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U. S. GEOLOGICAL SURVEY
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INTRODUCTION

The Point Pleasant quadrangle is in the Barnegat Bay region of the New Jersey Coastal Plain, in the southeastern part of the state. Outcropping geologic materials in the map area are Holocene to upper Miocene surficial deposits that include marine, estuarine, river, wetland, hillslope, and windblown sediments. They overlie the middle to lower Miocene Cohansey and Kirkwood formations, which are shallow-marine and coastal deposits. In the subsurface, unconsolidated Paleogene and Upper Cretaceous sediments underlie the Cohansey and Kirkwood formations. The Paleogene sediments include, from youngest to oldest, the Shark River, Manasquan, Marlboro, Vincentown, and Hornerstown formations, all of which were deposited in continental-shelf settings. The Upper Cretaceous sediments include, from youngest to oldest, the Red Bank, Navesink, Mount Laurel, Wenonah, Marshalltown, Englishtown, Woodbury, and Merchantville formations, all of which were also deposited in continental-shelf settings; and the Magothy, Raritan, and Potomac formations, which were deposited in fluvial and estuarine settings.

A summary of the resources provided by the formations, and of the geomorphic history of the map area as recorded by surficial deposits and landforms, is provided below. The age of the deposits and episodes of valley erosion are shown on the correlation chart. Table 1 (in pamphlet) shows the formations penetrated by selected wells and borings as interpreted from drillers' descriptions and geophysical well logs. These data were used to construct cross sections and to map the elevation of the base of Quaternary deposits. Table 2 (in pamphlet) provides logs for two power-auger holes drilled to a depth of 100 feet. The cross sections (sheet 2) show formations to a maximum depth of about 2200 feet, which is the depth of the deepest well (well 267 in table 1). Although no wells in the quadrangle reached pre-Mesozoic metamorphic basement rock beneath the Coastal Plain formations, wells and seismic data in adjacent areas indicate that basement is probably at a depth of about 1500 feet in the northwest corner of the quadrangle, deepening to about 2500 feet in the southeast (Volkert and others, 1996; Stanford and Sugarman, 2017). Basement rocks in this area are chiefly gneiss and schist. They are commonly weathered to saprolite to thicknesses of as much as 100 feet beneath the basal Cretaceous sediments.

RESOURCES

Numerous domestic wells, and one public-supply well (well 139 in table 1), tap sands within the Cape May, Cohansey and uppermost Kirkwood formations at depths between 25 and 100 feet. Many of the domestic wells are for lawn irrigation. Many other domestic wells, and eight public-supply wells (wells 102, 103, 104, and three adjacent wells in the same wellfield, a shallow well adjacent to well 97, and well 118) tap deeper sands within the Kirkwood at depths of 90 to 150 feet north of the Metedeconk River and up to 230 feet south of the Metedeconk. Deeper aquifers include sand in the upper member of the Englishtown Formation, which is tapped by six public-supply wells (73, 97, two wells adjacent to well 122, well 153 and another adjacent to it) at depths between 690 and 840 feet; the Magothy Formation, which is tapped by three wells (140, 157, and 255) at depths between 1190 and 1370 feet; and the Potomac Formation, which is tapped by well 267 at a depth interval of 1850 to 1980 feet. The Cohansey and upper Kirkwood formations lack thick, continuous clay beds and so are an unconfined aquifer. The deeper aquifers are confined by fine-grained beds in the lower Kirkwood, Shark River, Manasquan, Hornerstown, Navesink, Wenonah, Marshalltown, Woodbury, Merchantville, and Raritan formations. Additional information on aquifers in the map area is provided by Sugarman and others (2013).

Sand and gravel were dug for construction use from the upland gravel, high phase (map unit Tg) and the Cohansey Formation from large pits north of Herbertsville and west of Brielle (former pits are outlined on map). Sand of the Cape May Formation, upper terrace deposits, and windblown deposits on Metedeconk Neck was also dug at smaller pits. No pits were active at the time of mapping, and further extraction is limited by urbanization. Sand for beach replenishment is obtained from offshore sources (Castelli and others, 2015). Clay was mined for brickmaking from the Cohansey Formation at several locations in the Sawmill Creek valley north of Riviera Beach (Ries and others, 1904, and N. J. Geological and Water Survey permanent notes 29-33-723 and 29-33-733). The clay in this area occurred as one or more three- to five-foot thick beds interlaminated with white micaceous fine sand and underlain by iron-cemented sand.

SURFICIAL DEPOSITS AND GEOMORPHIC HISTORY

After the Cohansey Formation was deposited in the middle Miocene, sea level in the New Jersey region began a long-term decline. As sea level lowered during the middle and late Miocene, between about 15 to 5 million years ago (15-5 Ma, Ma = million years ago), the inner continental shelf emerged as a coastal plain. River drainage was established on this plain. The oldest surficial deposits in the quadrangle are gravels deposited by these rivers. This drainage eroded valleys into an earlier, higher fluvial gravel known as the Beacon Hill Gravel, which formerly covered the map area at an elevation of about 250 to 300 feet (Stanford, 2010). It has been eroded away in the quadrangle but there are remnants farther inland. Groundwater seepage, slope erosion, and channel erosion reworked the Beacon Hill Gravel and deposited it in floodplains, channels, and pediments in valleys that had been cut down between 150 and 200 feet below the level of the former Beacon Hill plain. These deposits are mapped as upland gravel, high phase (unit Tg). They cap the uplands north of Herbertsville and west of Brielle (fig. 1). The base of these deposits declines from an elevation of about 100 feet along the north edge of the quadrangle to about 75 feet to the east in Brielle. North of the quadrangle the base of the gravels continues to rise, to an elevation of 150 feet near Farmingdale, about 8 miles northwest of Brielle (Stanford, 2000a, 2000b). This slope indicates southeasterly stream flow (orange arrows on fig. 1).

After a period of higher sea level in the Pliocene, a renewed period of lowering sea level during the early Pleistocene, approximately 2.5 Ma to 800,000 years ago (800 ka, ka = thousand years ago), led to another period of valley incision. Groundwater seepage and channel and slope erosion reworked the upland gravel, high phase and deposited the upland gravel, lower phase (unit TQg) in shallow valleys 20 to 50 feet below the higher gravels. These deposits today cap hilltops and interfluves, and form shallow fills in headwater valleys, between 70 and 85 feet in elevation on the upland north of Herbertsville. They have been removed by later erosion elsewhere in the quadrangle.

Continuing incision during the middle Pleistocene (about 800 to 130 ka), primarily during periods of low sea level, formed the modern valley network. The lower reaches of these valleys were submerged during at least two periods of higher-than-present sea level in the middle and late Pleistocene. During these highstands, beach, estuarine, and nearshore deposits were laid down within valleys and in terraces along the bayshore and, north of Bay Head, along the oceanfront (fig. 1). These deposits are grouped into the Cape May Formation. The Cape May includes an older, eroded terrace deposit (Cape May Formation, unit 1, Qcm1) with a maximum surface elevation of 70 feet, and a lower, less eroded terrace deposit with a maximum surface elevation of 35 feet (Cape May Formation, unit 2, Qcm2). Fine-grained clay, silt, and fine sand in the subsurface beneath the outer part of the Cape May 2 terrace (Qcm2f, southeast of dashed purple line on fig. 1) is an estuarine and back-bay deposit laid down as sea level rose during deposition of the Cape May 2.

Amino-acid racemization ratios (AAR), optically stimulated luminescence ages, and radiocarbon dates from the Delaware Bay area (Newell and others, 1995; Lacovara, 1997; O'Neal and others, 2000; O'Neal and Dunn, 2003; Sugarman and others, 2007) suggest that the Cape May 1 is of middle Pleistocene age (possibly marine-isotope stage [MIS] 11, 420 ka, or MIS 9, 330 ka; marine isotope stages from Lisiecki and Raymo, 2005) and that the Cape May 2 is of Sangamonian age (MIS 5, 125-80 ka). AAR of shells from vibracores off Long Beach Island, about 30 miles south of Mantoloking, indicate that the Cape May 2 correlate there is of Sangamonian age (Uptegrove and others, 2012). Global sea level during MIS 11 may have reached about 70 feet above present sea level (Olson and Hearty, 2009), about the maximum level of the Cape May 1 terrace, and during MIS 5e it reached about 25 feet above present sea level, about the level of the Cape May 2 terrace. If the age assignments of these terraces are accurate, these elevations suggest that full interglacial sea levels in this region are close to eustatic, as modeled by Potter and Lambeck (2003). Middle Wisconsinan (MIS 3, 65-35 ka) highstand deposits are described from the Delmarva Peninsula and the Virginia-North Carolina coastal plain (Mallinson and others, 2008; Scott and others, 2010; Parham and others, 2013; DeJong and others, 2015) at elevations up to 15 feet, but in New Jersey are apparently restricted to the inner shelf, at elevations of -60 feet or below (Carey and others, 2005; Uptegrove and others, 2012). Seismic and vibracore data show an east-trending middle Wisconsinan shoreline about 20 miles south of Mantoloking, with estuarine clays extending several miles to the north, although the clays do not extend beneath the barrier beaches or Barnegat Bay (Uptegrove and others, 2012).

The base of the Cape May 2 deposits (contoured on fig. 1 at 25-foot interval) deepens to the southeast. This pattern implies southerly river flow during the MIS 6 lowstand (200-150 ka) before deposition of the Cape May 2. This southerly routing is also suggested by abandoned valleys between uplands capped by Cape May 1 deposits near Riviera Beach (green arrows on fig. 1), which may mark routes of the Manasquan River and Sawmill Creek, and by less-evident valleys crossing Metedeconk Neck (mostly west of the map area on the Lakewood quadrangle; the lower end of one is shown on fig. 1) that may mark routes of the Metedeconk River into what is now Kettle Creek. These abandoned valleys align with the southward trend of segments of the Manasquan and Metedeconk rivers upstream of the Cape May 2 terrace. They lead southward to the Toms River paleovalley, which exits eastward to the shelf in the Lavalette-Seaside Park area, 4 to 8 miles south of Mantoloking (Stanford and Sugarman, 2017).

Southerly paleodrainage of the Manasquan and Metedeconk rivers is also consistent with the distribution of Quaternary sediments offshore on the inner shelf. Seismic surveying shows that, south of the Bay Head area, the base of Pleistocene sediments is at an elevation of -140 to -100 feet along a line parallel to, and two miles east of, the present shoreline (Lugrin, 2016). North of Bay Head the Pleistocene deposits are absent and Holocene deposits lie directly on Miocene formations. Farther offshore, the seismic data show a pre-Wisconsinan shelf valley draining northeastward from the Lavalette area, about 4 miles south of Mantoloking (Lugrin, 2016). This shelf valley may be the drain for the pre-Cape May 2 Manasquan, Metedeconk, and Toms rivers during MIS 6 and, possibly, earlier lowstands (Stanford and Sugarman, 2017).

During the Cape May 2 highstand these valleys were filled with estuarine and nearshore deposits. As sea level lowered during the Wisconsinan the lower reaches of the Manasquan and Metedeconk rivers, and their tributaries on the Cape May 2 terrace, adopted new easterly routes on the Cape May 2 deposits. Incision of these streams created the present valleys (outlined by black ticked lines on fig. 1). These incisions reached depths of between -25 and -40 feet along the present coastline, as indicated by the position of lower terrace deposits (see below) beneath the Manasquan and Metedeconk estuaries (section CC').

Fluvial sediments laid down in modern valleys include upper and lower terrace deposits (units Qtu and Qtl) and floodplain (Qal) and wetland deposits (Qals) in valley bottoms. Colluvium deposited at the base of hillslopes in modern valleys includes upper colluvium (Qcu), which grades to the upper terraces and to the Cape May 2 marine terrace, and lower colluvium (Qcl), which grades to the lower terraces and to the modern floodplain. Like the upland gravels, the terrace, hillslope, and floodplain deposits represent erosion, transport, and redeposition of sand and gravel reworked from older surficial deposits and the Cohansey Formation by streams, groundwater seepage, and slope processes. Wetland deposits are formed by accumulation of organic matter in swamps and bogs.

Upper terrace deposits form terraces and pediments 25 to 40 feet above modern floodplains and estuaries in the Manasquan River and Sawmill Creek valleys. Upper colluvium forms footslope aprons that grade to the upper terrace. The terrace deposits and colluvium were laid down chiefly during periods of cold climate in the middle Pleistocene. During cold periods, permafrost impeded deep infiltration of rainfall and snowmelt. The resulting waterlogged soils accelerated groundwater seepage and slope erosion, increasing the amount of sediment entering valleys, leading to terrace deposition. At their seaward limit, some of the deposits grade to the Cape May 2 marine terrace, and may have been laid down during periods of temperate climate when sea level was high. This topographic equivalence indicates that some of the upper terrace deposits aggraded during the Cape May 2 highstand.

Lower terrace deposits (unit Qtl) form terraces with surfaces less than 15 feet above modern valley bottoms. They are of smaller extent than the upper terraces. They formed from stream and seepage erosion of the upper terrace and Cape May 2 deposits, and, in places, older deposits, chiefly during or slightly before the last period of cold climate corresponding to the late Wisconsinan glacial stage. Organic silt at the base of lower terrace deposits upstream of the quadrangle in the Manasquan and Metedeconk river basins yielded radiocarbon dates of 29,050±150 yrs BP (Beta 471459) (33.7-32.8 calibrated ka) from a site near Siloam in the Adelphia quadrangle and a date of 35,570+3180-2270 (GX-24257) (33.4-45.4 calibrated ka) from a site near Farmingdale in the Farmingdale quadrangle (Stanford and others, 2002). (Radiocarbon dates are calibrated using Reimer and others (2013) and the Calib 7.1.0 computer program. Calibrated dates are stated with two-sigma uncertainty.) These dates confirm deposition of the overlying terrace sediments in the middle and late Wisconsinan. Lower colluvium (Qcl) on grade with the lower terraces was also laid down during this time. As permafrost melted beginning around 18 ka, forest regrew and hillslope erosion slowed. The volume of sand washing into valleys was greatly reduced, and streams eroded into the lower terraces to form the modern floodplain (Qal and Qals). This erosion was largely complete by the beginning of the Holocene at 11 ka, based on radiocarbon dates on basal peat in floodplains in the region (Buell, 1970; Florer, 1972; Stanford, 2000c).

Inland eolian deposits (unit Qe) form dunes and dune fields. Dune ridges are as much as 15 feet tall, but are more commonly 3 to 6 feet tall, and are as much as 3000 feet long (fig. 2). Their long axes (line symbols on map) are oriented east-west to northeast-southwest. Some of the ridges are closely spaced and parallel, creating a rippled pattern. Some form rims on the southeast side of shallow basins (lower left of fig. 2). These basins may have been created or enlarged by wind erosion (French and Demitroff, 2001). These patterns indicate that the dunes were laid down by winds blowing from the northwest. Most eolian deposits are on the Cape May 2 terrace. One dune near Riviera Beach is on the lower terrace. This distribution indicates that the eolian deposits were laid down after deposition of the Cape May 2, and, in places, also formed after deposition of the lower terraces. This span corresponds to the Wisconsinan Stage, a period of intermittently cold climate between 80 and 11 ka.

Another product of cold climate is relict thermokarst basins. These are shallow depressions, circular or oval in plan, that are common on low-lying, flat landsurfaces where the water table is at shallow depth (fig. 2). They are shown by symbols where observed on Metedeconk Neck. Elsewhere they were once equally common but have been destroyed by urbanization. Most formed when ice-rich lenses within permafrost melted. Some may have formed or been enlarged by wind erosion, as discussed above.

Modern beach, bay, and salt-marsh deposits were laid down during Holocene sea-level rise, chiefly within the past 6 ka in the map area. As sea level rose, tidal-marsh peat and fine-grained bay deposits (Qm) were covered by advancing flood-tidal delta sand laid down at the landward mouths of inlets, and barrier overwash sand laid down by storm flows washing over the oceanfront dunes (Qbo, Qbu). On the barrier islands, beach (Qbs) and dune (Qbe) sand are laid down atop the delta and overwash sand. The beach and dune deposits are eroded by waves and currents as sea level rises and are rarely preserved in the subsurface.

Modern sediments in Barnegat Bay consist of tidal-delta and overwash sands forming flats on the bay side of the barrier spit and extending under the eastern part of the bay. In the bay these sands interfinger with salt-marsh peat and organic mud. The western part of the bay (west of the dashed black line on figure 1), adjacent to the salt marsh, is underlain by fine sand, silt, and clay eroded from mainland sources (Olsen and others, 1980; Psuty, 2004; Andrews and others, 2016; Bernier and others, 2016).

Sea level has risen between 1 and 1.3 feet between 1900 and 2017 in the New Jersey region, as measured at tide gauges (https://tidesandcurrents.noaa.gov/sltrends/sltrends.html). This rise has caused the salt marsh and bayshore to advance inland on natural shorelines that are not stabilized by seawalls, bulkheads, and artificial beach replenishment. Inland advance of the salt marsh is indicated by a fringe of dead trees and spread of *Phragmites* reeds along the advancing front. These features are observed on all the natural inland edges of salt marsh in the quadrangle.

DESCRIPTION OF MAP AND SUBSURFACE UNITS

Grain-size terms are from the modified Wentworth scale (Ingram, 1982). Color terms are from Munsell Color Company (1975).

ARTIFICIAL FILL—Sand, pebble gravel, minor clay and peat; gray, brown, very pale brown, white. In places includes man-made materials such as concrete, asphalt, brick, cinders, trash, and glass. Unstratified to poorly stratified. As much as 15 feet thick. In road and railroad embankments, dams, dikes, infilled pits, filled wetlands, dredge-spoil disposal cells, and land made from dredged material in bayfront residential developments. The extent of fill on salt-marsh deposits is based in part on the extent of the marsh as shown on topographic manuscript maps from the 1880s at a scale of 1:21,120 on file at the N. J. Geological and Water Survey, and aerial photography from the 1930s.

Qals WETLAND AND ALLUVIAL DEPOSITS—Fine-to-medium sand and pebble gravel, minor coarse sand and silty clayey sand; light gray, yellowish-brown, brown, dark brown; overlain by brown to black peat and gyttja. Peat is as much as 6 feet thick. Sand and gravel consist chiefly of quartz and are generally less than 3 feet thick. Sand and gravel are stream-channel deposits; peat and gyttja form from the vertical accumulation and decomposition of plant debris in swamps and marshes. In alluvial wetlands on modern valley bottoms.

Qal ALLUVIUM—Sediment as in unit Qals except peat and gyttja are thin and discontinuous and may be interbedded with or overlain by sand and gravel. As much as 10 feet thick. Includes small deposits of colluvium as in unit Qcl in places at the foot of steep slopes.

Qm TIDAL-MARSH AND ESTUARINE DEPOSITS—Peat, clay, silt, fine sand; brown, dark brown, gray, black; minor thin beds of medium-to-coarse sand and pebble gravel. Contains abundant organic matter and shells. As much as 50 feet thick. Deposited in tidal marshes, tidal flats, tidal channels, and bays and estuaries during Holocene sea-level rise, chiefly within the past 6 ka in the map area.

BARRIER-BEACH DEPOSITS—Sand and minor gravel deposited by waves (Qbs), wind (Qbe), and tidal and storm flows (Qbo), and reworked by human activity (Qbu), during the Holocene.

Qbs BEACH SAND—Fine-to-medium sand with few (1-5%) shells and shell fragments and minor (<1%) to few fine-to-medium quartz pebbles; very pale brown, white, light gray. Bedding is typically planar laminations that dip gently seaward. As much as 15 feet thick. Gravel is more common on mainland bay beaches than on ocean beaches or barrier bay beaches.

Qbe DUNE SAND—Fine-to-medium sand with a few coarse sand grains and shell fragments; white, light gray, very pale brown. Bedding is typically large-scale trough-planar cross beds; cross beds dip 10-30°, bed sets are 1-5 feet thick. As much as 30 feet thick. Includes artificially constructed dunes that may contain rip-rap, organic debris, and human-made materials like fencing and netting placed to promote stability.

Qbo OVERWASH AND TIDAL-DELTA SAND—Fine-to-medium sand, few shells and shell fragments, minor coarse sand and fine-to-medium pebble gravel, and a trace (<1%) of rip-up clasts of peat; light gray, very pale brown. Nonstratified to laminated to trough- and planar- cross-bedded. As much as 30 feet thick. Deposited in tidal channels and tidal flats associated with tidal deltas and by storm overwashes of the dune massif. In subsurface only. Underlies units Qbu, Qbe, and Qbs, and interfingers with unit Qm in the eastern part of Barnegat Bay.

Qbu DUNE AND OVERWASH SAND, UNDIVIDED—Sand as in units Qbe and Qbo, graded and mixed during urban development. May include areas of artificial fill. As much as 10 feet thick.

Qe EOLIAN DEPOSITS—Fine-to-medium quartz sand; very pale brown, white, yellowish brown (fig. 3). As much as 15 feet thick. Nonstratified to weakly subhorizontally stratified. Form dune ridges and dune fields. Modern eolian sand on the barrier beaches is mapped separately as unit Qbe.

Qcl LOWER COLLUVIUM—Fine-to-coarse sand, silty sand, pebble gravel; very pale brown, yellowish-brown, gray. Sand consists chiefly of quartz with a few (1-5%) glauconite and opaque-mineral grains and a trace of mica. Gravel consists of quartz and minor (<1%) ironstone in places. As much as 15 feet thick (estimated). Nonstratified to weakly subhorizontally stratified. Forms aprons at the base of steep slopes. The aprons grade to lower terraces or the modern floodplain and estuary.

Qtl LOWER TERRACE DEPOSITS—Fine-to-medium sand, pebble gravel, minor coarse sand; yellowish-brown, light gray, brown, dark brown. As much as 15 feet thick. Sand consists chiefly of quartz with a few to some (5-10%) glauconite and opaque-mineral grains and a trace of mica. Gravel consists of quartz and minor ironstone in places. Form terraces and pediments in valley bottoms with surfaces 2 to 15 feet above the modern floodplain and estuary. Include stratified and cross-bedded stream-channel deposits and nonstratified to weakly stratified overbank and seepage deposits.

Qtu UPPER TERRACE DEPOSITS—Fine-to-medium sand, pebble gravel, minor coarse sand; very pale brown, brownish-yellow, yellow. As much as 30 feet thick. Sand consists chiefly of quartz with a few to some glauconite and opaque-mineral grains and a trace of mica. Gravel consists of quartz and minor ironstone in places. Form terraces and pediments with surfaces 25 to 40 feet above the modern floodplain and estuary. Include stratified and cross-bedded stream-channel deposits and weakly stratified to nonstratified deposits laid down by overbank deposition and groundwater seepage on pediments.

Qcu UPPER COLLUVIUM—Fine-to-coarse sand, silty sand, pebble gravel; yellowish-brown, very pale brown, gray. As much as 20 feet thick. Sand consists chiefly of quartz with a few to some glauconite and opaque-mineral grains and a trace of mica. Gravel consists of quartz and minor ironstone. Nonstratified to weakly stratified.

CAPE MAY FORMATION—Sand and gravel (Qcm1, Qcm2) and clay, silt, and fine sand (Qcm2f) deposited in beach, nearshore, and estuarine settings during the middle and late Pleistocene.

Qcm2 CAPE MAY FORMATION, UNIT 2—Fine-to-medium sand, pebble gravel, minor coarse sand, a few thin beds of silty clay; yellow, very pale brown, yellowish-brown. As much as 50 feet thick. Sand consists chiefly of quartz with few to some glauconite and opaque-mineral grains. Gravel consists of quartz and minor ironstone in places. Nonstratified to horizontally stratified, cross-bedded in places (fig. 4). Forms a terrace with a maximum surface elevation of 35 feet.

Qcm2f CAPE MAY FORMATION, UNIT 2, FINE-GRAINED DEPOSITS—Clay, silt, fine sand, minor organic matter; light gray to gray. As much as 50 feet thick. In subsurface only, inferred from well records (fig.1, sections CC', DD').

Qcm1 CAPE MAY FORMATION, UNIT 1—Fine-to-medium sand, iron-cemented in places, pebble gravel, minor coarse sand, a few thin beds of silty clay; yellow, very pale brown, yellowish-brown, reddish-brown where iron-cemented. As much as 30 feet thick. Sand consists chiefly of quartz with a few glauconite and opaque-mineral grains. Gravel consists of quartz and minor ironstone in places. Nonstratified to horizontally stratified. Forms eroded terraces with a maximum surface elevation of 70 feet.

TQg UPLAND GRAVEL, LOWER PHASE—Fine-to-coarse sand, clayey in places, and pebble gravel; yellow, very pale brown, yellowish-brown. As much as 15 feet thick. Sand and gravel consist chiefly of quartz. Nonstratified to weakly horizontally stratified. Occurs as erosional remnants on hilltops and interfluves, and in headwater valleys, between 70 and 85 feet in elevation.

Tg UPLAND GRAVEL, HIGH PHASE—Fine-to-coarse sand, clayey in places; pebble gravel; trace small-cobble gravel; yellow, yellowish-brown, reddish-yellow. As much as 25 feet thick. Sand is chiefly quartz with a trace of weathered chert. Gravel is chiefly quartz. Nonstratified to horizontally stratified, cross-bedded in places (fig. 5). Cross-beds are commonly tabular-planar. Occurs as erosional remnants on uplands above 75 to 100 feet in elevation.

Tch COHANSEY FORMATION—Fine-to-medium sand, some medium-to-coarse sand, minor very fine sand, minor very coarse sand to very fine pebbles, trace fine-to-medium pebbles; very pale brown, brownish-yellow, white, reddish-yellow, rarely reddish-brown, red, and light red; with thin beds of white, yellow, and red clay and clayey very fine-to-fine sand in places (figs. 6, 7). Clay beds are 0.5 inch to 2 feet thick. Exposure is too limited to map sand and clay beds but in table 1 they are identified from well logs as "Tchs" and "Tchc" respectively. Sand is well-stratified to nonstratified; stratification ranges from thin, planar, subhorizontal beds to large-scale trough and planar cross-bedding. Sand is quartz; coarse-to-very coarse sand may include as much as 5% weathered chert and a trace of weathered feldspar. As much as 20 percent of the sand fraction consists of detrital heavy minerals (Markewicz, 1969), commonly concentrated along bedding planes. In these concentrations, ilmenite dominates the opaque minerals; to a lesser extent zircon and sillimanite dominate the nonopaque minerals. Kaolinite dominates the clay-sized minerals. Coarse-to-very coarse sands commonly are slightly clayey; the clays occur as grain coatings or as interstitial infill. This clay-size material is from weathering of chert and feldspar rather than from primary deposition. Pebbles are chiefly quartz with minor gray chert and rare gray quartzite. Some chert pebbles are light gray, partially weathered, pitted, and partially decomposed; some are fully weathered to white clay. In a few places, typically above or below clayey strata, sand may be hardened or cemented by iron oxide, forming reddish-brown hard sands or ironstone masses.

The basal contact of the Cohansey was not observed in the quadrangle. Elsewhere, the Cohansey appears to unconformably overlie the Kirkwood Formation although it may be age-equivalent to younger Kirkwood members downdip to the south. Micaceous fine sand typical of the Kirkwood occurs within the Cohansey in the northwest part of the map area, suggesting a gradational or interfingered contact of the two formations locally. Pollen and dinoflagellates indicate that the Cohansey is of middle to late Miocene age (Rachele, 1976; Greller and Rachele, 1983; Owens and others, 1988; deVerteuil, 1997; Miller and others, 2001).

Tkw KIRKWOOD FORMATION—Quartz sand, fine-to-medium grained, and clay-silt. Sand is nonstratified to cross-bedded and laminated, light gray, gray, and light-yellow, micaceous, with minor coarse sand and fine gravel. Sand consists chiefly of quartz, with small amounts of feldspar and mica (mostly muscovite). Detrital heavy minerals are concentrated on bedding planes and are chiefly opaques, especially ilmenite, with lesser amount of nonopaques including zircon, staurolite, garnet, rutile, and tourmaline. Clay and silt are dark gray to brown. Finely dispersed clay minerals include kaolinite, illite, and illite/smectite. The lowermost Kirkwood (below tielines on sections), termed the Asbury clay (Ries and others, 1904), or the Asbury Park Member (Isphording, 1970), is a dark gray to dark brown, peaty, laminated clay-silt with lenses of massive to locally cross-bedded fine sand. Pyrite is common in the clayey, organic-rich beds. At the base of the Kirkwood a bed of coarse glauconite-quartz sand, with granules and scattered shark teeth, typically 2 to 3 feet thick, rests unconformably on the Shark River Formation. Maximum thickness 150 feet.

The Kirkwood Formation, as revised by Owens and others (1998), includes the following members, in ascending order: (1) an unnamed lower member (equivalent to the Brigantine Member of Miller and others, 1997 or sequence Kw1a of Sugarman and others, 1993); (2) the Shiloh Marl Member (equivalent to sequence Kw1b of Sugarman and others, 1993); (3) the Wildwood Member (equivalent to sequence Kw2 of Sugarman and others, 1993); and (4) the Belleplain Member (equivalent to sequence Kw3 of Sugarman and others, 1993). Both the unnamed lower member and the Shiloh Marl Member are clayey at the base and sandy at the top, a pattern that is evident on gamma-ray geophysical logs. The unnamed lower member and Shiloh Marl Member are approximately 21-19 million years old, the Wildwood Member is 18-15 million years old, and the Belleplain Member is 13 million years old (Miller and others, 1997). Previous mapping indicates that the lower member and Shiloh Marl Member are present in the quadrangle, while the Wildwood and Belleplain members are present only south of the quadrangle (Sugarman and others, 1993). In the Sea Girt corehole (well 107), the lower member and Shiloh Marl Member were tentatively identified, as was a thin upper clay-silt possibly correlative to the Wildwood Member, although no datable material was found in the Kirkwood to substantiate this correlation (Miller and others, 2006).

Tsr SHARK RIVER FORMATION—Very fine-to-fine, slightly glauconitic and micaceous quartz sand, which thins to the northwest (above upper tielines on sections) grading downward into clay-silt, very fossiliferous, glauconitic (up to 15%), slightly micaceous, greenish-gray to very dark greenish-gray; nonstratified to thick-bedded and extensively burrowed (below upper tielines). Thin porcellanitic zones are present in places. There is less glauconite is the lower 40 feet of the formation (below lower tielines on sections), although glauconite is locally abundant in the basal 10 feet. Calcareous microfossils are abundant in the lower clay-silt; small, broken mollusk shells are present in the upper fine sand. Clay minerals include illite, illite/smectite, kaolinite, and minor amounts of clinoptilolite. The upper sand is also known as the Toms River Member and the lower clay-silt as the Squankum Member (Enright, 1969). Maximum thickness of the Shark River Formation in the map area is 230 feet.

The contact with the underlying Manasquan Formation is unconformable and is placed at the top of the pale-olive clay-silt of the Manasquan. It is marked by a sharp positive gamma-ray response on geophysical logs.

Calcareous nannofossils in samples from the Allaire State Park corehole (Sugarman and others, 1991) and in the Sea Girt corehole (Miller and others, 2006) indicate the Shark River is of middle Eocene age (nannozones NP 14-17).

Tmq MANASQUAN FORMATION—Clay-silt, dusky-yellow-green to pale-olive and grayish-green, extensively burrowed, nonstratified to thick-bedded, calcareous, minor very fine quartz sand. Cross-bedded laminae of very fine sand are present locally. Fine glauconite sand is commonly dispersed throughout the dominantly clayey matrix. Clay minerals include illite, illite/smectite, and minor clinoptilolite. In the Sea Girt corehole, silica-cemented porcellanite zones are common (Miller and others, 2006). The contact with the underlying Marlboro or Vincentown formations is marked by a sharp positive response on gamma-ray logs. Otherwise the formation, in general, has a neutral response on gamma-ray logs, not reflecting the dominant clay-silt lithology. Maximum thickness is 150 feet.

Calcareous nannofossils and planktonic foraminifers in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Manasquan is of early Eocene age (nannozones NP 11-12, foraminifer zones P 7-8).

Tmb MARLBORO FORMATION—Clay to sandy silty clay, greenish-gray, brown, reddish-brown, with glauconite, pyrite, and phosphate nodules. Maximum thickness is 35 feet, and the formation pinches out to south (section CC'). The Marlboro Formation was named by Glaser (1971) in Maryland and identified in the subsurface in New Jersey by Miller and others (2017).

Calcareous nannofossils in samples from the Sea Girt corehole indicate that the Marlboro Formation (identified as "unnamed clay" in Miller and others, 2006) is of earliest Eocene age (nannozone NP 9b).

Tvt VINCENTOWN FORMATION—Clayey silt and silt, extensively burrowed, slightly micaceous, finely laminated where not burrowed, dark greenish-gray to very dark gray, with thin beds of very fine quartz and glauconite sand and silt. Grades downward to a massive, slightly quartzose, glauconitic silt and glauconite sand with shell material at the base. The contact with the underlying Hornerstown Formation is marked by a sharp positive response on gamma-ray logs. Maximum thickness is 110 feet.

Calcareous nannofossils in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Vincentown is of late Paleocene age (nannozones NP 8 and 9a).

Tht HORNERSTOWN FORMATION—Glauconite, clayey, massive-bedded, very dark greenish-gray to very dark grayish-brown, with scattered shells and shell fragments. Glauconite grains are mainly medium to coarse sand in size and botryoidal. Contains 1 to 2 percent fine-to-very coarse-grained quartz sand, phosphate fragments, pyrite, and lignite. Matrix contains minor glauconite clay. Locally cemented by iron oxides and siderite. Unconformably overlies the Red Bank Formation. Maximum thickness is 40 feet.

Calcareous nannofossils and planktonic foraminifers in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Hornerstown is of early Paleocene age (nannozones NP 2-4, foraminifer zones P1-P3).

Krb-ns NAVESINK-RED BANK FORMATIONS (UNDIVIDED)—Glauconite, slightly quartzose, clayey, greenish-black, with calcareous shells. Glauconite grains are mainly medium to coarse sand in size. Unconformably overlies the Mount Laurel Formation. This contact is easily distinguished in the subsurface by a sharp positive gamma-ray response. Maximum thickness is 70 feet.

In outcrop in northern Monmouth County the Navesink Formation and the Red Bank Formation form an unconformity-bounded, coarsening-upward sequence consisting of a basal glauconite sand (Navesink Formation), a middle silt (lower Red Bank Formation), and an upper quartz sand (upper Red Bank Formation). Downdip from outcrop, the sand pinches out and the silt changes facies to glauconite.

Calcareous nannofossils in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Navesink is of Late Cretaceous (Maastrichtian) age (nannozones CC 23a, 25, 26).

Kml MOUNT LAUREL FORMATION—Quartz sand, fine- to coarse-grained, slightly glauconitic, extensively burrowed, slightly micaceous and feldspathic, commonly interbedded with thin layers of dark clay and silt, and intervals of scattered shells. Olive-gray to dark greenish-gray. Conformably overlies the Wenonah Formation. The transition from the Wenonah to the Mount Laurel is generally marked by an increase in grain size, a decrease in mica (Owens and Sohl, 1969), and the appearance of alternating thin beds of clay and sand in the Mount Laurel (Minard, 1969). Maximum thickness is 70 feet.

Calcareous nannofossils, and a strontium stable-isotope age of 74.5 Ma, in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Mount Laurel is of Late Cretaceous (late Campanian) age (nannozones CC21-22).

Kw-mt MARSHALLTOWN–WENONAH FORMATIONS (UNDIVIDED)—Glauconite, greenish-black, extensively burrowed, with silt and pyrite and rare shell fragments (Marshalltown), grading upward into a micaceous, lignitic, burrowed clayey fine sand to silt with traces of glauconite and pyrite (Wenonah). The Marshalltown-Wenonah is recognized in the subsurface by a gamma spike at the base of the Marshalltown passing into a relatively flat, high-intensity pattern above. The two formations are undivided due to the thinness of the Marshalltown Formation (approximately 10 feet) and its lithologic similarity to the lower Wenonah Formation. Unconformably overlies the Englishtown Formation. The lower contact is extensively burrowed; wood and locally coarse sand from the underlying Englishtown Formation are reworked into the basal Marshalltown. Maximum thickness is 60 feet.

Calcareous nannofossils in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Marshalltown is of Late Cretaceous (late Campanian) age (nannozone CC20).

Ketu **Ketl** ENGLISHTOWN FORMATION—Informally divided into the upper Englishtown and lower Englishtown members. The upper member consists of fine- to coarse-grained sand interbedded with thin, dark-gray, micaceous, woody, clay-silt that grades downward to glauconitic, dark greenish-gray, micaceous, and lignitic clay-silt to very fine quartz sand. The sand is dominantly quartz; less than 10 percent consists of feldspar, rock fragments, and glauconite. The upper member is defined on gamma-ray logs by a thick, low-intensity sand at its top (above tielines on sections) and a thick, high-intensity clayey unit (below tielines) at its base. The upper member unconformably overlies the lower Englishtown member. In the Sea Girt corehole, a 1.5-foot indurated zone marks the contact. Maximum thickness of the upper member is 150 feet. The lower member is quartz sand, feldspathic, micaceous and lignitic, fine- to medium-grained, medium-to dark-gray. Sand is typically cross-bedded. The contact of the lower member with the underlying Woodbury Formation is gradational. Maximum thickness of the lower member is 40 feet.

Calcareous nannofossils and strontium stable-isotope ages of 74-78 Ma in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Englishtown Formation is of Late Cretaceous (middle-late Campanian) age (nannozones CC19-20).

Kwb-mv MERCHANTVILLE-WOODBURY FORMATIONS (UNDIVIDED)—Clay and silt, some very fine sand with mica, and a few lenses of finely disseminated pyrite, lignite, and siderite (Woodbury Formation). Color ranges from dark gray to olive black. Bedding is nonstratified to finely laminated with alternating beds of very fine sand and clay-silt. Grades downward into an intercalated, thick-bedded sequence of glauconitic sand and silt and micaceous clayey silt (Merchantville Formation). Quartz and glauconite are the major sand components; feldspar, mica (colorless and green), and pyrite are minor constituents. Siderite-cemented beds are common. The Merchantville contains zones of broken calcareous mollusk shells. Unconformably overlies the Magothy Formation. Maximum thickness is 200 feet.

Calcareous nannofossils in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Merchantville and Woodbury formations are of Late Cretaceous (Santonian to mid-Campanian) age based on (nannozones CC16-18).

Kmg MAGOTHY FORMATION—Quartz sand and clay, thin- to thick-bedded. Sand is light- to medium-gray or brownish-gray; clay is olive-black to grayish-black. Bedding is horizontally laminated to cross-bedded. The sand is fine to very coarse, well sorted within each bed, predominantly quartz, and includes minor feldspar and mica. Pyrite-cemented and pyrite-coated sand concretions are common. Lignite is abundant in beds as much as 0.5 feet thick. Recognized on gamma logs as a series of thick sands and interbedded clay-silts. Unconformably overlies the Raritan Formation. Maximum thickness is 250 feet.

Pollen in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the Magothy is of Late Cretaceous (Turonian-Coniacian) age (pollen zones V-VII).

Krw **Krf** RARITAN FORMATION—Includes two members: the Woodbridge Clay Member (Krw) and the underlying Farrington Sand Member (Krf). The Woodbridge Clay Member is clay and silt, dark gray, nonstratified, with mica, pyrite, lignite, and siderite. Siderite forms layers 0.25 to 0.5 inches thick. Maximum thickness is 250 feet. The Farrington Sand Member is fine-to-medium quartz sand, white, yellow, red, light gray, commonly interbedded with thin coarse sand and fine gravel beds and thin to thick dark gray silt beds. Maximum thickness is 40 feet.

Pollen and calcareous nannofossils in samples from the Sea Girt corehole indicate that the Raritan is of Late Cretaceous (Cenomanian-Turonian) age (Miller and others, 2006). The Woodbridge Clay Member yielded zone IV pollen and nannozones CC 10-11. The Farrington Sand Member yielded zone III pollen. In the Sea Girt corehole the Raritan Formation is identified as the Bass River Formation based on downdip correlation to subsurface marine sediments in southern Burlington County (Petters, 1976). It is identified as Raritan Formation here because of its lithologic continuity with the outcropping updip Raritan in Middlesex County.

Kp3 POTOMAC FORMATION—Fine-to-coarse quartz sand with beds of clay and silty clay; white, yellow, red where weathered, gray where unweathered. Sands are nonstratified to horizontally bedded to cross-bedded, clays are in beds as much as 10 feet thick. More than 400 feet thick; full thickness is not penetrated by drillholes in the quadrangle.

Pollen in samples from the Sea Girt corehole (Miller and others, 2006) indicate that the uppermost Potomac in the quadrangle is of Late Cretaceous (Cenomanian) age (pollen zone III), indicating it is within the Potomac Formation, unit 3, of Doyle and Robbins (1977).

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Figure 1. Geomorphic and surficial geologic features of the Point Pleasant quadrangle.

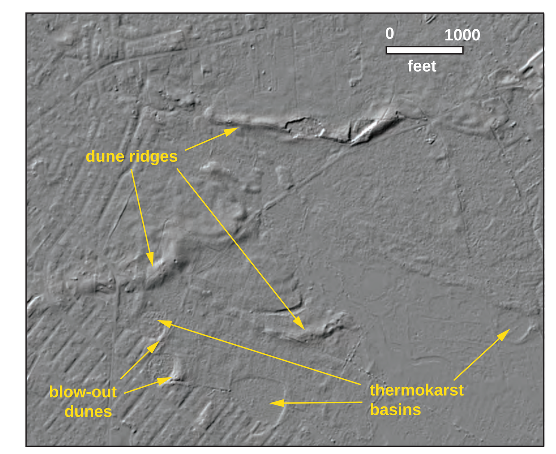
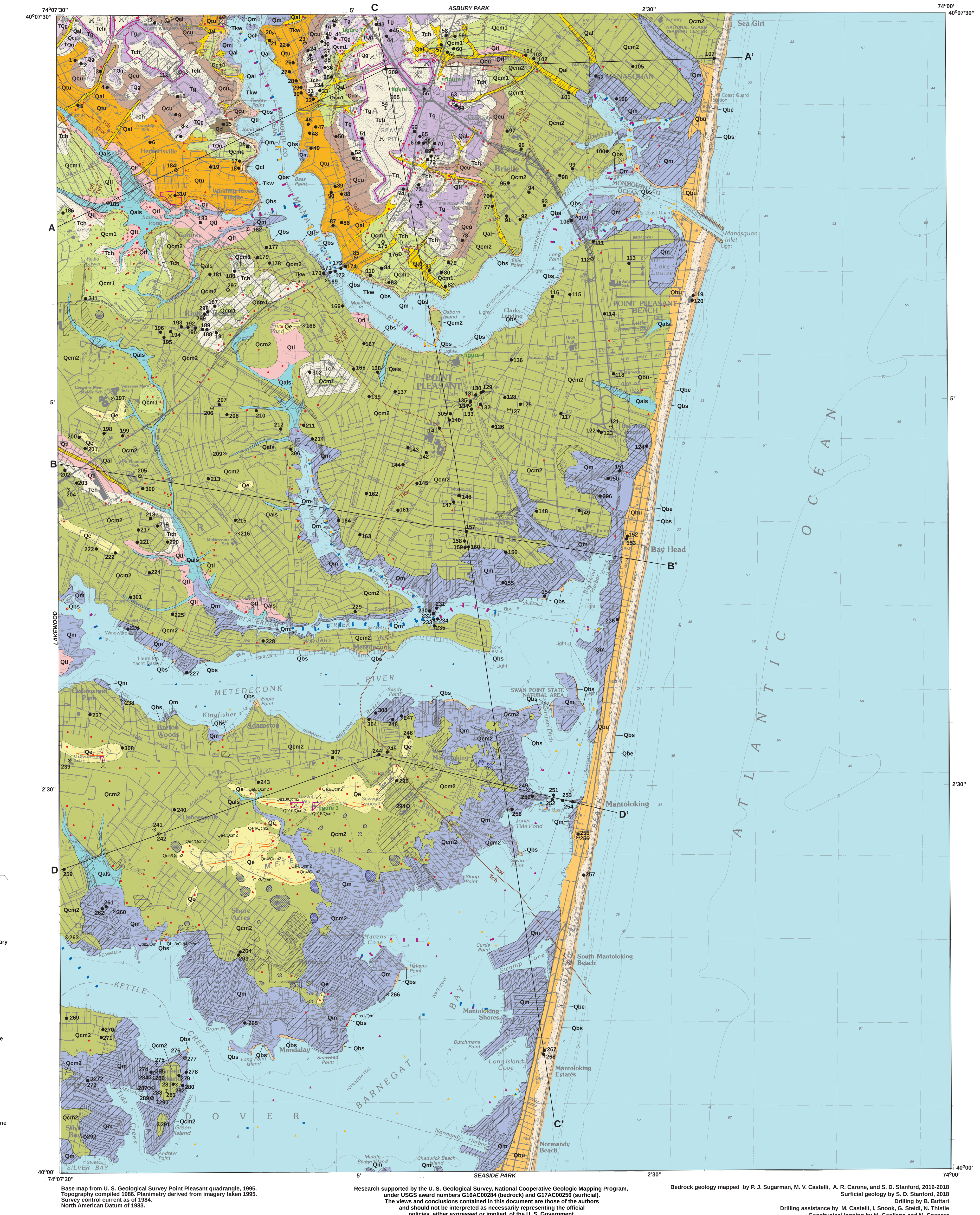


Figure 2. LiDAR hillshade image showing paleodune ridges and relict thermokarst basins on Metedeconk Neck. Dune orientation indicates winds blowing from the north and northwest. Easternmost thermokarst basin is partially covered by tidal-marsh deposits. Blow-out dunes rim basins that may have formed or been enlarged by wind erosion. Location shown on figure 1.



GEOLOGY OF THE POINT PLEASANT QUADRANGLE
MONMOUTH AND OCEAN COUNTIES, NEW JERSEY

by

Scott D. Stanford, Peter J. Sugarman, Michael V. Castelli, and Alexandra R. Carone

2018

Figure 3. Eolian sand (unit Qe) exposed in former sand pit in dune ridge on Metedeconk Neck. Location shown on map and inset.

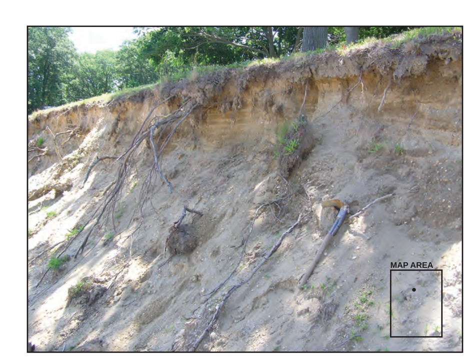


Figure 4. Cape May Formation, unit 2 (unit Qcm2), exposed in bank along Manasquan River. Thin horizontal bedding visible in upper part of bank is typical of tidally influenced deposition. Location shown on map and inset.

Figure 5. Upland gravel, high phase (unit Tg), exposed in former gravel pit west of Brielle. Cross bedding indicates former stream flow to east (right on photo). Photo by Meredith Johnson, N. J. Geological Survey, April 1936. Location shown on map and inset.

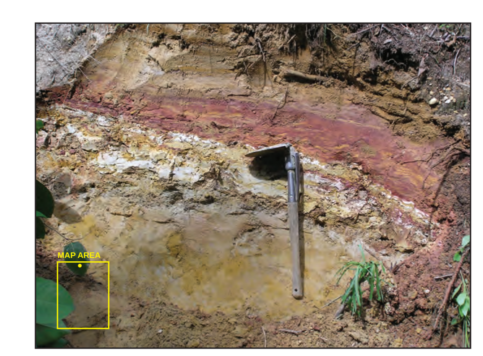


Figure 6. Interbedded clay (white beds) and sand (yellow and red beds) of the Cohansey Formation (unit Tch). Red color in sand above clay marks iron deposition where drainage is impeded. Location shown on map and inset.

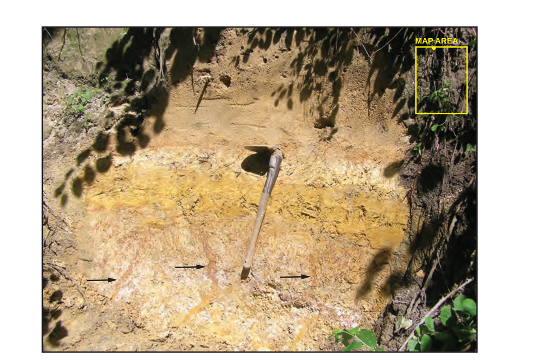
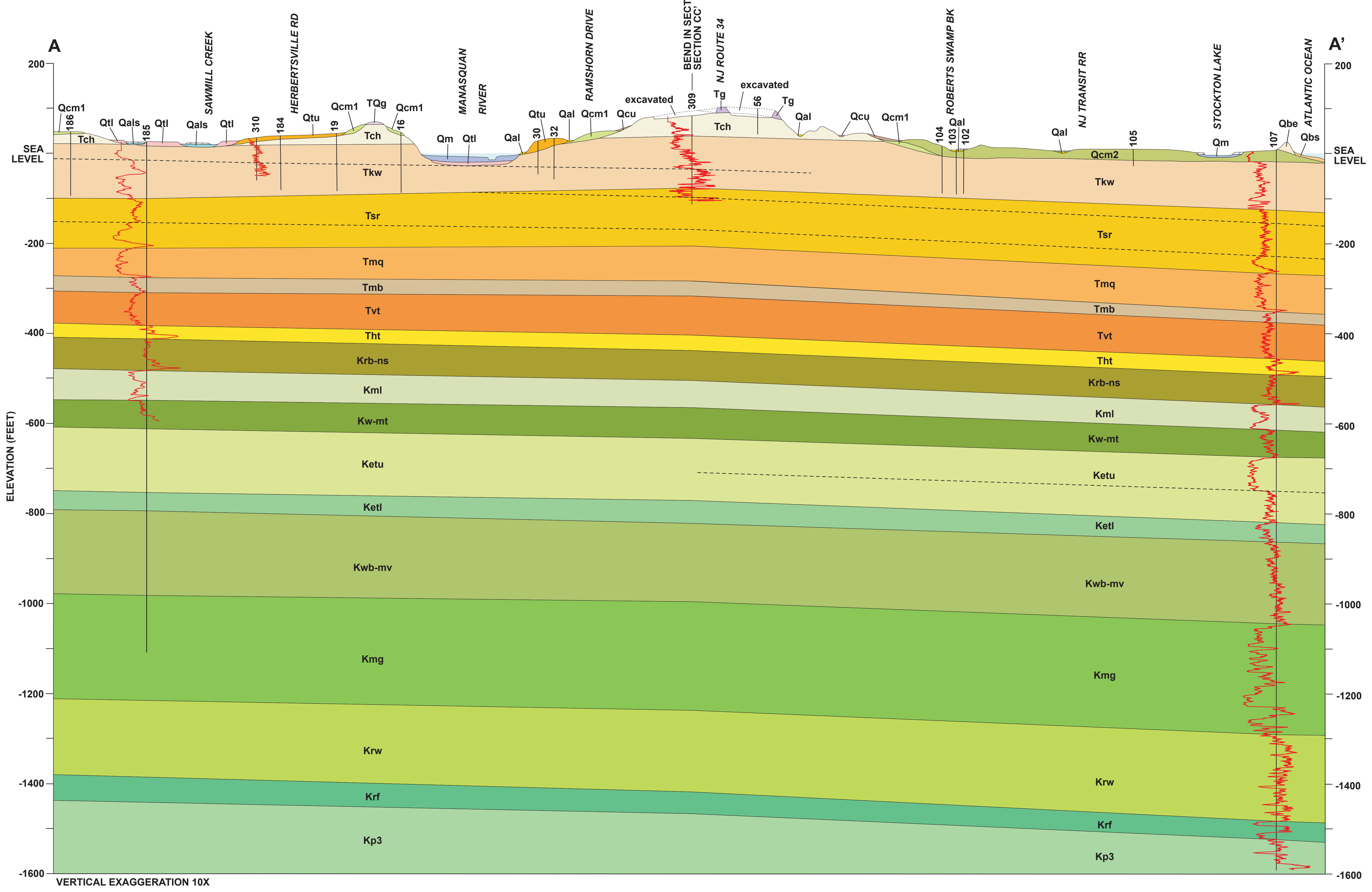
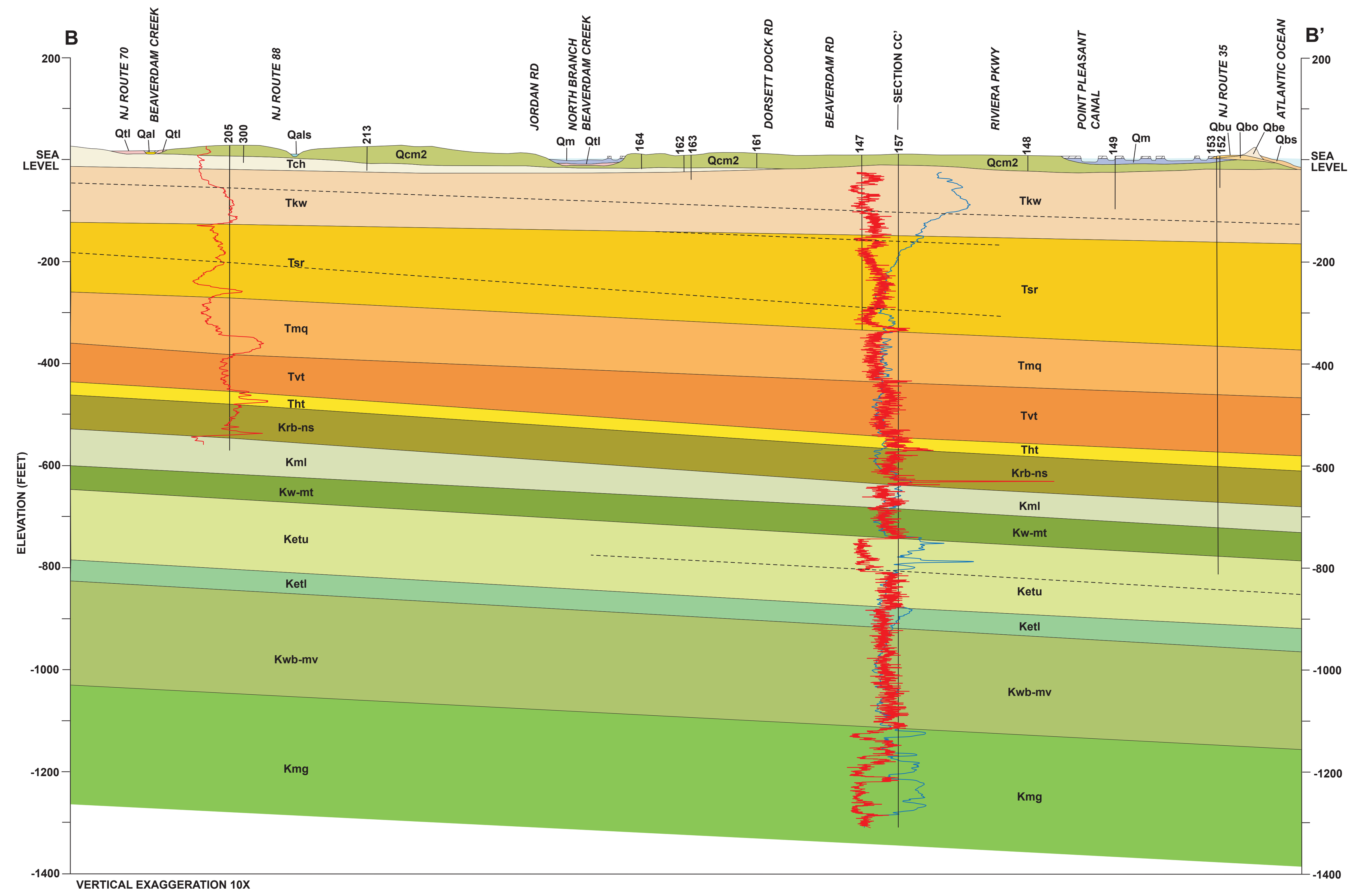
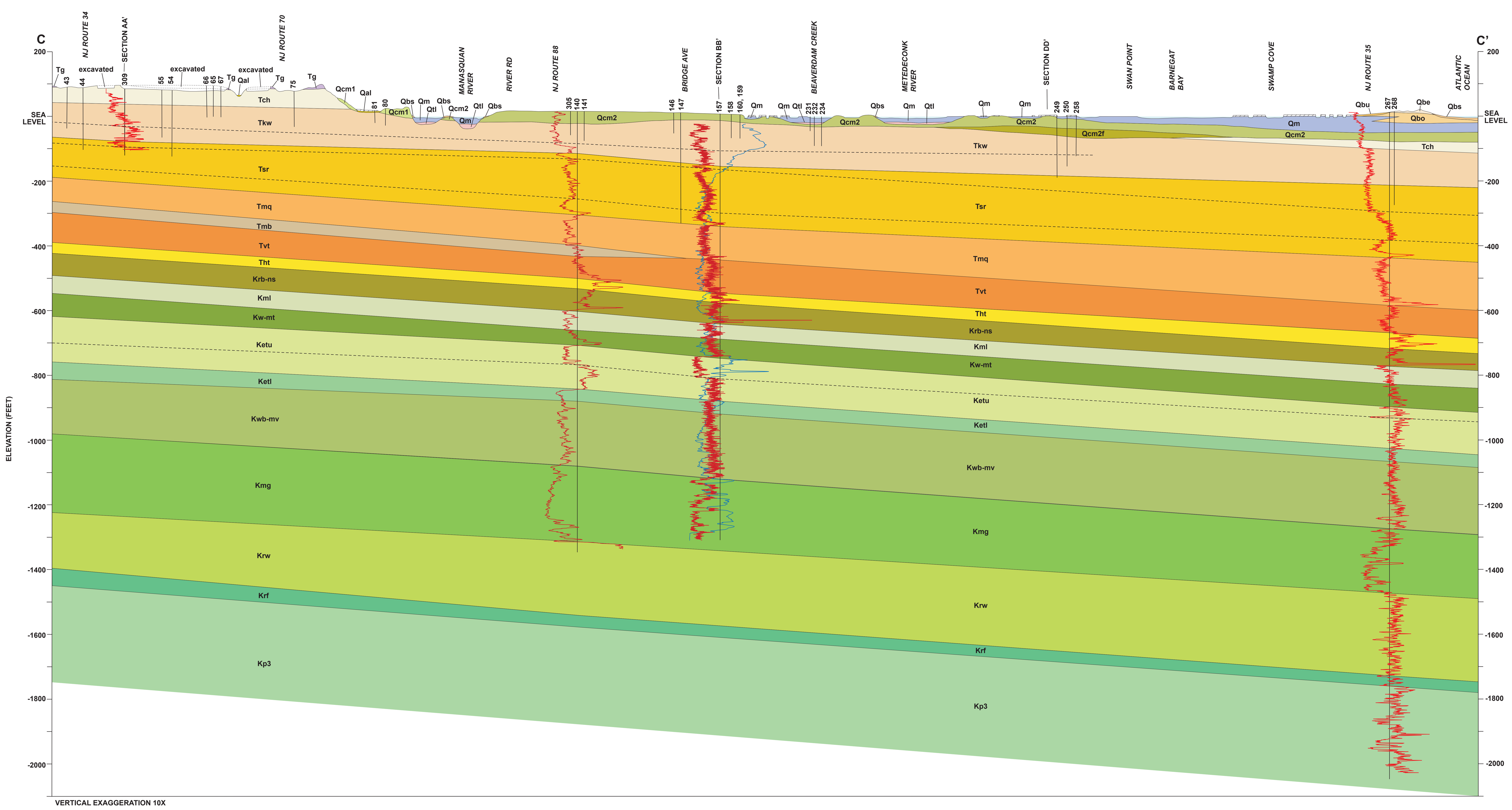
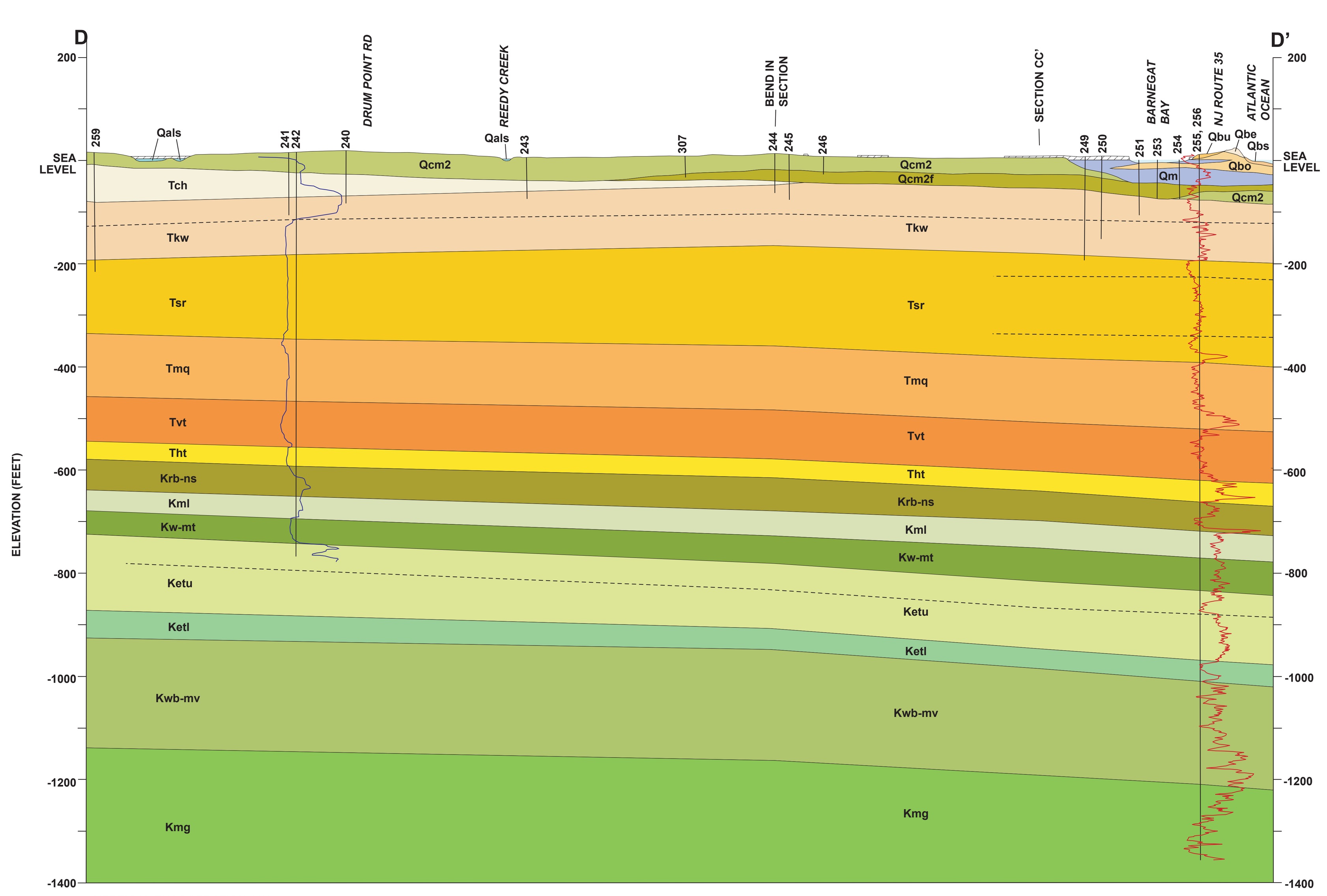


Figure 7. Alluvial sand (unit Qal, above shovel head) over clay of the Cohansey Formation. Subvertical features highlighted by orange color (arrows) below yellow bed may be burrows. Location shown on map and inset.









EXPLANATION OF SYMBOLS

47 — Well or boring—Number refers to listing in table 1.

74 — Well with geophysical log—Gamma-ray log is shown by red line, with radiation intensity increasing to right. Resistivity log is shown by blue line, with resistivity increasing to right.

Tieline—Correlates lithologic units within formations. Refer to unit descriptions on sheet 1.

GEOLOGY OF THE POINT PLEASANT QUADRANGLE MONMOUTH AND OCEAN COUNTIES, NEW JERSEY

SHEET 2: CROSS SECTIONS

by
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2018

HORIZONTAL SCALE 1:24 000

1 — 1/2 — 0 — 1 MILE

1000 — 0 — 1000 — 2000 — 3000 — 4000 — 5000 — 6000 — 7000 FEET

1 — .5 — 0 — 1 KILOMETER

Geology of the Point Pleasant Quadrangle
Monmouth and Ocean Counties, New Jersey

New Jersey Geological and Water Survey
Geologic Map Series GMS 18-5
2018

Pamphlet with tables 1 and 2 to accompany map

Table 1. Selected well and boring records. Footnotes at end of table (p. 7).

Well Number	Identifier[1]	Formations Penetrated[2]
1	14004	22 Q 78 Tchs 81 Tkw
2	18639	4 TQg 41 Tchs 49 Tchc 65 Tchs
3	31445	20 Q 60 Tchs
4	31386	10 Q 40 Tchs+Tchc 75 Tchs
5	20249	42 Q
6	24678	22 Q 40 Tchc 53 Tchs 55 Tkw
7	21902	4 TQg 51 Tchs 75 Tkw
8	2618	10 TQg 60 Tchs 70 Tkw
9	21890	14 Q 73 Tchs 140 Tkw
10	20533	35 Q 120 Tchs 135 Tkw
11	14863	15 fill 49 Tg 70 Tchs
12	23900	4 Tg 65 Tchs
13	15728	34 Q+Tchs 79 Tchs 90 Tkw
14	4410	18 Q 88 Tkw
15	14981	25 Q 135 Tkw
16	17773	60 Q+Tchs 140 Tkw
17	18910	35 Q+Tchs 140 Tkw
18	16249	45 Q+Tchs 120 Tkw
19	12002	72 Q+Tchs 125 Tkw
20	N 29-33-542	34 Q 104 Tkw
21	31568	20 Q 80 Tkw
22	16681	20 Q 40 Q or Tkw 70 Tkw
23	28	56 Q+Tchs 112 Tkw
24	2599	30 Q+Tchs 50 Tchs 89 Tkw
25	2365	25 Q+Tchs 101 Tkw
26	15208	15 Q 75 Tkw
27	30872	20 Q 126 Tkw
28	16614	52 Q+Tkw 75 Tkw
29	19741	30 Q 69 Tkw
30	20572	10 fill 24 Q 74 Tkw
31	20353	18 Q 153 Tkw 155 Tsr
32	20236	11 Q 136 Tkw 138 Tsr
33	18817	44 Q+Tkw 140 Tkw
34	2783	10 TQg+Tchs 39 Tchs+Tchc or Tkw 92 Tkw
35	20121	11 Q 139 Tkw 140 Tsr
36	23568	10 Tg 55 Tchs+Tkw 82 Tkw
37	20294	8 Tg 45 Tchs 130 Tkw
38	20351	30 Tg+Tchs 45 Tchs 125 Tkw

Well Number	Identifier[1]	Formations Penetrated[2]
39	20354	14 Q 26 Tchc 40 Tchs 100 Tkw
40	6038	8 TQg 24 Tchs 45 Tchc+Tchs 55 Tchs 157 Tkw
41	19569	16 TQg 23 Tchc 48 Tchs 154 Tkw
42	21006	10 Tg 25 Tchs 35 Tchc+Tchs 80 Tchs 120 Tkw
43	10603	4 Tg 9 Tchc 17 Tchs+Tchc 35 Tchs 39 Tchc 60 Tchs 128 Tkw
44	16549	3 Tg 23 Tchc 55 Tchs 200 Tkw
45	19264	13 Tg 20 Tchc 65 Tchs 140 Tkw
46	15531	32 Q 135 Tkw
47	14994	35 Q 134 Tkw
48	20482	36 Q 75 Tkw
49	18922	27 Q 53 Tkw
50	22287	44 Q 132 Tkw
51	18649	41 Tg+Tchs 71 Tchs 130 Tkw
52	20531	10 Q 29 Q or Tchs 138 Tkw
53	20330	10 Q 45 Tchs
54	5491	10 Tg+Tchs 30 Tchs+Tchc 50 Tchs 205 Tkw
55	2971	20 Tg+Tchs 40 Tchs+Tchc 148 Tkw
56	13539	25 Tg 27 Tchc 38 Tchs 39 Tchc 59 Tchs
57	16991	2 Q 150 Tkw
58	16533	5 Q 160 Tkw
59	22733	22 Q 152 Tkw
60	17528	4 fill 150 Tkw
61	18577	3 fill 22 Q 145 Tkw
62	15090	5 fill 9 Qm 28 Qcm2 45 Tkw
63	1336	25 Tg+Tchs 45 Tchs 192 Tkw
64	20842	14 Tg 18 Tchc 85 Tchs 95 Tkw
65	10208	20 Tg+Tchs 85 Tchs 98 Tkw or Tchs
66	10487	23 Tg+Tchs 50 Tchs+Tchc 93 Tchs 98 Tkw
67	12388	12 Tg 59 Tchs+Tchc 92 Tchs 94 Tkw
68	15181	30 Tg+Tchs 100 Tchs 125 Tkw
69	23455	4 Tg 17 Tchs 35 Tchs+Tchc 63 Tchs 176 Tkw 180 Tsr
70	23642	4 Tg 17 Tchs 35 Tchs+Tchc 63 Tchs 176 Tkw 180 Tsr
71	14415	20 Q+Tchs 25 Tchs 40 Tchs+Tchc 80 Tchs 116 Tkw
72	17229	18 fill 22 Q 25 Tchc 40 Tchs 54 Tchs+Tchc 137 Tkw
73	5292	8 Tg 119 Tchs 212? Tkw 848 TD
74	24650	33 Tg+Tchs 90 Tchs 115 Tchs+Tchc 197 Tkw 200 Tsr
75	12147	30 Tg+Tchs 50 Tchs 70 Tchs+Tchc 80 Tchs 140 Tkw
76	11444	19 Q 160 Tkw
77	11445	45 Q 140 Tkw
78	12069	5 Q 50 Tchs 60 Tkw
79	11246	19 Q 50 Tkw
80	22865	27 Q 52 Tkw
81	22492	5 Q 40 Tkw
82	22755	10 Q 40 Tchs
83	14302	30 Q 125 Tkw
84	15058	10 Q 40 Tchs+Tchc 140 Tkw
85	3973	39 Q 72 Tkw
86	20531	29 Q 138 Tkw
87	16401	32 Q 132 Tkw
88	20691	30 Q 140 Tkw
89	22470	22 Q 60 Tkw
90	22471	26 Q 120 Tkw
91	12418	21 Q 114 Tkw
92	31688	29 Q
93	29528	30 Q 117 Tkw
94	14995	40 Q 119 Tkw
95	30148	26 Q 60 Tkw

Well Number	Identifier[1]	Formations Penetrated[2]
96	8184	44 Q 68 Q+Tchs 179? Tkw 577 TD
97	69 + N 29-33-648	56 Q 75 Tchs 150 Tkw 792 TD
98	14504	24 Q
99	5328	26 Q 115 Tkw
100	24936	35 Q
101	DOT 234W-5	21 Q 50 Tkw
102	2438	20 Q 124 Tkw
103	13124	17 Q 126 Tkw
104	1004	25 Q 117 Tkw
105	15371	25 Q 36 Tkw
106	3849	9 fill 13 Qm 27 Qcm2 110 Tkw
107	49349, G Sea Girt corehole (Miller and others, 2006)	3 fill 23 Q 140 Tkw 1600 TD
108	22123	12 fill 16 Qm 27 Qtl 140 Tkw 200 Tsr
109	14583	12 fill 16 Qm 27 Qtl 160 Tkw
110	22775	17 Q 80 Tkw
111	24872	24 Q 132 Tkw 617 TD
112	10380	31 Q 80 Tkw
113	27975	28 Q 134 Tkw 157 Tsr
114	28998	33 Q 52 Tkw
115	18723	30 Q 31 Tkw
116	19720	18 Q 40 Tkw
117	29201	20 Q
118	6299	30 Q 167 Tkw 168 Tsr
119	24046	35 Q 37 Tkw
120	24049	32 Q 37 Tkw
121	5089	22 Q 165 Tkw 202 Tsr
122	19415	28 Q 120 Tkw
123	23241	29 Q 177 Tkw 180 Tsr
124	29323	22 Q 47 Tkw
125	26100	28 Q
126	18411	32 Q 80 Tkw
127	10235	35 Q 90 Tkw
128	32030	23 Q 100 Tkw
129	32001	32 Q
130	14834	30 Q 90 Tkw
131	DOT 478W-7	30 Q 56 Tkw
132	56684	35 Q 130? Tkw 800 TD
133	15099	26 Q
134	2857	24 Q 148 Tkw
135	DOT 478W-6	25 Q 55 Tkw
136	25924	28 Q
137	12883	27 Q 50 Tkw
138	23214	17 Q 42 Tkw
139	36930	23 Q 41 Tchs+Tchc 78 Tchs 85 Tkw
140	3345, G + 4530	43 Q 168 Tkw 1414 TD
141	10234	39 Q 40 Tchc 55 Tchs 90 Tkw
142	10233	35 Q 37 Tchc 57 Tchs+Tchc 72 Tchs 80 Tkw
143	23730	35 Q 36 Tchc
144	23548	24 Q
145	26821	26 Q
146	13182	23 Q 65 Tkw
147	32526	20 Q 200 Tkw 341 Tsr

Well Number	Identifier[1]	Formations Penetrated[2]
148	21068	30 Q
149	16733	11 Q 112 Tkw
150	DOT 376W-2	5 fill 6 Qm 10 Qcm2
151	DOT 376W-7	3 fill 7 Qm 10 Qcm2
152	24652	6 Qbu 10 Qm 27 Qcm2 65 Tkw
153	87	20 Q 180 Tkw 825 TD
154	27365	6 fill 9 Qm 25 Qcm2 42 Tkw
155	13158	4 fill 12 Qm 34 Qcm2 75 Tkw
156	28135	4 fill 6 Qm 30 Qcm2 120 Tkw
157	48193, G + 5445 + 49202	23 Q 210 Tkw 1457 TD
158	15003	25 Q 70 Tkw
159	13425	27 Q 72 Tkw
160	13275	25 Q 67 Tkw
161	24917	26 Q
162	11967	30 Q
163	15093	33 Q 35 Tchc 50 Tchs
164	18803	25 Q 30 Tchs
165	30860	17 Q 50 Tkw
166	24782	27 Q 40 Tkw
167	29888	35 Q 36 Tkw
168	485	36 Q
169	4324	28 Q 137 Tkw 180 Tkw or Tsr
170	6404	30 Q 130 Tkw 132 Tsr
171	DOT B2	33 Q 143 Tkw 171 Tsr
172	DOT B8	11 water 29 Qm 38 Qtl 129 Tkw 183 Tsr
173	DOT S4	17 water 21 Qm 47 Qtl 126 Tkw 228 Tsr
174	DOT B22	5 fill 11 Qm 31 Qcm2 145 Tkw 171 Tsr
175	8953	32 Q+Tchs 56 Tchs
176	17152	13 Q 35 Tchs 124 Tkw
177	466	18 Q 63 Tkw
178	298	12 Q 33 Tkw
179	300	15 Q 63 Tkw
180	21387	50 Tchs 80 Tkw
181	308	15 Q 63 Tkw
182	5441	44 Q 97 Tkw
183	21148	16 Q 82 Tkw
184	12630	37 Q+Tchs 122 Tkw
185	2956, G	8 Q 140? Tkw 1145 TD
186	28845	10 Q 40 Tchs 142 Tkw
187	413	30 Tchs 10 Tchc 66 Tchs
188	258	46 Tchs+Tchc
189	257	47 Tchs+Tchc
190	369	24 Q+Tchs 34 Tchc 45 Tchs
191	368	20 Tchs 32 Tchc 45 Tchs
192	354	20 Tchs 30 Tchc 43 Tchs
193	371	20 Q+Tchs 30 Tchc 44 Tchs
194	271	36 Q+Tchs+Tchc
195	410	15 Q+Tchs 25 Tchc 37 Tchs
196	543	10 Q+Tchs 21 Tchc 40 Tchs
197	6022 + 5946	30 Q 40 Qcm2f or Tchc 68 Tchs 158 Tkw 586 TD
198	21473	20 Q 70 Tchs
199	20711	51 Q+Tchs
200	24919	40 Q+Tchs
201	24634	36 Q+Tchs
202	10787	50 Q+Tchs 62 Tchs 63 Tchc or Tkw
203	23286	14 Q 85 Tchs 90 Tkw

Well Number	Identifier[1]	Formations Penetrated[2]
204	3076	14 Q 84 Tchs 178 Tkw 590 TD
205	4283, G	20 Q 60 Tchs 180 Tkw 591 TD
206	302	15 Q 20 Tchc 30 Tchs 32 Tchc 38 Tchs
207	395	9 Q 11 Tchc 43 Tchs
208	17024	12 Q 55 Q+Tchs 165 Tkw 172 Tsr
209	25005	17 Q 21 Tchc 33 Tchs 35 Tchc 55 Tchs
210	24822	17 Q 21 Tchc 38 Tchs+Tchc 55 Tchs
211	26085	6 Q 65 Tchs 125 Tkw 162 Tkw or Tsr 175 Tsr
212	17547	8 Q 54 Tchs
213	20878	32 Q 47 Tchs
214	13537	4 fill 10 Qm 24 Qcm2 35 Qcm2 or Tchs 42 Tchc+Tchs 56 Tchs
215	32105	32 Q 45 Tchc+Tchs or Q 55 Tchs
216	4420	67 Q+Tchs 67 Tchc or Tkw
217	23886	6 Q 26 Tchc+Tchs 52 Tchs
218	23898	5 fill 10 Q+Tchs 15 Tchc+Tchs 30 Tchc 52 Tchs
219	23969	15 Q+Tchs 30 Tchs 46 Tchc 58 Tchs
220	22822	15 Q+Tchs 45 Tchc 56 Tchs
221	23887	12 Q+Tchs 26 Tchs 38 Tchc 53 Tchs
222	20352	10 Q 20 Tchs 40 Tchs+Tchc 70 Tchs
223	15059	20 Q 30 Tchs+Tchc 70 Tchs
224	31316	10 Q 59 Tchs
225	32413	20 Q 45 Tchs+Tchc 77 Tchs
226	23890	3 fill 11 Qm 20 Qcm2
227	3637	8 fill 32 Qm over Qtl 72 Tchs 149 Tkw
228	12825	43 Q 54 Tchc 70 Tchs
229	5192	65 Q over Tchs 77 Tchs 164 Tkw
230	22276	8 fill 13 Qm 31 Qcm2 52 Tchs 141 Tkw 150 Tsr or Tkw
231	DOT B5	15 fill 35 Qm 42 Qtl+Qcm2 52 Tkw
232	DOT B7	31 fill 32 Qm 41 Qtl+Qcm2 102 Tkw
233	DOT B8	4 water 9 Qm 13 Qtl+Qcm2 102 Tkw
234	DOT B9	4 water 20 Qm 32 Qtl+Qcm2 92 Tkw
235	DOT B11	37 Qcm2 102 Tkw
236	22100	17 Qbu 56 Qm 100 Tkw
237	20032	20 Q 35 Tchc 53 Tchs 57 Tchc
238	4444	4 fill 25 Qm 35 Qcm2
239	2328	62 Q+Tchs 192? Tkw 528 TD
240	5484	45 Q 68 Tchc 70 Tchs 100 Tkw
241	6701	35 Q 69 Tchs 125 Tkw
242	2875, R	45 Q 82? Tchs 202 Tkw 786 TD
243	7753	42 Q 65 Tchc+Tchs 69 Tchs
244	29727	25 Qcm2 50 Qcm2f 75 Tchs
245	2279	28 Qcm2 58 Qcm2f 87 Tchs
246	29941	30 Qcm2 31 Qcm2f
247	13179	6 fill 11 Qm 35 Qcm2 62 Qcm2f 90 Tkw
248	16334	3 fill 9 Qm 24 Qcm2 65 Qcm2f 100 Tkw
249	19140	14 fill 22 Qm 30 Qcm2 60 Qcm2f 200 Tkw
250	3494	28 Qm 48 Qcm2 70 Qcm2f 160 Tkw
251	24254	9 water 21 Qbo 50 Qm 71 Qcm2f 109 Tkw
252	24253	7 water 19 Qbo 44 Qm 77 Qcm2f
253	24255	7 water 19 Qbo 44 Qm 77 Qcm2f
254	24257	5 water 10 Qm 16 Qbo 26 Qm+Qbo 49 Qm 76 Qcm2f
255	1325 + 3142, G	33 Qbu over Qbo 75 Qm+Qcm2 185 Tkw 1465 TD
256	681	8 Qbu 17 Qm 29 Qbo 40 Qm 45 Qcm2 83 Qcm2f 215 Tkw 400 TD
257	11951 + 11952	9 Qbu 20 Qbo+Qm 35 Qbo 72 Qm+Qcm2f 80 Tkw or Qcm2
258	21587	3 fill 8 Qm 20 Qcm2 63 Qcm2f 67 Qcm2 123 Tkw
259	15645	23 Q 49 Tchs 82 Tchs+Tchc 98 Tchs 207 Tkw 230 Tsr
260	5331	3 fill 10 Qm 58 Qcm2 76 Tchs 79 Tchc 101 Tchs 113 Tchs 205 Tkw

Well Number	Identifier[1]	Formations Penetrated[2]
261	5549	3 fill 12 Qm 55 Qcm2 87 Tchs 200 Tkw
262	5521	5 fill 20 Qm 40 Qcm2 64 Tchs 80 Tchc 89 Tchs 108 Tchs+Tchc 185 Tkw 189 Tsr?
263	4463	50 Q 103 Tchs 187 Tkw 195 Tsr?
264	2938	50 Q+Tchs 200 Tkw 210 Tsr
265	9817	5 fill 10 Qm 20 Qcm2 35 Qcm2f 60 Qcm2
266	5885	45 Qm 65 Qcm2f 78 Qcm2
267	24348 + 25859, G	20 Qbu+Qm 28 Qbo 58 Qm 100 Qcm2+Tchs+Tchc 205 Tkw 2250 TD
268	29267	30 Qbu+Qm 62 Qm 103 Qcm2+Tchs+Tchc 206 Tkw 275 Tsr
269	17606	24 Qcm2 30 Qcm2f 57 Tchs 112 Tkw
270	16212	68 Qcm2 75 Qcm2f
271	19257	24 Qcm2 68 Qcm2+Qcm2f 79 Tchs 100 Tkw
272	759	15 fill 21 Qm 60 Qcm2 80 Qcm2f 112 Tchs 160 Tkw
273	2732	10 fill 20 Qm 93 Qcm2+Qcm2f 215 Tkw
274	5391	2 fill 6 Qm 39 Qcm2 45 Qcm2f 55 Qcm2 57 Qcm2f 81 Tchs 175 Tkw
275	76	61 Qcm2 66 Qcm2f 93 Tchs 210 Tkw
276	1327	48 Qcm2 60 Tchs 212 Tkw
277	724	2 fill 6 Qm 18 Qcm2 39 Qcm2f 72 Qcm2+Qcm2f 164 Tkw
278	53	3 fill 8 Qm 30 Qcm2 93 Qcm2 or Tchs 112 Tchs 165 Tkw
279	4896	50 Qcm2 60 Tchs+Tchc 218 Tkw
280	5396	79 Qcm2 118 Tchs 170 Tkw
281	30623	65 Qcm2 90 Tchs 103 Tchs+Tchc 233 Tkw 290 Tsr
282	385	30 Qcm2 50 Qcm2f 70 Tchs 85 Tchc 109 Tchs 120 Tchc or Tkw 214 Tkw
283	1648	50 Qcm2 60 Qcm2f+Qcm2 130 Tchs+Tkw 170 Tkw
284	516	3 fill 7 Qm 59 Qcm2 78 Qcm2f 131 Tchs+Tkw 167 Tkw
285	1191	40 Qcm2 60 Qcm2f 70 Qcm2 140 Tchs+Tkw 169 Tkw
286	714	3 fill 7 Qm 20 Qcm2 35 Qcm2f 69 Qcm2+Tchs 167 Tkw
287	1137	4 fill 15 Qm 56 Qcm2+Qcm2f 71 Tchc 86 Tchs 171 Tkw
288	1116	15 Qm 50 Qcm2 56 Qcm2+Qcm2f 96 Tchs+Tchc 173 Tkw
289	172	25 Qcm2 40 Qcm2f 50 Tchs 67 Tchc 88 Tchs 164 Tkw
290	47	40 Qm 50 Qcm2 63 Tchs 166 Tkw
291	1329	4 Qcm2 20 Qcm2+Qcm2f 38 Qcm2f 50 Qcm2 65 Qcm2+Qcm2f 90 Tchs 168 Tkw
292	57	10 Qm 50 Qcm2 83 Qcm2f 130 Tchs 250 Tkw 321 Tsr
293	34306	5 fill+Qm 25 Qcm2 30 Qcm2f 50 Tchs
294	42972	26 Qcm2 40 Qcm2f
295	42973	30 Qcm2 45 Qcm2f 60 Tchs
296	15080	5 fill 7 Qm 20 Qcm2 22 Qcm2f
297	559	19 Q+Tchs 27 Tchc 36 Tchs
298	344	30 Tchs 38 Tchc 47 Tchs
299	305	35 Tchs 45 Tchc 50 Tchs
300	540	15 Q+Tchs 23 Tchc 34 Tchs
301	6103	20 Q 45 Tchc+Tchs 56 Tchs
302	2770	36 Tchs
303	16713	21 Qcm2 62 Qcm2f 100 Tkw
304	26086	20 Qcm2 64 Qcm2f 82 Tkw
305	USGS Point Pleasant 3	28 Q 71 Tkw
306	USGS Point Pleasant 2	8 Q 24 Q+Tchs 26 Tkw
307	USGS Point Pleasant 1	32 Qcm2 41 Qcm2f
308	26099	24 Q 27 Tchs 34 Tchs+Tchc 46 Tchc 52 Tchs+Tchc 56 Tchs
309	40257, G	80 Tchs 197 Tkw
310	E201704340, G	9 Q 20 Tchs 100 Tkw
311	E201704341, G	10 Q 55 Tchs 83 Tkw

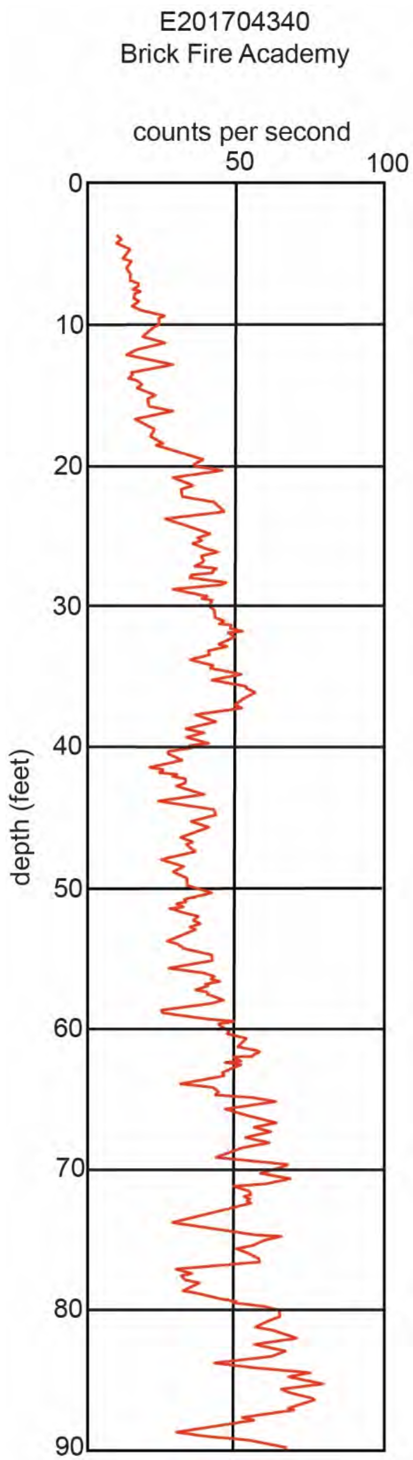
[1]Numbers of the form xxxxx are N. J. Department of Environmental Protection well-permit numbers. All are preceded by the prefix "29-." A "+" indicates that two or more wells were drilled at same location. Numbers of the form E20170xxxx are also N. J. Department of Environmental Protection well-permit numbers. Numbers of the form N xx-xx-xxx are Atlas Sheet Coordinate locations for entries in the N. J. Geological and Water Survey permanent note collection. Identifiers prefixed by "DOT" are bridge borings from the N. J. Department of Transportation, accessed at http://www.state.nj.us/transportation/refdata/geologic/. Identifiers prefixed by "USGS" are auger borings drilled in cooperation with the U. S. Geological Survey during a statewide geologic mapping program in the 1990s. The Sea Girt corehole (well 107) is a stratigraphic research corehole with detailed information available in the cited reference. A "G" following the identifier indicates that a gamma-ray log is available for the well; an "R" indicates that a resistivity log is available for the well.

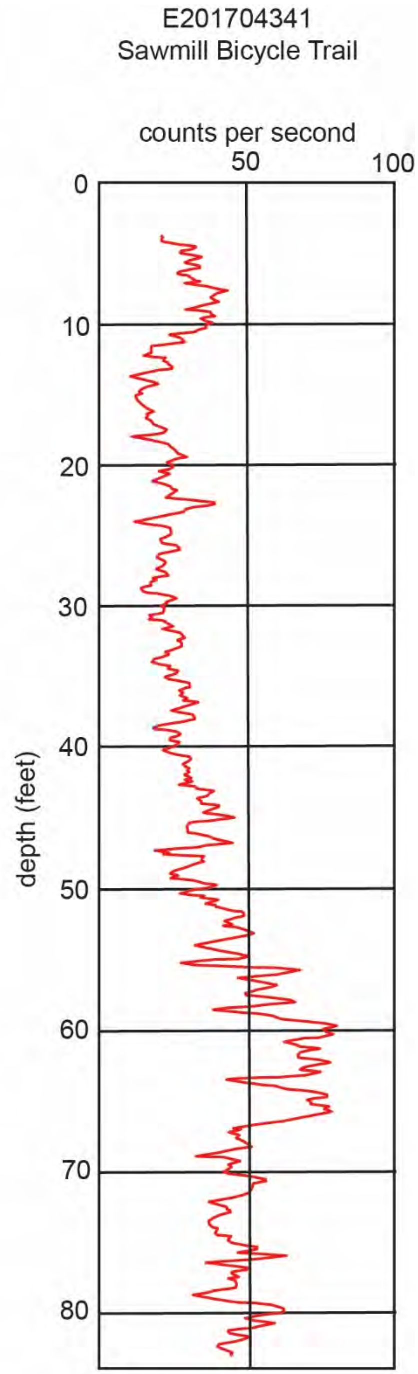
[2]Number is depth (in feet below land surface) of base of unit indicated by abbreviation following the number. Final number is total depth of well rather than base of unit. For example, "12 Q 34 Tchc 62 Tchs" indicates Q from 0 to 12 feet below land surface, Tchc from 12 to 34 feet, and Tchs from 34 to bottom of hole at 62 feet. Units are inferred from drillers' or geologists' lithologic descriptions on well records filed with the N. J. Department of Environmental Protection, or provided in the cited publications, and from geophysical well logs. Formation abbreviations and the corresponding drillers' descriptive terms used to infer the formation are: Q = Quaternary surficial deposits, undifferentiated (units Qtu, Qtl, Qals, Qal, Qcu, Qcl, Qcm1, Qcm2) = yellow, white, tan, brown, gray sand and gravel, minor silty and clayey sand. TQg, Tg = upland surficial deposits = yellow, brown, white, gray sand, silty sand, and gravel. Quaternary surficial units along the bayshore and oceanfront are differentiated as follows: Qcm2, Qbo, Qbe, Qbs, Qbu = yellow, brown, gray, white sand and gravel, Qm = peat, meadow mat, meadow mud, sod, organic mud, and gray to brown mud, Qcm2f = gray to brown clay, silt, fine sand, marl, soft clay, minor peat and vegetation. Bedrock formations are: Tchs = white, yellow, gray, brown (minor red, orange) fine, medium, and coarse sand (and minor fine gravel) of the Cohansey Formation; Tchc = yellow, white, gray (minor red, orange) clay, silty clay, and sandy clay of the Cohansey Formation; Tkw = gray and brown clay, hard clay, silt, fine sand, medium sand, clayey sand, "marl", minor white, yellow, and red coarse sand, of the Kirkwood Formation; Tsr = green clay and sand, glauconite clay and sand. A "+" sign indicates that units are mixed, interbedded, or cannot be separately identified from the information provided in the log for that depth interval. "TD" indicates total depth of deep wells for which units below the Kirkwood Formation are not listed. Typically, drilling methods and lithologic descriptions are not sufficiently detailed to identify formations below the Kirkwood from the lithologic descriptions alone. Refer to cross sections for deeper formations in these wells, as identified from geophysical well logs. Units shown for wells may not match the map and sections due to variability in drillers' descriptions and the similar lithology of the surficial deposits, Cohansey Formation, and Kirkwood Formation.

Table 2. Lithologic logs of test borings. Gamma-ray logs after table (p. 10).

N. J. permit number and identifier	Lithologic log	
	Depth (feet below land surface)	Description (map unit assignment in parentheses) Color names from Munsell Color Company (1975)
E201704340 well 310 (Brick Fire Academy)	0-5	medium to very coarse quartz sand, trace fine sand and granules; grayish orange (10 YR 7/4) to dark yellowish orange (10 YR 6/6) (Qtu)
	5-10	fine to medium quartz sand, tr. coarse sand and granules, poorly sorted; dark yellowish orange (10 YR 6/6) (Qtu to 9 based on gamma log)
	10-15	medium to coarse quartz sand, occasional granules, trace fine sand, moderately sorted; grayish orange (10 YR 7/4) (Tch)
	15-20	medium to coarse quartz sand, trace very coarse sand, 1-2% opaque heavy minerals; moderate yellowish brown (10 YR 5/4) (Tch)
	20-25	fine to medium sand, some coarse, trace granules, 1% opaque heavy minerals; grayish orange (10 YR 7/4) (Tch)
	25-30	medium to very coarse coarse quartz sand, some quartz granules, rare mica, 1% heavy minerals, wet; moderate yellowish brown (10 YR 5/4) (Tch)
	30-35	fine sand, some very fine and medium, slightly silty, 2-3% heavy minerals; dark yellowish orange (10 YR 6/6) (Tkw, gamma log shows contact with Tch at 20)
	35-40	very fine to fine sand, well sorted, 3-4% opaque heavy minerals; dark yellowish orange (10 YR 6/6) to moderate yellowish brown (10 YR 5/4) (Tkw)
	40-45	silty fine sand, occasional granule, slightly micaceous, 3% opaque heavy minerals, well sorted; dark yellowish orange (10 YR 6/6) to moderate yellowish brown (10 YR 5/4) (Tkw)
	45-50	silty fine sand, occasional granule, slightly micaceous, 3% opaque heavy minerals, well sorted; dark yellowish orange (10 YR 6/6) to moderate yellowish brown (10 YR 5/4); on auger when pulled up: silty very fine to fine sand, slightly micaceous; pale yellowish brown (10 YR 6/2) (Tkw)
	50-55	silty fine sand, occasional granule, slightly micaceous, 3% opaque heavy minerals, well sorted; dark yellowish orange (10 YR 6/6) to moderate yellowish brown (10 YR 5/4) (Tkw)
	55-60	silty fine sand, occasional granule, slightly micaceous, 3% opaque heavy minerals, well sorted; dark yellowish orange (10 YR 6/6) to moderate yellowish brown (10 YR 5/4) (Tkw)
	60-65	clayey very fine to fine sand, micaceous, with finely disseminated organic material; dark yellowish brown (10 YR 7/2) (Tkw)
	65-70	silty very fine to fine sand, micaceous, 2-3% heavy minerals, moderately sorted; moderate yellowish brown (10 YR 5/4) (Tkw)
	70-75	silty fine sand, slightly micaceous (muscovite), 2-3% opaque heavy minerals; moderate yellowish brown (10 YR 5/4) (Tkw)
	75-80	silty very fine to fine sand, slightly micaceous (muscovite), 2-3% opaque heavy minerals; moderate yellowish brown (10 YR 5/4) (Tkw)
	80-85	on auger when pulled up: clayey very fine sand, micaceous, with finely disseminated organic material; dark yellowish brown (10 YR 7/2) (Tkw)
	85-90	clay-silt, micaceous, with finely disseminated organic material; dark yellowish brown (10 YR 7/2) (Tkw)
	90-95	fine sand, micaceous, 1-2% heavy minerals; well sorted; moderate yellowish brown (10 YR 5/4) (Tkw)
	95-100	fine sand, micaceous, 1-2% heavy minerals; well sorted; moderate yellowish brown (10 YR 5/4) (Tkw)

E201704341 well 311 (Sawmill Bicycle Trail)	0-5	peaty very fine to fine quartz sand, some roots; dark yellowish brown (10 YR 2/2) (Qcm1)
	5-10	silty somewhat organic fine to medium quartz sand, tr. coarse sand, 2% very fine opaque heavy minerals?, pale yellowish brown (10 YR 6/2) to dark yellowish brown (10 YR 2/2) (Qcm1)
	10-15	silty very fine to fine sand, some ironstone laminae and thin beds; dark yellowish brown (10 YR 4/2) (Tch but Tkw-like composition to 45)
	15-20	silty very fine to fine sand, 1-2% opaque heavy minerals; pale yellowish brown (10 YR 6/2) (Tch)
	20-25	peaty clay-silt, trace granules, micaceous; dusky yellowish brown (10 YR 2/2) weathering to dark yellowish brown (10 YR 4/2) (Tch)
	25-30	silty very fine to fine quartz sand, some medium, trace mica, 1% heavy minerals; pale yellowish orange (10 YR 8/6) to dark yellowish orange (10 YR 6/6) (Tch)
	30-35	silty fine sand, some very fine and medium, slightly micaceous, 2% heavy minerals; grayish orange (10 YR 7/4) (Tch)
	35-40	silty fine sand, some very fine and medium, slightly micaceous, 2% heavy minerals; grayish orange (10 YR 7/4) (Tch)
	40-45	fine sand, some very fine, slightly micaceous, 2% heavy minerals; very pale orange (10YR 8/2) to grayish orange (10 YR 7/4) (Tch)
	45-50	fine sand, some very fine and medium, slightly micaceous, 1% opaque heavy minerals; pale yellowish brown (10 YR 6/2) (Tch)
	50-55	medium to very coarse quartz sand, poorly sorted; moderate yellowish brown (10 YR 5/4) (Tch)
	55-60	medium to very coarse quartz sand, poorly sorted, slightly micaceous, 2% opaque heavy minerals, grayish orange (10 YR 7/4) to moderate yellowish brown (10 YR 5/4) (Tch from 50-55 interval, gamma log indicates Tkw at 55)
	60-65	medium to very coarse quartz sand, poorly sorted, some granules; pale yellowish brown (10 YR 6/2) (Tch from 50-55 interval, gamma log indicates Tkw below 55)
	65-70	very fine to fine sand, some medium, trace granules, 2% heavy minerals, moderately sorted; grayish orange (10 YR 7/4) (Tkw)
	70-75	silty very fine to fine sand, trace mica; dark yellowish brown (10 YR 4/2)
	75-80	silty fine sand, some finely disseminated organic matter, trace mica; dark yellowish brown (10 YR 4/2) (Tkw)
	80-85	silty very fine sand, some finely disseminated organic matter, trace mica; dusky yellowish brown (10 YR 2/2) (Tkw)
	85-90	clay-silt, micaceous, with finely disseminated organic material; dusky yellowish brown (10 YR 2/2) (Tkw)


E201704340
Brick Fire Academy
counts per second
50
100
0
10
20
30
40
50
60
70
80
90
depth (feet)


E201704341
Sawmill Bicycle Trail
counts per second
50
100
0
10
20
30
40
50
60
70
80
depth (feet)