qmt	159	75	8	11	4	0	1
10	Qmt	144	69	10	13	8	0	0
11	Qtm	137	73	11	5	7	1	2
12	Qtm	169	59	15	18	7	1	0
13	Qt	138	72	7	9	10	1	0
14	Qt	143	70	11	4	11	1	2
15	Qt	118	85	7	2	7	0	0
16	Qt	123	81	12	2	3	2	0
17	Qt	119	84	5	1	7	1	2
18	Qrw	181	72	9	2	17	1	0
19	Qt	110	91	4	0	2	1	2
20	Qic	169	71	7	2	18	1	0
21	Qt[3]	110	73	15	4	7	0	0
21	Qt[4]	128	78	16	2	4	0	0
22	Qtm	188	48	10	40	3	0	0
23	Qtm	171	41	6	48	3	1	0
24	Qtm	165	39	10	35	7	1	8
25	Qtm	146	68	7	18	5	2	0
26	Qtm	168	59	12	20	4	1	4
27	Qtm	181	55	19	25	1	0	0
28	Qtm	165	45	25	26	2	1	0
29	Qtm	179	20	18	56	2	1	0
30	Qtm	160	29	5	62	2	1	0
31	Qt	184	65	9	12	11	0	3
32	Qic	143	70	16	8	6	0	0

[1]Quartz and quartzite; 1-4% chert.
[2]Purple to red-brown quartzite-conglomerate of the Green Pond Formation.
[3]Count in till.
[4]Count in gravel bed in till.

Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

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Extracted from: Surficial Geology of the Perth Amboy and Arthur Kill Quadrangles (OFM 28)

Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Stanford, S.D., 2002, Surficial Geology of the Elizabeth Quadrangle, Essex, Hudson, and Union Counties, New Jersey: New Jersey Geological Survey, Open-file Map OFM 42, scale 1:24,000. (*GRI Source Map ID 55336*)

Ancillary Map Notes

Introduction

Surficial deposits in the Elizabeth quadrangle include artificial fill, alluvial, estuarine, and windblown (eolian) sediments of postglacial age, and glacial sediments that are of late Wisconsin. age. The postglacial deposits are generally less than 20 feet thick. The glacial sediments include stratified sand, gravel, silt, and clay deposited in glacial lakes and by glacial streams, and till deposited by glacial ice. The stratified glacial sediments are as much as 300 feet thick. Till is as much as 90 feet thick.

The surficial deposits are delineated on the accompanying map and cross sections and are described below. The glacial and postglacial events they record are also discussed below. A brief summary of the hydrologic and engineering characteristics of the deposits is also provided below. Well and test-boring data used to draw bedrock-surface contours and to infer the subsurface distribution of the deposits are plotted on the map, and selected logs are listed in Appendix 1. Table 2 provides the composition of gravel clasts in the glacial deposits. Table 1 summarizes penetration-test data for the surficial materials. Figure 1 shows the extent of glacial lakes and ice margins in the quadrangle and adjacent areas. The chronologic relationships of the deposits are shown in the "Correlation of Map Units"

Hydrologic and Engineering Characteristics

Surficial deposits in the Elizabeth quadrangle convey water from the surface into the underlying bedrock and adjoining surface-water bodies. They also provide support for foundations. and are the materials excavated for underground structures, road and railroad cuts, and shipping channels. Before the 1930s they were ruined for clay, sand, and gravel at a few places (Merrill and others, 1902). Urbanization precludes extraction now, although sand, silt, and clay dredged from Newark Bay, the Arthur Kill, and the Kill van Kull, if sufficiently free from contamination, may be usable for fill or landfill cover.

Hydraulic conductivities of the surficial deposits can be estimated from statewide glacial aquifer-test data on file at the N. J. Geological Survey (www.state.M.us/depinjgs/ geodataidgs02-I) and published aquifer-test and laboratory data summarized by Stanford and Witte (in press). Sand and gravel deposits (units Qbn, Qwb, Qez, Qbnf, Qpt, and parts of Qat) are highly permeable, with estimated hydraulic conductivities between 101 and 103 feet per day (ft/d). Silt and clay lake-bottom deposits (parts of units Qbnl mid Ql) are of low permeability, with estimated hydraulic conductivities of 10-5 to 10-3 Bid. Fine sand and silt in lake-bottom, alluvial, and estuarine deposits (parts of units Qbnl, Q1, Qpt, Qm, and Qat) and sandy silt till (unit Qt) are somewhat more penneable, with estimated hydraulic conductivities of 10-3 to 10-1 ft/d. Estuarine and salt-marsh deposits (Qm) and fill (af) have variable hydraulic conductivities that depend on the clay and silt content of the material. Sandy tidal-channel sediments, salt-marsh peats with little mineral soil, and fill composed of sand, cinders, gravel, demolition debris, slag, and trash, may be highly permeable.

The strength of the surficial materials depends on their grain size, compaction, and water content. Estuarine, salt-marsh, and alluvial deposits (units Qm and Qat) are of low strength because they have not been subject to water or sediment loads greater than those at present, and have been continuously saturated or moist, and so are not compact. They also may contain significant amounts of organic matter, which is weaker than mineral soil. Standard Penetration Test (SFT) data from test borings (Table 1) can be used to assess the compaction and strength of surficial deposits. These tests report the number of blows of a 140-pound hammer falling 30 inches that are required to drive a sampling tube 12 inches into the test material. For unit Qm they show a range of 0-38, with a mean of 3 and a standard deviation of 4 (647 tests). Forty-six percent of the tests had values of zero, indicating that the weight of the hammer or drilling rods alone was sufficient to drive the sampling tube the required distance. For unit Qal, the SPT values range from 0-89, with a mean of 24 and a standard deviation of 14 (221 tests), with 2 percent having values of zero. Construction on these materials generally requires the use of pilings to transfer loads to the underlying bedrock or till, or the excavation of the natural material and replacement with engineered fill of greater strength. The lake-bottom deposits are similarly of low strength because they have been continuously saturated from the time of deposition, except for the upper parts, which were exposed and desiccated when the glacial lakes drained. The desiccated layer, which is as much as 20 feet thick, but is not everywhere present, is more compact than the underlying lake-bottom material. SPT data show an overall mean of 14 and a standard deviation of 14 (1559 tests) for lake-bottom sediment, with 11 percent having a value of zero. The desiccated layer yields blow counts generally between 20 and 50, with some rare values as large as 150.

Sand and gravel (units Qbn, Qbnf Qwb, Qez, Qpt) are coarser-grained and, where they crop out, better-drained than the lake-bottom and postglacial deposits and thus are of greater strength. SPT values for these sands range from 2 to 139, with a mean of 27 and a standard deviation of 17 (573 tests). Most till (Qt) in the quadrangle was deposited beneath glacial ice and so has been consolidated by the weight of the ice. SPT values for till range from 3 to 330, with a mean of 67 and a standard deviation of 58 (723 tests). In till, low SPT values are typically recorded within 10 feet of the land surface, where soil processes and bioturbation have disaggregated the matrix of the till. In many cases, in till at depths greater than 10 feet, blows were stopped at 50 or 100 for penetrations of less than 6 inches. Thus, till is generally the surface of refusal for driven pilings.

Artificial fill consists of a variety of materials, including uncompacted trash and demolition debris, and compacted engineered fills composed of sand, silt, and gravel. SPT values for fill range widely from 0 to 191, with a mean of 18 and a standard deviation of 19 (737 tests), with 1.2 percent having a value of zero.

Data on the density, grain size, and Atterberg limits for the surficial materials are provided by Rogers and others (1951, 1952).

Postglacial Deposits

These include man-made fill (af), sediment deposited in estuaries and salt marshes (Qm), in freshwater swamps (Qs), in river flood plains and channels (Qal, Qpt), and windblown sediment blanketing parts of the west slope of the Palisades Ridge (Qe). They were all deposited after glacial retreat.

After glacial lake Bayonne drained to the Hackensack level (see below), the Passaic River, which likely included meltwater fed from the glacier to the north, cut a channel through the deltaic sand at and north of downtown Newark. This sediment was redeposited downstream as a broad terrace (Qpt) on the former Lake Bayonne lake-bottom. The Ironbound section of Newark (east of Route 21 and north of Interstate 78) is located on this terrace. This deposit may include some shallow-water deltaic sediment deposited in Lake Hackensack. Draining of Lake Hackensack caused the Passaic to cut its channel into the terrace and to deposit sandy alluvium (included in unit Qal) on the bottom of drained Lake Bayonne-Hackensack. This alluvial sand is now covered by salt-marsh deposits and fill in the Newark Bay-Newark Airport area. The Elizabeth River and its tributaries likewise cut channels and floodplains (included in unit Qal) into the glacial deposits after Lake Woodbridge drained and the Elizabeth River glaciofluvial deposit became inactive. At the same time, westerly winds blew fine sand and silt from the unvegetated former lake bottom in the Newark Bay area and deposited this sediment as a sheet along the base of the west slope of the Palisades Ridge (Qe). Some of the sand beneath the salt-marsh deposits may also be windblown.

Deposition of the alluvial sediments in the Newark Bay and Arthur Kill areas, and along the lower reaches of the Elizabeth and Passaic Rivers, was gradually replaced by estuarine and salt-marsh sedimentation (Qm) as sea level rose and flooded the former lake plains. Most of the salt-marsh sediment in the Newark Bay-Arthur Kill area has been deposited within roughly the past 3000 years (Newman and others, 1969).

Landfilling on the marsh and alluvial deposits began shortly after permanent European settlement in the 1600s. The earliest fills were likely along the Newark and Elizabeth waterfronts. Large-scale filling for railroad and industrial facilities and trash disposal occurred during the latter part of the nineteenth century and early twentieth century. The period between 1920 and 1970 saw continued filling for Newark Airport and the Port Newark-Port Elizabeth marine terminals. Virtually all of the original salt marsh, and some areas of formerly open water in Newark Bay, have been filled.

Glacial Deposits

These include till--a poorly sorted, nonstratified sediment containing gravel clasts and boulders, deposited directly from glacial ice (Qr) and sorted, stratified sediments. The stratified sediments include sand and gravel laid down by glacial meltwater in river plains (Qez), in glacial-lake deltas (Qwb, Qbn, possibly Qsp) and in glacial-lake fans (Qbnf), and varved silt, clay, and fine sand deposited on the bottoms of glacial lakes (Qnbl, Ql).

Before these deposits were laid down the underlying bedrock surface was shaped by glacial erosion. The bedrock surface (plotted at 50-foot contour interval on the geologic map) shows elongate northeast-southwest-trending troughs that descend to nearly 300 feet below sea level in the Newark-Harrison area, and to more than 100 feet below sea level in the Newark Bay area. To the south these troughs shallow and grade into a gently rolling bedrock surface less deeply scoured. The troughs are closed to an elevation of just below sea level, indicating that they are products of glacial scour, not filled preglacial valleys. Their southward shallowing may reflect reduced erosive capacity of the glacial ice as it thinned and spread upon exiting the higher-relief topography farther north in the Hackensack River Valley.

The bedrock valley extending westward from the Weequahic Lake area is the eastern end of the Kenilworth valley of Nemickas (1974), which is a tributary of the preglacial Raritan valley (Stanford, 1993). This is thus a preglacial fluvial valley only slightly modified by glacial erosion. Indeed, stratified sediments (Qsp) preserved beneath till in the Hillside- Irvington area are situated in a tributary valley that may have been dammed to form a lake basin during glacial advance. The bedrock surface beneath these deposits thus was not eroded during the most recent glaciation.

The upland in the northwestern sector of the quadrangle is underlain by glacially streamlined sandstone and siltstone bedrock. Till is generally thin over most of this area, indicating that the topography is the product primarily of glacial erosion. However, borings in the southern part of the upland along the Newark-Hillside-Irvington border record till as much as 80 feet thick, indicating that some of the ridges here may be drumlins formed by deposition of till.

Late Wisconsinan ice reached its southernmost position at Perth Amboy, about 12 miles south of Elizabeth (fig. 1), about 21,000 yrs B. P. (years before present), based on radiocarbon dates of organic material at the bottom of postglacial bogs in western New Jersey (Harmon, 1968; Cotter and others, 1986) and on organic sediments beneath till on Long Island (Sirkin, 1986). A continuous terminal moraine was deposited at the position of maximum advance (fig. 1). As the ice front retreated, a series of glacial lakes formed, dammed to the south by the moraine (Stanford and Harper, 1991). One of these, Lake Bayonne, occupied the Arthur Kill, Newark Bay, and upper New York Bay lowlands, and had an outlet over the moraine at Perth Amboy (fig. 1). This outlet was gradually lowered by erosion, and therefore the level of Lake Bayonne steadily declined. In the Elizabeth quadrangle a delta deposited in Lake Bayonne at Newark has a top elevation of about 30 feet above sea level. Adjusting for postglacial rebound of Earth's surface in response to release of the weight of the glacier, this altitude indicates the spillway at Perth Amboy had been eroded to about 25 feet below sea level (using the rebound rate of 3.5 feet per mile to the north from Stanford and Harper, 1991). Deposits in Lake Bayonne include deltaic sand and gravel (Qbn), lacustrine-fan sand and gravel (Qbnf), and lake-bottom silt, clay, and fine sand (Qbnl).

Continued erosion of the outlet at Perth Amboy, and along the Arthur Kill to the north, uncovered diabase bedrock at an elevation of 30 feet below sea level in the Arthur Kill about 4 miles south of Elizabeth. The diabase halted further downcutting and formed the stable spillway for Lake Hackensack (fig. 1). An auxiliary spillway was also established across diabase in the Kill van Kull near the Bayonne bridge (fig. 1). In the Elizabeth quadrangle, Lake Hackensack occupied the lowest parts of the Newark Bay lowland, although there was little accumulation of additional sediment on top of the Lake Bayonne deposits in this area because the ice margin at the time was more than 10 miles north of quadrangle. The lake drained eastward into the Hudson Valley when the retreating ice front uncovered Sparkill Gap, a deep gap through the Palisades Ridge, about 24 miles north of Newark.

The Elizabeth quadrangle includes a small area of deltaic and lacustrine-fan sand and gravel (Qwb) deposited in association with glacial Lake Woodbridge, which occupied the southwestern part of the Rahway River basin and was dammed on the east by the glacier margin. The deposit in the Elizabeth quadrangle was actually laid down in a local pond dammed between a Lake Woodbridge delta in Kenilworth and the eastward-retreating ice margin in the valley of the West Branch of the Elizabeth River (Stanford, 1991). Two deposits of lacustrine silt (Ql) were laid down in similarly-dammed tributary valleys to the south.

When the retreating ice margin uncovered the Elizabeth River Valley these local ponds drained. Meltwater draining down the valley deposited a fluvial plain (Qez) with an ice-contact head at the west end of Weequahic Lake. The valley fill beneath the northern part of this plain may contain lacustrine sand that filled a small glacial lake before fluvial drainage was established. Likewise, deposits forming the knobby topography in the Weequahic Lake area, east of the head of the fluvial plain, were also laid down in a lake. This lake may have been dammed by the ice-contact slope at the head of the plain and by ice blocks remaining in the area as the main glacier margin retreated eastward. The downstream end of the plain, at Elizabethport, drained into Lake Bayonne at an elevation of about 10 feet. The east edge of the plain is not confined by a valley side today and may have been walled by the glacier margin (margin M1 in fig. 1). Stratified deposits beneath the till in this area (wells 197, 198, 199, 236, 238, 246) suggest that the ice front readvanced approximately 1 mile to this position, which corresponds to the head of the plain at Weequahic Lake.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Table 1 - Standard Penetration Test Data

Map Units	Range of SPT Values	Mean ± Standard Deviation	Percentage of Zero Values	Number of Borings	Number of Tests
af	0-191	17.8±19.2	1.2%	223	737
Qm	0-38	2.8±4.5	45.9%	218	647
Qal	0-89	24.0±13.9	1.8%	67	221
Qbn, Qbnf, Qwb, Qez, Qpt	2-139	27.3±17.3	0%	79	573
Qbnl	0-157	13.7±13.9	11.4%	224	1559
Qt	3-330	67.4±57.8	0%	247	723

Table 1.--Standard Penetration-Test (SPT) data for surficial materials in the Elizabeth quadrangle.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Table 2 - Pebble Count and Compositions

Site	Unit	Number of pebbles	Percentage of pebbles: red sandstone and shale [1]	gray sandstone and shale [2]	conglomerate [3]	gneiss [4]	Pensauken Formation [5]	gray quartzite [6]
1	Qbn	130	77	14	2	5	2	0
2	Qbn	144	69	15	0	12	2	2
3	Qt	93	97	0	0	3	0	0
4	Qez	123	81	8	0	10	0	1
5	Qez	122	82	5	0	12	0	1
6	Qez	141	71	5	0	23	0	1
7	Qez	117	85	10	1	4	0	0
8	Qt	115	87	9	0	4	0	0

[1]Passaic Formation.
[2]Primarily Passaic and Lockatong Formations, with some Paleozoic clasts.
[3]Purple to red-brown quartzite conglomerate from the Green Pond and Skunnemunk Formations.
[4]Proterozoic gneiss from the Hudson Highlands.
[5]White to yellow-stained quartz and quartzite.
[6]Either from the Shawangunk Formation or the Pensauken Formation.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Figure 1 - Glacial Extents

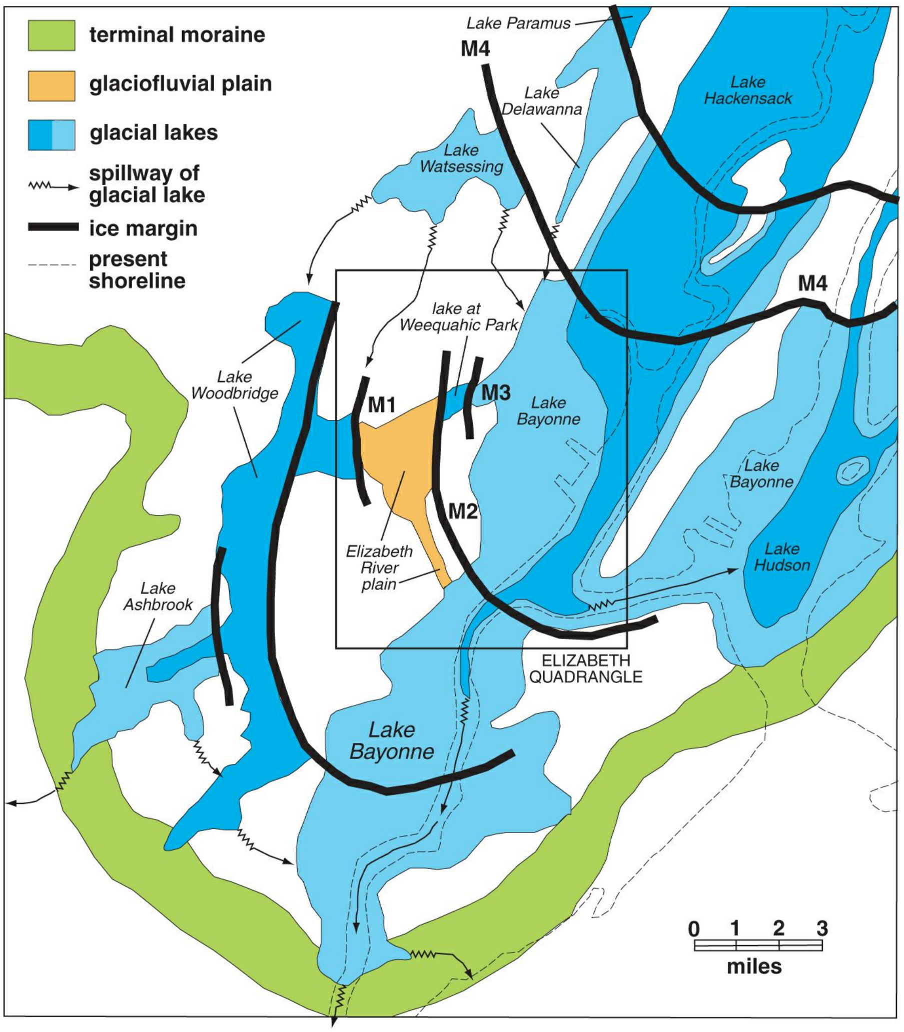
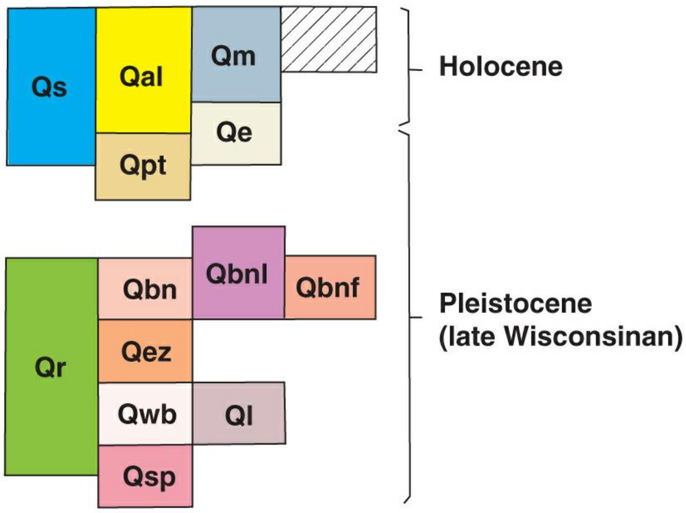


Figure 1.--Ice margins, glacial-lake spillways, and maximum extent of glacial lakes in the Elizabeth quadrangle and vicinity. Arrows show route of drainage from spillways. Ice margins include: M1= last ice margin before deposition of glacial Lake Woodbridge deposits ends. M2=ice margin during deposition of the Elizabeth River glaciofluvial plain. This margin may mark the limit of a readvance from a position about 1 mile to the northeast. M3= last ice margin before lake in Weequahic Park area lowers to Lake Bayonne level. M4=ice margin during deposition of the Newark delta.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Correlation of Map Units



Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Appendix 1 - Selected Well and Boring Logs

Selected Well and Boring Logs 1-77

Well No.	Identifier[1]	Driller's Log	
		Depth[2]	Description[3]
1	26-672	0-25	clay and boulders (Qt)
		25-312	red sandstone rock
2	26-11130	abbreviated log	
		0-7	fill
		7-20	red-brown silty sand and gravel (Qt)
3	26-1334	0-21	hardpan (Qt)
		21-214	red rock
4	BWA files 26-12-785	0-58	red clay, stones and boulders (Qt)
		58-304	red sandstone rock
5	26-22852	0-20	red-brown clay silt, trace gravel (Qt)
		20-50	brown weathered sandstone
6	26-22335	0-15	red-brown sand and silt (Qt)
		15-30	weathered sandstone
7	26-25843	0-3	red-brown medium-to-fine sand and gravel (Qt)
		3-51	red shale
8	26-28623	abbreviated log	
		0-26	red-brown silty clay with rock fragments (Qt)
		26-35	red-brown rock fragments (bedrock)
9	26-19805	0-6	brown to black sand and gravel (fill over Qt)
		6-18	red-brown shale
10	NJGS files	0-8	brick and rubble fill
		8-40	red sand, coarse gravel, trace clay (Qbn)
11	26-12137	abbreviated log	
		0-11	brown fine sand, trace fine gravel (Qbn)
		11-14	medium gravel and fine sand (Qbn)
		14-48	fine sand and fine gravel (Qbn)
12	26-3173	0-50	sand and gravel (Qbn)
		50-70	red rock
		70-215	red shale
13	26-3532	0-30	sand and dirt (Qbn)
		30-44	fine sand (Qbn)
		44-300	red rock
14	26-24369	abbreviated log	
		0-12	red-brown silty sand (Qbn)
		12-22	red-brown clay silt (Qbn)
		22-36	red-brown silty sand (Qbn)
		36-56	red-brown sandy silt (Qbn)
		56-65	red-brown silty sand (Qbn)
		65-71	red shale, highly weathered red rock
15	26-25416	0-7	red-brown coarse sand with clay and stone (fill)
		7-20	large stone, rock (fill over Qbn)
		20-23	clay (Qbn)
		23-40	medium sand, red (Qbn)
		40-45	clay with weathered bedrock
16	26-25763	abbreviated log	
		0-4	fill
		4-28	red-brown fine-to-medium sand, trace silt (Qbn)
		28-43	red-brown very fine sand and silt (Qbn)
		43-54	red-brown sand, trace silt, some gravel (Qt)
		54-61	weathered siltstone
17	26-19958	0-10	cobbles and sand (Qbn)
		10-34	sand (Qbn)
18	26-4930	0-56	sand, gravel (Qbn)
		56-308	red shale
19	26-15069	abbreviated log	
		0-14	brown medium-to-fine sand and gravel (Qbn)
		14-50	brown fine sand and silt (Qbn)
20	26-1053	0-147	sandy clay, clay (Qbn over Qbnl)
		147-700	shale
21	NJGS files	0-6	sand, brick, cinder fill
		6-13	fine red sand and gravel (Qbn)
		13-25	red sand and coarse gravel (Qbn)
		25-35	fine red sand (Qbn)
		35-45	red silt (Qbnl)
		45-58	red sand, gravel, clay binder (Qt)
		58-63	shale
22	26-3924	0-10	basement
		10-65	gravel, sand, clay (Qbn over Qbnl)
		65-280	red rock
23	26-3194	0-75	red sandy clay (Qbn over Qbnl)
		75-300	red shale
24	26-28483	0-50	brown fine sand (Qbn)
		50-53	fine-to-coarse sand and gravel (Qt)
		53-55	broken shale
25	26-28481	0-7	fill
		7-28	sand and gravel, silt (Qt)
		28-40	red shale
26	26-22996	0-3	fill
		3-6	red-brown clay silt (Qt)
		6-8	weathered shale (Qt?)
		8-28	red shale
27	26-19107	0-3	red-brown fine sand, some silt, little cobbles and gravel (Qt)
		3-52	red-brown siltstone
28	26-9762	0-14	gravel till (Qt)
		14-19	shale bedrock
29	26-25529	0-4	sand, gravel, brick fill
		4-19	red-brown clay, silt, gravel (Qt)
		19-54	red shale
30	26-22996	0-3	sand, gravel, wood fill
		3-6	red-brown clay silt (Qt)
		6-8	weathered shale (Qt?)
		8-28	red shale
31	26-16549	0-30	red-brown silty fine sand, trace gravel (Qt)
		30-35	red-brown decomposed shale
32	26-27185	0-38	red-brown fine sand with silt and gravel, trace cobbles (Qt)
		38-41	decomposed shale (Qt?)
		41-46	shale
33	26-3864	0-8	fill
		8-19	clay and stone (Qt)
		19-32	red hardpan with clay and sand (Qt)
		32-500	red shale
34	26-17979	0-8	sand, cement, brick, glass fill
		8-24	Brunswick Formation (bedrock)
35	26-29971	abbreviated log	
		0-6	silt, sand, gravel, crushed stone, brick, wood fill
		6-17	red-brown silt, clay, trace sand and gravel (Qt)
		17-29	weathered siltstone
36	26-25003	0-25	till (Qt)
37	26-7998	abbreviated log	
		0-22	reddish to gray-reddish sandy clayey silt with gravel (Qt)
		22-24	micaceous laminated red shale
38	26-22287	abbreviated log	
		0-14	red-brown sandy clayey silt (Qt)
		14-18	red-brown weathered shale
39	NJGS files	0-21	red sand, clay, gravel, boulders (Qt)
		21-26	shale
40	26-968	0-35	fill (till over Qt)
		35-298	red rock
41	26-156	0-20	earth (Qt)
		20-496	red rock
42	26-29462	0-13	red-brown medium-to-fine silty sand (Qt)
		13-34	red shale
43	26-6962	0-55	sand, gravel, clay (Qt)
		55-200	shale
44	26-13759	abbreviated log	
		0-2	sand, gravel, brick fill
		2-10	brown fine-to-coarse sand and gravel (Qbn)
		10-70	brown fine sand and silt (Qbn)
		70-102	red-brown clayey silt and fine sand (Qbnl)
45	NJGS files Pennsylvania Railroad bridge boring 6A	0-21	cinder, gravel, clay fill
		21-31	sand and gravel (Qbn)
		31-71	red sand and clay (Qbnl)
		71-162	red clay (Qbnl)
		162-182	rock
46	26-315	0-78	earth and clay (Qbn over Qbnl)
		78-303	red shale rock
47	BWA files 26-22-254	0-30	sand and gravel (Qbn)
		30-104	gravel (Qbn over Qt)
		104-107	clay, sand, and stones (Qt)
		107-119	soft gray rock, yellow clay
		119-123	soft gray rock and a little clay
		123-389	red and gray shale and sandstone
48	26-9859	abbreviated log	
		0-38	red-brown sandy silt to silty sand, trace gravel (Qt)
49	26-28999	0-10	brown clayey silt (Qt)
		10-26	red shale
50	NJGS files Pennsylvania Railroad bridge boring 8D	0-10	water
		10-17	black silt, sand and gravel (Qal)
		17-27	red sand and gravel (Qal or Qpt)
		27-48	red sand (Qbn or Qpt)
		48-59	red sand and clay (Qbnl)
		59-71	red clay (Qbnl)
		71-92	red sand (Qbnl)
		92-200	red clay (Qbnl)
		200-213	rock
51	26-20110	0-13	fill
		13-21	black clay with peat (Qm)
		21-52	red-brown medium-to-fine sand, some gravel (Qal or Qpt)
52	BWA files 26-12-979	abbreviated log	
		0-15	fill
		15-35	dark fine sand, some gravel at base (Qm)
		35-45	sticky clay (Qm?)
		45-65	fine reddish brown sand and some stone (Qal or Qpt)
		65-145	sandy clay and soft brownstone (Qbnl)
		145-180	sticky clay (Qbnl)
		180-193	coarse brown sand (Qbnf)
		193-212	brownstone (Qbnf?)
		212-218	water-bearing gravel (Qbnf)
		218-659	brownstone
53	26-12783	0-3	black cindery fill
		3-9	red-brown medium-to-fine sand, trace silt (Qpt)
		9-18	gray silty clay with medium-to-fine sand layers (Qpt)
		18-25	gray medium-to-fine sand with silty layers (Qpt)
		25-34	red-brown coarse-to-fine sand, little silt, little coarse-to-fine gravel (Qbn)
		34-42	red-brown fine sand and silt (Qbn)
54	N 26-12-981	2 wells show 320 and 305 feet to bedrock	
55	26-5729	0-6	red-brown silty fine-to-medium sand, trace clay and gravel (Qbn)
		6-25	red-brown medium-to-fine sand, little silt (Qbn)
		25-35	red fine-to-medium sand, little silt, trace gravel (Qbn)
		35-40	red silty fine sand, gravel, trace clay--till (Qbn?)
56	26-4982	0-176	sand and gravel (Qbn)
		176-194	red shale
57	26-8676	abbreviated log	
		0-6	sand, brick, cinder, silt, clay fill
		6-16	tan fine sand, trace silt (Qbn)
		16-32	red-brown coarse-to-fine sand, trace silt and gravel (Qbn)
58	26-20605	abbreviated log	
		0-20	no log (probably fill over Qm)
		20-40	brownish gray medium-to-coarse sand (Qal)
		40-113	laminated fat clay and sandy silt (Qbnl)
		113-151	reddish brown gravel with sand and silt (Qbnf)
		151-404	reddish brown shale
59	26-20606	0-90	overburden, no log (Qm over Qbnl)
		90-112	till or gravel (Qt or Qbnf)
		112-431	shale
60	26-22204	0-3	gray-brown fine-to-medium sand, trace silt and wood (fill)
		3-12	silt with trace of fine sand (Qm?)
		12-86	sand with trace of silt (Qal over Qbnl)
61	26-537	0-90	sand and red clay (Qpt over Qbnl)
		90-112	soft red shale
		112-225	harder red shale
62	26-8105	0-9	brown sand and gravel fill
		9-50	layers of red-brown sand, silty sand, with some gravel (Qpt)
		50-77	red-brown silty sand (Qbnl)
63	26-8104	0-12	miscellaneous fill
		12-16	gray silt (fill or Qal)
		16-62	red-brown sand, some silt (Qpt over Qbnl)
64	26-8103	0-7	brown sand fill
		7-34	reddish brown medium-to-fine sand, some silt, some fine gravel (Qpt)
		34-38	red clay and silt (Qbnl)
		38-43	red fine sand, little silt (Qbnl)
		43-47	red silt, little fine sand (Qbnl)
		47-76	red fine sand, little silt (Qbnl)
		76-77	red fine sand, trace silt, trace gravel, little decomposed shale (Qt over bedrock?)
65	26-25150	0-7	black and gray silt and sludge (fill over Qm)
		7-20	red-brown fine sand and silt (Qpt)
		20-25	brown fine-to-coarse sand, some gravel (Qpt)
		25-35	red-brown silty sand (Qpt)
		35-45	red-brown silty fine sand and some gravel (Qpt)
66	26-2926	0-11	fill
		11-33	sandy shale (sic) (Qpt)
		33-55	sand with little gravel (Qpt)
		55-73	sand with red shale (Qbnl, "red shale" may be clay laminae)
		73-406	hard red shale
67	NJGS files	0-15	cinder, wood, steel fill
		15-20	brown peat (Qm)
		20-31	gray organic silt with decomposed vegetation (Qm)
		31-35	medium-to-fine brown sand with trace of gravel and trace of silt (Qpt)
68	26-2130	0-10	fill
		10-30	sandy clay (Qpt)
		30-45	clay (Qbnl)
		45-55	sandy clay (Qbnl)
		55-70	clay and gravel (Qbnl)
		70-90	sandy clay (Qbnl)
		90-140	clay matrix (Qbnl)
		140-144	soft shale
		144-500	red shale
69	26-9677	0-10	fill
		10-15	peat (Qm)
		15-51	fine sand and silt (Qpt)
		51-62	silty clay (Qbnl)
70	26-6983	abbreviated log	
		0-14	sandy fill with brick, wood, glass, gravel
		14-19	dark gray organic clayey silt (Qm)
		19-26	gray organic silt, fine sand, clay (Qm)
		26-40	gray-brown fine-to-medium sand and silt (Qpt)
		40-50	black to red-brown fine gravel and sand (Qpt)
		50-71	brown fine sand with silt lenses and a few silty clay seams (Qbnl)
		71-81	dense brown silty sand, some gravel (Qt)
71	26-355	0-8	fill
		8-35	gray clay (Qm)
		35-116	sand, gravel, and clay (Qpt over Qbnl)
		116-208	red rock
72	26-94	0-6	fill
		6-24	river bottom muck (Qm)
		24-42	sand and gravel (Qpt)
		42-67	fine silt (Qbnl)
		67-78	sand and gravel (Qt or Qbnf)
		78-87	fine silt (Qbnl or Qt)
		87-359	red shale rock
73	N 26-22-277	abbreviated log	
		0-5	fill
		5-30	red sand, some gravel (Qbn)
74	26-1940	0-90	clay, sand (Qpt over Qbnl)
		90-500	red rock and shale
75	26-3293	0-55	overburden (Qpt over Qbnl)
		55-300	sandstone
76	NJGS files	0-7	cinder, black dirt, black sand fill
		7-23	medium-to-fine brown sand (Qpt)
		23-27	medium-to-fine red sand, some gravel, trace silt (Qpt)
		27-50	medium-to-fine red sand (Qpt or Qbn)
77	26-12781	0-18	dark gray-brown sand, silt, gravel fill
		18-26	brown peat, gray silt, little fine sand (Qm)
		26-32	brown organic peat (Qm)
		32-40	fine-to-medium organic brown sand, some

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Selected Well and Boring Logs 77-142

			small gravel, more silt (Qpt or Qm)
78	26-1783	0-65	clay and stones (Qpt over Qbn)
		65-503	shale
79	26-11462	abbreviated log	
		0-10	wood, silt, cinders, sand fill
		10-25	red-brown fine-to-medium sand (Qpt)
		25-52	red-brown fine sand and silt, some clay (Qbnl)
		52-58	red-brown silty clay with sand and gravel (Qt)
		58-62	rock
80	26-4947	0-72	silt, clay (Qpt over Qbnl)
		72-400	red shale, sandstone
81	26-5082	abbreviated log	
		0-20	black muck (fill over Qm)
		20-40	red fine sand and muck (Qpt)
		40-45	red fine sand (Qpt)
		45-70	red clay and pieces of shale (Qbnl, "pieces of shale" may be varve fragments)
		70-85	red clay (Qbnl)
		85-300	red shale
82	26-2141	0-82	clay and dead sand (Qpt over Qbnl)
		82-500	red rock
83	NJGS files Pulaski Skyway boring 91	0-10	fill
		10-20	river mud (Qm)
		20-50	red sand (Qal or Qbn)
		50-61	soft red shale
		61-81	red shale
84	NJGS files Pulaski Skyway boring 97	0-10	cinder fill
		10-30	brown sand (Qpt)
		30-50	fine red sand and clay (Qbnl)
		50-60	coarse red sand and clay (Qt)
		60-80	red shale
85	26-11791	0-5	brown silty sand (Qpt)
		5-10	brown silty sand and gravel (Qpt)
		10-15	brown medium-to-fine sand (Qpt)
		15-20	brown clay and sand (Qpt or Qbnl)
		20-30	brown sand and silt (Qpt or Qbnl)
		30-45	brown silty clay (Qbnl)
		45-47	brown silt (Qbnl)
86	26-26675	0-19	medium and fine sands (Qpt)
		19-45	silty running sands (Qbnl)
87	26-22917	0-23	medium-to-fine sand with large gravel and cobbles (Qpt)
		23-26	red clay (Qbnl)
		26-50	very fine sand and silty red sand (Qbnl)
88	NJGS files	0-9	coarse red sand and gravel (Qpt)
		9-19	fine red sand (Qpt)
		19-26	fine red sand and clay (Qbnl)
		26-44	coarse red sand, large gravel, a little clay (Qbnf)
		44-52	fine red sand, large gravel, a little clay (Qbnf)
89	NJGS files	0-16	fine red sand (Qbn)
		16-22	fine red sand, gravel (Qbn)
		22-26	fine red sand, gravel, clay (Qbn)
90	26-4514	0-82	sand and gravel (Qpt over Qbn)
		82-300	red shale
91	26-10144	0-10	fill--silty sand with brick fragments
		10-20	fine-to-medium red silty sand, trace clay (Qpt)
		20-52	fine-to-medium red-brown silty sand (Qpt or Qbnl)
92	NJGS files Central Railroad of New Jersey boring 47	0-6	fill
		6-15	sand and ashes (fill over Qm)
		15-17	coarse sand (Qal)
		17-31	sand (Qal)
		31-34	gravel (Qal)
		34-45	sand and clay (Qbnl)
		45-50	sand (Qt?)
		50-51	red shale
93	26-28979	0-20	miscellaneous fill--ash, sand
		20-22	chemical residue
		22-24	black peat (Qm)
		24-50	brown-red medium-to-fine sand with silt (Qal over Qbnl)
		50-55	brown-red shale till (Qt)
		55-57	weathered shale
94	26-28981	abbreviated log	
		0-18	miscellaneous fill--brick, concrete, cinder, chemical residue
		18-20	brown peat (Qm)
		20-37	dark-gray organic silt (Qm)
		37-42	gray-brown medium-to-fine sand (Qal)
		42-49	dark-brown silt (Qbnl)
		49-58	red-brown glacial till (Qt)
		58-59	bedrock
95	NJGS files Central Railroad of New Jersey boring 45	0-5	fill
		5-24	red sand and clay (Qm over Qal)
		24-34	gray sand and clay (Qbnl)
		34-44	fine sand (Qbnl)
		44-54	red sand and clay (Qbnl or Qt)
		at 54	red shale
96	NJGS files Route 25 viaduct boring 59	0-6	clayey sand fill
		6-29	red silty medium-to-coarse sand (Qpt)
		29-54	red silty clayey medium-to-coarse sand to sandy clay (Qbnl)
		54-55	red clayey gravel with shale fragments (Qt)
97	NJGS files Route 25 viaduct boring 52	0-5	fill
		5-25	red medium-to-coarse sand (Qpt)
		25-46	red clayey fine sand (Qbnl)
		46-55	red sandy clay (Qbnl)
		55-67	gravelly and sandy clay (Qt)
		67-68	red shale
98	NJGS files Route 25 viaduct boring 48	0-6	sand and gravel fill
		6-32	red fine-to-coarse silty sand, little clay (Qpt)
		32-76	stiff red clay and sandy clay (Qbnl)
		76-82	red gravelly clay (Qt)
		82-83	red shale
99	26-1180	0-NR	clay, silty clay, quicksand (Qpt over Qbnl)
		NR-500	red shale
		well cased to 120 feet	
100	NJGS files Route 25 viaduct boring 41	0-5	fill
		5-19	red very-fine-to-medium sand (Qpt)
		19-62	stiff red silty clay (Qbnl)
		62-80	red clayey gravel (Qt)
		80-85	red clay with shale fragments (Qt or bedrock)
101	26-13206	abbreviated log	
		0-5	brown sand, brick, cinder fill
		5-32	red-brown coarse-to-fine sand (Qpt)
102	NJGS files Route 25 viaduct boring 37	0-5	cinder fill
		5-26	red clayey fine sand (Qpt)
		26-81	red silty clay, a little sandy clay (Qbnl)
		81-87	red till (Qt)
103	NJGS files Route 25 viaduct boring 34	0-4	reddish medium sand with organic matter (fill)
		4-32	red clayey very-fine-to-medium sand (Qpt)
		32-80	stiff red clay, a little sandy clay (Qbnl)
		80-82	clayey shale gravel and red shale (Qt over bedrock)
104	NJGS files Route 25 viaduct boring 30	0-5	cinder fill
		5-42	red sandy clay (Qbnl)
		42-61	red clay, some gravel (Qt)
105	NJGS files Route 25 viaduct boring 23	0-21	cinder fill
		21-61	red clay (Qbnl)
		61-67	red clay with gravel (Qt)
		67-74	red shale
106	26-2977	0-20	fill--dirt, wood, sand
		20-77	clay, sand, and gravel mix (Qpt over Qbnl)
		77-306	red shale
107	26-2053	0-95	silt, clay sediments (Qpt over Qbnl)
		95-400	shale
108	Woolman, 1896, p. 183, Unger well	0-80	clay and quicksand (Qbn over Qbnl)
		at 80	red rock
109	26-4345	0-20	garbage (fill)
		20-71	red hardpan (Qbnl)
		71-405	red shale
110	26-25246	abbreviated log	
		0-10	fill--black sand, gravel, wood
		10-13	gray silt (Qm)
		13-18	gray to red-brown fine-to-medium sand, trace fine gravel (Qpt)
		18-70	red-brown silty clay (Qbnl)
		70-74	red dense silt and clay with some gravel (Qt)
		74-87	bedrock
111	26-25243	abbreviated log	
		0-6	fill--black cinders, gravel, ash, sand
		6-8	gray-brown clay, fine-to-medium sand (Qm?)
		8-60	red-brown silt and clay, trace gravel (Qbnl)
		60-65	silt, gravel, weathered gravel (Qt)
		65-67	red-brown weathered shale
112	26-5450	abbreviated log	
		0-6	fill--bricks, cinders, sand
		6-8	black, brown peat (Qm)
		8-10	gray fine-to-coarse sand (Qpt)
		10-62	reddish brown silt and clay, little gravel (Qbnl)
		62-71	red-brown silt and clay with gravel (Qt)
		71-72	reddish brown shale
113	26-4784	0-5	stony fill
		5-38	gray clay (Qbnl)
		38-50	red hardpan (Qt)
		50-105	red shale
		105-170	red sandstone
114	26-24406	0-48	red-brown sand and silt (Qpt over Qbnl)
		48-72	red-brown till (Qt)
		72-78	red-brown sandstone
115	26-24849	abbreviated log	
		0-3	fill
		3-46	red-brown fine sand and silt (Qpt over Qbnl)
		46-52	red silt with gravel (Qt or Qbnl)
116	26-1420	0-42	fill-clay-sand-clay (Qbnl)
		42-220	shale
117	26-20558	0-18	fill--black, brown sand, wood, brick, cement
		18-44	red-brown fine-to-medium sand, silt (Qbnl)
		44-57	red shale, decomposed
118	26-30444	abbreviated log	
		0-13	miscellaneous fill
		13-30	gray silty clay (Qm)
		30-41	fine-to-medium sand, some silt (Qal)
		41-52	brown clayey silt (Qbnl)
119	26-17934	abbreviated log	
		0-27	brown, gray sand, silt, some cinders, wood, slag (fill)
		27-30	brown peat (Qm)
		30-35	gray sand and silt, little peat (Qal)
		35-65	red silt, clay, trace fine sand (Qbnl)
		65-70	red dense sand and gravel, little silt, trace clay (Qt)
		70-75	red weathered siltstone
		75-85	red siltstone
120	26-15459	abbreviated log	
		0-29	brown, gray silt, sand, cinders (fill)
		29-34	brown peat (Qm)
		34-42	red fine sand, little silt (Qal)
		42-55	red silt, some clay (Qbnl)
		55-65	red very stiff silt, some clay, trace sand and gravel (Qt)
		65-75	red weathered shale
121	26-20333	abbreviated log	
		0-19	fill--brown sand, silt, gravel, wood
		19-33	gray-brown organic silt and peat (Qm)
		33-68	red-brown clayey silt, little sand, trace gravel (Qbnl)
		68-73	red-brown fine-to-coarse sand with some gravel and silt (Qt)
		73-76	red-brown fractured shale
122	26-13397	0-35	medium-to-fine sand, some gravel (Qpt)
123	26-4006	0-48	fill (possible old well crypt)
		48-92	light brown sand (Qpt over Qbn)
		92-113	red clay (Qbnl)
		113-203	red hardpan (Qt or Qbnl)
		203-496	red shale
124	26-1302	0-4	fill
		4-11	sandy clay (Qpt)
		11-24	quick sand (Qpt)
		24-32	hardpan (probably desiccated Qbnl)
		32-53	hard dry clay (desiccated Qbnl)
		53-76	sandy clay (Qbnl)
		76-98	clay-gravel matrix (Qbnl or Qbnf)
		98-133	sandy clay (Qbnl)
		133-181	clay-gravel matrix (Qbnf or Qt)
		181-245	soft shale
		245-485	red shale
125	Herpers and Barksdale, 1951, p. 47	0-5	concrete and cinders (fill)
		5-15	yellow clay (fill or Qpt)
		15-27	fine red sand (Qpt)
		27-55	red quicksand (Qpt)
		55-80	tough red clay (desiccated Qbnl)
		80-125	soft red clay (Qbnl)
		125-190	red sandy clay (Qbnl)
		190-210	soft red clay (Qbnl)
		210-215	hardpan (Qbnl or Qt)
		215-225	sand and clay (Qbnl or Qt)
		225-408	red rock
126	26-28694	0-11	dark red-brown silty fine sand (Qpt)
		11-26	dark red and brown fine-to-medium sand (Qpt)
		26-40	dark red and brown silty fine-to-medium sand (Qpt or Qbnl)
127	NJGS files Route 21 viaduct boring 1	abbreviated log	
		0-2	cinders, sand, broken stone (fill)
		2-6	red sand and gravel (Qpt)
		6-16	yellow and red clay (Qbnl)
		16-58	red sand and red clay (Qbnl)
		58-65	red fine sand (Qbnl or Qbnf)
		65-73	red fine sand and gravel (Qbnf or Qbnl)
		73-82	red fine sand and red clay (Qbnl)
		82-85	red clay (Qbnl)
		85-87	red fine sand (Qbnl)
128	26-12065 boring 7	abbreviated log	
		0-6	fill--black cinders, ash, gravel
		6-30	red-brown sand, little silt (Qpt)
		30-63	red-brown clay and silt (Qbnl)
		63-78	red-brown fine-to-medium sand, little silt (Qbnf)
		78-91	red-brown coarse-to-fine sand, some gravel, little silt (Qbnf)
129	26-12065 boring 5	abbreviated log	
		0-6	fill-black cinders, ash, gravel, sand
		6-33	red-brown fine-to-coarse sand (Qpt)
		33-75	red-brown silt and clay, trace fine sand (Qbnl)
		75-101	red-brown coarse-to-fine sand, little silt (Qbnl)
130	NJGS files Route 21 viaduct boring 23	abbreviated log	
		0-3	cinders and broken stone (fill)
		3-12	soft silt (Qm)
		12-23	fine red sand, trace red clay, soft (Qpt)
		23-109	red clay and fine red sand, hard (Qbnl)
131	26-12065 boring 1	abbreviated log	
		0-6	dark gray silt and clay (fill)
		6-20	black peat (Qm)
		20-36	brown, gray medium-to-fine sand, little clayey silt (Qal)
		36-140	red-brown silt and clay, trace fine sand (Qbnl)
132	26-12065 boring 8	abbreviated log	
		0-6	black sand, gravel, silt, wood (fill)
		6-16	brown, black clayey silt and peat (Qm)
		16-31	brown fine sand (Qpt)
		31-96	red-brown silt and clay, trace fine sand (Qbnl)
		96-111	red-brown fine sand and silt (Qt or Qbnf)
133	26-5309	0-160	sand, clay (Qpt over Qbnl)
		160-190	red shale
134	26-19891	0-5	soil and cinder fill
		5-15	brown silty medium-to-fine sand and gravel (fill)
		15-20	organic peat (Qm)
		20-30	brown silty medium-to-fine sand and gravel (Qpt)
		30-45	brown silty fine sand (Qbnl)
		45-82	brown silty medium-to-fine sand and gravel (Qbnf)
135	26-11053	0-8	brown silt, sand and gravel fill
		8-11	peat (Qm)
		11-13	brown sand with organics (Qm)
		13-32	red-brown silty sand (Qpt)
		32-101	red-brown silty clay, some sand (Qbnl)
136	26-13433	0-6	miscellaneous fill
		6-15	black silty sand, trace organics (Qm)
		15-45	red-brown silty fine sand (Qal or Qbnl)
		45-75	red-brown silty clay (Qbnl)
		75-85	red-brown clayey silt (Qbnl)
		85-100	decomposed shale
137	26-25028	0-10	gray-black fine silty sand with wood and cinders (fill)
		10-20	gray-brown fine silty sand (Qm and Qal)
		20-40	red-brown fine silty sand (Qal or Qbnl)
		40-50	red-brown silt, some fine sand (Qbnl)
138	NJGS files Route 25 viaduct boring 15	0-19	cinder fill
		19-25	gray silty clayey fine sand with vegetable matter (Qm)
		25-35	red fine silty sand (Qal)
		35-60	red sandy clay (Qbnl)
		60-74	red silty fine sand (Qbnl)
		74-77	gravelly red clay and decomposed shale (Qt)
139	26-22658	0-5	light-brown silty fine sand and fine gravel (fill)
		5-13	red-brown clayey sandy silt, trace shale fragments (fill)
		13-17	light-brown organic silty sand (Qm)
		17-52	red-brown sandy silt, trace fine gravel (Qbnl)
140	26-22659	0-19	red-brown sandy clayey silt, trace gravel (fill?)
		19-35	red-brown clayey silt (Qbnl)
		35-52	red-brown sandy clayey silt, trace fine gravel (Qbnl or Qt)
141	NJGS files Route 25 viaduct boring 1	0-7	cinder fill
		7-20	red sandy clay (Qbnl)
		20-40	red clayey fine sand (Qbnl)
		40-53	red-brown stiff clay with gravel (Qbnl or Qt)
		53-54	decomposed red shale
142	26-3850	0-7	fill
		7-17	black muck (Qm)
		17-60	red clay (Qbnl)

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		60-74	red clay and gravel (Qt)
		74-495	red shale
143	26-3043	0-18	fill
		18-57	red clay (Qbnl)
		57-400	red shale
144	26-8749	abbreviated log	
		0-4	black cinders (fill)
		4-6	brown-black organic clay (Qm)
		6-24	red-brown silty fine sand (Qal)
		24-58	varved red-brown silty clay (Qbnl)
		58-66	red-brown clayey silt and gravel (Qt)
		at 66	shale fragments
145	26-20715	abbreviated log	
		0-17	black sand, silt, refuse (fill)
		17-20	brown fine sand, some silt (Qal)
		20-25	red-brown silt, trace sand and gravel (Qal)
		25-33	red-brown silt (Qbnl)
		33-39	brown clayey silt (Qbnl)
146	29-12312	abbreviated log	
		0-10	brown silt, sand, gravel, wood (fill)
		10-23	brown peaty silt and peat (Qm)
		23-27	brown-gray silty fine sand, trace peat (Qal)
		27-37	red silt (Qbnl)
		37-43	brown-red fine-to-medium gravel and sand (Qbnf)
		43-71	brown-red clay and silt (Qbnl)
		71-76	red clay and silt with little gravel (Qt)
		76-80	red hard silty weathered shale
147	26-12311	abbreviated log	
		0-16	brown silt, sand, gravel, rubble (fill)
		16-23	brown-black peat (Qm)
		23-25	gray fine sand (Qal)
		25-46	brown-red silt and clay (Qbnl)
		46-58	red-brown silt, some clay and gravel (Qt)
		58-65	red silty weathered shale
148	26-6880	0-2	red-brown sandy clayey silt with gravel and brick fragments (fill)
		2-12	red-brown clayey silt and silty clay, some medium-to-fine sand and gravel (Qt)
		12-51	red shale
149	26-7377	0-11	red-brown coarse-to-fine sand, some gravel and cobbles, trace silt (Qt)
		11-14	red shale
150	26-1098	0-40	earth, clay, dirt (Qt)
		40-250	red rock
151	26-286	0-45	earth (Qt)
		45-402	red rock
152	26-686	0-79	mixture of hardpan, sand and streaks of clay (Qt)
		79-213	red rock
153	26-1659	0-25	loose sand, stone, and clay (Qt)
		25-230	red sandstone
154	26-4452	0-5	fill
		5-28	hardpan and clay (Qt)
		28-46	fractured shale
		46-201	red shale and sandstone
155	26-622	0-6	fill
		6-19	clay and stone (Qt)
		19-56	sand and gravel (Qsp or Qt)
		56-70	soft red rock
		70-209	red rock
156	26-18789	abbreviated log	
		0-37	red-brown sandy silt with gravel (Qt)
157	26-10993	0-25	brown medium-to-fine sand, little coarse-to-fine gravel, trace silt, trace cobbles (Qt)
		25-30	red-brown sandstone
158	26-4513	0-10	overburden (Qt)
		10-300	red shale
159	26-1857	0-20	fill
		20-36	red clay (Qt)
		36-425	red sandstone rock
160	26-453	0-12	boulders and clay (Qt)
		12-48	sand, gravel and boulders (Qt or Qsp)
		48-53	red clay (weathered rock or Qsp)
		53-903	gray and red rock
161	26-2187	0-4	fill
		4-10	sandy clay (Qt)
		10-25	clay matrix (Qt)
		25-35	sandy clay (Qt)
		35-50	hardpan (Qt)
		50-80	sandy clay and clay matrix (Qt)
		80-250	shale
162	26-27698	0-2	fill
		2-95	sand and gravel and cobbles (Qt)
163	26-132	0-76	red earth (Qt)
		76-229	red shale
164	26-720	0-3	dirt (fill)
		3-38	sand, clay and some boulders (Qt)
		38-245	red rock
		245-260	gray rock
		260-400	red rock
165	26-15410	abbreviated log	
		0-60	reddish brown silty sand to silty clay with gravel (Qt)
166	26-81	0-95	red dirt and some boulders (Qt)
		95-200	red shale
167	26-57	0-29	reddish clay, sand, boulders (Qt)
		29-42	fine red sand, some gravel, clay (Qt)
		42-61	red hardpan with fine sand and broken rock (Qt)
		61-63	fine red sand (Qsp)
		63-71	coarse gray and brown sand, broken rock (Qsp?)
		71-83	red clay, hardpan (weathered rock?)
		83-312	red shale
		312-322	red and gray shale
168	26-273	0-35	sandy soil (Qt)
		35-65	hardpan (Qt)
169	26-4453	0-40	sand and gravel (Qt)
		40-536	red sandstone
170	NJGS files	0-6	top soil, cinders, ashes--fill
		6-11	red silty sand, clay and gravel (Qt)
		11-16	fine red silty sand (Qt)
		16-26	red silty sand, clay and gravel (Qt)
		at 26	refusal (bedrock)
171	26-23919	0-34	till (Qt)
		34-50	coarse sand (Qsp)
		50-57	fine sand (Qsp)
172	26-27962	0-26	dark reddish brown silty fine sand, clay streaks (Qt)
		26-39	dark reddish brown silty fine-to-medium sand (Qt)
		39-75	dark reddish brown silty fine sand with clay streaks (Qt or Qsp)
173	26-1171	0-82	earth, clay, dirt (Qt)
		82-183	red rock
174	26-26252	abbreviated log	
		0-25	red-brown sandy silt to clayey silt with gravel (Qt)
175	26-615A	0-15	cinder fill
		15-35	red hard pan (Qt)
		35-45	red hard clay (Qt or weathered rock)
		45-108	very hard sand rock
176	26-25771	abbreviated log	
		0-8	silt, stone fill
		8-18	reddish silt and gravel (Qt)
		18-27	shale
177	26-1984	0-18	clay and boulders (Qt)
		18-241	red rock
178	26-5955	0-8	red-brown coarse-to-fine sand, some coarse-to-fine gravel, some silt, trace cobbles (Qt)
		8-11	soft red shale
		11-26	red shale and sandstone
179	26-23969	0-10	fine-to-coarse sand fill
		10-35	fine-to-coarse sand and gravel, some silt, trace clay (Qez)
		35-58	fine sand and silt (Qez, lacustrine beds?)
		58-64	boulder at 58 (till or rock)
		64-69	red shale
180	26-11440	abbreviated log	
		0-8	red, gray sand, cement, brick, slag, concrete--fill
		8-22	red-brown silt and medium-to-fine sand, some gravel (Qez)
		22-38	red-brown medium-to-fine sand, some gravel, trace silt (Qez)
		38-54	red-brown medium-to-coarse sand and gravel (Qez)
		54-56	red-brown silt (Qez, lacustrine beds?)
181	26-4624	0-100	sand, gravel (Qez)
		100-250	sandstone
182	26-4309	0-50	overburden (Qez)
		50-225	red shale and red sandstone
183	26-3615	0-18	red sand (Qez)
		18-21	gravel (Qez)
		21-77	fine red sand (Qez, lacustrine beds?)
		77-84	sand and gravel (Qez or Qt)
		84-461	red rock
184	26-237	0-6	fill
		6-11	red clay (Qez)
		11-54	red sandy clay (Qez, lacustrine beds?)
		54-79	clay, stones and gravel (Qt)
		79-379	red shale rock
185	26-55	0-7	soft red dirt (Qez)
		7-92	red dirt and clay (Qez, lacustrine beds?)
		92-352	red rock
186	26-201	0-10	clay (Qal or Qez)
		10-20	coarse sand (Qez)
		20-24	small gravel (Qez)
		24-90	soft red shale
		90-600	hard red shale
187	26-6780	abbreviated log	
		0-27	red-brown silty sand, some gravel (Qt)
		27-31	red weathered shale
		at 31	refusal (rock)
188	26-11874	0-4	gravel, clay and sand (Qt)
		4-12	red-brown silt and clay (Qt)
		12-22	bedrock
189	26-11879	0-6	red-brown silty clay and weathered shale (Qt)
		6-20	bedrock
190	26-1782	0-22	red sand and gravel (Qt)
		22-420	red rock
191	26-117	0-17	red earth (Qt)
		17-125	red shale
192	26-852	0-23	clay, gravel, fine sand (Qt)
		23-475	red shale
193	26-221	0-19	top soil, brown dirt and silt (Qt)
		19-22	boulders (Qt)
		22-400	shale
194	26-45	0-22	dirt, gravel, hardpan (Qt)
		22-151	red shale
195	26-697	0-29	red sandy clay (Qez over Qt)
		29-202	red shale and sandstone
196	26-9855	0-5	brown silt (fill or Qt)
		5-12	brown clayey silt (Qt)
		12-30	red silty clay (Qt)
197	26-696	0-7	cinders and fill
		7-19	blue clay (Qt or fill)
		19-49	red clay (Qt)
		49-50	sand and gravel (Qt or Qbn)
		50-76	red soupy sand and clay (Qt or Qbn)
		76-88	reddish brown hardpan (Qt)
		88-89	dirty sand and gravel (Qt)
		89-93	soupy red clay (Qt or Qbn)
		93-203	clay and red shale
198	26-19272	0-12	fine sand, silt, some clay (Qt)
		12-74	fine-to-medium sand (Qbn)
		74-120	bedrock
199	26-25006	0-5	sand (Qt or fill)
		5-10	silt, sand and clay (Qt)
		10-40	fine silty sand (Qbn)
		40-73	fine-medium sand (Qbn)
200	26-912	0-3	cinders and fill
		3-7	blue gray clay (fill or Qt)
		7-40	red clay (Qt)
		40-41	red sandstone
		41-500	red shale
201	NJGS files	0-7	gravel, sand, clay, cinders--fill
		7-14	red sand, clay, gravel (Qbn or fill)
		14-30	fine red sand and silt (Qbn)
202	26-7488	0-10	cinder fill, some wood (fill over Qm)
		10-64	coarse-to-fine brown sand, trace silt (Qbn)
		64-100	brown sand and clayey silt (Qbn)
203	26-20060	abbreviated log	
		0-6	black sand and cinders (fill)
		6-8	red-brown clayey sand, some silt (fill)
		8-16	gray organic clay with peat fibers (Qm)
		16-20	brown fine-to-medium sand, trace clay and silt (Qal)
		20-60	red-brown clayey silt to silty clay (Qbnl)
		60-104	red-brown fine-to-medium sand, some silt and gravel (Qbnf)
		104-105	red-brown till (Qt)
		105-110	shale
204	NJGS files	0-19	cinder fill
		19-38	bog (Qm)
		38-48	reddish clay (Qbnl)
		48-62	yellow clay (Qbnl)
		62-74	gray clay (Qbnl)
		74-83	red sand (Qbnf)
		83-112	fine red sand, little clay (Qbnf)
		112-123	gravel, sand, little clay (Qt)
205	NJGS files	0-2	brown clay, sand, gravel (fill or Qt)
		2-9	red clay, sand, gravel (Qt)
		9-20	red sand, gravel, clay (Qt)
206	26-137	0-115	earth (fill over Qm over Qbnl)
		115-603	red rock
207	26-20812	0-15	fill--clay, wood, cinders, sand
		15-22	gray organic silt (Qm)
		22-25	gray fine sand (Qal)
		25-32	red silt (Qbnl)
208	26-7486	abbreviated log	
		0-8	cinder fill
		8-16	dark-brown peat and organic silt (Qm)
		16-90	brown fine-to-coarse sand, trace silt (Qbnf)
		90-100	red decomposed sandstone, shale and siltstone
209	NJGS files Route 21 viaduct boring 37	0-45	red sand, red clay and broken stone (Qal over Qbnl)
		45-48	gray sand (Qbnl)
		48-58	fine red sand (Qbnl)
		58-70	fine red sand and small amount of red clay (Qbnl)
		70-88	red clay and small amount of red sand (Qbnl)
		88-91	red clay (Qbnl)
210	26-19933	0-5	miscellaneous fill--soil, cinders
		5-10	peat (Qm)
		10-15	brown medium-to-fine sand (Qal)
		15-20	brown coarse-to-fine sand and gravel (Qal)
		20-50	brown fine sand and silt (Qbnl)
		50-65	brown silt and clay, trace fine sand (Qbnl)
		65-75	brown clay, trace fine sand (Qbnl)
		75-82	brown medium-to-fine sand and silt (Qbnf?)
211	NJGS files Route 21 viaduct boring 31	0-11	soft silt (Qm)
		11-25	fine red sand (Qal)
		25-42	fine red sand and red clay (Qbnl)
		42-56	red clay and red sand (Qbnl)
		56-91	red clay (Qbnl)
212	NJGS files Newark Airport boring NA-1-2	abbreviated log	
		0-10	cinder and ash fill
		10-25	gray peaty organic silt (Qm)
		25-41	red fine-to-very-fine silty sand (Qal)
		41-110	red clayey silt (Qbnl)
		110-111	fine red sandy silt (Qt)
		111-120	red shale
213	NJGS files Newark Airport boring NA-1-6	abbreviated log	
		0-7	cinders and ash fill
		7-13	black peaty organic silt (Qm)
		13-46	red fine sand, a little coarse sand (Qal)
		46-85	red sandy silt to silty clay (Qbnl)
		at 85	refusal (bedrock or till)
214	NJGS files Newark Airport boring NA-4-42	abbreviated log	
		0-6	black peaty organic silt (Qm)
		6-18	red very fine silty sand (Qal)
		18-28	red silt (Qbnl)
		28-73	red fine sand, trace silt (Qbnl)
		73-85	granite and shale boulders (Qt or Qbnf)
		85-90	red fine sand, trace silt, very dense (Qt)
215	NJGS files Newark Airport boring NA-1-7	abbreviated log	
		0-13	cinder and garbage fill
		13-21	gray peaty organic silt (Qm)
		21-24	gray sandy silt (Qm or Qal)
		24-64	red clayey silt to silty clay (Qbnl)
		64-71	red silty clay and shale gravel, very dense (Qt)
		at 71	refusal (bedrock)
216	NJGS files Newark Airport boring NA-4-41	abbreviated log	
		0-3	black peaty organic silt (Qm)
		3-66	red fine-to-coarse sand, trace gravel (Qbn)
		66-75	red silty fine sand (Qbnl)
		75-91	red clayey silt and clayey silt (Qbnl)
		91-93	red silty clay and shale fragments (Qt)
		93-98	red shale rock
217	NJGS files Newark Airport boring NA-4-44	abbreviated log	
		0-6	peat (Qm)
		6-8	brown silty fine sand (Qal)
		8-23	red very fine sandy silt (Qbnl)
		23-27	red clayey silt (Qbnl)
		27-44	red silty fine sand, some shale gravel (Qt)

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Selected Well and Boring Logs 217-293

		44-51	red clayey silt to silty sand, some shale gravel (Qt)
		51-56	red shale rock
218	NJGS files	abbreviated log	
	Newark Airport	0-7	peaty organic silt to silty sand (Qm)
	boring NA-4-46	7-32	red silty coarse-to-fine sand, some gravel (Qbn or Qt)
		32-37	red clayey silt (Qbnl)
		37-42	red silty very fine sand (Qbnl)
		42-64	red silty clay, some shale gravel and granite boulders (Qt)
		64-69	red shale rock
219	NJGS files	abbreviated log	
	Newark Airport	0-7	garbage and ash fill
	boring NA-4-50	7-10	peaty organic silt (Qm)
		10-15	gray very fine sandy silt (Qal)
		15-19	fine red sand (Qal)
		19-53	red clayey silt (Qbnl)
		53-61	red shale rock
220	NJGS files	abbreviated log	
	Newark Airport	0-9	gray peaty organic silt
	boring NA-1-9	9-20	red to gray fine sand (Qal)
		20-55	red silty clay to fine-sandy silt (Qbnl)
		55-57	red silty clay and shale fragments (Qt)
		at 57	refusal (bedrock)
221	NJGS files	abbreviated log	
	Newark Airport	0-1	red silty sand and gravel fill
	boring NA-4-22	1-18	gray peaty organic silt (Qm)
		18-20	gray medium-to-fine silty sand (Qal)
		20-40	red clayey silt and shale fragments (Qbnl)
		40-43	highly compressed red silty clay and some shale fragments (Qt)
		43-48	red shale rock
222	NJGS files	abbreviated log	
	Newark Airport	0-16	gray peaty organic silt to fine sand (Qm)
	boring NA-4-21	16-41	red silt, trace red clay and quartz gravel (Qbnl)
		41-47	highly compressed red silty clay and decomposed shale fragments (Qt)
		47-52	red shale rock
223	NJGS files	abbreviated log	
	Newark Airport	0-24	gray peaty organic silt (Qm)
	boring NA-4-24	24-49	red silty clay (Qbnl)
		49-54	red shale rock
224	NJGS files	abbreviated log	
	Newark Airport	0-9	peaty organic silt (Qm)
	boring NA-4-38	9-14	gray silty very fine sand (Qal)
		14-29	red clayey silt (Qbnl)
		29-37	red silty clay and some shale fragments (Qt)
		37-42	red shale rock
225	NJGS files	abbreviated log	
	Newark Airport	0-2	peaty organic silt (Qm)
	boring NA-4-35	2-9	gray silty fine sand (Qal)
		9-20	red fine-sandy silt (Qbnl)
		20-41	red silt (Qbnl)
		41-44	red silty clay, some decomposed shale fragments (Qt)
		44-49	red shale rock
226	NJGS files	abbreviated log	
	Newark Airport	0-1	peat (Qm)
	boring NA-4-28	1-19	brown to gray silty very-fine-to-fine sand (Qal)
		19-35	red clayey silt (Qbnl)
		35-38	red silty clay, some shale gravel (Qt)
		38-43	red shale rock
227	NJGS files	abbreviated log	
	Newark Airport	0-2	peat (Qm)
	boring NA-4-30	2-3	sandy silt (Qal)
		3-13	silty sand (Qal)
		13-29	sandy clayey silt (Qbnl)
		29-32	gravelly silty clay (Qt)
		32-37	rock
228	NJGS files	abbreviated log	
	Newark Airport	0-2	silty sand (fill?)
	boring NA-4-17	2-10	sandy silt (Qm)
		10-13	sand (Qal)
		13-18	sandy silt (Qbnl)
		18-34	silt (Qbnl)
		34-40	rock
229	NJGS files	abbreviated log	
	Newark Airport	0-11	cinder fill
	boring NA-4-15	11-14	clayey organic silt (Qm)
		14-36	silty sand (Qal over Qbnl or Qt)
		36-39	gravelly silty clay (Qt)
		39-47	rock
230	NJGS files	0-4	light-brown sand and silt (fill)
		4-9	organic silt and clay (Qm)
		9-24	fine red sand and silt (Qbnl)
		24-40	fine red sand, clay, trace of silt and some gravel (Qt)
		at 40	refusal (bedrock)
231	NJGS files	0-10	hydraulic fill with decomposed vegetation (fill over Qm)
		10-15	gray medium-to-fine sand with traces of silt and gravel (Qal)
		15-35	reddish brown fine sand with some gravel and clay (Qbnl)
		35-39	reddish brown fine sand with shale rock (Qt)
		at 39	refusal (bedrock)
232	26-26105	0-4	cinder fill
		4-6	black organic silt (Qm)
		6-20	red-brown sandy silt and clay (Qbnl)
		20-45	red-brown decomposed shale (Qt?)
		45-50	red-brown shale
233	NJGS files	abbreviated log	
	Newark Airport	0-6	cinder, rubbish fill
	boring NA-4-13	6-9	organic silt and peat (Qm)
		9-42	sand (Qal over Qbnl)
		42-55	gravelly clayey silt (Qt)
		55-63	rock
234	26-8310	0-51	sand (Qbn)
		51-600	red shale
235	26-6867	0-55	overburden (Qt)
		55-420	red sandstone
236	26-24309	0-10	red-brown clayey silt with gravel and some sand (Qt)
		10-26	red-brown clayey silt with small rounded gravels and silt lens (Qt)
		26-36	fine-to-medium sand with very thin clayey silt lenses (Qbnl or Qsp)
237	26-65	0-40	sand and gravel (Qt)
		40-49	clay and hardpan (Qt)
		49-101	shale
238	26-9102	0-36	red-brown silty clay (Qt)
		36-50	red-brown fine sand, some silt (Qbnl)
239	26-22281	abbreviated log	
		0-22	brown clay and silt, little to some fine gravel (Qt)
		22-55	brown clay and silt, little to some fine sand (Qbnl)
		55-57	brown silt and clay, little medium-to-fine gravel with rock fragments (Qt)
240	26-23034	abbreviated log	
		0-5	sand and gravel fill
		5-11	brown, red fine sand and silt, trace clay (Qt)
		11-30	red-brown shale
241	NJGS files	0-4	fill
		4-7	reddish brown fine sand (Qt)
		7-20	reddish brown medium-to-fine sand with trace clay and gravel (Qt)
		20-21	red shale
242	NJGS files	0-3	crushed stone, sand, gravel fill
		3-13	red sand, clay, gravel (Qt)
		13-18	shale rock
243	26-14742	0-12	dark-brown medium-to-coarse sand, little silt, some medium gravel (Qt)
		12-15	red siltstone
244	26-6387	0-3	red clayey silt and gravel (Qt)
		3-18	soft red shale
245	26-14148	0-3	sand fill
		3-8	silty clay, shale (Qt)
		8-18	weathered shale
246	26=19640	0-7	sand and gravel fill
		7-20	brown clay-silt (Qt)
		20-58	brown sandy silt (Qt or Qbnl)
		58-68	glacial till, some layers of silty sand (Qt)
		68-70	shale bedrock
247	26-18320	abbreviated log	
		0-8	sand, silt fill
		8-25	red-brown coarse-to-fine sand with clayey silt and gravel (Qt)
		25-27	red-brown to gray weathered shale
248	26-18219	abbreviated log	
		0-15	red-brown fine-to-coarse sand, trace silt (Qez)
		15-20	red-brown coarse-to-fine sand with gravel, trace silt and clay (Qt)
		20-23	red-brown weathered shale
		23-30	shale
249	26-29355	0-10	red-brown sand (Qez)
		10-12	red-brown clay to rock (Qt)
250	26-10122	0-3	fill
		3-6	brown silt, gravel (fill or Qal)
		6-10	red clay (Qez)
		10-16	red sand (Qez)
		16-18	red gravel (Qt or Qez)
		at 18	bedrock
251	NJGS files	0-3	fine red and brown clay and sand (Qt or fill)
		3-14	fine red sand, clay, gravel (Qt)
		14-16	soft red shale
252	26-138	0-10	earth, clay, soft rock (Qt)
		10-255	red shale rock
253	26-5144	0-20	clay (Qt)
		20-235	shale
254	26-2363	0-33	red clay (Ql over Qt)
		33-250	red rock
255	26-30361	0-5	fill--sandy clay and gravels, brick, etc.
		5-20	red-brown silty sand and clay, some gravels and small cobbles throughout (Qt)
		20-26	weathered red-brown shale
256	26-8367	0-9	decomposed red shale, coarse-to-fine angular sand, little medium-to-fine gravel, trace clay (Qt)
		9-17	red shale
257	26-3384	0-24	overburden (Qt)
		24-500	hard and soft red rock
258	26-25592	0-8	some fill, hard-packed sand and gravel (Qt)
		8-180	soft to medium red shale
259	26-20132	0-4	fill--red-brown clay, trace fine-to-medium gravel
		4-9	reddish brown clay, trace gravel (Qt)
		9-20	shale rock
260	26-5807	0-15	overburden (Qt)
		15-200	shale
261	26-21150	0-4	gray clay fill
		4-13	red-brown silty clay (Qt)
		13-41	red shale
262	26-13124	0-14	red clayey silt with red shale fragments (Qt)
		at 14	decomposed red shale
263	26-4055	0-10	hardpan (Qt)
		10-290	red shale
264	26-13121	0-4	red clayey silt with red shale fragments (Qt)
		4-14	decomposed red shale
265	26-5674	abbreviated log	
		0-2	fill
		2-14	red-brown clayey silt with gravel and sand (Qt)
		14-16	red shale
266	26-2969	0-27	clay (Qt)
		27-360	shale
267	26-1282	0-40	red clay and shale (Qt)
		40-202	more solid shale
268	26-24634	0-6	fill
		6-30	red shale
269	26-22909	0-8	coarse sand (Qt)
		8-15	red shale
270	26-27833	0-2	fill
		2-11	red, brown silty clay (Qt)
		11-14	brown shale
271	26-179	0-15	earth and clay (Qt)
		15-255	red shale rock
272	29-19373	0-6	fill
		6-15	medium and fine sand (Qt)
		15-31	sandy clay (Qt)
		31-38	weathered rock
		38-91	bedrock
273	26-22736	abbreviated log	
		0-12	silt and clay with some sand, gravel, and rock fragments (Qt)
		12-13	red and green siltstone and shale
274	26-9343	0-4	sand, cinder fill
		4-7	red silty clay, trace coarse-to-fine sand and fine gravel (Qt)
		7-9	weathered shale
		9-18	red shale
275	26-19987	0-4	fine-to-coarse sand, gravel, trace silt (Qt)
		4-12	decomposed shale
276	26-23157	abbreviated log	
		0-12	reddish brown clays and silts, some fine sands (Qt)
		12-16	red shale
277	26-562	0-5	earth and clay (Qt)
		5-400	red shale rock
278	26-13613	abbreviated log	
		0-22	red clayey silt and fine gravel, trace fine-to-coarse sand (Qt)
		at 22	red shale bedrock
279	26-6947	abbreviated log	
		0-2	brown to black sand and gravel fill
		2-8	red clayey sandy silt, trace shale fragments (Qt)
		8-55	red shale and sandstone rock
280	26-19371	0-5	sand (fill or Qt)
		5-13	sandy clay (Qt)
		13-20	rock
		20-57	bedrock
281	26-20752	abbreviated log	
		0-6	brown fine-to-medium sand, some fine gravel and silt (Qez)
		6-37	brown, red-brown clayey silt with some gravel and trace sand and boulders (Qt)
		37-45	red shale rock
282	26-1870	0-31	clay (Qt)
		31-92	shale
283	26-1661	0-45	clay (Qt)
		45-264	red shale
284	26-10953	abbreviated log	
	boring 73	0-50	brown clayey silt, trace sand, little gravel (Qt)
		50-56	red shale
285	26-10953	abbreviated log	
	boring 27	0-40	brown sand fill
		40-49	brown to brown-red clayey silt, little gravel and sand (Qt)
		49-65	brown fine sand and silt (Qbnl or Qt)
		65-75	brown-red clayey silt with gravel and sand (Qt)
		75-80	red shale
286	26-8211	0-10	silty sand (fill)
		10-19	meadow mat (Qm)
		19-24	gray fine sand, little coarse sand and fine gravel, trace silt and clay (Qal)
		24-50	brown silty clay, little fine sand to fine gravel (Qbnl)
		50-76	brown silty clay, little fine sand to coarse gravel (Qbnl over Qt)
		76-90	red shale
287	26-10981	abbreviated log	
		0-4	brown silty sand (fill?)
		4-19	brown clayey silt, little sand and gravel (Qt)
		19-30	brown fine sand, little silt (Qt or Qbnl)
		30-44	red clayey silt, some to little sand and gravel (Qt)
		44-49	red shale
288	26-3156	0-66	red clay and red fine sand (Qt over Qbnl?)
		66-467	red rock
289	26-21943	0-70	overburden (Qt over Qbnl?)
		70-550	red shale
290	26-8210	abbreviated log	
		0-19	brown sand, silt, wood, metal--fill
		19-21	red-brown fine-to-coarse sand and silt, little fine gravel (Qal)
		21-47	red-brown silt, trace clay, little fine -to-coarse sand, trace rock fragments (Qbnl)
		47-55	decomposed red shale
		55-65	red shale
291	26-8216	0-24	fill--dark-brown silt, metal, concrete, paper, wood
		24-42	red-brown fine sand, some silt (Qal over Qbnl)
		42-61	red-brown silt, little fine-to-coarse sand, trace clay (Qbnl)
		61-80	red shale
292	26-29940	0-7	fill--brown medium-to-fine sand, trace fine gravel, trace silt
	boring 20	7-17	trash fill
		17-22	dark gray organic silt and decomposed vegetation, some clay (Qm)
		22-27	brown medium-to-fine sand, trace silt and fine gravel (Qal)
		27-38	reddish brown silty fine sand (Qbnl)
		38-46	reddish brown clayey silt (Qbnl)
		46-52	reddish brown clayey silt and shale fragments
		at 52	refusal (bedrock)
293	26-5473	0-8	medium-to-fine brown sand (fill)
		8-14	miscellaneous fill
		14-20	brown organic silt (Qm)
		20-24	dark gray silt-clay (Qm)
		24-30	red-brown fine silty sand (Qal)
		30-54	red-brown silt, trace sand (Qbnl)

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Selected Well and Boring Logs 293-356

		54-64	red-brown silty clay (Qbnl)
		64-73	red shale
294	26-29940 boring 1	0-6	brown medium-to-fine sand, trace silt, trace fine gravel (fill)
		6-17	black sand, silt, stone, metal, paper, wood (fill)
		17-28	dark gray to brown organic silty clay, some decomposed vegetation (Qm)
		28-33	brown silty medium-to-fine sand, trace fine gravel, trace clay (Qal)
		33-43	reddish brown silt (Qbnl)
		43-58	reddish brown silty clay (Qbnl)
		58-60	reddish brown silty clay, some shale fragments (Qbnl or Qt)
295	26-5469	abbreviated log	
		0-18	red-brown sand and gravel (fill)
		18-30	wood, metal, sand, gravel--refuse fill
		30-32	gray fine-to-medium sand and organic silty clay (Qm)
		32-38	red-brown fine sand, trace silt and gravel (Qal)
		38-53	red-brown silty clay, trace fine sand and gravel (Qbnl)
		53-56	red-brown sandy silty clay and gravel (Qt)
		56-67	red shale
296	26-29940 boring 14	abbreviated log	
		0-4	brown medium-to-fine sand, trace silt, trace fine gravel (fill)
		4-20	black sand, silt, metal, wood (fill)
		20-23	dark gray organic silt (Qm)
		23-27	dark gray silty fine sand (Qal)
		27-33	dark gray silt, trace clay, trace fine sand (Qbnl)
		33-42	reddish brown silty fine sand (Qbnl)
		42-62	reddish brown clayey silt to silty clay (Qbnl)
		62-65	reddish brown silty clay and shale fragments (Qt)
297	26-11722	abbreviated log	
		0-10	brown-gray sand, silt, wood, gravel, brick (fill)
		10-20	gray peaty silt (Qm)
		20-30	gray to brown-red fine sand, little silt (Qal)
		30-46	brown-red varved silt and clay (Qbnl)
		46-48	red sandy silt, some gravel (Qt)
		48-53	red weathered shale
		at 53	refusal (bedrock)
298	26-30045	0-5	gray top soil, trace organics (Qm)
		5-10	red-gray sand and gravel, trace clay (Qal)
		10-20	gray clay (Qbnl)
		20-40	red-brown clay (Qbnl)
		40-42	red decomposed shale
		42-45	red shale
299	26-5471	0-12	miscellaneous refuse
		12-14	gray organic clay and silt (Qm)
		14-17	gray silty fine sand (Qal)
		17-24	gray clay and silt (Qbnl)
		24-28	gray silty fine sand (Qbnl)
		28-73	red-brown silt, trace sand (Qbnl)
		73-88	red silty clay, shale fragments (Qbnl or Qt)
		88-93	red shale, some gray silt and sand (Qt?)
		93-103	red shale
300	26-18486	0-4	brown fine sand and gravel (fill)
		4-10	red-brown fine sandy silt, trace clay (fill)
		10-16	layered red-brown silt and sand (fill)
		16-31	gray-green organic silt, trace fine sand (Qm)
		31-70	layered red-brown sandy silt to silty sand and clay (Qbnl)
		70-90	red-brown till (Qt)
		90-100	red-brown sandy shale
301	26-5474	abbreviated log	
		0-9	brown sand fill
		9-16	garbage fill
		16-23	gray clay and silt (Qm)
		23-27	fine gray sand, trace of silt (Qal)
		27-44	red fine silty sand (Qbnl)
		44-62	red-brown varved silty clay (Qbnl)
		62-72	red glacial till (Qt)
		72-82	red shale
302	NJGS files Central RR of NJ Newark Bay bridge boring 30	0-11	water
		11-13	mud (Qm)
		13-19	gray sand (Qal)
		19-37	red clay with sand (Qbnl)
		37-50	red clay (Qbnl)
		50-61	red sandstone
303	NJGS files Central RR of NJ Newark Bay bridge boring 26	0-9	water
		9-16	mud (Qm)
		16-28	gray sand (Qal)
		28-55	red clay (Qbnl)
		55-64	red sandstone
304	NJGS files Central RR of NJ Newark Bay bridge boring 18	0-9	water
		9-13	mud and shells (Qm)
		13-19	gray sand and gravel (Qal)
		19-27	gray sand (Qal)
		27-38	red clay (Qbnl)
		38-47	gravel with clay (Qt)
		47-55	red sandstone
305	NJGS files Central RR of NJ Newark Bay bridge boring 12	0-10	water
		10-15	mud (Qm)
		15-29	gray sand (Qal)
		29-40	red clay (Qbnl)
		40-54	clay and gravel (Qt)
		54-64	gray sandstone
306	NJGS files Central RR of NJ Newark Bay bridge boring 9B	0-27	water
		27-31	mud (Qm)
		31-37	red clay with gravel (Qal or Qbnl)
		37-65	red clay (Qbnl)
		65-71	red sand (Qt or Qbnf)
		71-81	gray sandstone
307	NJGS files Central RR of NJ Newark Bay bridge boring 4A	0-18	water
		18-24	mud (Qm)
		24-28	clay with gravel (Qal or Qbnl)
		28-54	red clay (Qbnl)
		54-59	red sandstone
		59-67	gray sandstone
308	NJGS files Central RR of NJ Newark Bay bridge boring 1	0-8	water
		8-13	mud (Qm)
		13-15	sand and mud (Qal)
		15-20	coarse gray sand (Qal)
		20-42	red clay with gravel (Qbnl over Qt)
		42-54	gray sandstone
309	26-24453	0-5	brown fine-to-medium sand, trace silt with fine-to-coarse gravel and brick (fill)
		5-15	gray fine-to-coarse sand and gravel, trace silt, trace boulders (Qe over Qt)
		15-35	red till (Qt)
310	26-24456	0-15	sand, gravel, brick, concrete fill
		15-36	red-brown till (Qt)
311	26-19191	abbreviated log	
		0-17	green-brown to red medium-to-fine sand and clayey silt, little gravel (Qt)
		17-19	light-brown siltstone
312	26-10958	0-7	black silt, trace gravel, trace sand (Qm)
		7-9	brown clayey silt, little gravel and coarse sand (Qt)
		9-12	red gravel, little silt and sand (Qt)
		12-27	red shale
313	26-14102	abbreviated log	
		0-27	red-brown very-fine-sand and silt to clayey silt, little gravel (Qt)
		27-30	red-brown shale--highly weathered
314	26-21712	0-20	brown to red-brown medium-to-fine silty sand with gravel (Qt)
		20-22	shale
315	26-24201	abbreviated log	
		0-30	silty clay with little fine-to-coarse sand and fine-to-medium gravel (Qt)
		at 30	shale
316	NJGS files Goethals Bridge boring 24+79.33	0-18	brown dirt or soil (fill over Qt)
		18-25	red clay and sand (Qt)
		at 25	red shale
317	NJGS files Goethals Bridge boring 27+42	0-23	red clay (Qt)
		23-34	red shale
318	26-15643	0-35	red-brown silty clayey coarse-to-fine sand (Qt)
		35-40	red shale
319	NJGS files Goethals Bridge boring 35+34	0-31	red clay (Qt)
		31-41	gneiss and shale boulders (Qt)
		41-51	red shale
320	NJGS files Goethals Bridge boring 40+81	0-11	ash and sand (fill)
		11-22	red sand and clay (Qt)
		22-60	red shale and sandstone
321	NJGS files Goethals Bridge boring 49+96	0-9	water
		9-36	silt (Qm)
		36-41	sand, gravel (Qal or Qt)
		41-45	broken shale (Qt?)
		45-53	red shale
322	26-30240	0-10	sand, cinder, wood, gravel fill
		10-18	dark brown peat and dark gray organic silt (Qm)
		18-24	reddish brown silt, clay, sand, gravel (Qt)
		24-26	reddish brown shale
323	26-8295	abbreviated log	
		0-7	building rubble (fill)
		7-15	brown silty clay (Qm)
		15-19	brown clayey silt (Qm or Qbnl)
		19-30	brown sandy silt (Qbnl or Qt)
		30-31	bedrock
324	26-29715	abbreviated log	
		0-13	black to red-brown gravel, clay, sand fill
		13-17	brown-gray meadow mat, little clay, trace silt (Qm)
		17-29	brown to gray clay and organics (Qm)
		29-32	red-brown fine-to-coarse gravel and clay (Qt)
		at 32	red-brown siltstone
325	26-20380	0-9	red silty clay with fine sand and shale (fill)
		9-14	brown and black peat (Qm)
		14-23	red silty fine sand trace medium-to-fine gravel (Qt)
		23-35	decomposed shale and rock fragments
		35-40	red shale rock
326	26-26040	abbreviated log	
		0-10	dark brown cinders, construction debris (fill)
		10-19	greenish, yellow, red silty clay, little sand, some gravel (Qt)
		19-20	red-brown silt and shale
327	26-29456	0-6	brown to black sand and cinder fill
		6-15	red-brown clayey sand (Qt)
		15-41	red-brown shale
328	26-29444	abbreviated log	
		0-11	light gray to reddish brown silty clay and sand, some gravel and pebbles (fill)
		11-19	meadow mat and gray clay (Qm)
		19-22	reddish brown fine sand (Qt)
		at 22	shale
329	26-29443	0-7	red-brown to black silty clay and sand fill
		7-14	brown silty fine sand (Qm or Qt)
		14-21	red-brown clay with gravel (Qt)
		21-49	red-brown fractured shale
330	26-29452	0-12	light gray fine sand (fill)
		12-31	reddish-brown medium sand and gravel, some shale fragments (Qt)
331	26-23436	0-15	fill
		15-30	till (Qt)
		30-50	bedrock
332	26-20126	abbreviated log	
		0-12	brown, black, red-brown gravel, sand, silt, cinders, clay (fill)
		12-25	gray-black organic silt (Qm)
		25-34	red-brown silt, some fine-to-coarse gravel, little fine-to-coarse sand, trace clay (Qt)
		34-40	red siltstone
333	26-20122	abbreviated log	
		0-13	black, brown, red-brown cinders, sand, gravel, silt, ashes (fill)
		13-26	gray organic silt (Qm)
		26-35	red-brown silt, some fine-to-medium gravel, little fine-to-coarse sand (Qt)
		35-45	red siltstone
334	26-6308	0-10	fill--concrete, sand, gravel, bricks
		10-17	black organic silt and peat (Qm)
		17-18	weathered shale
335	26-28063	0-15	clay and peat (fill over Qm)
		15-17	clay (Qm)
		17-31	sand (Qal)
		31-36	clay (Qbnl)
		36-82	clay, till and bedrock (Qbnl over Qt)
336	NJGS files Peddie Ditch boring 16	0-13	mud and silt (Qm)
		13-25	sand (Qal)
		25-40	very hard and tough red clay (Qbnl)
337	N 26-22-286	0-26	muck and fill (fill over Qm)
		26-28	fine gray sand and clay (Qal)
		28-54	fine red sand and clay (Qbnl)
		54-70	red clay (Qbnl)
		70-80	fine red sand and clay (Qbnl)
		80-100	fine red sand (Qbnf)
338	N 26-22-288	0-15	fill
		15-17	decayed vegetation (Qm)
		17-22	fine gray sand and clay (Qal)
		22-38	red silt (Qbnl)
		38-44	chocolate-brown clay with thin strata of fine sand (Qbnl)
339	N 26-22-196 boring 4	0-11	fill
		11-30	red silty sand and gravel (Qez)
		30-42	red silty medium sand (Qez)
340	26-19962	0-9	fill
		9-12	organic silt (Qm)
		12-72	brown silty medium-to-fine sand (Qpt over Qbnl)
341	NJGS files	0-8	dirt fill
		8-12	red fine sand (Qal)
		12-57	red fine sand and clay (Qbnl)
		57-58	gravel, little sand (Qbnf or Qt)
342	NJGS files	0-16	clay and ash fill
		16-23	river mud (Qm)
		23-25	gray sand and clay (Qal)
		25-34	clay and a little sand (Qbnl)
		34-62	red clay (Qbnl)
		62-92	clay, very fine sand (Qbnl)
		92-100	red clay (Qbnl)
343	N 26-22-542	0-13	red sand, red shale, brown and gray clay (Qt)
		13-22	red silt (Qbnl?)
		22-30	red sand and gravel (Qbnf?)
		at 30	brown clay (Qbnl?)
344	N 26-22-372	0-5	fill
		5-19	fine red sand, some clay (Qbn)
		19-28	red clay with sand and gravel (Qbnl)
		28-36	red clay (Qbnl)
		36-46	red clayey fine-to-medium sand and gravel (Qt)
		46-50	red clay, some shale fragments (Qt)
		50-68	red shale
345	NJGS files Peddie Ditch boring 14	0-12	mud and silt (Qm)
		12-18	sand (Qal)
		18-40	very hard and tough red clay (Qbnl)
346	NJGS files Peddie Ditch boring 12	0-12	mud and silt (Qm)
		12-16	sand (Qal)
		16-40	very hard and tough red clay (Qbnl)
347	NJGS files Peddie Ditch boring 10	0-15	mud and silt (Qm)
		15-40	very hard and tough red clay (Qbnl)
348	NJGS files Peddie Ditch boring 8	0-16	mud and silt (Qm)
		16-18	sand (Qal)
		18-40	very hard and tough red clay (Qbnl)
349	NJGS files Port Newark boring 4B	0-9	soft meadow muck (Qm)
		9-17	sand and clay (Qal)
		17-56	red clay (Qbnl)
		at 56	shale
350	NJGS files Port Newark boring 20B	0-10	soft meadow muck (Qm)
		10-16	sand and clay (Qal)
		16-37	red clay (Qbnl)
		at 37	shale
351	NJGS files Port Newark boring 284	0-9	cinders and sand (fill)
		9-18	organic silt (Qm)
		18-28	sand (Qal)
		28-33	sandy silt (Qal)
		33-63	clay (Qbnl)
		63-72	till (Qt)
		72-82	shale
352	NJGS files Port Newark boring 363	0-39	water
		39-41	organic silt (Qm)
		41-50	clay with gravel (Qal?)
		50-62	clay (Qbnl)
		62-67	shale
353	NJGS files Port Newark boring 280	0-18	cinders, silt, clay (fill)
		18-29	sand (Qal)
		29-38	silt and clay (Qbnl)
		38-65	clay (Qbnl)
		65-79	sandy silty clay (Qbnl)
		79-87	till (Qt)
		87-97	shale
354	NJGS files	0-5	clay fill
		5-19	mud (Qm)
		19-23	gray fine sand, some clay (Qal)
		23-31	grayish brown sand (Qal)
		31-66	red clay (Qbnl)
		66-71	clay and gravel (Qt)
		at 71	rock
355	NJGS files Port Newark boring 210	0-8	sand, gravel fill
		8-21	organic silt, peat (Qm)
		21-32	silty sand (Qal)
		32-44	clayey silt (Qbnl)
		44-64	silty clay (Qbnl)
		64-67	sandy silty clay (Qbnl)
		67-70	silty clay (Qbnl)
		70-74	till (Qt)
356	NJGS files Port Newark boring 220	0-22	water
		22-35	organic silt (Qm)
		35-67	clayey silt (Qbnl)
		67-88	sandy silty clay (Qbnl)
		88-96	till (Qt)

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Selected Well and Boring Logs 357-414

357	NJGS files	0-5	water
	Port Newark	5-48	silty clay (Qbnl)
	boring 223	48-53	silt (Qbnl)
		53-77	silty clay (Qbnl)
		77-83	shale
358	Lovegreen, 1974	0-9	gray organic silt (Qm)
	fig. 17	9-15	brown sand (Qal)
		15-53	reddish brown varved clay and silt (Qbnl)
		53-55	red sandstone
359	Lovegreen, 1974	0-15	gray organic silt (Qm)
	fig. 17	15-25	reddish brown varved clay and silt
		25-39	red sandstone
360	Lovegreen, 1974	0-9	fill
	fig. 17	9-18	gray organic silt (Qm)
		18-54	reddish brown varved clay and silt
		54-59	red sandstone
361	Lovegreen, 1974	0-18	fill
	fig. 17	18-26	brown sand (Qal)
		26-60	reddish brown varved clay and silt
		60-61	red sandstone
362	Lovegreen, 1974	0-14	gray organic silt (Qm)
	fig. 17	14-18	brown sand (Qal)
		18-53	reddish brown varved clay and silt (qbnl)
		53-55	red sandstone
363	Lovegreen, 1974	0-8	fill
	fig. 17	8-15	gray organic silt (Qm)
		15-35	brown sand (Qal)
		35-38	reddish brown varved clay and silt (Qbnl)
		38-41	red sandstone
364	Lovegreen, 1974	0-11	gray organic silt (Qm)
	fig. 17	11-42	brown sand (Qal)
		42-45	reddish brown varved clay and silt (Qbnl)
		45-50	red sandstone
365	Lovegreen, 1974	0-38	gray organic silt (Qm)
	fig. 17	38-55	reddish brown varved clay and silt (Qbnl)
		55-65	red sandstone
366	Lovegreen, 1974	0-30	gray organic silt (Qm)
	fig. 17	30-47	gray sand (Qal)
		47-92	reddish brown varved silt and clay (Qbnl)
		92-101	red sandstone
367	Lovegreen, 1974	0-8	fill
	fig. 17	8-39	gray organic silt (qm)
		39-94	reddish brown varved silt and clay (Qbnl)
		94-110	red sandstone
368	Lovegreen, 1974	0-21	gray organic silt (Qm)
	fig. 17	21-60	reddish brown varved silt and clay (Qbnl)
		60-70	red sandstone
369	NJGS files	abbreviated log	
	Newark Bay	0-20	black organic silty clay and peat (Qm)
	boring 3025	20-27	gray to reddish brown fine sand, trace silt and gravel (Qal)
		27-88	red-brown varved silty clay (Qbnl)
		88-95	red-brown silty clay, some gravel (Qt)
		95-105	red shale
370	NJGS files	abbreviated log	
	Newark Bay	0-30	brown fine sand fill
	boring 3136	30-43	brown to gray fine sand, little silt, trace gravel (Qal)
		43-105	red-brown varved clayey silt to silty clay (Qbnl)
		105-114	red shale
371	NJGS files	abbreviated log	
	Newark Bay	0-20	brown sand to black silty clay fill
	boring 3023	20-40	gray organic silty clay, trace fine sand, trace shells (Qm)
		40-90	red-brown varved silty clay (Qbnl)
		90-93	red-brown clayey silt, trace gravel, trace red shale (Qt)
		93-113	red shale
372	NJGS files	abbreviated log	
	Newark Bay	0-2	water
	boring 3103	2-17	gray organic silty clay (Qm)
		17-30	gray fine sand, little silt (Qal)
		30-95	red-brown varved clayey silt (Qbnl)
		95-101	red-brown clayey silt, trace red shale fragments (Qt)
		101-106	red shale
373	NJGS files	abbreviated log	
	Newark Bay	0-4	water
	boring 3098	4-17	black to dark gray organic silty clay, trace fine sand, trace shells (Qm)
		17-30	gray fine sand, trace silt and gravel (Qal)
		30-85	red-brown varved silty clay (Qbnl)
		85-91	red-brown clayey silt, trace gravel, little red shale (Qt)
		91-101	red shale
374	NJGS files	abbreviated log	
	Newark Bay	0-10	water
	boring 3042	10-30	gray to black organic silty clay, little shells and fine sand (Qm)
		30-35	brown coarse-to-fine sand, some gravel (Qal)
		35-95	red-brown varved silty clay (Qbnl)
		95-105	red shale
375	NJGS files	0-7	water
	Port Newark	7-24	organic silt and sandy silt (Qm)
	boring 262	24-43	clayey silt (Qbnl)
		43-61	sandy silty clay (Qbnl)
		61-70	till (Qt)
		70-75	shale
376	NJGS files	abbreviated log	
	Newark Bay	0-3	water
	boring 3021	3-24	black, gray organic silty clay, trace fine sand (Qm)
		24-95	red-brown varved silty clay (Qbnl)
		95-100	red shale
377	NJGS files	abbreviated log	
	Newark Bay	0-2	water
	boring 3091	2-20	black organic silty clay, trace fine sand (Qm)
		20-25	brown fine sand, trace silt and gravel (Qal)
		25-89	red-brown varved silty clay (Qbnl)
		89-96	red shale
378	NJGS files	abbreviated log	
	Port Newark	0-21	organic silt (Qm)
	boring 27	21-27	silty sand (Qal)
		27-58	silty clay (Qbnl)
		58-63	shale
379	NJGS files	0-9	gravel (fill)
	Port Newark	9-14	organic silt (Qm)
	boring 14	14-22	clayey silt (Qm)
		22-29	sand (Qal)
		29-34	silty clay (Qbnl)
		34-61	sandy silty clay (Qbnl)
		61-69	till (Qt)
		at 69	refusal on rock
380	NJGS files	0-7	clayey silt (Qm)
	Port Newark	7-18	organic silt and peat (Qm)
	boring 4	18-22	silty sand (Qal)
		22-34	silt (Qbnl)
		34-39	silty clay (Qbnl)
		39-54	sandy silty clay (Qbnl)
		54-63	till (Qt)
		63-69	shale
381	NJGS files	0-11	organic silt (Qm)
	Port Elizabeth	11-14	organic sand (Qal)
	boring 38	14-20	sandy silt (Qal)
		20-40	silty clay (Qbnl)
		40-52	till (Qt)
		52-57	shale
382	NJGS files	0-12	organic silt (Qm)
	Port Elizabeth	12-20	silty sand (Qal)
	boring 6	20-43	sandy silt (Qal)
		43-62	sandy silty clay (Qbnl)
		62-72	till (Qt)
		72-77	shale
383	NJGS files	0-18	peat and organic silt (Qm)
	Port Elizabeth	18-29	sand (Qal)
	boring 20	29-36	silty sand (Qal)
		36-49	silty clay (Qbnl)
		49-53	clayey silt (Qbnl)
		53-63	sandy silty clay (Qbnl)
		63-72	silty clay (Qbnl)
		72-79	till (Qt)
		79-84	shale
384	NJGS files	0-13	organic silt (Qm)
	Port Elizabeth	13-23	silty sand (Qal)
	boring 28	23-29	sandy silt (Qal)
		29-69	sandy silty clay (Qbnl)
		69-71	silty clay (Qbnl)
		71-74	till (Qt)
		74-84	shale
385	NJGS files	0-8	organic silt and peat (Qm)
	Port Elizabeth	8-18	silty sand (Qal)
	boring 2	18-27	silty clay (Qbnl)
		27-32	shale
386	NJGS files	abbreviated log	
	Port Elizabeth	0-15	organic silt and peat (Qm)
	boring 11	15-27	silty sand (Qal)
		27-33	sandy silt (Qal)
		33-71	silty clay (Qbnl)
		71-77	till (Qt)
		77-85	shale
387	NJGS files	abbreviated log	
	Port Elizabeth	0-9	organic silt (Qm)
	boring 24	9-25	silty sand (Qal)
		25-33	sandy silt (Qal)
		33-60	silty clay (Qbnl)
		60-61	till (Qt)
		61-66	shale
388	NJGS files	0-13	organic silt and peat (Qm)
	Port Elizabeth	13-28	silty sand (Qal)
	boring 34	28-39	sandy silt (Qal)
		39-71	silty clay (Qbnl)
		71-81	till (Qt)
		81-101	shale
389	NJGS files	abbreviated log	
	Port Elizabeth	0-15	organic silt and peat (Qm)
	boring 16	15-25	silty sand (Qal)
		25-38	sandy silt (Qal)
		38-77	sandy silty clay (Qbnl)
		77-79	decomposed shale (Qt?)
		79-89	shale
390	NJGS files	abbreviated log	
	Port Elizabeth	0-11	organic silt, sand, peat (Qm)
	boring 32	11-23	silty sand (Qal)
		23-35	sandy silt (Qal)
		35-70	silty clay (Qbnl)
		70-74	till (Qt)
		74-79	shale
391	NJGS files	abbreviated log	
	Port Elizabeth	0-12	organic silt and peat (Qm)
	boring 9	12-37	silty sand, sand (Qal)
		37-53	silty clay (Qbnl)
		53-54	decomposed shale (Qt?)
392	NJGS files	abbreviated log	
	Port Elizabeth	0-16	organic silt and peat (Qm)
	boring 22	16-38	silty sand to sandy silt (Qal)
		38-76	silty clay (Qbnl)
		76-77	decomposed shale (Qt?)
		77-82	shale
393	NJGS files	abbreviated log	
	Port Elizabeth	0-11	organic silt and peat (Qm)
	boring 36	11-40	sand, silty sand (Qal)
		40-81	silty clay (Qbnl)
		81-95	till (Qt)
		95-110	shale
394	NJGS files	0-3	water
	Port Elizabeth	3-17	organic silt (Qm)
	boring 801	17-34	silty sand (Qal)
		34-73	silty clay (Qbnl)
		73-83	till (Qt)
		83-94	rock
395	NJGS files	0-2	water
	Port Elizabeth	2-15	organic silt (Qm)
	boring 636	15-29	silty sand and gravel (Qal)
		29-70	silty clay (Qbnl)
		70-80	till (Qt)
		80-91	rock
396	NJGS files	abbreviated log	
	Port Elizabeth	0-8	water
	boring 30	8-15	organic silt and sand (Qm)
		15-28	silty sand and sand (Qal)
		28-63	silty clay (Qbnl)
		63-85	till (Qt)
		85-90	shale
397	NJGS files	0-20	water
	U. S. Army	20-25	mud and sand (Qm)
	Corps of Engineers	25-31	sand (Qal)
	boring 142	31-38	stiff clay (Qbnl)
398	NJGS files	abbreviated log	
	Newark Bay	0-7	water
	boring 3107	7-22	gray organic silty clay, trace fine sand, trace shells (Qm)
		22-29	gray fine sand, trace silt, trace gravel (Qal)
		29-66	red-brown varved silty clay (Qbnl)
		66-71	brown and white sandstone, red shale
399	NJGS files	0-15	water
	U. S. Army	15-26	mud (Qm)
	Corps of Engineers	26-28	sand (Qal)
	boring 120	28-30	clay and gravel (Qal)
		30-43	clay (Qbnl)
400	NJGS files	0-16	water
	U. S. Army	16-24	mud and sand (Qm)
	Corps of Engineers	24-28	sand and gravel (Qal)
	boring 117	28-39	clay (Qbnl)
401	NJGS files	0-2	water
	Port Elizabeth	2-14	organic sand (Qm)
	boring 649	14-25	sand (Qal)
		25-68	clayey silt (Qbnl)
		68-75	till (Qt)
		75-85	rock
402	NJGS files	0-4	water
	Port Elizabeth	4-15	peat, organic sand (Qm)
	boring 837	15-20	sand (Qal)
		20-50	silty clay (Qbnl)
		50-69	till (Qt)
		69-75	rock
403	NJGS files	abbreviated log	
	Allied Chemical	0-9	rubbish and silt fill
	boring 12-2	9-21	fibrous peat and organic silt (Qm)
		21-32	red-gray fine sand (Qal)
		32-57	red clayey silt (Qbnl)
		57-67	red clayey silt and coarse-to-fine gravel, with some coarse-to-fine sand (Qt)
404	NJGS files	abbreviated log	
	Allied Chemical	0-8	brown silt and fine sand to red coarse-to-fine sand--hydraulic fill
	boring 22-8	8-19	peat and gray organic silt (Qm)
		19-50	brown silt and fine sand (Qbnl)
		50-66	red clayey silt, some fine sand and angular cherty gravel (Qt)
405	NJGS files	abbreviated log	
	Allied Chemical	0-8	brown silt--hydraulic fill
	boring 22-7	8-14	peat, organic silt (Qm)
		14-29	gray coarse-to-fine sand, some gravel (Qal)
		29-50	red varved silt to clayey silt (Qbnl)
		50-65	red clayey silt, some coarse-to-fine gravel, little coarse-to-fine sand, boulders (Qt)
406	NJGS files	abbreviated log	
	Allied Chemical	0-9	brown silt--hydraulic fill
	boring 22-5	9-15	fibrous peat and organic silt (Qm)
		15-30	brown medium-to-fine sand (Qal)
		30-59	red varved silt and fine sand (Qbnl)
		59-65	red coarse-to-fine sand, some coarse-to-fine gravel, little clayey silt (Qt)
407	NJGS files	abbreviated log	
	Allied Chemical	0-8	brown silt--hydraulic fill
	boring 22-6	8-16	fibrous peat (Qm)
		16-30	gray medium-to-fine sand, trace silt (Qal)
		30-49	brown varved silt and fine sand (Qbnl)
		49-61	red clayey silt, some gravel, little fine sand (Qt)
408	NJGS files	abbreviated log	
	Allied Chemical	0-16	fibrous peat and gray organic silt (Qm)
	boring 12-4	16-26	gray medium-to-fine sand, little gravel and silt (Qal)
		26-70	red varved clayey silt (Qbnl)
		70-76	red clayey silt and decomposed shale gravel, little fine sand, stiff (Qt)
409	NJGS files	abbreviated log	
	Allied Chemical	0-7	cobbly gravelly sand--hydraulic fill
	boring 32-6	7-13	gray organic silt (Qm)
		13-22	red coarse-to-fine sand, some gravel (Qal)
		22-43	reddish-brown coarse-to-fine sand, trace silt (Qal or Qbnl)
		43-58	reddish brown varved silt and fine sand (Qbnl)
		58-60	reddish brown sandy silt and gravel (Qt)
410	NJGS files	0-2	water
	Port Elizabeth	2-9	peat (Qm)
	boring 817	9-35	silty sand (Qal)
		35-58	silty clay (Qbnl)
		58-72	till (Qt)
		72-82	rock
411	NJGS files	0-3	water
	Port Elizabeth	3-14	peat and organic sand (Qm)
	boring 814	14-20	silty sand (Qal)
		20-51	silty clay (Qbnl)
		51-64	till (Qt)
		64-74	rock
412	NJGS files	abbreviated log	
	Allied Chemical	0-6	red to brown cobbly gravel and sand (fill)
	boring 32-3	6-13	gray organic sand, little silt (Qm)
		13-45	gray to grayish red coarse-to-fine sand, some silt and gravel (Qal)
		45-58	red clayey silt (Qbnl)
		58-65	red clayey silt, some coarse-to-fine sand and gravel, boulders (Qt)
413	NJGS files	abbreviated log	
	Allied Chemical	0-4	cobbly gravelly sand--hydraulic fill
	boring 32-1	4-14	gray organic silt, some shells (Qm)
		14-43	gray medium-to-fine sand, trace silt (Qal)
		43-53	gray clayey silt, little fine sand (Qbnl)
		53-65	red clayey silt, some silt and gravel, boulders (Qt)
414	NJGS files	0-18	water

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Selected Well and Boring Logs 414-455

	Port Elizabeth	18-22	peat (Qm)
	boring 823	22-61	silty clay (Qbnl)
		61-66	till (Qt)
		66-76	rock
415	NJGS files	0-7	water
	U. S. Army	7-16	sand and shells (Qm)
	Corps of Engineers	16-26	clay and shale (Qt)
	boring 181	at 26	shale
416	NJGS files	0-17	water
	U. S. Army	17-37	clay and shale (Qt)
	Corps of Engineers	at 37	stiff clay (Qt?)
	boring 182		
417	NJGS files	0-17	water
	U. S. Army	17-25	sand (Qm over Qal)
	Corps of Engineers	25-38	stiff clay (Qbnl)
	boring 179		
418	NJGS files	0-28	water
	U. S. Army	28-32	sand (Qm or Qal)
	Corps of Engineers	32-34	hard gravel (Qt)
	boring 178	34-35	hard clay and shale (Qt)
		at 35	shale rock
419	NJGS files	0-12	water
	U. S. Army	12-15	mud (Qm)
	Corps of Engineers	15-17	sand (Qal)
	boring 177	17-32	stiff clay (Qbnl)
		at 32	rock
420	NJGS files	0-18	water
	U. S. Army	18-32	mud, sand, shells (Qm)
	Corps of Engineers	32-34	sand (Qal)
	boring 183	34-37	clay and shale (Qt)
		at 37	shale
421	NJGS files	0-18	water
	U.S. Army	18-21	gravel (Qt?)
	Corps of Engineers	at 21	hardpan or rock (Qt or bedrock)
	boring 203		
422	NJGS files	0-30	water
	U. S. Army	30-31	sand (Qm)
	Corps of Engineers	at 31	rock
	boring 186		
423	NJGS files	0-4	water
	U. S. Army	4-9	sand (Qm)
	Corps of Engineers	9-12	clay (Qbnl or Qt)
	boring 199	12-13	clay and shale (Qt)
		at 13	shale rock
424	NJGS files	abbreviated log	
	Bayonne bridge	0-24	red clay, sand, gravel (Qt)
	boring 70	24-30	trap rock
425	NJGS files	abbreviated log	
	Bayonne bridge	0-16	red clay, boulders, running sand (Qt)
	boring 106	at 16	rock
426	NJGS files	abbreviated log	
	Bayonne bridge	0-8	cinders (fill)
	boring 37	8-14	mud and silt (Qm)
		14-16	gray fine sand (Qe)
		16-19	sand and gravel (Qt)
		19-29	trap rock
427	NJGS files	abbreviated log	
	Bayonne bridge	0-9	water
	boring 30	9-14	mud and silt (Qm)
		14-23	rock
428	NJGS files	0-6	water
	Bayonne bridge	6-21	mud and silt (Qm)
	boring 17	21-31	rock
429	NJGS files	0-21	water
	U. S. Army	21-23	boulders (Qt? or bedrock)
	Corps of Engineers		
	boring 85		
430	NJGS files	0-22	water
	U. S. Army	22-32	sand and boulders (Qt)
	Corps of Engineers	at 32	rock
	boring 87		
431	NJGS files	0-30	water
	U. S. Army	30-31	rock or boulder (bedrock)
	Corps of Engineers		
	boring 88		
432	NJGS files	0-3	water
	U. S. Army	3-15	mud and shells (Qm)
	Corps of Engineers	15-19	sand (Qal)
	boring 167	19-31	sand and gravel (Qbn?)
433	NJGS files	0-16	water
	U. S. Army	16-19	mud (Qm)
	Corps of Engineers	19-26	gravel (Qal)
	boring 168	26-36	hard clay (Qbnl)
		at 36	hard clay or shale
434	NJGS files	0-24	water
	U. S. Army	24-31	mud (Qm)
	Corps of Engineers	31-34	sand (Qal)
	boring 57	34-39	clay (Qbnl)
435	NJGS files	0-14	water
	U. S. Army	14-25	clay (Qt or Qm)
	Corps of Engineers	at 25	rock
	boring 13		
436	NJGS files	0-15	water
	U. S. Army	15-23	clay (Qt or Qm)
	Corps of Engineers	at 23	rock
	boring 1		
437	NJGS files	0-24	water
	U. S. Army	24-29	clay (Qt or Qm)
	Corps of Engineers	at 29	rock
	boring 2		
438	NJGS files	0-18	water
	U. S. Army	18-20	sand and clay (Qt)
	Corps of Engineers	at 20	rock
	boring 5		
439	NJGS files	0-20	water
	U. S. Army	20-24	sand (Qm or Qbn)
	Corps of Engineers	24-27	gravel (Qal or Qbn)
	boring 3	at 27	rock
440	NJGS files	0-1	water
	U. S. Army	1-16	mud (Qm)
	Corps of Engineers	16-21	sand (Qal)
	boring 7	21-30	clay (Qt or Qbnl)
		at 30	rock
441	NJGS files	0-1	water
	U. S. Army	1-20	mud (Qm)
	Corps of Engineers	20-24	sand (Qal)
	boring 8	24-28	clay (Qt or Qbnl)
		at 28	rock
442	NJGS files	0-10	water
	U. S. Army	10-23	mud (Qm)
	Corps of Engineers	23-26	sand (Qal)
	boring 9	at 26	rock
443	NJGS files	0-16	water
	U. S. Army	16-31	clay (Qt or Qbnl)
	Corps of Engineers	at 31	rock
	boring 11		
444	NJGS files	0-1	water
	U. S. Army	1-17	mud (Qm)
	Corps of Engineers	17-20	sand (Qal)
	boring 10	20-27	clay (Qbnl or Qt)
		at 27	rock
445	NJGS files	0-1	water
	U. S. Army	1-18	mud (Qm)
	Corps of Engineers	18-25	sand (Qal)
	boring 12	25-28	clay (Qbnl or Qt)
		at 28	rock
446	NJGS files	0-12	water
	U. S. Army	12-15	mud (Qm)
	Corps of Engineers	15-23	clay (Qbnl or Qt)
	boring 14	at 23	rock
447	N 26-12-976	0-267	silt and clay (Qpt over Qbnl)
		267-272	gravel--cobbles of gneiss, baked shale, sandstone, up to 4 inches in diameter (Qbnf)
448	NJGS files	0-30	clay (Qbn or fill)
	Newark subway	30-50	fine sand and clay (Qbn, Qbnl)
	boring 5		
449	NJGS files	0-35	sand, gravel (Qbn)
	Newark subway	at 35	red shale and sandstone
	boring 7A		
450	NJGS files	0-20	sand (Qt or fill)
	Newark subway	20-28	sand and clay (Qt)
	boring 25		
451	Smock, 1891, p. 262	0-225	alternating layers of sand and clay (Qbn over Qbnl)
452	N 26-22-232	foundation exposure shows	
		0-25	glacial sand and gravel (Qbn)
		25-39	very compact, tough red stony clay till (Qt)
		at 39	red sandstone
453	NJGS files	0-8	water
	Stickle bridge	8-30	(no log, probably Qal over Qbn)
	boring 22	30-37	red silty sand and gravel (Qbn)
		37-39	red clay with fragments of red shale (Qt)
		39-49	red sandy shale and argillaceous red sandstone
454	NJGS files	0-15	(no log, probably fill over Qpt)
	Stickle bridge	15-37	red clayey sand and gravel (Qpt)
	boring 31	37-76	red clayey silty very fine sand (Qbnl)
		76-86	red shale and sandstone
455	26-10495	abbreviated log	
		0-66	red hard silt, little fine-to-coarse sand, little gravel, trace clay (Qt)
		66-69	red weathered shale

[1]Numbers of the form 26-xxxx are well permit numbers issued by the N. J. Department of Environmental Protection, Bureau of Water Allocation. Numbers of the form N 26-xx-xxx are N. J. Atlas Sheet grid locations of entries in the N. J. Geological Survey permanent note collection. The notation "NJGS files" indicates borings from various construction or dredging projects that are on file at the N. J. Geological Survey but that are not entered into the permanent note collection. The notation "BWA files" followed by a N. J. Atlas Sheet grid location indicates borings with logs in the Bureau of Water Allocation files that do not have well permit numbers. Notations of the form "Lovegreen, 1974" refer to logs provided in the cited publications.

[2]Depth in feet below ground or water surface.

[3]Inferred map units and comments by author in parentheses. All descriptions are reproduced as they appear in the original source, except for minor format, spelling, and punctuation changes. Notation "NR" indicates "not reported'. Logs identified as abbreviated have been condensed for brevity. Map units are inferred from the known extent of materials at the surface and from known depositional settings, in addition to the driller's descriptions.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Map Location

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

Explanation of Map Symbols

Contact--Solid where well-defined by landforms; dashed where approximate, gradational, or featheredged. Some contacts are modified from Salisbury (1895), Merrill and others (1902), and unpublished manuscript maps of R. D. Salisbury and C. E. Peet on file at the N.J. Geological Survey.

Striation--Observation at dot. Data from Salisbury and Peet (1895).

-43 **Elevation of bedrock surface in well or boring**--Data from Parrillo (1959). “Less-than” sign (<) indicates bottom of boring did not reach bedrock.

70 **Elevation of bedrock surface in well or boring**--Data from Lovegreen (1974). Values are inferred from a bedrock topography map with a contour interval of 20 feet.

-79 **Elevation of bedrock surface from seismic reflection survey**--Data from Jeffrey Waldner and David Hall, N. J. Geological Survey, 1997.

-168 **Elevation of bedrock surface in well or boring**--Data from Nemickas (1974).

35 **Elevation of bedrock surface in well or boring**--Data from Herpers and Barksdale (1951).

-70 **Elevation of bedrock surface in well or boring**--Data from files of the N. J. Geological Survey. Elevations in the Newark Bay-Port Newark-Port Elizabeth area are referenced to mean low water, which is 2.3 feet below mean sea level. Elevations elsewhere are referenced to base map datum.

264 90 **Well with log in table 1**--Location judged to be accurate to within 100 feet. Elevation of bedrock surface, datum as above, in parentheses.

47 52 **Well with log in table 1**--Location judged to be accurate to within 500 feet. Elevation of bedrock surface, datum as above, in parentheses.

50 **Elevation of bedrock surface**--Contour interval 50 feet.

r **Large bedrock outcrop**--May be partly covered by fill or construction.

(r) **Former bedrock outcrop**--Shown on unpublished manuscript maps by C. E. Peet, R. D. Salisbury, and H. B. Kummel (on file at the N. J. Geological Survey) but no longer exposed.

47 **Well with log in table 1**--On sections, projected to line of section.

Depth to bedrock in well or boring--On sections, projected to line of section. Dot indicates bedrock surface penetrated, no dot indicates bedrock not reached.

af/Qe **Unit to left of slash overlies unit to right**--Shows extent of material underlying thin eolian deposits.

Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

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Extracted from: Surficial Geology of the Elizabeth Quadrangle (OFM 42)

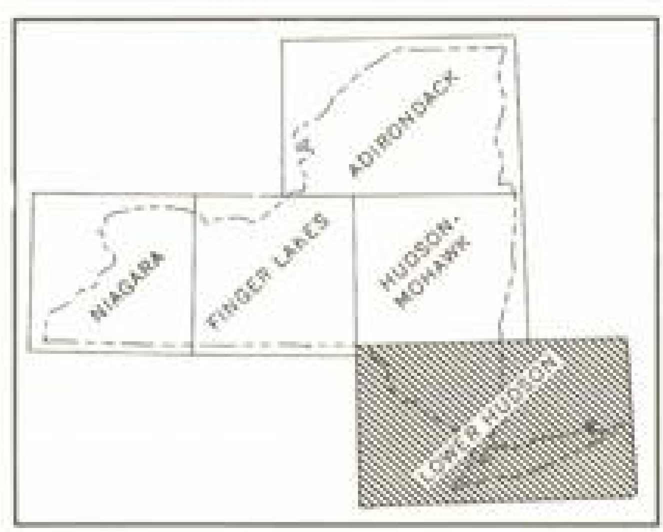
Small Scale Sources

Geology of New York, Lower Hudson Sheet

Surficial Geologic Map of New York, Lower Hudson Sheet (Map and Chart Series 40)

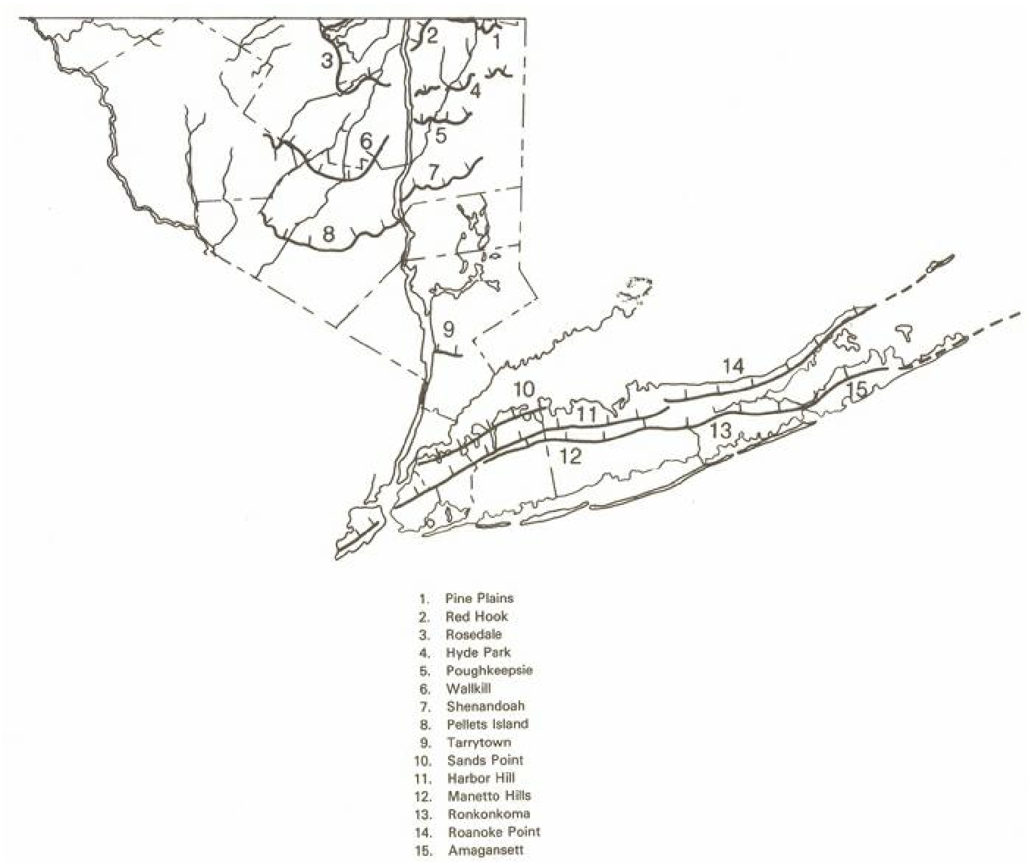
Cadwell, D.H., Connally, G.G., Dineen, R.J., Fleisher, P.J., Fuller, M.L., Sirkin, Les, and Wiles, G.C., 1999, Surficial Geologic Map of New York, Lower Hudson Sheet: New York State Museum, Map and Chart Series 40, scale 1:250,000. (*GRI Source Map ID 1574*)

Index Map



Extracted from: Surficial Geologic Map of New York, Lower Hudson Sheet (Map and Chart Series 40)

Figure 1 - Generalized Ice Margins



Extracted from: [Surficial Geologic Map of New York, Lower Hudson Sheet (Map and Chart Series 40)]

Geomorphic History of Southeastern New York

The Lower Hudson Sheet of the New York State Surficial Geologic Map includes parts of five physiographic provinces - the Appalachian Uplands, the Hudson-Mohawk Lowlands, the New England Uplands, the Triassic Lowland, and the Atlantic Coastal Lowlands. The bedrock geology varies widely among the different provinces. The bedrock beneath the Appalachian Uplands comprises sandstone, shale and limestone beds of Silurian and Devonian age that dip gently to the southwest. Beneath the Hudson-Mohawk Lowlands are beds of Ordovician shale, sandstone and limestone. The New England Uplands are composed of diverse group of sedimentary rocks (shale, graywacke and limestone) and a suite of metamorphic rocks (phyllite, schist, quartzite and marble). The Triassic Lowland in Rockland County, is developed on shale, sandstone and diabase beds of Triassic and Jurassic ages. The Atlantic Coastal Lowlands lie upon a thick mantle of glacier-derived sediments that are draped over cuestas of Cretaceous sedimentary rocks.

The landscapes in southeastern New York have a pronounced glacial imprint. Upland and valley regions alike were reshaped by glacial erosion and deposition during both glacier advance and retreat. However, this imprint is not uniform across southeastern New York. The effects are greater in the Hudson Valley and Atlantic Coastal Plain where weaker, more easily eroded strata are present.

New York State was subjected to glaciation several times during the Pleistocene Epoch. Each successive glacial episode masked or destroyed completely the geologic record of the previous one. Glacial deposits found in the area of this Lower Hudson Sheet were derived almost entirely from Late Wisconsinan (Woodfordian) glaciation, an expansion of the ice sheet that began about 28,000 years ago and culminated perhaps 21,750 years ago on Long Island. As this Late Wisconsinan (Woodfordian) glacier advanced over the landscape the glacier incorporated and transported large quantities of rock and soil. Its erosive power was enhanced in the Hudson Valley region by the parallelism of the valley and glacier flow and uplands, as in the southern Catskill Mountains, where thinner ice prevailed. On long Island a record of multiple glaciation was discovered along the north shore near Port Washington. Here, deformed masses of stratified clay, peat and oyster reef beds of pre-Woodfordian age are interbedded with Woodfordian outwash. Radiocarbon dates from the organic beds range from more than 42,800 to 21,750 yr B.P. and pollen analysis suggests a relatively warm climate developed and then ameliorated during this mid-Wisconsinan warm interval. A till beneath the organics, the Montauk Till, is assigned an early Wisconsinan age (Altonian) and the Rosyln Till (Woodfordian) caps the organics section.

Three major lobes of the Woodfordian glacier deposited moraines on Long Island. On western Long Island, deposition of the Harbor Hill Moraine was controlled by the Hudson-Champlain Lobe, with ice advancing to southern Staten Island. In central Long Island the deposition of the Ronkonkoma Moraine was controlled by the Connecticut Lobe. The deposition of moraines on eastern Long Island was controlled by eastern Connecticut-western Rhode Island Lobe.

After formation of the complex of moraines on Long Island the Woodfordian glacier began its sporadic retreat northward to Canada, a process that produced a series of proglacial lakes and recessional moraines. Because the ice was thinner over the upland regions they were deglaciated before adjacent lowland areas. In southeastern New York, for example, the Taconic Mountains, Shawangunk Mountains, southern Catskill Mountains and the Hudson Highlands emerged through the Taconic Mountains, Shawangunk Mountains, southern Catskill Mountains and the Hudson Highlands emerged through the thinning ice while a tongue of glacial ice remained active with the lower Hudson Valley. Recessional moraines, indicated in Figure 1, formed where the margin of the glacier remained stationary temporarily deposits of drift in the valleys are thicker (up to 100's of meters) than drift in the uplands (generally less than 5 meters).

During the retreat of the Hudson-Champlain Glacial Lobe, Glacial Lake Hudson formed in the lower Hudson Valley between the terminal moraine and the glacier margin. This lake gradually enlarged as the ice front receded northward to the Hudson Highlands. With further retreat of the ice this lake continued to enlarge throughout the mid- and upper Hudson Valley where it is known as Glacial Lake Albany. The location of the outflow channel is an enigma of these lakes. Although theories abound, it has not been determined whether outflow was south across the terminal moraine or across a bedrock divide into another drainage basin (e.g. Sparkill Gap).

The existence of Glacial Lake Hudson and Albany has been deduced from the materials deposited in the lake and by recognition of its shoreline features. Deltas of sand and gravel developed where streams entered the lake. Examples of such deltas can be observed in Westchester County along the Peekskill Hollow Creek; in Orange County on Moodna Creek; in Dutchess County on Crum Elbow Creek; and in Ulster county along the Esopus Creek. The dam for Lakes Hudson and Albany remained intact for 5000-8000 years. When the dam failed Lake Albany drained, leaving lacustrine deposits as evidence of its former existence.

Two recessional moraines occur in the Wallkill Valley, which is west of the Hudson River and north of the Hudson Highlands. The older Pellets Island Moraine was deposited against the Hudson Highlands. North of this the Wallkill Moraine extends westward into the Minisink Valley and Catskill Mountains. East of the Hudson River the Shenandoah and Poughkeepsie Moraines correlate with the Pellets Island and Wallkill Moraines, respectively. The younger Red Hook and Pine Plains Moraines may be correlative with Rosendale readvance ice margins in the northern Wallkill Valley.

The Wisconsinan glacier receded form New York State about 12,000 years ago. After deglaciation the landforms of New York have been reshaped only moderately by postglacial processes, mainly along the floodplains of streams and the adjacent valley walls.

Extracted from: Surficial Geologic Map of New York, Lower Hudson Sheet (Map and Chart Series 40)

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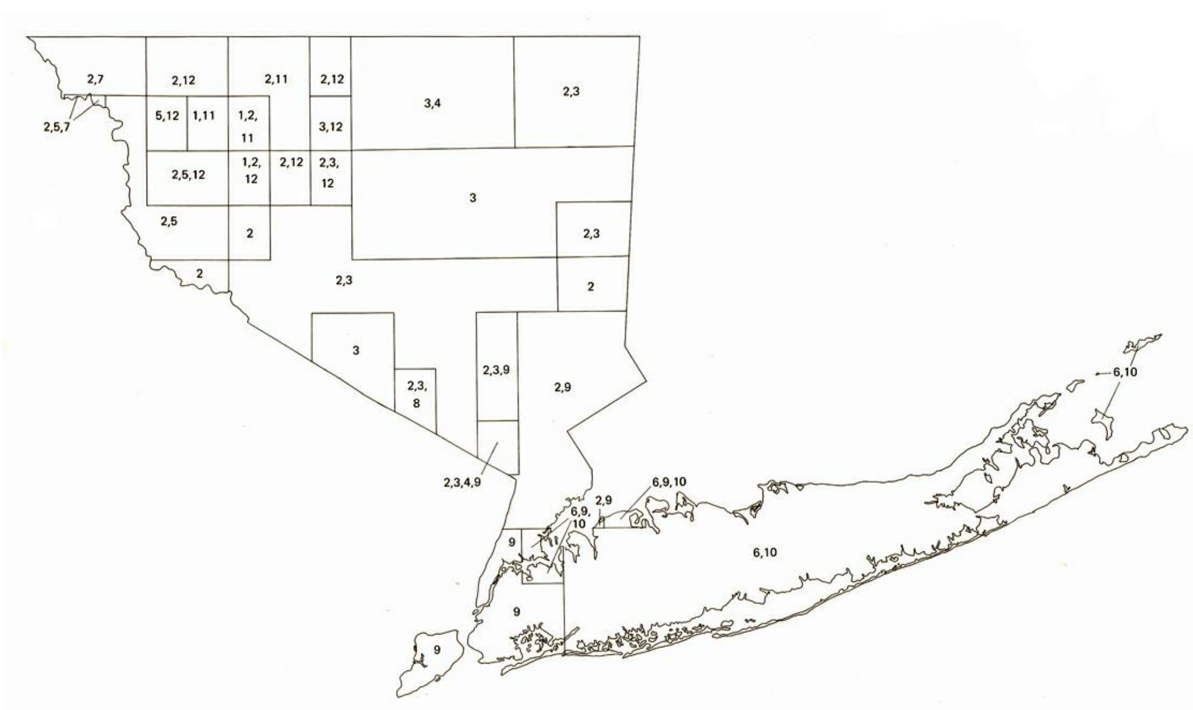

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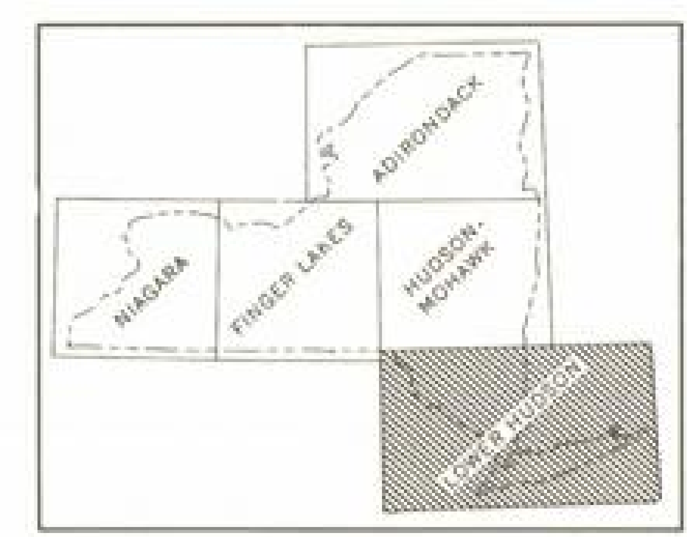
Bedrock Map of New York, Lower Hudson Sheet (Map and Chart Series 15)

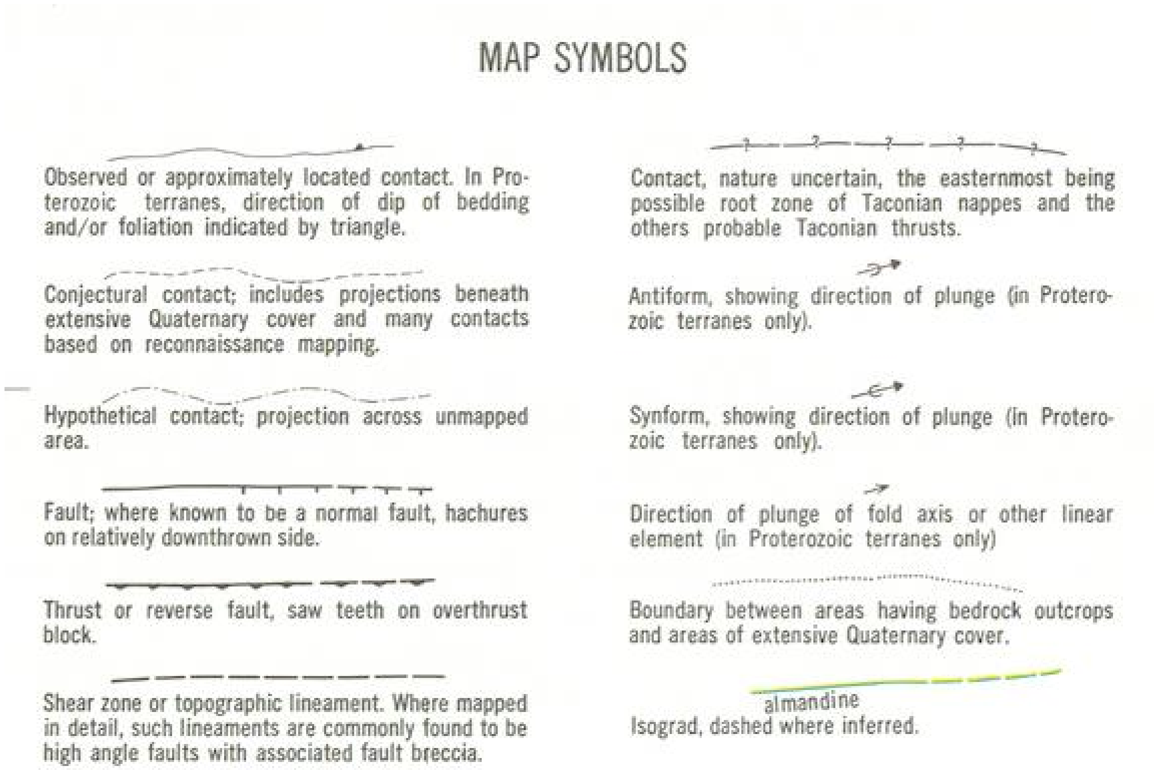
Rickard, L.V., Isachsen, Y.W., and Fisher, D.W., 1970, Geologic Map of New York, Lower Hudson Sheet: New York State Museum, Map and Chart Series 15, scale 1:250,000. (*GRI Source Map ID 7288*)

Index Map



Extracted from: Geologic Map of New York, Lower Hudson Sheet (Map and Chart Series 15)

Map symbols



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Geology New Jersey

Bedrock Geology of New Jersey (DGS 04-6)

Pristas, R.P., 2004, Bedrock geology of New Jersey: New Jersey Geological Survey, Digital Geodata Series DGS 04-6, scale 1:100,000. (*GRI Source Map ID 7285*)

Note: Only cross section graphics are included in this Digital Geodata Series map. Graphical map elements such as legends, correlations, indexes, etc. are not present.

Surficial Geology of New Jersey (DGS 07-2)

Pristas, R. P., 2007, Surficial Geology of New Jersey: New Jersey Geological Survey, Digital Geodata Series DGS 07-2, scale 1:100,000. (*GRI Source Map ID 74858*)

Note: Only cross section graphics are included in this Digital Geodata Series map. Graphical map elements such as legends, correlations, indexes, etc. are not present.

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