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INTRODUCTION

The Forked River and Barnegat Light quadrangles are in the Barnegat Bay region of the New Jersey Coastal Plain, in the southeastern part of the state. Geologic materials in the map area include surficial deposits of late Miocene to Holocene age that overlie the Cohansey and Kirkwood formations, which are marginal marine deposits of early to late Miocene age. The surficial deposits include marine, estuarine, river, wetland, hillslope, and windblown sediments. The Kirkwood Formation was deposited in marine-delta and shallow-shelf settings in the early and middle Miocene. The Cohansey Formation was deposited in coastal settings in the middle and late Miocene, when sea level was at times more than 200 feet higher in this region than at present. As sea level lowered after deposition of the Cohansey, rivers flowing on the emerging Coastal Plain deposited gravel. Continued lowering of sea level caused streams to erode into the gravel and the underlying Cohansey Formation. During the latest Miocene, Pliocene, and Pleistocene, about 8 million years ago (8 Ma) to 20,000 years ago (20 ka), stream and hillslope sediments were deposited in several stages as valleys were progressively deepened by stream incision, and widened by seepage erosion, in step with lowering sea level. During at least two interglacial periods in the middle and late Pleistocene, when sea level was higher than at present, marine and estuarine sediments were laid down in terraces that parallel the modern shoreline. Most recently, salt-marsh, estuarine, and beach deposits were laid down during Holocene sea-level rise, within the past 10 ka.

A brief summary of the stratigraphy and depositional settings of the Kirkwood and Cohansey 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) lists the formations penetrated in selected wells and test borings, as interpreted from drillers' lithologic descriptions and geophysical logs.

The cross sections show materials to a depth of 300 to 400 feet, which includes the Cohansey Formation and the upper half of the Kirkwood Formation. This depth includes water-producing sands in the Cohansey Formation, which supply most domestic wells and three public-supply wells (wells 136, 247, 257 in table 1) in the map area, and two aquifer sands in the Kirkwood Formation which supply ten public supply wells (wells 8, 9, 102, 103, 104, 206, 230, 237, 240, and 252). Several wells and test holes in the map area penetrated below this depth (wells 40, 108, 109, 206, 213, 246, 253, 257, 260, 261, 268, 269, and 270). Well 260 penetrated the entire Coastal Plain section and drilled into biotite gneiss basement rock from 3862 to 3891 feet below land surface (Gill and others, 1963). Formations below an elevation of -300 feet are described in Gill and others (1963), Zapecza (1989) Miller and others (1994), and Owens and others (1998).

KIRKWOOD FORMATION

The Kirkwood Formation (Tkw) above elevation -300 feet in the map area consists of five marine-delta and shallow-shelf units as described in the Island Beach corehole (well 261) (Miller and others, 1994). These units can be traced through the map area from geophysical well logs (see tielines on sections). The uppermost Kirkwood unit in the corehole (unit 1 of Miller and others, 1994) is an interbedded clay and sand that lacks definitive age control and is here placed in the Cohansey Formation, based on the elevation of the Cohansey-Kirkwood contact in mainland wells (between -90 and -130 feet) and its lithologic similarity to the Cohansey. Unit 2 in the corehole is a uniform gray to grayish-brown marine clay that can be traced throughout the map area from geophysical and lithologic logs. It is as much as 40 feet thick (possibly 70 feet thick in the corehole) and marks the top of the Kirkwood as identified from well logs, where the transition from interbedded, generally oxidized, medium-to-coarse sands and thin clays in the Cohansey to gray, fine sand and thicker clays in the Kirkwood is taken as the contact. Diatoms in this unit in the Island Beach corehole indicate a late early Miocene age (18-17 Ma) (Miller and others, 1994), corresponding to the Kirkwood 2 sequence of Sugarman and others (1993), or Wildwood Member of Owens and others (1998). Unit 3 is medium-to-coarse sand with minor thin clay beds, as much as 100 feet thick. On the mainland, gamma logs show a clay-over-sand unit (unit 3a on sections) as much as 50 feet thick below the unit 3 sand, although it was not described in the Island Beach corehole. Unit 3 sand is an aquifer. Unit 4 is gray clay with a few thin sand beds and is 20 to 45 feet thick. Unit 5, the lowest unit shown on this map, is sand with a few thin clay beds and silt beds. It is 165 feet thick at Island Beach. Unit 5, like unit 3, is an aquifer. Unit 5 is underlain by another clayey unit in the Island Beach corehole that contains shells giving a strontium stable-isotope age of 21.8 Ma (Miller and others, 1994), placing the clay within the Kirkwood 1 sequence of Sugarman and others (1993), or lower member of Owens and others (1998). The boundary between the Kirkwood 1 and 2 sequences may be at the base of the unit 4 clay (Miller and others, 1994).

COHANSEY FORMATION

The Cohansey Formation consists of stacked successions of beach and shoreface sand (Tchs) overlain by interbedded sand and clay deposited in tidal flats, bays, and coastal swamps (Tchc) (Carter, 1972, 1978). Pollen and dinoflagellates recovered from peat beds in the Cohansey at Legler, about 15 miles northwest of Forked River, indicate a coastal swamp-tidal marsh environment (Rachele, 1976). The Legler pollen (Greller and Rachele, 1983), pollen from a corehole near Mays Landing, New Jersey (Owens and others, 1988), and dinocysts from coreholes in Cape May County, New Jersey (deVerteuil, 1997; Miller and others, 2001), indicate a middle to early late Miocene age for the formation. The Cohansey generally lacks datable marine fossils, particularly in updip areas where it has been weathered. Lower parts of the Cohansey in updip settings like the map area may be age-equivalent to the upper Kirkwood downdip (for example, Kirkwood sequence 2, about 17-15 Ma, and sequence 3, 12-14 Ma) and may be the coastal facies of the Kirkwood shallow-shelf deposits. This facies relationship may account for the westward deepening of the Kirkwood-Cohansey contact, as defined by the transition to thicker, more continuous, marine clays, to the west of the Forked River quadrangle (Stanford, 2010, 2011). The lower Cohansey in this area may be beach and bay facies that correlate to the inner-shelf sediment in Kirkwood sequences 2 or 3 to the east and south, for example, units 2, 3, and 4 of the Kirkwood in the Island Beach corehole.

In the map area, clays in the Cohansey are in thin beds or laminas generally less than 6 inches thick, and are always interbedded with sand. In outcrop, they are oxidized and multicolored but, in the subsurface, dark organic clays are reported in a few drillers' logs. Clayey strata are generally less than 35 feet thick. In outcrop, some can be traced as far as two miles, and, in the subsurface, some beds are traceable as far as four miles. The western edge of the map area (sections CC', BB') includes the east termini of clay beds that can be traced updip to the west for more than 12 miles in the Brookville and Woodmansie quadrangles (Stanford 2010, 2011). The laminated bedding and thin but areally extensive geometry of the clayey beds are indicative of bay or estuarine intertidal settings. Alluvial clays generally are thicker and more areally restricted because they are deposited in flood plains and abandoned river channels. The repetitive stacking of bay clays and beach sand (chiefly tidal-delta and shoreface deposits) indicates that the Cohansey was deposited during several rises and falls of sea level during a period of overall rising sea level.

SURFICIAL DEPOSITS AND GEOMORPHIC HISTORY

Sea level in the New Jersey region began a long-term decline following deposition of the Cohansey Formation. As sea level lowered, the inner continental shelf emerged as a coastal plain. River drainage was established on this plain. The Beacon Hill Gravel, which caps the highest elevations in the Coastal Plain, is the earliest record of this drainage. It is absent in the map area but caps elevations above 165 to 180 feet to the west of the map area in the Brookville and Woodmansie quadrangles, and likely extended into the map area before being eroded in the late Miocene. The Beacon Hill is quartz-chert gravel deposited by rivers draining southward from the Valley and Ridge province in northwestern New Jersey and southern New York (Stanford, 2009). In the Beacon Hill, and in upland gravels reworked from the Beacon Hill, rare chert pebbles containing coral, brachiopod, and pelecypod fossils of Devonian age indicate that some of these rivers drained from north of what is now Kittatinny Mountain, where chert-bearing Devonian rocks crop out.

Continued decline of sea level during the late Miocene and early Pliocene (approximately 8 to 3 Ma) caused the regional river system to erode into the Beacon Hill plain. As it did, it shifted well to the west of the map area into what is now the Delaware River basin. The map area became an upland from which local streams drained eastward to the Atlantic and westward into the regional trunk river. These local streams eroded shallow valleys into the Beacon Hill Gravel. Groundwater seepage, slope erosion, and channel erosion reworked the gravel and deposited it in floodplains, channels, and pediments, 40 to 60 feet below the level of the former Beacon Hill plain. These deposits are mapped as Upland Gravel, High Phase (Tg). Today, owing to topographic inversion, they cap ridgetops. Orange arrows on figure 1 show drainage routes of streams at this time, as inferred from the location and elevation of the ridgetop deposits.

Further lowering of sea level in the early Pleistocene (approximately 2 Ma to 800 ka) 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 (TQg) in shallow valleys 20 to 50 feet below the higher gravels. These deposits today cap interfluves and form more extensive mantles in head-of-valley areas and upper slopes. Stream drainage at this time, inferred from interfluve deposits, is shown by green arrows on figure 1.

Continuing incision in the middle and late Pleistocene (about 800 to 20 ka) formed the modern valley network. Fluvial sediments laid down in modern valleys include Upper and Lower Terrace Deposits (Qtu and Qtl), inactive floodplain deposits in dry valleys (Qald), and active floodplain and wetland deposits in valley bottoms (Qals). Like the upland gravels, the terrace, fan, 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 formed by accumulation of organic matter in swamps and bogs.

Upper Terrace Deposits form terraces and pediments 5 to 25 feet above modern wetlands. They were laid down chiefly during periods of cold climate in the middle Pleistocene. During cold periods, permafrost impeded infiltration of rainfall and snowmelt and this, in turn, accelerated groundwater seepage and slope erosion, increasing the amount of sediment entering valleys, leading to terrace deposition. Some of the deposits may have been laid down during periods of temperate climate when sea level was high, because at their seaward limit the upper terraces grade to the Cape May 2 marine terrace (see below). This topographic equivalence indicates that some of the upper terrace deposits aggraded during the Cape May 2 highstand, although the marine terrace appears to be slightly inset into the upper terrace in places, suggesting that it is somewhat younger.

Lower Terrace Deposits (Qtl) form low, generally wet, terraces with surfaces less than 10 feet above modern floodplains within inland valleys, and broader, fan-like deposits where valleys open onto marine terraces along the bayshore. They are of much smaller extent than the upper terraces. They formed from stream and seepage erosion of the Upper Terrace Deposits, probably during or slightly after the last period of cold climate around 25 ka. Dry-valley alluvium (Qald), colluvium (Qc) and inland windblown deposits (Qe) were likely also laid down at this time. Fan-like lower terrace deposits, sourced from several small, steep valleys cut into the upland back from the Cape May 2 terrace near Barnegat, spread out onto the Cape May platform fronting the upland. To the south of Barnegat, in the Ship Bottom quadrangle, similarly positioned sand and gravel deposits overlie an organic silt dated to 34,890±960 (GX-16789-AMS, Newell and others, 1995), indicating deposition of the fans in the late Wisconsinan. Lower terrace deposits similarly spread out onto the Cape May platform at the mouths of Cedar Creek and Lochiel Creek and are likely also of late Wisconsinan age. These deposits were laid down during the last stages of Wisconsinan valley incision into the upper terrace and the Cape May 2 marine terrace. Hachured lines on figure 1 show the extent of this incision. Modern floodplain and wetland deposits (Qals) were laid down within the past 10 ka, based on radiocarbon dates on basal peat in other alluvial wetlands in the region (Buell, 1970; Florer, 1972; Stanford, 2000).

During at least two periods of higher-than-present sea level in the middle and late Pleistocene, beach and estuarine deposits were laid down within valleys and in terraces along the bayshore (fig. 1). These marine deposits are grouped into the Cape May Formation. This formation includes an older, eroded terrace (Cape May Formation, unit 1, Qcm1) with a maximum surface elevation of 70 feet; a more prominent, continuous terrace with a maximum surface elevation of 35 feet (Cape May Formation, unit 2, Qcm2); a platform deposit that slopes gently seaward from the foot of the Cape May 2 terrace (Qcm2p); and fine-grained clay, silt, and fine sand in the subsurface beneath the platform and outer part of the Cape May 2 terrace (Qcm2f, east of dashed purple line on fig. 1). Seismic and vibracore data offshore from Barnegat Inlet and Long Beach Island show that the Cape May platform deposits (chiefly tidal-channel and tidal-delta sands) extend beneath the barrier beaches onto the inner shelf, although the fine-grained deposits do not (Uptegrove and others, 2012). Hydrologically, the fine-grained deposits act as a confining unit for underlying aquifer sands in the Cohansey Formation along the mainland bayshore, where many shallow (<100 feet) domestic wells flowed at the surface when first drilled.

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 oxygen-isotope stage 11, 420 ka, or stage 9, 330 ka) and that the Cape May 2 is of late Pleistocene (Sangamonian) age (stage 5, 125-80 ka). AAR data from vibracores off Long Beach Island indicate that the Cape May there is of Sangamonian age (Uptegrove and others, 2012). Global sea level during stage 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 stage 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 (stage 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) 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 three miles south of Barnegat Inlet, with estuarine clays to the north extending nearly to the inlet, although they do not extend beneath the barrier beaches or Barnegat Bay (Uptegrove and others, 2012).

Modern beach, bay, and salt-marsh deposits were laid down during Holocene sea-level rise, chiefly within the past 10 ka in the map area. As sea level rose, salt-marsh peat and fine-grained bay deposits (Qm) were covered by advancing tidal-delta and barrier overwash sand (Qbo). On the barrier islands, beach (Qbs) and dune (Qbei, Qbeo) 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. The barrier sand-over-fine bay deposits stratigraphy extends seaward from the barrier beaches for a distance of about three miles onto the inner shelf (Uptegrove and others, 2012). Radiocarbon dates on peat in the Island Beach corehole (Miller and others, 1994) at an elevation of -13 feet (4532±58 yrs BP, GX-19018) and at an elevation of -46 feet (5625±170 yrs BP, GX-19017), and on peat in a vibracore in Barnegat Inlet (well 271 in table 1, Wellner, 1990) at an elevation of -42 feet (8810±170 yrs BP, lab number not reported) confirm a Holocene age for these deposits. The Barnegat Inlet and lower corehole peats are both within estuarine mud and so are likely in-situ. Their ages are consistent with the regional sea-level rise curve for New Jersey (Psuty, 1986; Miller and others, 2009). The upper corehole peat is within sand and so may be a clast that has been eroded and redeposited. It lies about 15 feet higher than expected for a tidal-marsh peat of its age.

Present-day sediments in Barnegat Bay consist of tidal-delta and overwash sands forming flats on the bay side of the barrier beaches and extending under the eastern part of the bay. They are overlain in places by thin (<2 feet thick) salt-marsh peat and organic mud. The western part of the bay (west of the dashed black line on fig. 1), adjacent to the salt marsh, is underlain by fine sand, silt, and clay deposited in the bay from mainland sources (Lucke, 1934; Olsen and others, 1980; Psuty, 2004). The tidal delta sands were deposited in part during migration of Barnegat Inlet, which shifted southward about a mile between 1839 (the earliest accurate survey) and 1939, before being stabilized in its present location by jetties (Lucke, 1934; Seabergh and others, 1998). Clam Island, High Bar Island, and the Sedge Islands, and the extensive sandy tidal flats around them, are all part of the Barnegat Inlet flood tidal delta, which extends westward from the inlet across most of the bay south of a line between Oyster Creek and Johnny Allens Cove on Island Beach. More recently, construction of a new jetty on the south side of Barnegat Inlet between 1987-1991 altered tidal flow and sediment movement in the inlet area, causing some shoreline erosion in the bay and significant accretion of sand on the ocean beach just south of the inlet (see 1986 shoreline, fig. 1).

Tide-gauge data show that sea level along the New Jersey coast during the 20th century rose at a rate of 3-4 mm/yr (Miller and others, 2009), of which 1-2 mm/yr is late Holocene (4 ka to 1900 AD) geologic background (Englehart and others, 2009). Based on these values, between 1880 and 1989 sea level here rose between 0.9 and 1.3 feet. This rise caused retreat of the western bayshore by as much as 400 feet, based on the shoreline shown on 1:21,120 scale maps of the N. J. Geological Survey completed c. 1880 (red lines on fig. 1) . The salt marsh likewise advanced landward, although the 1880 maps do not show the marsh limit in sufficient detail to track the advance accurately. Recent advance of the salt marsh is marked by fringes of dead trees along the upland margin of the marsh, and the spread of *Phragmites* reeds onto the upland. Ditching and diking of the marsh, and dredging and filling for residential and commercial development along the bayshore since the middle of the 20th century, have altered tidal flows and shoreline configuration, masking the effects of sea-level rise along much of the remaining natural bayfront.

DESCRIPTION OF MAP UNITS

ARTIFICIAL FILL—Sand, pebble gravel, minor clay and peat; gray, brown, very pale brown, white. In places includes human-made materials such as concrete, asphalt, brick, cinders, and glass. Unstratified to poorly stratified. As much as 15 feet thick. In road and railroad embankments, dams, dikes, infilled pits, filled wetlands, and land made from dredged material in bayfront residential developments.

aft — TRASH FILL—Trash mixed and covered with silt, clay, sand, and minor gravel. As much as 20 feet thick.

Qals — WETLAND AND ALLUVIAL DEPOSITS—Fine-to-medium sand and pebble gravel, minor coarse sand; light gray, yellowish-brown, brown, dark brown; overlain by brown to black peat and gyttja. Peat is as much as 8 feet thick. Sand and gravel are chiefly 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.

Qm — SALT-MARSH AND ESTUARINE DEPOSITS—Peat, clay, silt, fine sand; brown, dark brown, gray, black; minor medium-to-coarse sand and pebble gravel. Contains abundant organic matter and shells. As much as 40 feet thick; deposits at the surface along the eastern bayshore are generally less than 2 feet thick and overlie unit Qbo. Deposited in salt marshes, tidal flats, and bays during Holocene sea-level rise, chiefly within the past 9 ka in the map area.

BARRIER-BEACH DEPOSITS—Sand and minor gravel deposited by waves (Qbs), wind (Qbei, Qbeo), and tidal and storm flows (Qbo), 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 consists typically of 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.

Qbeo, Qbei — 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 crossbeds; crossbeds dip 10-30°, bed sets are 1-5 feet thick. Shells and human-made debris form deflation lags in blow-out basins and within the deposit. As much as 30 feet thick. Outer, sparsely vegetated dunes (Qbeo) form a massif just back from the beach where dunes are actively sculpted by wind scour in chutes and swales and by deposition on lee slopes. Inner, vegetated dunes (Qbei) are stabilized by dense thickets of shrubs and small trees. They lack evidence of active scour and deposition and form a somewhat lower massif behind the outer dunes, which shelter them from the sea wind.

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. Unstratified to laminated to trough- and planar-tabular crossbedded. As much as 40 feet thick. Deposited in tidal channels and tidal flats associated with tidal deltas and by storm overwashes of the dune massif. Forms a platform on the bay side of barrier beaches and Barnegat Inlet.

Qald — DRY-VALLEY ALLUVIUM—Fine-to-medium sand and pebble gravel, minor coarse sand; very pale brown, white, brown, dark brown, light gray. As much as 5 feet thick. Sand and gravel are quartz. In dry valley bottoms forming headwater reaches of streams. These valleys lack channels or other signs of surface-water flow. They may have formed during periods of cold climate when permafrost impeded infiltration, increasing surface runoff. The deposits are therefore largely relict.

Qe — EOLIAN DEPOSITS—Fine-to-medium quartz sand; very pale brown, white. As much as 15 feet thick. Form elongate dune ridges on the upper terrace and Cape May 2 terrace northwest of Waretown. Likely formed during one or more periods of cold climate in the Wisconsinan when terrace sands were exposed to wind erosion. Modern eolian sand on the barrier beaches is mapped separately as units Qbei and Qbeo.

Qc — COLLUVIUM—Fine-to-coarse sand, pebble gravel; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz with a trace of white weathered chert in places. As much as 15 feet thick (estimated). Forms aprons at the base of steep slopes in the Forked River, Waretown Creek, and Lochiel Creek valleys. The aprons grade to upper and lower terraces. Deposited by downslope movement of material on the slopes, chiefly during periods of cold climate.

Qtl — LOWER TERRACE DEPOSITS—Fine-to-medium sand, pebble gravel, minor coarse sand; light gray, brown, dark brown. As much as 15 feet thick. Sand and gravel are quartz. Form terraces and pediments in valley bottoms with surfaces 2 to 10 feet above modern wetlands. Include both stratified stream-channel deposits and unstratified pebble concentrates formed by seepage erosion of older surficial deposits. Sand includes gyttja in places, and peat less than 2 feet thick overlies the sand and gravel in places. The gyttja and peat are younger than the sand and gravel and accumulate due to poor drainage. Gravel is more abundant in lower terrace deposits than in upper terrace deposits due to removal of sand by seepage erosion.

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 and gravel are quartz. Form terraces and pediments with surfaces 5 to 25 feet above modern wetlands. Include stratified stream-channel deposits and poorly stratified to unstratified deposits laid down by groundwater seepage on pediments.

CAPE MAY FORMATION—Beach, nearshore, and estuarine deposits of middle and late Pleistocene age. Includes marine-terrace sand and gravel (Qcm1, Qcm2), platform sand (Qcm2p), and bay and estuarine clay, silt, and fine sand (Qcm2f).

Qcm1 — CAPE MAY FORMATION, UNIT 1—Fine-to-medium sand, pebble gravel, minor clayey sand to sandy clay, and coarse sand; yellowish-brown, yellow, very pale brown. As much as 40 feet thick. Sand and gravel are quartz with minor weathered chert (fig. 1). Forms eroded terraces with a maximum surface elevation of 70 feet. Includes beach, dune, tidal-flat, tidal-channel, and shoreface sediment.

Qcm2 — CAPE MAY FORMATION, UNIT 2, TERRACE DEPOSIT—Fine-to-medium sand, pebble gravel, minor coarse sand; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz. As much as 40 feet thick. Forms a terrace with a maximum surface elevation of 35 feet. Includes beach, dune, tidal-flat, tidal-channel, and shoreface sediment.

Qcm2p — CAPE MAY FORMATION, UNIT 2, PLATFORM DEPOSIT—Fine-to-medium sand, with pebbles in places, minor clayey sand to sandy clay; very pale brown, light gray, yellowish-brown. As much as 25 feet thick. In places, the platform deposit is overlain by black to dark brown freshwater peat and gyttja of Holocene age, as much as 6 feet thick. Forms a platform that gently slopes bayward from the foot of the Cape May 2 terrace, and extends beneath Holocene salt-marsh and estuarine deposits to the inner shelf. Includes beach and shoreface deposits laid down during sea-level decline from the Cape May 2 highstand. Groundwater seepage is common across the platform outcrop, enabling organic deposits to accumulate in low areas. Where continuous, these organic deposits are mapped as unit Qals; elsewhere they are patchy and diffuse and are included with unit Qcm2p.

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 AA', BB'). Deposited in a bay during sea-level rise to the Cape May 2 highstand.

TQg — UPLAND GRAVEL, LOWER PHASE—Fine-to-medium sand, clayey in places, and pebble gravel; minor coarse sand; yellow, very pale brown, reddish-yellow. Sand and gravel are quartz with a few (<5%) white to brown weathered chert in the coarse sand-to-pebble gravel fraction. Clay is chiefly from weathering of chert. As much as 30 feet thick, generally less than 10 feet thick. Occurs as erosional remnants on interfluves, and as more continuous deposits in headwater valleys, between 70 and 120 feet in elevation. Includes stratified stream-channel deposits, poorly stratified deposits laid down by groundwater seepage on pediments, and pebble concentrates formed from older surficial deposits and the Cohansey Formation as sand is removed by groundwater sapping or surface runoff.

Tg — UPLAND GRAVEL, HIGH PHASE—Fine-to-medium sand, some coarse sand, clayey in places, and pebble gravel; yellow, brownish-yellow, reddish-yellow, very pale brown. Sand and gravel are quartz, with as much as 5% chert, and traces of weathered feldspar, in the coarse sand-to-fine pebble gravel fraction. Most chert is weathered to white and yellow clay, some chert pebbles are gray to dark gray and unweathered to partially weathered. Clay-size material chiefly is from weathering of chert and feldspar. As much as 15 feet thick. Occurs as erosional remnants on ridgetops, above 120 feet in elevation. Includes stratified and crossbedded stream-channel deposits and poorly stratified to unstratified pebble concentrates formed as sand and clay are removed by groundwater sapping or surface runoff.

COHANSEY FORMATION—Fine-to-medium quartz sand, with some strata of medium-to-very coarse sand, very fine sand, and interbedded clay and sand, deposited in estuarine, bay, beach, and inner-shelf settings. The Cohansey is here divided into two map units: a sand facies and a clay-sand facies, based on gamma-ray well logs and surface mapping using 5-foot hand-auger holes, exposures, and excavations. Total thickness of the Cohansey in the map area is as much as 250 feet.

Tchs — Sand Facies—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. Well-stratified to unstratified; stratification ranges from thin, planar, subhorizontal beds to large-scale trough and planar crossbedding (fig. 3). Sand is quartz; coarse-to-very coarse sand may include as much as 5% weathered chert and a trace of weathered feldspar. 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 clayey strata, sand may be hardened or cemented by iron oxide, forming reddish-brown hard sands or ironstone masses. Locally, sand facies includes isolated lenses of interbedded clay and sand like those within the clay-sand facies described below. The sand facies is as much as 100 feet thick.

Tchc — Clay-Sand Facies—Clay interbedded with clayey fine sand, very fine-to-fine sand, fine-to-medium sand, less commonly with medium-to-coarse sand and pebble lags. Clay beds are commonly 0.5 to 3 inches thick, rarely as much as 2 feet thick, sand beds are commonly 1 to 6 inches thick but are as much as 2 feet thick (fig. 4). Clays are white, yellow, very pale brown, reddish-yellow, light gray; sands are yellow, brownish-yellow, very pale brown, reddish-yellow. Rarely, clays are brown to dark brown and contain organic matter. As much as 35 feet thick.

Tkw — KIRKWOOD FORMATION—Fine sand, fine-to-medium sand, sandy clay, and clay, minor medium-to-coarse sand; gray, dark gray, brown. Sand is quartz with some mica and lignite. In subsurface only. Approximately 400 feet thick in map area. In map area, the upper 200 feet of the Kirkwood consists of five clay-sand units traceable on gamma logs and described from the Island Beach corehole (Miller and others, 1994) (see discussion above). These units are shown by tielines on sections AA', BB', and CC'.

MAP SYMBOLS

Contact of surficial deposits—Solid where well-defined by landforms as visible on 1:12,000 stereo airphotos, long-dashed where approximately located, short-dashed where gradational or featheredged, dotted where excavated.

Contact of Cohansey facies—Approximately located. Dotted where covered by surficial deposits.

(Tchc) Concealed Cohansey facies—Covered by surficial deposits.

4 Qbs2/Qm Material penetrated by hand-auger hole, or observed in exposure or excavation. Number indicates thickness of surficial material, in feet, where penetrated. Symbols within surficial deposits without a thickness value indicate that surficial material is more than 5 feet thick. Where more than one unit was penetrated, the thickness (in feet) of the upper unit is indicated next to its symbol and the lower unit is indicated following the slash.

Material formerly observed—Recorded in N. J. Geological and Water Survey files.

figure 4 Photograph location

147 Well or test boring showing formations penetrated—Location accurate to within 200 feet. List of formations penetrated provided in table 1.

47 Well or test boring showing formations penetrated—Location accurate to within 500 feet. List of formations penetrated provided in table 1.

-25 Elevation of base of surficial deposits—Contour interval 25 feet. Shown only on mainland where surficial deposits are generally more than 20 feet thick.

Geophysical log—On sections. Gamma-ray log is shown in red, with radiation intensity increasing to right. Resistivity log is shown in blue, with resistance increasing to right.

Head of seepage valley—Line at top of scarp at head of small valleys and hillslope embayments formed by seepage erosion. Most of these features have little to no seepage today and were formed during times when the water table was higher than at present.

Active seepage—Line at position of groundwater emergence, seepage drains downslope from this position.

Fluvial scarp—Line at top of scarp, ticks point toward channel. Marks a possible former route of Waretown Creek at Waretown as sea level declined from the Cape May 2 highstand.

Shallow topographic basin—Line at rim, pattern in basin. Includes thermokarst basins formed from melting of permafrost and a few deflation basins, chiefly on Island Beach, formed from wind erosion.

Excavation perimeter—Line encloses excavated area.

Sand pit—Inactive in 2012.

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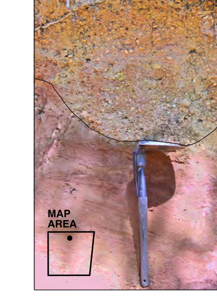


Figure 2. Cape May Formation, unit 1 (above line) in channeled contact on cross-bedded sand of the Cohansey Formation. Location shown on map and inset.

Figure 3. Plane-bedding to low-angle cross bedding in Cohansey Formation, Sand Facies. Quartz pebbles on the surface are a lag from erosion of the Upland Gravel, High Phase. Location shown on map and inset.

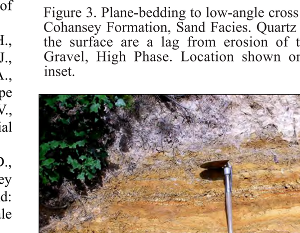


Figure 4. Interbedded clay (white beds) and sand (yellow and orange beds) of the Cohansey Formation, Clay-Sand Facies. Location shown on map and inset.

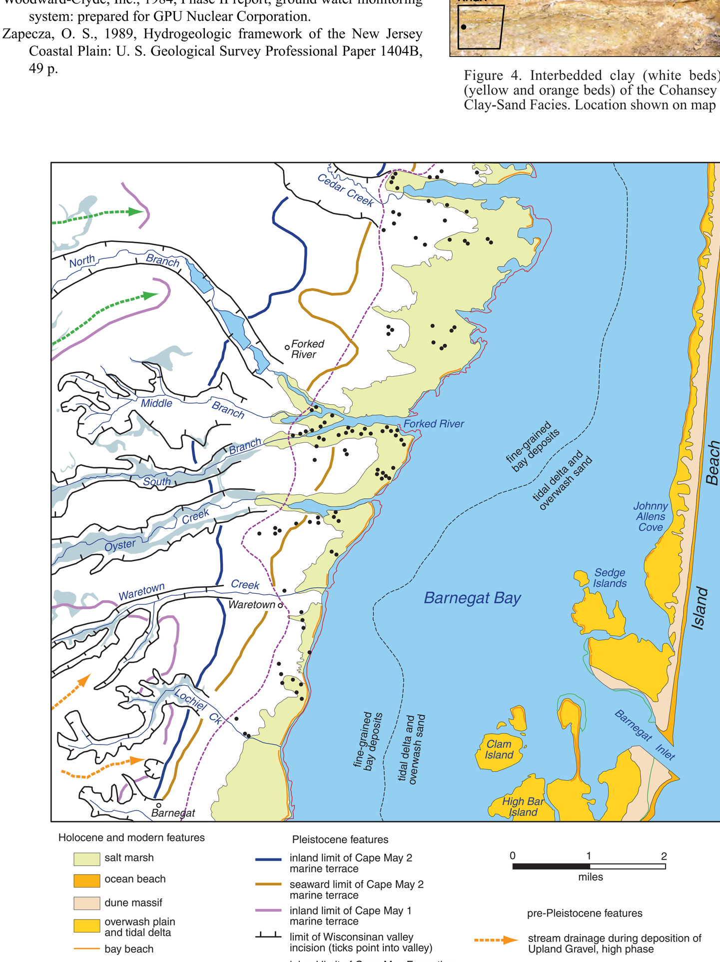
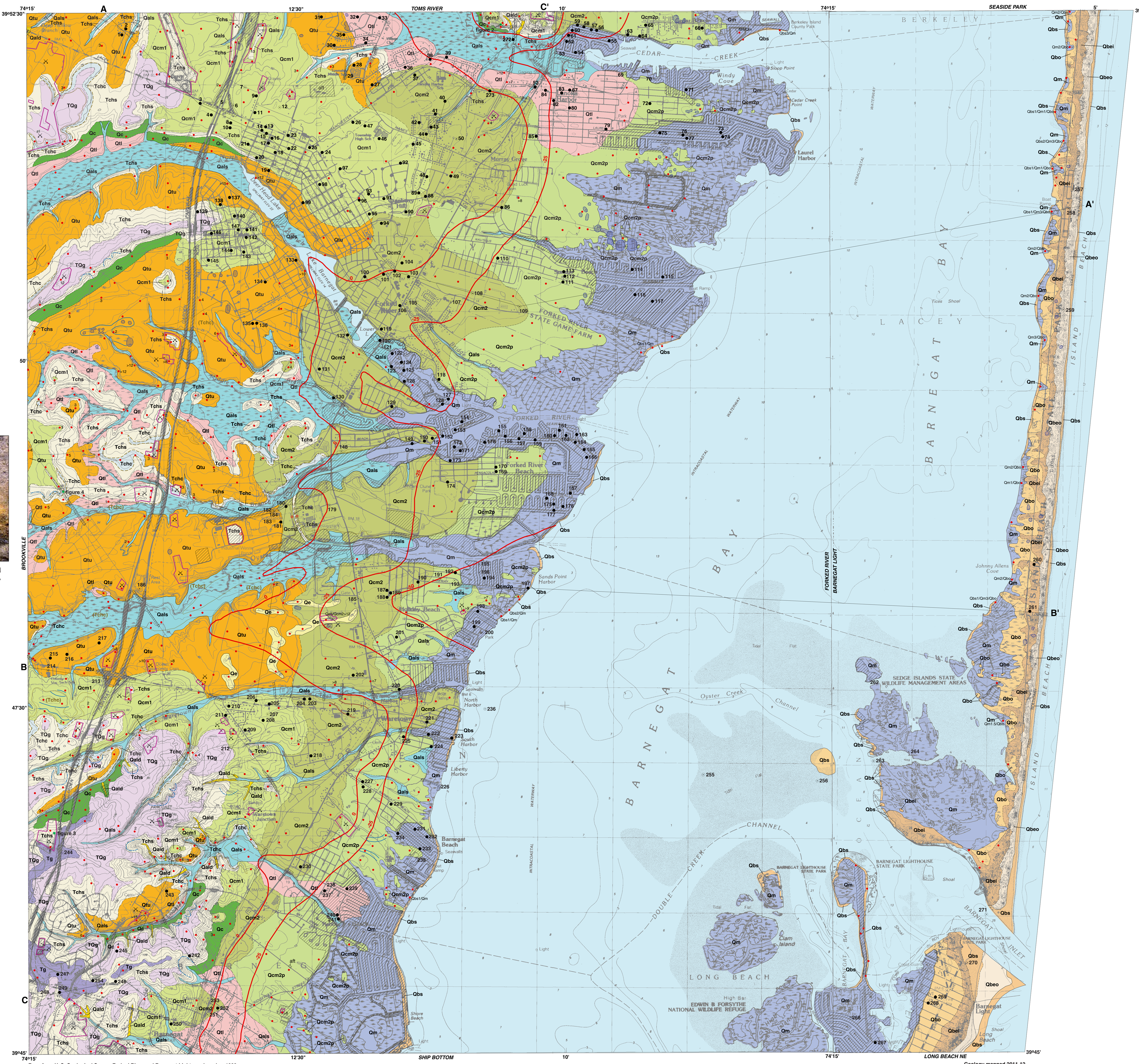


Figure 1. Geomorphic features, Quaternary sedimentary settings, and outcrops of Cohansey clay in the map area. The boundary between delta sand and fine bay deposits in Barnegat Bay is based, in part, on Lucke (1934), Olsen and others (1980), and Psuty (2004).



Base from U. S. Geological Survey Forked River and Barnegat Light quadrangles, 1989
Corner tics on North American Datum of 1927
Shorelines and deposits in the Barnegat Inlet area are mapped from 2007 imagery.
They differ from the base, which was mapped from 1981 aerial photography.

APPROXIMATE MEAN DECLINATION, 1989

SCALE 1:24 000

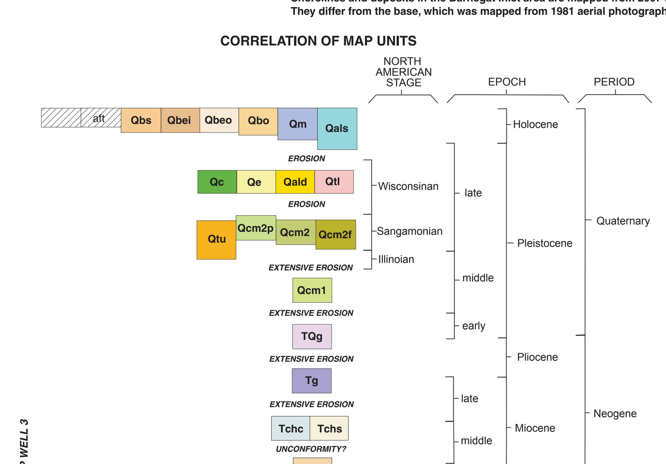
CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

LOCATION IN NEW JERSEY

Geology mapped 2011-12
Cartography by S. Stanford
Reviewed by K. G. Miller and G. R. Whittecar

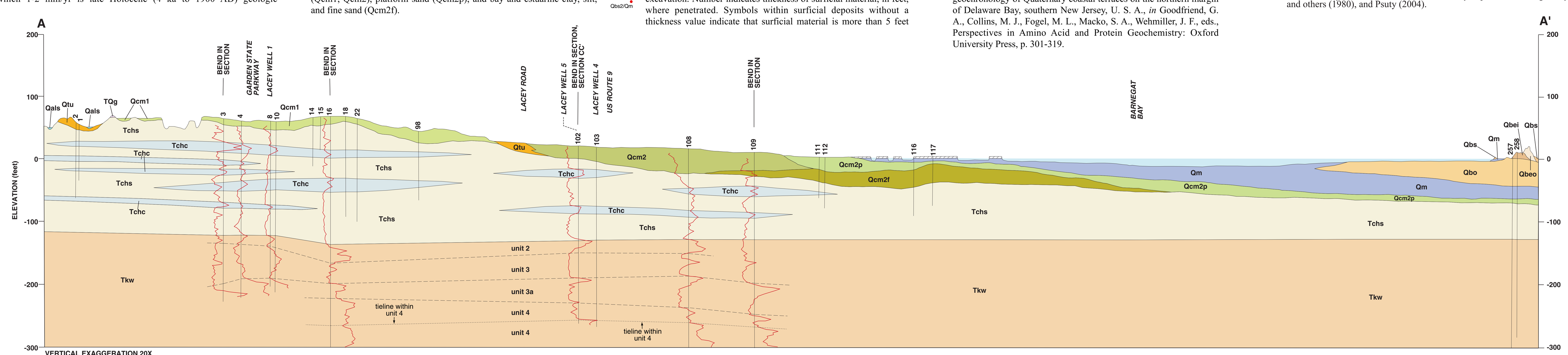
Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G11AC20258.
The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U. S. Government.

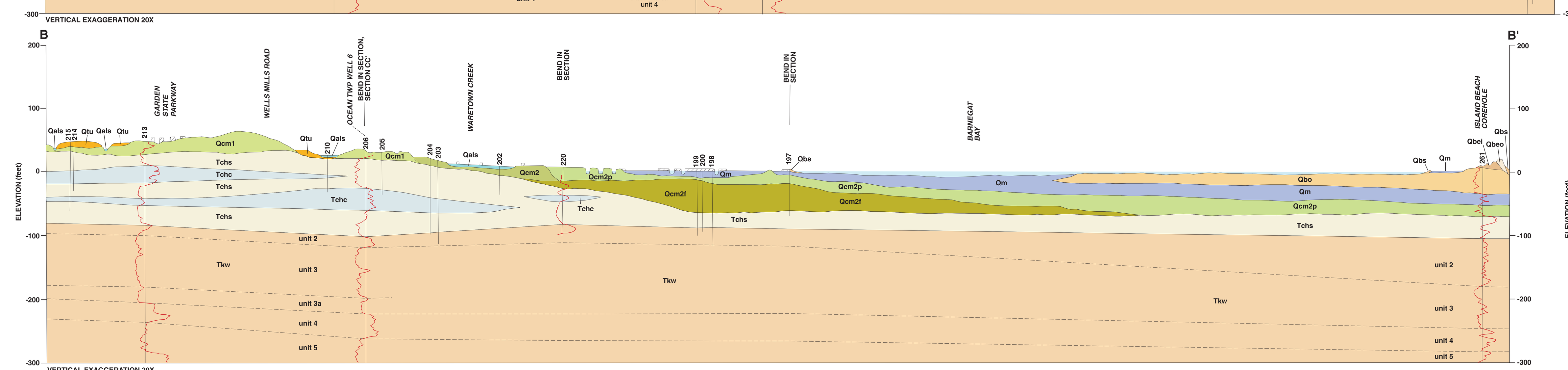
CORRELATION OF MAP UNITS

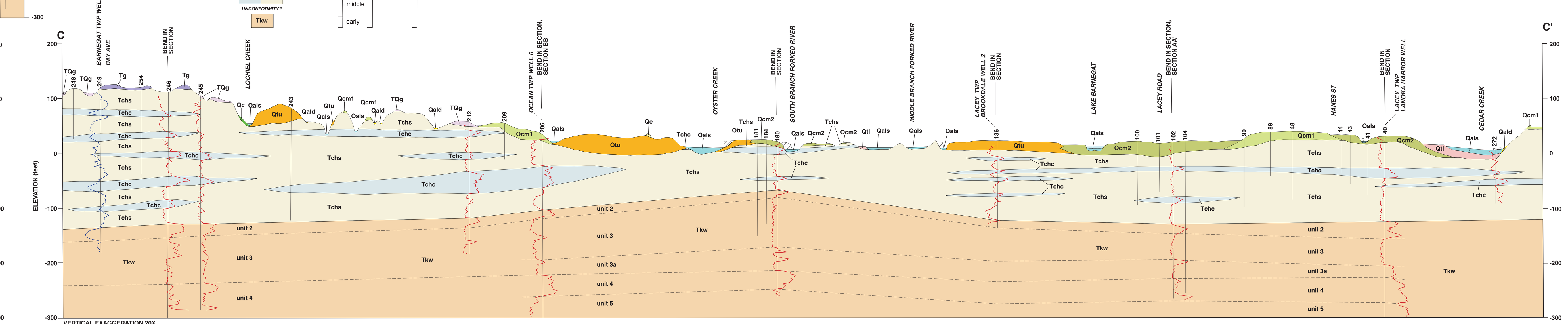


GEOLOGY OF THE FORKED RIVER AND BARNEGAT LIGHT QUADRANGLES OCEAN COUNTY, NEW JERSEY

by
Scott D. Stanford
2013







Geology of the Forked River and Barnegat Light Quadrangles
Ocean County, New Jersey

New Jersey Geological and Water Survey
Geologic Map Series GMS 13-2
2013

pamphlet with table 1 to accompany map

Table 1. Selected well and boring records.

Well Number	Identifier[1]	Formations Penetrated[2]
1	18003	10 Q 25 Tchs 30 Tchc 50 Tchs 60 Tchc 89 Tchs
2	24445	31 Tchs 35 Tchc 53 Tchs 58 Tchc 71 Tchs 74 Tchc 118 Tchs 120 Tchc
3	21466, G	30 Tchs 40 Tchc 180 Tchs+Tchc 280 Tkw
4	21355, G	14 Q 17 Tchc 56 Tchs+Tchc 178 Tchs 280 Tkw
5	24713, G	45 Q+Tchs 83 Tchs 112 Tchc+Tchs 165 Tchs 276 Tkw
6	24716, G	45 Q+Tchs 70 Tchs 85 Tchc 125 Tchs 170 Tchs+Tchc 270 Tkw
7	21286, G	20 Q 25 Tchc 55 Tchs 65 Tchc 140 Tchs 150 Tchc 175 Tchs 261 Tkw
8	21282, G, Lacey Twp well 1	13 Q 40 Tchs 50 Tchc 136 Tchs 160 Tchs+Tchc 180 Tchs 263 Tkw
9	25534, G, Lacey Twp well 2	11 Q 138 Tchs 252 Tkw
10	21284, G	18 Q 28 Tchs 32 Tchc 107 Tchs 118 Tchc 188 Tchs 272 Tkw
11	20927	10 Q 81 Tchs 91 Tchc 96 Tchs
12	23737, G	149 Tchs 310 Tkw
13	17403	20 Q 47 Tchs
14	6517	11 Q 55 Tchs+Tchc 74 Tchs
15	17405	22 Q 50 Tchs
16	17409, G	10 Q 35 Tchs 42 Tchc 60 Tchs 65 Tchc 75 Tchs 80 Tchc
17	17407	14 Q 52 Tchs
18	20219	8 Q 10 Tchc 50 Tchs 60 Tchs+Tchc 110 Tchs 140 Tchs+Tchc 160 Tchs
19	9803	15 Q 30 Tchs 40 Tchc 55 Tchs 75 Tchc 95 Tchs
20	16337	29 Tchs 30 Tchc 52 Tchs 54 Tchc 150 Tchs
21	17745	30 Q 55 Tchs 73 Tchs+Tchc 114 Tchs 121 Tchc 125 Tchs 136 Tchc 150 Tchs
22	18545	10 Q 50 Tchs+Tchc 100 Tchs 135 Tchs+Tchc 163 Tchs
23	17404	14 Q 18 Tchs 20 Tchc 42 Tchs 48 Tchc
24	26749	15 Q 25 Tchs+Tchc 35 Tchc+Tchs 105 Tchs+Tchc 120 Tchc+Tchs 165 Tchs+Tchc 181 Tkw
25	12915	10 Q 110 Tchs 115 Tchc 150 Tchs
26	23480	12 Q 28 Tchs 38 Tchc 48 Tchs 55 Tchc 60 Tchs
27	25357	12 Tchs 19 Tchc 40 Tchs 47 Tchc 60 Tchs 64 Tchc 95 Tchs
28	7613	18 Q 30 Tchs 50 Tchc 96 Tchs+Tchc 98 Tchc 105 Tchs+Tchc 111 Tchs 115 Tchc 137 Tchs 138 Tchc 150 Tchs 160 Tchs+Tchc
29	11394	12 f 60 Tchs+Tchc 112 Tchs 118 Tchc 147 Tchs
30	22578	9 Q 45 Tchs 73 Tchc 78 Tchs 83 Tchc+Tchs 93 Tchs 97 Tchc 101 Tchs
31	22529	13 Q 18 Tchc 97 Tchs 100 Tchc
32	22591	10 Tchs 27 Tchs+Tchc 35 Tchs 83 Tchs+Tchc 110 Tchs
33	17731	15 Q 30 Tchs 40 Tchs+Tchc 65 Tchs 85 Tchs+Tchc 104 Tchs
34	18459	20 Tchs 40 Tchs+Tchc 45 Tchc 50 Tchs+Tchc 73 Tchs
35	19340	10 Tchs 40 Tchs+Tchc 52 Tchs 70 Tchs+Tchc 100 Tchc+Tchs 120 Tchs
36	2060	40 Q+Tchs 55 Tchc 65 Tchs
37	25099	8 Q 50 Tchs 54 Tchc 80 Tchs
38	17786	26 Tchs 32 Tchc 65 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
39	27308	25 Q+Tchs 65 Tchs 75 Tchc 115 Tchs
40	29690, G + 29679, Lacey Twp, Lanoka Harbor well	60 Tchs 70 Tchc 155 Tchs 370 Tkw 910 TD
41	26546	18 Q 19 Tchc 52 Tchs 56 Tchc 72 Tchs 77 Tchc 100 Tchs
42	11120	20 Q 35 Tchs 40 Tchc 95 Tchs
43	19814	30 Q 40 Tchs 71 Tchs+Tchc 91 Tchs
44	7578	10 Q 21 Tchs+Tchc 42 Tchs 53 Tchs+Tchc 71 Tchs
45	9640	20 Q 30 Tchs 35 Tchc 50 Tchs 55 Tchc 70 Tchs
46	7761	16 Q 21 Tchs 67 Tchs+Tchc 100 Tchc 140 Tchs 150 Tkw or Tchs+Tchc
47	21590	18 Q 24 Tchs 25 Tchc 70 Tchs
48	26747	18 Tchs 19 Tchc 46 Tchs 47 Tchc 68 Tchs 71 Tchc 96 Tchs 100 Tchc 125 Tchs
49	22782	23 Tchs 28 Tchc 41 Tchs 49 Tchc 63 Tchs 66 Tchc 101 Tchs 103 Tchc 167 Tchs 371 Tkw
50	5586	10 Q 21 Tchs 32 Tchc 53 Tchs+Tchc 65 Tchs
51	21314	15 Q 23 Tchs 33 Tchc 38 Tchs 49 Tchc 70 Tchs 75 Tchc
52	26395	23 Q or Tchs 24 Tchc 59 Tchs 62 Tchc 90 Tchs 100 Tchc 105 Tchs 107 Tchc 140 Tchs
53	885	16 Qals 28 Qcm 38 Qcmf 53 Tchs
54	27155	6 f 14 Qm 43 Qcm 48 Tchc 72 Tchs 74 Tchc 83 Tchs 85 Tchc 93 Tchs 95 Tchc 110 Tchs
55	28005	4 f 12 Qm 45 Qcm 75 Tchs 85 Tchc or Tkw 132 Tchs or Tkw
56	7852	11 Qm 21 Qcm 29 Tchc 78 Tchs 80 Tchc or Tkw
57	7883	6 Qm 25 Qcm 53 Tchs+Tchc 57 Tchc 72 Tchs 75 Tkw or Tchs+Tchc
58	7910	5 f over Qm 16 Qcm 29 Tchs or Qcm 30 Tchc 54 Tchs 60 Tchs+Tchc 70 Tchs
59	7920	6 Qm 25 Qcm 53 Tchs+Tchc 57 Tchc 72 Tchs 75 Tkw
60	7878	3 f 14 Qm 24 Qcm 28 Qcmf 35 Tchs 58 Tchs+Tchc 70 Tchs
61	7879	2 f 13 Qm 23 Qcm 35 Qcmf 45 Tchs 55 Tchc 70 Tchs 73 Tkw
62	7934	12 f over Qm 22 Qcm 37 Qcmf 45 Tchs 55 Tchc 70 Tchs
63	7921	7 Qm 28 Qcm 37 Qcmf 55 Tchs 63 Tchs+Tchc 70 Tchs
64	8332	25 Qcm 40 Qcmf 48 Tchc 62 Tchs 90 Tchc+Tchs 110 Tchs
65	7930	29 Qcm 43 Qcmf 53 Tchs 57 Tchc 75 Tchs
66	26350	10 Qcm 49 Qcmf 54 Tchs 74 Tchc 95 Tchs
67	21403	27 Qtl 37 Qcmf 49 Tchs 56 Tchc 70 Tchs 75 Tchs
68	13026	31 Qcm 38 Qcmf 60 Tchs 66 Tchs+Tchc
69	20027	5 f over Qm 24 Qcm 36 Qcmf 44 Qcm 59 Tchs+Tchc 86 Tchs 89 Tkw
70	22108	31 Qcm 45 Qcmf 62 Tchs 115 Tchc+Tchs 160 Tkw
71	23990	3 f 15 Qm 20 Qcm 40 Qcmf 50 Tchs 62 Tchc 80 Tchs
72	19919	23 Qcm 42 Qcmf 68 Tchs 69 Tchc
73	22240	3 f 18 Qm 28 Qcm 41 Qcmf 60 Tchs 76 Tchc 118 Tchs 120 Tchc or Tkw
74	24444	12 f 16 Qm 35 Qcm 48 Qcmf 90 Tchs 105 Tkw
75	23451	8 f 18 Qm 26 Qcm 52 Qcmf 70 Tchs 78 Tchc+Tchs or Tkw 120 Tchs or Tkw
76	22766	3 f 18 Qm 23 Qcm 42 Qcmf 60 Tchc+Tchs 105 Tchs
77	11581	10 Qcm 40 Qcmf 100 Tchs 110 Tchs+Tchc or Tkw 125 Tchs or Tkw
78	11786	10 Qcm 40 Qcmf 100 Tchs 110 Tchs+Tchc or Tkw 125 Tchs or Tkw
79	21920	37 Qcmf 60 Tchs
80	1356	29 Qtl 45 Qcmf 49 Tchs 63 Tchs+Tchc 68 Tchs 70 Tchc or Tkw
81	9564	11 Qcm 27 Qcmf 35 Tchs 57 Tchs+Tchc 60 Tchs
82	21403	27 Qtl 37 Qcmf 49 Tchs 56 Tchc 70 Tchs 75 Tchc
83	3111	30 Qtl 36 Qcmf 58 Tchs+Tchc 70 Tchs
84	23015	24 Qtl 29 Tchc 52 Tchs
85	19130	7 Qcm 15 Tchc 18 Tchs 24 Tchc+Tchs 36 Tchc 52 Tchs
86	12402	20 Q 110 Tchs
87	12983	30 Q 100 Tchs 105 Tchc 120 Tchs
88	23468	10 Q 35 Tchs+Tchc 60 Tchs 70 Tchs+Tchc 90 Tchc 125 Tchs+Tchc 135 Tchs
89	18253	31 Tchs 41 Tchs+Tchc 62 Tchs 72 Tchs+Tchc 78 Tchs
90	17799	20 Q 55 Tchs 70 Tchc 128 Tchs
91	26450	5 Q 23 Tchs 32 Tchc 50 Tchs 54 Tchc 86 Tchs or Tkw 90 Tchc or Tkw 110 Tchs or Tkw 115 Tchc or Tkw

Well Number	Identifier[1]	Formations Penetrated[2]
92	20430	15 Q 35 Tchs 45 Tchc 65 Tchs
93	22429	25 Q 45 Tchs 67 Tchs+Tchc 83 Tchs 90 Tchs+Tchc
94	23598	30 Q 65 Tchs+Tchc 80 Tchs 81 Tchc
95	20988	12 Q 25 Tchs 38 Tchc 50 Tchs 55 Tchc 80 Tchs 85 Tchc
96	20312	10 Q 18 Tchs 28 Tchc 36 Tchs 40 Tchc 45 Tchs+Tchc 60 Tchs 68 Tchc
97	17798	10 Q 29 Tchc 65 Tchs 95 Tchc 115 Tchs
98	17383	21 Q 41 Tchc 68 Tchs 72 Tchc 78 Tchc+Tchs 88 Tchc 95 Tchs 98 Tchc 110 Tchs
99	3227	10 Q 11 Tchc 40 Tchs 52 Tchc+Tchs 57 Tchs
100	20934	10 Q 12 Tchc 18 Tchc+Tchs 45 Tchs 53 Tchc 90 Tchs 95 Tchc 115 Tchs
101	21158	25 Q 40 Tchs 60 Tchs+Tchc 87 Tchs
102	27212, G, Lacey Twp well 5	42 Tchs 54 Tchc 98 Tchs 110 Tchc 150 Tchs 282 Tkw
103	27225, Lacey Twp well 4	24 Tchs 25 Tchc 52 Tchs 57 Tchc 81 Tchs 95 Tchc 121 Tchs 122 Tchc 142 Tchs 286 Tkw
104	27226, Lacey Twp well 3	23 Tchs 24 Tchc 74 Tchs 89 Tchc 142 Tchs 278 Tkw
105	24319	16 Q 31 Tchs 32 Tchc
106	24323	29 Q 33 Tchc
107	1063	92 Tchs 206 Tkw
108	53-133, G	65 or 145 Tch 490? Tkw 967 TD
109	53-51, G	30 Tchs 40 Tchc 55 Tchs 68 Tchc 90 Tchs 495 Tkw
110	27145	43 Q 52 Tchs+Tchc 55 Tchc 57 Tchs 60 Tchc 76 Tchs
111	1276	4 f 5 Qm 19 Qcm 39 Qcmf 40 Tchs 41 Tchc 60 Tchs 65 Tchc
112	13094	24 Qcm 43 Qcmf 55 Tchs 58 Tchs+Tchc 72 Tchs 80 Tchs+Tchc
113	23162	19 Qcm 38 Qcmf 71 Tchs 95 Tchc 120 Tchs 124 Tchc or Tkw 140 Tchs or Tkw
114	25397	7 f 14 Qm 30 Qcm 40 Qcmf 80 Tchs
115	16693	5 f 18 Qm 28 Qcm 42 Qcmf 51 Tchs Tchs+Tchc 77 Tchs
116	15644	10 Qm 20 Qcm 50 Qcmf 80 Tchs+Tchc 94 Tchs
117	27363	6 f 9 Qm 11 Qcm 46 Qcmf 75 Tchs 80 Tchs+Tchc
118	27766	20 Q 43 Tchs 53 Tchs+Tchc 59 Tchs
119	5003, G	17 Q 32 Tchs 50 Tchc 62 Tchs 100 Tchc
120	14040	25 Q 40 Tchs 94 Tchs+Tchc 96 Tchc
121	402	10 Q 87 Tchs
122	1028	102 Tchs 147 Tkw
123	23423	20 Qals 23 Tchc 70 Tchs
124	21619	11 f 15 Qm 75 Tchs
125	5990	4 f 14 Qm 18 Qm 20 Tchc 38 Tchs 60 Tchc 66 Tchs
126	21648	4 f 14 Qm 90 Tchs 100 Tkw or Tchc
127	10415	5 f 20 Qm 55 Tchs 70 Tchc 92 Tchs
128	24817	6 f 14 Qm 60 Tchs
129	10660	40 Q 50 Tchs 52 Tchs+Tchc
130	4999, G	10 f 15 Q 70 Tchs 82 Tchc 90 Tchs 100 Tchc
131	16691	15 Q 25 Tchs 35 Tchs+Tchc 64 Tchs
132	25778	15 Q 48 Tchs 65 Tchc 90 Tchs
133	25925	18 Q 35 Tchs 42 Tchc 55 Tchs
134	4037	10 Q 15 Tchs 20 Tchc 30 Tchs 35 Tchc 50 Tchs
135	14359, Lacey Twp Brookdale well 1	15 Q 104 Tchs+Tchc 131 Tchs 143 Tchc 146 Tchs 154 Tkw
136	18150, G, Lacey Twp Brookdale well 2	15 Q 30 Tchs 35 Tchc 55 Tchs 58 Tchc 68 Tchs 74 Tchc 95 Tchs 100 Tchc 110 Tchs 112 Tchc 146 Tchs 159 Tkw
137	7861	21 Q 44 Tchc 46 Tchs 59 Tchc 61 Tchs 68 Tchc 76 Tchs 81 Tchc 88 Tchs
138	18375	10 Q 82 Tchs+Tchc 120 Tchs
139	19496	15 Q 37 Tchs 80 Tchs+Tchc 111 Tchs
140	7479	8 Q 39 Tchs 49 Tchc 90 Tchs
141	17388	17 Q 40 Tchc+Tchs 45 Tchs 72 Tchc+Tchs 85 Tchs 90 Tchs+Tchc 115 Tchs
142	21796	15 Q 30 Tchs+Tchc 40 Tchs 60 Tchc 70 Tchs 80 Tchs+Tchc 90 Tchs
143	27707	33 Tchs 34 Tchc 58 Tchs 64 Tchc 70 Tchs 72 Tchc 95 Tchs 99 Tchc 145 Tchs
144	17370	17 Q 60 Tchs 88 Tchc 100 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
145	19005	12 Q 35 Tchs+Tchc 37 Tchc 62 Tchs+Tchc 79 Tchs
146	6529	10 Q 40 Tchs 45 Tchc 60 Tchc+Tchs 70 Tchs
147	16800	30 Tchs 50 Tchc 120 Tchs
148	26041	14 Q 19 Tchc 53 Tchs 55 Tchc 86 Tchs 87 Tchc 98 Tchs 102 Tchc or Tkw 107 Tchs or Tkw 168 Tkw
149	17495	6 f 14 Qm 20 Qcm 25 Qcmf 70 Tchs
150	23425	15 Qm 21 Qcmf 70 Tchs
151	25417	6 f 14 Qm 22 Qcm 28 Qcmf 50 Tchs 54 Tchc 80 Tchs
152	6308	2 f 14 Qm 24 Qcm 31 Qcmf 70 Tchs
153	23470	14 Qm 30 Qcmf 35 Qcm 80 Tchs
154	21702	5 f 20 Qm 38 Qcm 42 Qcmf 55 Tchs
155	19014	8 f 16 Qm 22 Qcm 44 Qcmf 65 Tchs
156	378	2 f 6 Qm 13 Qcm 38 Qcmf 93 Tchs 99 Tchc or Tkw 105 Tchs or Tkw
157	597	6 f 15 Qm 36 Qcmf 46 Qcm 64 Tchs
158	455	2 f 19 Qm 21 Qcm 38 Qcmf 49 Tchs
159	23334	3 f 12 Qm 28 Qcm 48 Qcmf 62 Tchs
160	26009	3 f 13 Qm 26 Qcm 48 Qcmf 56 Tchs+Tchc 80 Tchs
161	19880	2 f 20 Qm 25 Qcm 50 Qcmf 90 Tchs
162	563	17 Qm 36 Qcmf 64 Tchs
163	426	1 f 6 Qm 20 Qcm 38 Qcmf 59 Tchs
164	502	2 f 7 Qm 12 Qcm 36 Qcmf 65 Tchs
165	419	2 f 8 Qm 24 Qcm 48 Qcmf 58 Tchs
166	616	2 f 6 Qm 18 Qcm 44 Qcmf 64 Tchs
167	18336	4 f 16 Qm 24 Qcm 46 Qcmf 65 Tchs
168	24591	10 f 18 Qm 30 Qcm 48 Qcmf 90 Tchs
169	10876	31 Qcm 42 Qcmf 48 Tchs 51 Tchc 70 Tchs
170	10875	28 Qcm 45 Qcmf 70 Tchs
171	20918	2 f 25 Qm 30 Qcm 39 Qcmf 65 Tchs
172	27309	4 f 16 Qm 30 Qcm 48 Qcmf 65 Tchs
173	25804	12 f 16 Qm 38 Qcm 40 Qcmf 60 Tchs
174	12582	30 Qcm 40 Qcmf 105 Tchs
175	11369	20 Qcm 60 Qcmf 100 Tchs
176	22319	10 f 15 Qm 30 Qcm 50 Qcmf 60 Tchs 75 Tchs+Tchc 100 Tchs
177	21102	10 f 14 Qm 25 Qcm 48 Qcmf 74 Tchs
178	416	2 f 6 Qm 23 Qcm 38 Qcmf 50 Tchs
179	W17 (Woodward-Clyde, 1984)	18 Q 33 Tchc 100 Tchs 150 Tkw
180	25829, G	10 Q 15 Tchc 62 Tchs 67 Tchc 90 Tchs 279 Tkw
181	1346	93 Tch 176 Tkw
182	27154	15 Tchs 20 Tchc+Tchs 90 Tchs
183	26728	10 Tchs 23 Tchc 87 Tchs 90 Tchc
184	24754	67 Tchs 70 Tchc 73 Tchs 77 Tchc+Tchs 95 Tchs 102 Tchs+Tchc 153 Tkw
185	1292	48 Qcm 51 Qcmf
186	987	27 Q 45 Tchs 50 Tchs+Tchc 65 Tchs
187	6966	39 Qcm 46 Qcmf 54 Tchs 61 Tchc 70 Tchs
188	6982	34 Qcm 58 Qcmf 78 Tchs
189	10347	13 Qcm 62 Qcmf 85 Tchs
190	351	30 Qcm 56 Qcmf 107 Tchs 109 Tchc 110 Tchs 130 Tkw
191	60	28 Qcm 58 Qcmf 62 Tchs
192	320	22 Qcm 55 Qcmf 82 Tchs 83 Tchc 130 Tchs
193	448	15 Qcm 57 Qcmf 63 Tchs
194	367	3 f 5 Qm 16 Qcm 59 Qcmf 65 Tchs
195	210	3 f 6 Qm 15 Qcm 58 Qcmf 63 Tchs
196	315	4 f 7 Qm 19 Qcm 58 Qcmf 63 Tchs
197	303	2 f 6 Qm 20 Qcm 62 Qcmf 70 Tchs
198	27834	3 f 15 Qm 35 Qcm 68 Qcmf 90 Tchs 120 Tkw
199	22784	5 f 6 Qm 45 Qcmf 50 Qcm 75 Qcmf 105 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
200	831	10 f 20 Qm 60 Qcmf 100 Tchs
201	20933	34 Qcm 48 Qcmf 55 Tchs 63 Tchc+Tchs 73 Tchs
202	24985	15 Q 25 Tchs 30 Tchc 55 Tchs
203	15162	60 Tchs 95 Tchc 130 Tchs
204	22699	10 Q 20 Tchs+Tchc 60 Tchs 100 Tchc 120 Tchs
205	24419	21 Tchs 23 Tchc 40 Tchs 48 Tchc 60 Tchs 62 Tchc
206	29963, G + 32755, Ocean Twp well 6	60 Tchs 100 Tchc 138 Tchs 440 Tkw
207	21701	20 Q 50 Tchs 54 Tchc 60 Tchs
208	22469	25 Q 42 Tchs 60 Tchc+Tchs 72 Tchs 100 Tchc 118 Tchs
209	23256	20 Q 35 Tchs 45 Tchc 65 Tchs
210	25855	17 Tchs 23 Tchc 48 Tchs 51 Tchc 68 Tchs 75 Tchc
211	28083	17 Tchs 22 Tchc 48 Tchs 55 Tchc 80 Tchs 90 Tchc
212	38848, G	10 Tchs 20 Tchc 90 Tchs 130 Tchs 160 Tchs 237 Tkw
213	1038, G	20 Q 40 Tchs 75 Tchc 135 Tchs 430 Tkw 455 TD
214	1310	29 Q 50 Tchc 65 Tchs+Tchc 74 Tchs 75 Tchc
215	44797	11 Q 49 Tchc 82 Tchs 92 Tchc 110 Tchs
216	40450	24 Q 40 Tchc 48 Tchs 53 Tchc 58 Tchs 61 Tchc 91 Tchs 100 Tchs+Tchc 130 Tchs 150 Tkw
217	40339	19 Q 47 Tchc+Tchs 52 Tchc 60 Tchs 75 Tchc 82 Tchs+Tchc 105 Tchs
218	23745	40 Q+Tchs 50 Tchs 55 Tchc 70 Tchs
219	13551	46 Tchs 52 Tchc 71 Tchs+Tchc or Tkw 91 Tchc or Tkw 111 Tchc+Tchs or Tkw 125 Tchs or Tkw
220	5001, G	22 Qcm 35 Qcmf 50 Tchc 90 Tchs 100 Tkw
221	15479	25 Qcm 40 Qcmf 50 Tchs 85 Tchc or Tkw 111 Tchs or Tkw
222	20577	5 f 23 Qm 25 Qcm 42 Qcmf 65 Tchc 84 Tchc or Tkw 115 Tchs or Tkw
223	322	102 Q+Tchs+Tchc 130 Tkw
224	19976	1 f 4 Qm 60 Q+Tchs 78 Tchc 86 Tchs 100 Tchs+Tchc 125 Tchs
225	21630	4 f 8 Qm 45 Q+Tchs 50 Tchc+Tchs 75 Tchs 90 Tchc 100 Tchs
226	33-22-254, G	10 Q 44 Qcmf 55 Tchs 280 Tkw
227	17942	25 Qcm 50 Qcmf 130 Tchs
228	23860	50 Q+Tchs 65 Tchc 75 Tchs+Tchc 100 Tchs
229	7791	15 Qcm 50 Qcmf 116 Tchs+Tchc 119 Tchc or Tkw
230	5834, Ocean Twp well 4	40 Q 60 Tchc 80 Tchs 93 Tchs+Tchc 160 Tkw
231	17261	8 f 21 Qm 53 Qcm 69 Qcmf 91 Tchc or Tkw 106 Tchs or Tkw 119 Tchc+Tchs or Tkw 135 Tchs or Tkw
232	20885	3 f 23 Qm 26 Qcm 129 Qcmf+Tchs+Tchc 135 Tchs 156 Tkw
233	11161	5 f 15 Qm 45 Qcmf 50 Tchs 85 Tchc 90 Tchs 145 Tkw
234	682	22 Qcm 39 Qcmf 65 Qcmf+Tchc 93 Tchc+Tchs or Tkw 129 Tchs or Tkw
235	764	5 Qm 15 Qcm 80 Qcmf + Tchc 95 Tchs 117 Tchc or Tkw 146 Tchs or Tkw
236	C18 (Lucke, 1934)	7 Qbs 25 Qm
237	1839, Ocean Twp well 3	32 Qtl over Qcm 38 Qcmf 50 Tchs+Tchc 56 Tchc 74 Tchs+Tchc 86 Tchc 96 Tchc+Tchs 120 Tkw
238	1148	34 Qtl over Qcm 45 Qcmf 64 Tchs+Tchc 70 Tchs 125 Tchc or Tkw 130 Tchc+Tchs or Tkw 152 Tchs or Tkw 155 Tkw
239	26161	6 Qcm 22 Qcmf 30 Tchs
240	27089, Ocean Twp well 5	1 f 3 Qm 22 Qcm 53 Qcmf 91 Tchs+Tchc 102 Tchc 180 Tkw
241	5000, G	17 Qcm 60 Qcmf 69 Tchs 90 Tchc 100 Tchc+Tchs
242	25101	15 Tchs 33 Tchc 80 Tchs
243	22297	31 Q 34 Tchc 53 Tchs 58 Tchc 97 Tchs 114 Tchc 138 Tchs 144 Tchc 168 Tchs 176 Tchc 190 Tchs 196 Tchc
244	372	33 Q 89 Tchs+Tchc 92 Tchc 97 Tchs 99 Tchc+Tchs 130 Tchs+Tchc
245	43984, G	235 Tch 388 Tkw
246	26095, G	65 Tchs 80 Tchc 105 Tchs 120 Tchc 150 Tchs 170 Tchc 195 Tchs 210 Tchc 240 Tchs 565 Tkw 600 TD
247	29909, Barnegat Twp well 7	93 Tchs 127 Tchs+Tchc 132 Tchs 158 Tchc+Tchs 170 Tchs 182 Tchc 255 Tchs 280 Tkw
248	1000	18 Tchs 28 Tchs+Tchc 45 Tchs 55 Tchc+Tchs 57 Tchs 67 Tchc 89 Tchs+Tchc

Well Number	Identifier[1]	Formations Penetrated[2]
249	1429, E, Barnegat Twp well 4	14 Q 41 Tchs 51 Tchc 62 Tchs 65 Tchc 67 Tchs 74 Tchc 120 Tchs 122 Tchc 143 Tchs 147 Tchc 168 Tchs 186 Tchs 217 Tchs 224 Tchc 252 Tchs 262 Tkw
250	24010	10 Tchc 15 Tchs 20 Tchc 40 Tchs+Tchc 48 Tchc 76 Tchs
251	396	77 Q+Tchs 120 Tchc 148 Tchs 149 Tkw
252	2356, E, Barnegat Twp well 4	10 Q 11 Tchc 52 Tchs 63 Tchc 72 Tchs 118 Tchc 138 Tchs 193 Tkw
253	33-22-451	160 Tch 570 Tkw
254	25398	30 Tchs 60 Tchs+Tchc 75 Tchs 130 Tchs+Tchc 160 Tchs
255	C17 (Lucke, 1934)	27 Qbo
256	C16 (Lucke, 1934)	24 Qbo
257	1134, E	33 Qbei+Qbo 48 Qbo 64 Qm 410 Tch over Tkw
258	1066	54 Qbei+Qbo 73 Qm 78 Qcm 293 Tch over Tkw
259	829	52 Qbei+Qbo 68 Qm 160 Tch over Tkw
260	1031, G (Gill and others, 1963)	74 Qbei+Qbo 85 Qm 90 Qcm 110 Tch 400 Tkw 3891 TD (biotite gneiss basement at 3862)
261	31139, G, Island Beach corehole (Miller and others, 1994)	40 Qbei+Qbo 60 Qm 78 Qcm 120 Tch 505 Tkw 1223 TD
262	53-131	5 Qm 36 Qbo 58 Qm 94 Qcmf 320 Tch over Tkw
263	C1 (Lucke, 1934)	1 Qm 29 Qbo
264	839	40 Qbo 52 Qm 74 Qcm or Tch 84 Tch or Tkw
265	C19 (Lucke, 1934)	1 Qm 22 Qbo
266	16849	2 f 5 Qm 20 Qbo
267	13375	34 Qbo 59 Qm 75 Qcm or Tch 82 Tch or Tkw
268	1206, E, Barnegat Light Boro well 3	47 Qbo 70 Qm 94 Qcm or Tch 491 Tch over Tkw 682 TD
269	364, Barnegat Light Boro well 2	58 Qbo 95 Qm 510? Tch over Tkw 675 TD
270	53-127	40 Qbs over Qbo 60 Qm 130 Qcm over Tch 491 Tkw
271	core 3 (Wellner, 1990)	26 water depth 33 Qbo 42 Qm
272	5006, G	22 Q 57 Tchs+Tchc 65 Tchc 100 Tchs
273	25527	23 Q 30 Tchs 34 Tchc 60 Tchs 65 Tchc 76 Tchs 77 Tchc 89 Tchs 91 Tchc or Tkw

[1]Two, three, four, or five digit numbers without hyphens are N. J. Department of Environmental Protection well-permit numbers. All are preceded by the prefix “33-“. Identifiers of the form 53-xxx are also N. J. Department of Environmental Protection well-permit numbers. Identifiers of the form 33-xx-xxx are N. J. Atlas Sheet grid locations of wells in the state well files that do not have permit numbers. Identifiers of the form “C17 (Lucke, 1934)” are borings from the cited reference. References are also provided for research test holes (wells 260 and 261). A “G” following the identifier indicates that a gamma-ray log is available for the well; an “E” indicates that an electric log (resistivity and spontaneous potential) is available. Public and community supply wells are identified by municipality and well number or well name.

[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 Tchs 34 Tchc 62 Tchs” indicates Tchs 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. Formation abbreviations and the corresponding drillers’ descriptive terms used to infer the formation are: f=fill, Q=yellow and white sand and gravel surficial deposits, undifferentiated west of the bayshore area (units Tg, TQg, Qtu, Qtl, Qals, Qcm1, Qcm2). Stacked surficial units along the bayshore and on the barrier beaches are differentiated as follows: Qcm (includes Qcm2 and Qcm2p), Qbo, Qbei, Qbs=yellow, white, gray sand and gravel, Qm=peat, meadow mat, and gray to brown mud, Qcmf=gray to brown clay, silt, fine sand. 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, black) clay, silty clay, and sandy clay of the Cohansey

Formation; Tkw=gray and brown clay, silt and sand of the Kirkwood Formation. A “+” sign indicates that units are mixed or interbedded. “TD” indicates total depth of deep wells for which units below Tkw are not listed. 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, or from geophysical well logs where lithologic descriptions are not available. Units shown for wells may not match the map and sections due to variability in drillers’ descriptions and the thin, discontinuous geometry of many clay beds. In many well logs, surficial deposits cannot be distinguished from Cohansey sands; thus, the uppermost Tchs unit in well logs generally includes overlying surficial deposits.