DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

Prepared in cooperation with the
U. S. GEOLOGICAL SURVEY
NATIONAL COOPERATIVE GEOLOGIC MAPPING PROGRAM

INTRODUCTION

The Mays Landing quadrangle is in the Outer Coastal Plain of New Jersey, in the southeastern part of the state. The surficial deposits outcropping in this quadrangle are of late Miocene to Holocene age and overlie the Cohansey and Kirkwood formations, which are marginal marine deposits of Miocene age. These surficial deposits consist of river, wetland, estuarine, hillslope, and windblown sediments. The Kirkwood Formation was deposited in marine delta and shallow shelf settings during the early and middle Miocene. The Cohansey Formation was deposited in coastal settings during the middle and late Miocene when sea level was significantly higher than at present. As sea level lowered after the deposition of the Cohansey, rivers flowing on the emerging Coastal Plain deposited fluvial gravel. Continued lowering of sea level caused streams to erode into the gravel and the underlying Cohansey Formation. During the late Miocene, Pliocene, and Pleistocene, about 8 million years ago (8 Ma) to 11,000 years ago (11 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 during the middle and late Pleistocene, when sea level was higher than at present, estuarine sediments were laid down as terraces in valleys less than 55 feet above sea level. Most recently, alluvial and wetland deposits were laid down during the Holocene (11 ka to present).

A summary of the stratigraphy of the Cohansey and Kirkwood Formations in the quadrangle and the geomorphic history of the map area as recorded by surficial deposits and landforms, is provided below. The ages of the deposits and erosional episodes are shown on the correlation chart. Table 1 lists the formations penetrated by wells and borings, as interpreted from drillers' lithologic logs and downhole geophysical logs. Cross sections A-A' and B-B' show materials to a depth of 600 feet and 400 feet below sea level, respectively, which includes the Cohansey Formation, the Kirkwood Formation, and the Atlantic City Formation. Most domestic water wells in the quadrangle tap sands in the Cohansey Formation at depths between 70 and 130 feet. In the western part of the quadrangle, public water supply wells tap the Kirkwood Formation at depths between 275 and 335 feet based on geophysical logs in wells 20 and 21. These wells are drawing from the upper sand of the Atlantic City 800-foot sand water bearing zone. To the southeast, in well 13, the Atlantic City 800-foot sand is located between 450 feet and 550 feet below sea level. A leaky confining unit around 20 feet thick is present throughout cross section A-A' separating this aquifer into an upper and lower sand (Sugarman and others, 2020). The Rio-Grande water bearing zone is also shown on both cross sections and is located between 280 and 360 feet below sea level in well 13. Aquifers are shown by the blue dashed lines on both cross sections.

KIRKWOOD FORMATION

The Kirkwood Formation (Tkw) consists of four sequences of back-bay marine-delta, and shallow shelf sediments as sampled and described in the Bass River corehole, which is approximately 13 miles to the north-east in the New Gretna quadrangle (Miller and others, 1998). The sequences are mapped in cross-section using geophysical logs and interpretations from regional coreholes. In the Bass River corehole, these four sequences can be correlated to the three lithic sequences described in the ACGS-4 corehole located approximately 1.5 miles to the northwest of Lake Lenape in the Dorothy quadrangle (Owens and others, 1988). Shells at the base of Kirkwood Formation in the Bass River corehole yield strontium stable-isotope ages of 20.8, 20.9, 21.1, and 21.4 Ma (Miller and others, 1998), indicating an early Miocene age for this sequence. The Kirkwood 1a (Kw1a) sequence of Sugarman and others (1993) correlates to the lowest lithic unit of the ACGS-4 corehole which is described as a coarsening upward sequence with highly bioturbated, olive-green clayey, micaceous, very glauconitic fine sand grading to massive beds of silty fine sand grading to a coarse sand to fine gravel (Owens and others, 1988). The Kirkwood 1b (Kw1b) sequence of Sugarman and others (1993) correlates to the middle lithic sequence of the ACGS-4 corehole which consists of laminated to very thinly intercalated silt and very fine sand grading up to a loose olive-gray, medium to coarse, quartz sand with broken shells oriented parallel to bedding (Owens and others, 1988). The Kirkwood 2 sequence contains diatoms that indicate an early to middle Miocene age (Miller and others, 1998). A boundary between sequences 2a and 2b of Sugarman and others (1993) is present in the western part of cross section A-A' with sequence 2b (Kw2b) pinching out from southeast to northwest. The Kirkwood 2a (Kw2a) sequence correlates with the upper lithic sequence in the ACGS-4 corehole which consists of yellowish-brown diatomaceous, clayey silt and fine sand, grading to thin beds of olive-gray silt and light-yellow, micaceous, medium sand (Owens and others, 1988). The microfossils found in the ACGS-4 corehole indicate that the Kirkwood Formation is approximately 22 to 15 Ma. This age was more accurately defined in the Bass River corehole.

COHANSEY FORMATION

The Cohansey Formation consists of stacked successions composed of beach and shoreface sand (Tchs) overlain by interbedded sand and clay (Tchc) deposits in tidal flats and back bays, and coastal swamps (Carter, 1972; 1978). Pollen and dinoflagellates recovered from peat beds in the Cohansey at Legler, in northern Ocean County, are indicative of a coastal swamp tidal marsh environment (Rachele, 1976). The Legler pollen (Greller and Rachele, 1983), recovered from the ACGS corehole (Owens and others, 1988), and dinocysts obtained from coreholes in Cape May County, New Jersey (deVerteuil, 1997; Miller and others, 2001), indicate a middle to early late Miocene age for the Cohansey. 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 sequences 2a and 2b, about 17-15 Ma, Sugarman and others, 1993) and may represent the coastal facies of the Kirkwood shallow-shelf deposits.

In the map area, clays in the Cohansey are in beds or laminae generally less than 6 inches thick, but as much as 3 feet thick, and are interbedded with sand. Clay-sand facies strata are generally less than 20 feet thick. Gamma-ray and lithologic logs (cross-sections A-A' and B-B') show many clay beds in the subsurface, two of which are 20 feet thick in some areas and are shown to be continuous for approximately three miles. In outcrop they commonly are oxidized and multicolored, but in the subsurface, they are described to be predominantly blueish-gray or white.

The laminated bedding and 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 floodplains and abandoned river channels. The representative stacking of bay clays and beach sand (predominantly tidal delta and shoreface deposit) indicate that the Cohansey was deposited during several rises and falls of sea level during a longer period of overall rising sea level.

SURFICIAL DEPOSITS AND GEOMORPHIC HISTORY

As sea level lowered following the deposition of the Cohansey Formation, the inner continental shelf emerged as a coastal plain. The Bridgeton Formation (Tb) is the earliest record of river drainage across this plain, in the map area (Salisbury and Knapp, 1917). The Bridgeton river system deposited a broad braidplain across southern New Jersey, mostly south and west of the present-day Mullica River basin. This braidplain is found predominantly in the part of the Mays Landing quadrangle that is east of the Great Egg Harbor River. Gravel in the Bridgeton is composed of primarily quartz, quartzite, chert, and trace amounts of red and grey sandstone and siltstone, gneiss, and schist.

The Bridgeton Formation overlies the middle-to-late Miocene Cohansey. It is older than the Pensauken Formation of Pliocene age, in the Delaware valley to the north and west of the Mays Landing quadrangle, but lacks datable material. The Bridgeton Formation is likely of late Miocene age. A substantially greater age than the Pensauken Formaton is further indicated by the deep and intense weathering of the Bridgeton Formation. Feldspar minerals have weathered to clay, and iron-bearing silicate minerals have weathered to oxides and hydroxides (Owens and others, 1983). This weathering gives the deposit a clayey sand texture and a distinctive orange-to-reddish color. Chert, gneiss, siltstone, and schist pebbles are deeply weathered or decomposed through the entire thickness of the deposit.

As sea level continued to lower through the late Miocene and early Pliocene, the Bridgeton river system downcut and shifted westward to what is now the lower Delaware valley. To the east, including the Mays Landing quadrangle, new drainages were established when the Bridgeton plain was abandoned, including the Great Egg Harbor River and its tributaries. These streams cut broad shallow valleys into the Bridgeton Formation to the depths seen in present day by the middle, or possibly the early Pleistocene.

Continuing incision during the middle and late Pleistocene (about 800 to 11 ka) formed the modern valley network. Fluvial sediments laid down in modern valleys include upper and lower terrace deposits (Qtu and Qtl), and active floodplain and wetland (Qals) deposits in valley bottoms. The terrace 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 the accumulation of organic matter in swamps and bogs. Upper terrace deposits form terraces and pediments above modern floodplains. They were laid down chiefly during periods of cold climate during the middle Pleistocene. During cold periods, permafrost impeded the infiltration of rainfall and snowmelt and this, in turn, accelerated groundwater seepage, runoff, and slope erosion, increasing the amount of sediment entering valleys, leading to terrace deposition.

Lower terrace deposits (Qtl) form low, generally wet, terraces with surfaces between two and ten feet above modern valley bottoms. They are inset into the upper terrace and the Cape May unit 2 terrace and were laid down in shallow valleys and lowlands eroded after the deposition of the Cape May unit 2. This erosion occurred during a period of lower-than-present sea level and colder-than-present climate known as the Wisconsinan stage of the last glacial period, between about 80 and 11 ka.

Lower terraces are most prominent along the South River, Babcock Creek, and north of Lake Lenape. The lower terrace is scribed in places by a network of shallow braided channels. These channels are wetter than the adjacent unchanneled terrace and are marked by grass and shrub glades, distinct from pine forest found on the slightly higher terrace. The braided channels formed when permafrost impeded infiltration and thus increased seepage and runoff. The increased runoff washed sand from uplands into valleys, choking streams with sediment and causing channels to aggrade and split to form a braided pattern.

The lower terrace deposits were laid down chiefly during or slightly after the last period of cold climate between 25 and 15 ka. Near Manahawkin, in the Ship Bottom quadrangle, sand and gravel of the lower terrace overlie an organic silt dated to 34,890±960 radiocarbon years (GX-16789-AMS, Newell and others, 1995) (38,410-40,550 calibrated years with one sigma error, calibrated using Reimer and others, 2013). In the Chatsworth quadrangle, to the north of the Mays Landing quadrangle, organic sediment within lower terrace sand dated to 20,350±80 radiocarbon years (Beta 309764, Stanford, 2012) (24,450-24,150 calibrated years with one sigma error). These dates indicate deposition of the lower terrace deposits during the late Wisconsinan.

Another feature related to permafrost are thermokarst basins. These are shallow closed basins, circular to oval in plan view, generally less than an acre in area, and less than 5 feet in depth (symbolled on the map with a blue hatched pattern). In the Mays Landing quadrangle, thermokarst basins occur predominantly on the border of the Cape May unit 2 and 3. Most formed when ice-rich lenses at shallow depth in the frozen sediments melted, leaving small depressions (Wolfe, 1953; French and others, 2005).

Based on radiocarbon dates on basal peat in other alluvial wetlands in the region (Buell, 1970; Florer, 1972; Stanford, 2000) modern wetland and fluvial deposits (Qals) were deposited within the past 10 ka. Pollen in organic silt at a depth of 4 feet in unit Qals in the Oswego Lake quadrangle, to the northeast of Mays Landing, contains 50% spruce, 38% birch, 3% pine, 1% oak, and 6% herb (Watts, 1979). This pollen assemblage indicates an age no younger than about 10 radiocarbon ka (about 12,000 calibrated years) for the onset of deposition of the alluvial deposit here based on the youngest occurrence of spruce in the region (Sirkin and others, 1970).

Eolian deposits (Qe) are present in the Mays Landing quadrangle. They include elongate dune ridges, some of which are single narrow ridges and others form larger deposits consisting of many contiguous dunes as seen along Babcock Creek (figure 1). The dunes are generally oriented east-west or northwest-southeast, and are as much as 1/2-mile- long and 10 feet tall. A few dune ridges are curved or crescentic, with the crescents opening to the east or southeast. These orientations suggest that the dunes were formed by winds blowing from the west and northwest. The windblown deposits occur chiefly on the Cape May terraces throughout the quadrangle but are also found bordering upper and lower terraces. In many places, windblown deposits were laid down at the upland edge of lower terraces, or on the lower terrace most notably to the north of Lake Lenape. This association suggests the windblown sand in these settings was blown from the lower terrace deposits, as the terrace deposits were laid down.

The distribution of eolian deposits shows that the deposits largely postdate the Cape May unit 2 and upper terrace deposits, and in places are the same age, or slightly younger than, the lower terrace deposits. These relations indicate deposition occurred during the Wisconsinan stage (80-11 ka).

During at least two periods of higher-than-present sea level in the middle and late Pleistocene, estuarine deposits were laid down in terraces in the Great Egg Harbor River Valley. These marine deposits are grouped into the Cape May Formation. The Cape May includes an older, eroded terrace Cape May Formation, unit 1 (Qcm1) that has a maximum surface elevation of 55 feet. A younger, less eroded terrace with a maximum surface elevation of 35 feet marks the Cape May Formation, unit 2 (Qcm2). The youngest estuarine deposit, Cape May Formation, unit 3 (Qcm3), is marked by a lower terrace with a maximum surface elevation of 15 feet. The Cape May unit 1 deposits lie within wide valleys which are inset into the Bridgeton Formation. The valleys were shallower and broader at the time of deposition of the Cape May unit 1 than they are today because the base of the Cape May unit 1 is higher than that of the upper and lower terrace deposits, and of modern floodplain sediments. Limited remnants of the Cape May unit 1 are found to the southwest of Laureldale.

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; Stanford and others, 2016) suggest that the Cape May unit 1 is of middle Pleistocene age (possibly oxygen-isotope stage 11, around 420 ka, or stage 9, around 330 ka, or older) and that the Cape May unit 2 is of Sangamonian age (stage 5, 125-80 ka). AAR data from vibracores on the inner continental shelf off Long Beach Island northeast of the quadrangle indicates that the Cape May is of Sangamonian age (Uptegrove and others, 2012). Unit 2 of the Cape May formation is as much as 25 feet thick and forms an eroded terrace with a maximum surface elevation of 35 feet. During one or more periods of low sea level following the Cape May unit 1 highstand, but before the Cape May unit 2 highstand, the Great Egg Harbor River incised slightly more than 50 feet below present sea level as shown on cross section A-A'. During the Cape May unit 2 highstand this incised valley was filled with fine-grained estuarine deposits (unit Qcm2f) over a thin basal fluvial sand and gravel. The Cape May unit 3 was deposited during sea-level fall from the unit 2 highstand with a maximum surface elevation of 15 feet and is Sangamonian or early Wisconsinan age.

DESCRIPTION OF MAP UNITS

Artificial Fill—Sand, silt, gravel, clay; gray to brown; demolition debris (concrete, brick, wood, metal, etc.), cinders, ash, slag, glass, trash. Unstratified to weakly stratified. As much as 20 feet thick, generally less than 15 feet thick. In highway embankments and filled wetlands and flood plains. Many small areas of fill, particularly along streams in urban areas, are not mapped.

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 10 feet thick. Sand and gravel consist chiefly of quartz and are generally less than three 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.

Qs **Freshwater Swamp and Marsh Deposits**—Peat and gyttja, black to brown, with wood in places. As much as 10 feet thick. Deposited in areas of groundwater seepage along the shores of the Great Egg Harbor River, in topographic basins, and upstream of salt-marsh deposits.

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 20 feet thick. Deposited along tidal rivers, salt marshes, tidal flats, and bays during Holocene sea level rise, chiefly within the past 9 ka in the map area.

Qe **Eolian Deposits**—Fine-to-medium quartz sand; very pale brown, white. As much as 10 feet thick. Form elongate dune ridges on the Cape May unit 2 terrace and upper and lower terrace deposits. Likely formed during one or more periods of cold climate during the Wisconsinan when terrace sands were exposed to wind erosion.

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 two to 10 feet above modern wetlands. Includes 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 two 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 the lower terrace deposits than in upper terrace deposits due to the 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 15 feet thick. Sand and gravel are quartz. Form terraces and pediments with surfaces five to 45 feet above modern wetlands. Includes stratified stream-channel deposits and poorly stratified to unstratified deposits laid down by groundwater seepage on pediments.

Qcm1 **Cape May Formation, Unit 1**—Fine-to-medium sand, pebble gravel, minor clayey sand; yellowish-brown, very pale brown. Sand and gravel are quartz. As much as 20 feet thick. Forms eroded terraces with a maximum surface elevation of 55 feet. Includes shoreface, tidal-flat, tidal-channel and fluvial sediment.

Qcm2 **Cape May Formation, Unit 2**—Fine-to-medium sand, pebble gravel, minor coarse sand; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz. As much as 25 feet thick. Forms eroded terraces with a maximum surface elevation of 35 feet. Includes shoreface, tidal-flat, tidal-channel and fluvial sediment.

Qcm3 **Cape May Formation, Unit 3**—Fine-to-medium sand, pebble gravel, minor coarse sand; yellow, very pale brown, yellowish-brown. Sand and gravel are quartz. As much as 20 feet thick. Forms terraces with a maximum surface elevation of 15 feet. Includes shoreface, tidal-flat, tidal-channel and fluvial sediment.

Qcm2f **Cape May Formation, Unit 2, Fine-Grained Facies**— Silt, clay, minor sand: gray, light gray. As much as 50 feet thick. Forms a valley fill in the Great Egg Harbor River valley. In subsurface only (section A-A').

Tb **Bridgeton Formation**—(Salisbury and Knapp, 1917) Fine-to-coarse sand to clayey sand, reddish-yellow, brownish -yellow, reddish-brown; pebble gravel. Unstratified to well stratified, with some cross-beds in sand. Cemented by iron in places. Sand consists of quartz with some weathered feldspar and a little weathered chert. Gravel consists of quartz with some chert. Most chert pebbles are weathered to white and yellow clay. As much as 30 feet thick. Occurs as erosional remnants predominantly in the eastern portion of the quadrangle. This plain was laid down by an easterly to southeasterly flowing river system (Owens and Minard, 1979; Martino, 1981). Stratigraphic position and petrologic correlations with marine deposits in the Delmarva Peninsula indicates a late Miocene age (Owens and Minard, 1979; Pazzaglia, 1993).

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 divided into two map units: a sand facies (Tchs) and a clay-sand facies (Tchc), based on gamma-ray and resistivity well logs and surface mapping using five-foot hand-auger holes, exposures, and excavations. Total thickness of the Cohansey in the map area is as much as 180 feet.

Tchs **Cohansey Formation, 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 comprised of 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 include isolated lenses of interbedded clay and sand like those within the clay-sand facies described below. The sand facies is as much as 150 feet thick.

Tchc **Cohansey Formation, 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 three inches thick, rarely as much as two feet thick, sand beds are commonly one to six inches thick but are as much as two feet thick. 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 20 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 450 feet thick in the eastern part of the quadrangle. The Kirkwood consists of four clay-sand sequences traceable on gamma-ray logs and samples from the Bass River corehole (Miller and others, 1998, see discussion under "Kirkwood Formation" above). The Kirkwood in the quadrangle is of early to middle Miocene age, based on strontium stable-isotope ratios and diatoms (Miller and others, 1998).

Tac **Atlantic City Formation**—Silty, clayey, glauconitic (as much as 10%) fine-to-medium quartz sand, minor coarse sand; olive, olive-brown, brown, dark gray; with mica, shells, and shell fragments. In subsurface only. At least 120 feet thick in the western portion of the quadrangle based on interpretations from well 35-04656 (Sugarman and others, 2020) located approximately six miles to the west of cross-section A-A'. Of early Oligocene age, based on strontium stable-isotope ratios and calcareous nannofossils (Miller and others, 1994, 1998; Pekar and others, 1997).

REFERENCES

Buell, M. F., 1970, Time of origin of New Jersey Pine Barrens bogs: Bulletin of the Torrey Botanical Club, v. 97, p. 105-108.

Carter, C. H., 1972, Miocene-Pliocene beach and tidal flat sedimentation, southern New Jersey: Ph.D dissertation, Johns Hopkins University, Baltimore, Maryland, 186 p.

Carter, C. H., 1978, A regressive barrier and barrier-protected deposit: depositional environments and geographic setting of the late Tertiary Cohansey Sand: Journal of Sedimentary Petrology, v. 40, p. 933-950.

deVerteuil, Laurent, 1997, Palynological delineation and regional correlation of lower through upper Miocene sequences in the Cape May and Atlantic City boreholes, New Jersey Coastal Plain, *in* Miller, K. G., and Snyder, S. W., eds., Proceeding of the Ocean Drilling Program, Scientific Results, v. 150X: College Station, Texas, Ocean Drilling Program, p. 129-145.

Florer, L. E., 1972, Palynology of a postglacial bog in the New Jersey Pine Barrens: Bulletin of the Torrey Botanical Club, v. 99, p. 135-138.

French, H. M., Demitroff, M., and Forman, S. L., 2005, Evidence for late Pleistocene thermokarst in the New Jersey Pine Barrens (latitude 39° N), eastern USA: Permafrost and Periglacial Processes, v. 16, p. 173-186.

Greller, A. M., and Rachele, L. D., 1983, Climatic limits of exotic genera in the Legler palynoflora, Miocene, New Jersey, USA: Review of Paleobotany and Palaeoecology, v. 40, p. 149-163.

Lacovara, K. J., 1997, Definition and evolution of the Cape May and Fishing Creek formations in the middle Atlantic Coastal Plain of southern New Jersey: unpublished Ph.D. dissertation, University of Delaware, Newark, Delaware, 245 p.

Martino, R. L., 1981, The sedimentology of the late Tertiary Bridgeton and Pensauken formations in southern New Jersey: unpublished Ph.D. dissertation, Rutgers University, New Brunswick, N.J., 299 p.

Miller, K. G., Sugarman, P. J., Browning, J. V., Olsson, R. K., Pekar, S. F., Reilly, T. J., Cramer, B. S., Aubry, M. P., Lawrence, R. P., Curran, J., Stewart, M., Metzger, J. M., Uptegrove, J., Bukry, D., Burkle, L. H., Wright, J. D., Feigenson, M. D., Brenner, G. J., and Dalton, R. F., 1998, Bass River Site, *in* Miller, K. G., Sugarman, P. J., and Browning, J. V., eds., Proceedings of the Ocean Drilling Program, Initial Reports, v. 174AX, p. 5-43.

Miller, K. G., Sugarman, P., VanFossen, M., Liu, C., Browning, J. V., Queen, D., Aubry, M.-P., Burckle, L. D., Goss, M., and Bukry, D., 1994, Island Beach site report, *in* Miller, K. G., and others, eds., Proceedings of the Ocean Drilling Program, Initial Reports, v. 150X, p. 5-26.

Miller, K. G., Sugarman, P. J., Browning, J. V., Pekar, S. F., Katz, M. E., Cramer, B. S., Monteverde, D., Uptegrove, J., McLaughlin, P. P., Jr., Baxter, S. J., Aubry, M.-P., Olsson, R. K., VanSickel, B., Metzger, K., Feigenson, M. D., Tifflin, S., and McCarthy, F., 2001, Ocean View site, *in* Miller, K. G., Sugarman, P. J., Browning, J. V., and others, eds., Proceedings of the Ocean Drilling Program, Initial Reports, v. 174AX (Supplement 2): College Station, Texas, Ocean Drilling Program, p. 1-72.

Newell, W. L., Powars, D. S., Owens, J. P., and Schindler, J. S., 1995, Surficial geologic map of New Jersey: southern sheet: U. S. Geological Survey Open File Map 95- 272, scale 1:100,000.

O'Neal, M. L., and Dunn, R. K., 2003, GPR investigation of multiple stage 5 sea-level fluctuations on a siliclastic estuarine shoreline, Delaware Bay, southern New Jersey, USA, *in* Brisbane, C. S., and Jol, H. M., eds., Ground penetrating radar in sediments: Geological Society, London, Special Publication 211, p. 929-940.

O'Neal, M. L., Wehmiller, J. F., and Newell, W. L., 2000, Amino acid geochronology of Quaternary coastal terraces on the northern margin of Delaware Bay, southern New Jersey, U. S. A., *in* Goodfriend, G. A., Collins, M. J., Fogel, M. L., Macko, S. A., Wehmiller, J. F., eds., Perspectives in Amino Acid and Protein Geochemistry: Oxford University Press, p. 301-319.

Owens, J. P., Bybell, L. M., Paulachok, G., Ager, T. A., Gonzalez, V. M., and Sugarman, P. J., 1988, Stratigraphy of the Tertiary sediments in a 945-foot-deep corehole near Mays Landing in the southeast New Jersey Coastal Plain: U. S. Geological Survey Professional Paper 1484, 39 p.

Owens, J.P., Hess, M.M., Denny, C.S., Dworink, E.J., 1983, Postdepositional alteration of surface and near-surface minerals in selected Coastal Plain formations of the middle Atlantic states: U. S. Geological Survey Professional Paper 1067-F, 45 p.

Owens, J. P., and Minard, J. P., 1979, Upper Cenozoic sediments of the lower Delaware valley and northern Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland: U. S. Geological Survey Professional Paper 1067D, 47p.

Pazzaglia, F. J., 1993, Stratigraphy, petrography, and correlation of late Cenozoic middle Atlantic Coastal Plain deposits: implications for late-stage passive margin geologic evolution: Geological Society of America Bulletin, v. 105, p. 1617-1634.

Pekar, S. P., Miller, K. G., and Olsson, R. K., 1997, Data report: the Oligocene Sewell Point and Atlantic City formations, New Jersey Coastal Plain, in Miller, K. G., and Snyder, S. W., eds., Proceedings of the Ocean Drilling Program, Scientific Results, v. 150X, p. 81-87.

Rachele, L. D., 1976, Palynology of the Legler lignite: a deposit in the Tertiary Cohansey Formation of New Jersey, USA: Review of Palaeobotany and Palynology, v. 22, p. 225-252.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Cheng, H., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Haflidason, H., Hajdas, I., Hatte, C., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., Manning, S. W., Niu, M., Reimer, R. W., Richards, D. A., Scott, E. M., Southon, J. R., Turney, C. S. M., and van der Plicht, J., 2013, IntCal13 and MARINE 13 radiocarbon age calibration curves 0- 50,000 years cal BP: Radiocarbon, v. 55, no. 4, p. 1869-1887.

Salisbury, R. D., and Knapp, G. N., 1917, The Quaternary formations of southern New Jersey: N.J. Geological Survey Final Report, v. 8, 218 p.

Sirkin, L. A., Owens, J. P., Minard, J. P., Rubin, M., 1970, Palynology of some upper Quaternary peat samples from the New Jersey coastal plain: U. S. Geological Survey Professional Paper 700D, p. D77-D87.

Stanford, S. D., 2000, Geomorphology of selected Pine Barrens savannas: report prepared for N. J. Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management, 10 p. and appendices.

Stanford, S. D., 2012, Geology of the Chatsworth quadrangle, Burlington County, New Jersey: N. J. Geological Survey Open-File Map OFM 97, scale 1:24,000.

Stanford, S. D., Witte, R. W., Braun, D. D., and Ridge, J. C., 2016, Quaternary fluvial history of the Delaware River, New Jersey and Pennsylvania, USA: the effects of glaciation, glacioisostasy, and eustasy on a proglacial river system: Geomorphology, v. 264, p. 12-28.

Sugarman, P. J., Johnson-Bowman, M., Malerba, N. L., Strioteleva, Y., Barr, K., Filo, R. M., Carone, A. R., Monteverde, D. H., Castelli, M. V., Pristas, R. S., 2020, Framework and Properties of Aquifers in Atlantic County, New Jersey: N. J. Geological Survey Open-File Map OFM 130, scale 1:100,000.

Sugarman, P. J., Miller, K. G., Browning, J. V., Monteverde, D. H., Uptegrove, J., McLaughlin, P. P., Jr., Stanley, A. M., Wehmiller, J., Kulpecz, A., Harris, A., Pusz, A., Kahn, A., Friedman, A., Feigenson, M. D., Barron, J., and McCarthy, F. M. G., 2007, Cape May Zoo site, *in* Miller, K. G., Sugarman, P. J., Browning, J. V., and others, eds., Proceeding of the Ocean Drilling Program, Initial Reports, v. 174AX (Supplement 7), p. 1-66.

Sugarman, P. J., Miller, K. G., Owens, J. P., and Feigenson, M. D., 1993, Strontium isotope and sequence stratigraphy of the Miocene Kirkwood Formation, south New Jersey: Geological Society of America Bulletin, v. 105, p. 423-436.

Uptegrove, J., Waldner, J. S., Monteverde, D. H., Stanford, S. D., Sheridan, R. E., and Hall, D. W., 2012, Geology of the New Jersey offshore in the vicinity of Barnegat Inlet and Long Beach Island: N. J. Geological and Water Survey Geologic Map Series GMS 12-3, scale 1:80,000.

Watts, W. A., 1979, Late Quaternary vegetation and of central Appalachia and the New Jersey Coastal Plain: Ecological Monographs, v. 44, p. 427-469.

Wolfe, P. E., 1953, Periglacial frost-thaw basins in New Jersey: Journal of Geology, v. 61, p. 133-141.

EXPLANATION OF MAP SYMBOLS

Contact—Solid where well-defined by landforms as visible on LiDAR imagery, dashed where approximately located.

Material penetrated by hand-auger hole or observed in exposure or excavation. Hand-auger holes were dug to five feet or until refusal. Material descriptions of each hand-auger hole are written in field notes, on file at NJGWS.

47 Well or test boring—Location accurate to within 200 feet. Log of formations penetrated shown in Table 1.

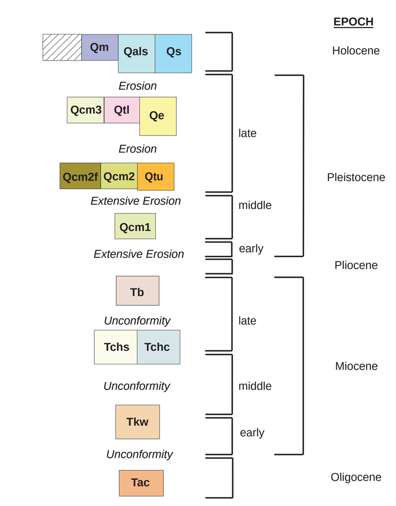
Well with geophysical log—Gamma-ray log is shown by red line. Radiation intensity increases to right. Single point resistance log is shown by blue line, with resistance increasing to right.

Shallow topographic basin—Line at rim, pattern in basin. Includes thermokarst basins formed from melting permafrost.

Sand pit—Inactive in 2021

Excavation perimeter—Line encloses excavated area.

CORRELATION OF MAP UNITS



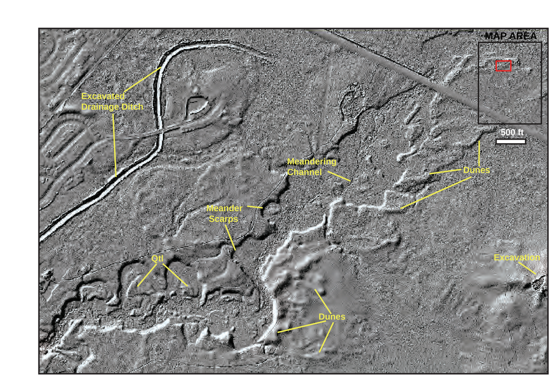
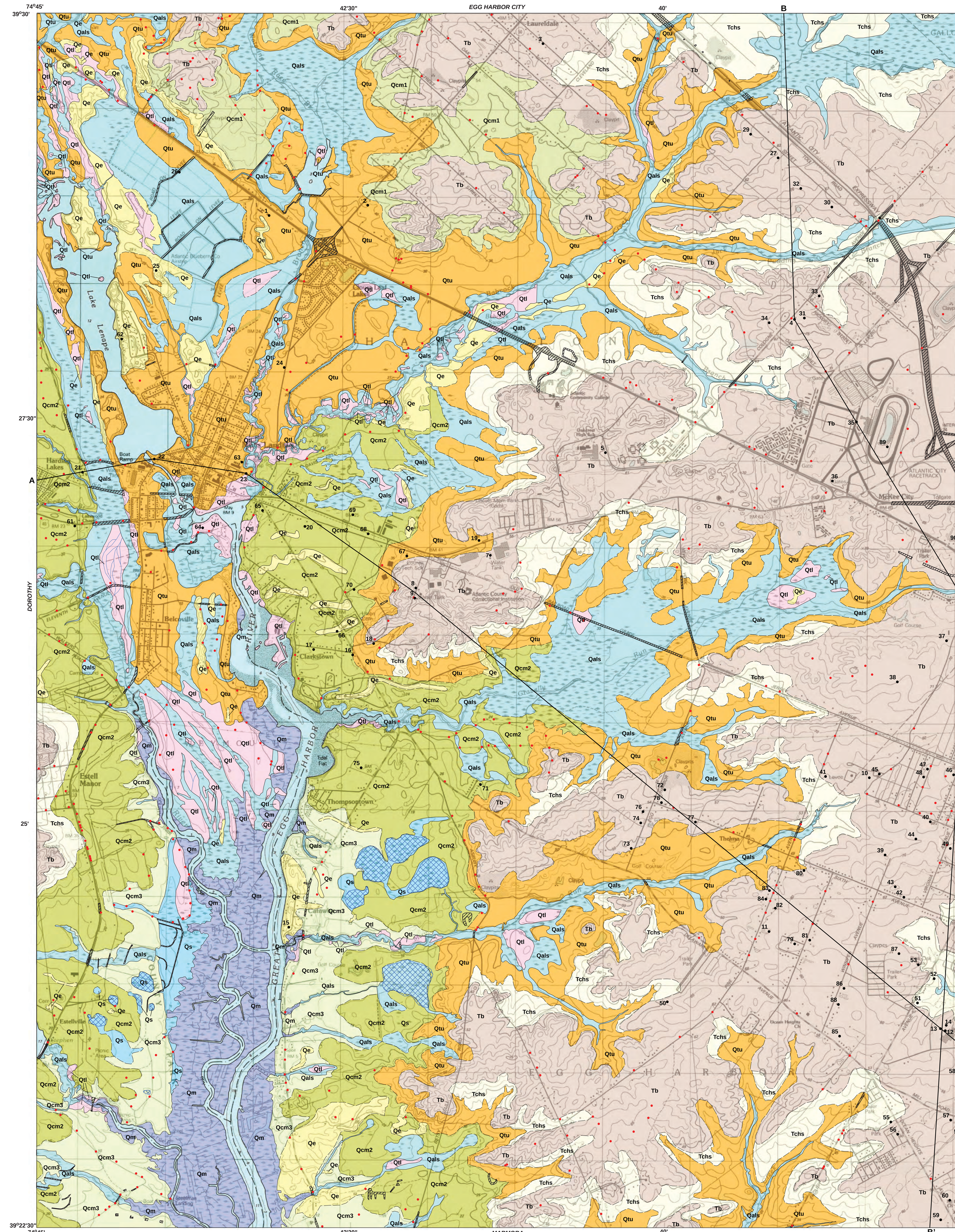


Figure 1. LiDAR imagery showing eolian dune ridges, the present day meandering channel and meander scarps of Babcock Creek, lower terrace deposits (Qtl) just above the modern floodplain, and an excavated drainage ditch. The outline of the quadrangle is shown as a black rectangle in the upper right corner with the area of this figure outlined in red. Area shown is appoximately 1.6 square miles.



Base Map from U. S. Geological Survey, 1989.
North American Datum of 1927.
Topography by photogrammetric methods from aerial photographs taken 1981. Revised from aerial photographs taken 1986.

APPROXIMATE MEAN DECLINATION, 2021

SCALE 1:24 000

CONTOUR INTERVAL 5 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

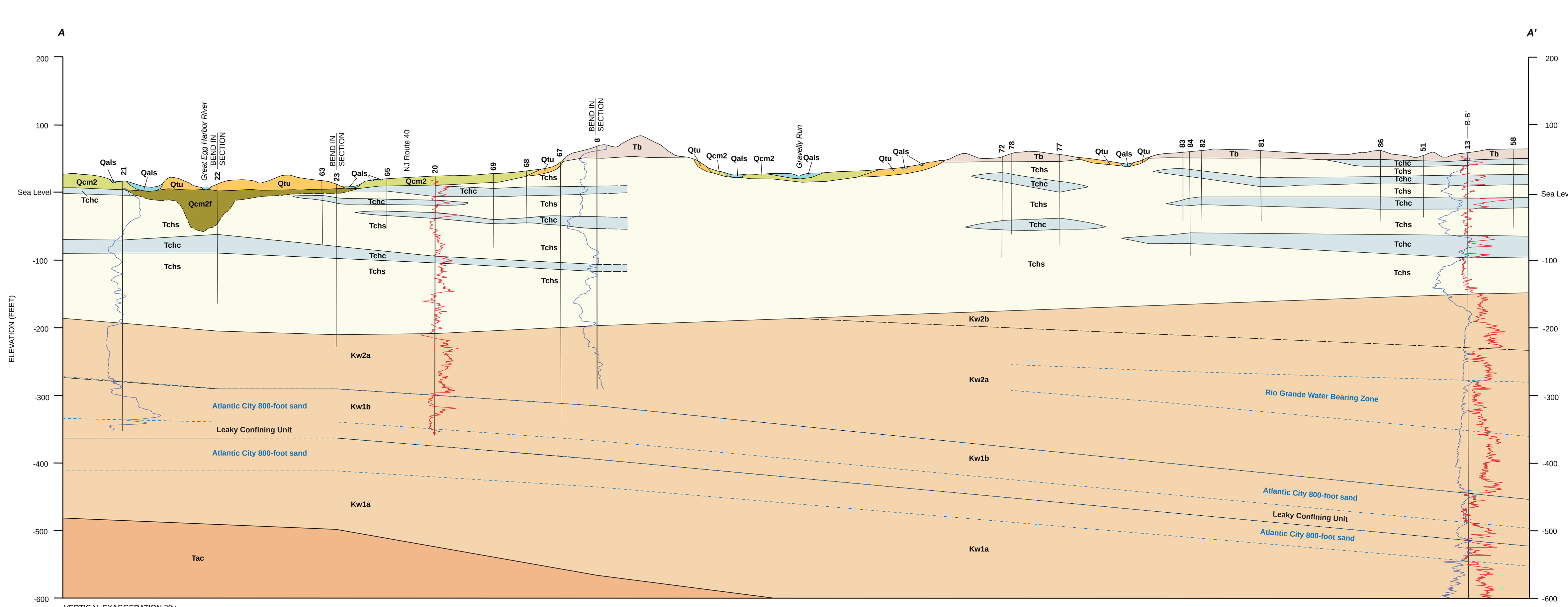
DEPTH CURVES AND SOUNDING IN FEET-DATUM IS MEAN LOWER LOW WATER
SHORELINE REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS 4 FEET

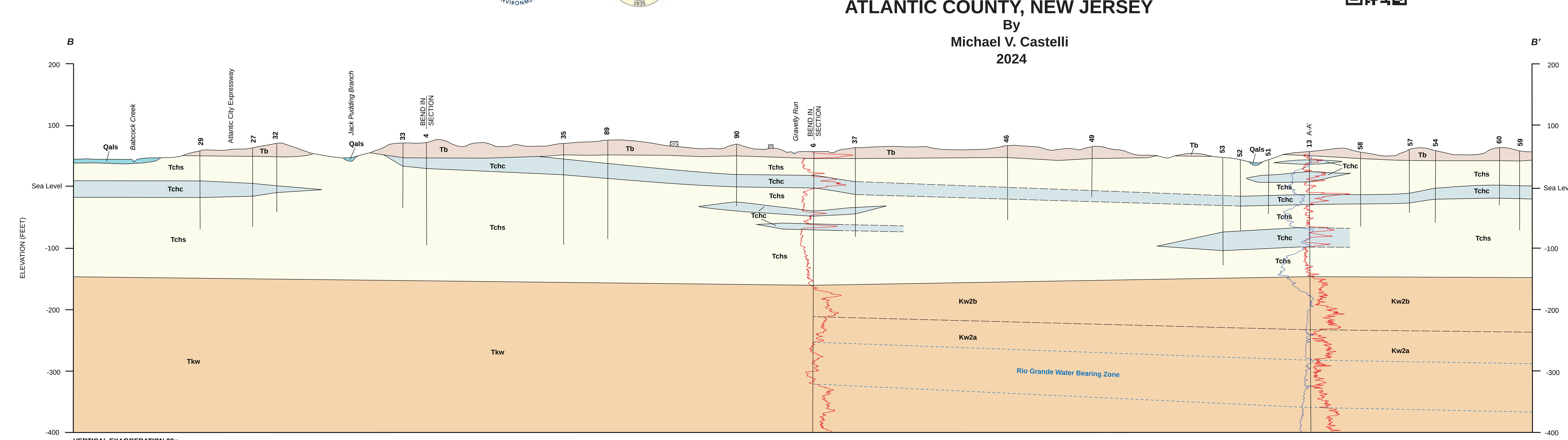
LOCATION IN NEW JERSEY

Geology mapped 2020-2021
Cartography by M. Castelli
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under Statemap award number G20AC00242.

GEOLOGY OF THE MAYS LANDING QUADRANGLE, ATLANTIC COUNTY, NEW JERSEY

By
Michael V. Castelli
2024





Geology of the Mays Landing Quadrangle
Atlantic County, New Jersey

New Jersey Geological and Water Survey
Open File Map OFM 163
2024

pamphlet with table 1 to accompany map

Table 1. Selected well and boring records, bolded well numbers are depicted in cross-sections.
Well numbers 13, 51, and 58 are shown on cross sections A-A' and B-B'.

Well Number	Identifier[1]	Formations Penetrated[2]
1	36-00382	14 Qals 160 Tchs 180 Tchc
2	36-00416	128 Tchs 147 Tchc 157 Tchs
3	36-01738	20 Tb 40 Tchs 60 Tchc 80 Tchs 100 Tchc 105 Tchs 135 Tchc 145 Tchs
4	36-02458	25 Tb 140 Tchs+Tchc 170 Tchs
5	36-00290	16 Tb 24 Tchc 42 Tchs 45 Tchc 95 Tchs 130 Tchc 165 Tchs
6	36-17655G	14 Tb 35 Tchs 55 Tchc 90 Tchs 95 Tchc 110 Tchs 120 Tchc 200 Tchs 400 Tkw 650 TD
7	36-00396	11 Tb 88 Tchs 95 Tchc 165 Tchs 194 Tkw
8	28-08310R	20 Tb 50 Tchs 60 Tchc 95 Tchs 110 Tchc 140 Tchs 150 Tchs 260 Tchs 378 Tkw
9	36-28242	27 Tb 83 Tchs 84 Tchc 165 Tchs
10	36-00401	20 Tb 70 Tchs 95 Tchc 104 Tchs 126 Tchc 249 Tchs+Tchc
11	36-03134	30 Tb+Tchs 45 Tchs 70 Tchc 98 Tchs 115 Tchs
12	36-05517	13 Tb 18 Tchc 40 Tchs 46 Tchc 74 Tchs 76 Tchc 170 Tchs+Tchc 377 Tkw
13	36-05091G+R	17 Tb 19 Tchc 70 Tchs 78 Tchc 82 Tchs 86 Tchc 126 Tchs 158 Tchs+Tchc 195 Tchs 600 Tkw TD 678
14	36-05518	15 Tb 38 Tchs 58 Tchc 71 Tchs
15	36-02408	60 Q+Tchs 65 Tchc 122 Tchs 186 Tchc 212 Tkw
16	36-03546	25 Q 38 Tchc 118 Tchs 187 Tchc 197 Tkw
17	36-03112	15 Q 20 Tchc 30 Tchs 35 Tchc 53 Tchs 58 Tchc 110 Tchs 172 Tchc 212 Tkw
18	36-03547	16 Tb 35 Tchs 38 Tchc 121 Tchs 170 Tchc 186 Tchs
19	36-00449	110 Tchs 120 Tchc 168 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
20	36-28907G	10 Qcm2 25 Tchc 35 Tchs 40 Tchc 55 Tchs 65 Tchc 120 Tchs 128 Tchc 180 Tchs 381 Tkw
21	36-00391R	14 Qcm2 27 Tchs 31 Tchc 72 Tchs 83 Tchc 185 Tchs 371 Tkw
22	56-82	22 Qtu 54 Qcm2f 94 Tchs 98 Tchc 176 Tchs
23	36-15	13 Q 15 Tchc 18 Tchs 27 Tchc 130 Tchs 240 Tkw
24	36-26422	90 Q+Tchs 195 Tchs 460 Tkw
25	36-00480	20 Q 50 Tchs 62 Tchc 65 Tchs 67 Tchc 83 Tchs 86 Tchc 116 Tchs 129 Tchc
26	36-00479	19 Q 47 Tchc 81 Tchs 89 Tchc 115 Tchs 126 Tchc
27	36-24793	20 Tb 60 Tchs 80 Tchc 129 Tchs
28	36-32679	15 Tb 102 Tchs
29	36-21729	12 Tb 50 Tchs 77 Tchc 118 Tchs
30	36-26729	20 Tb 40 Tchs 75 Tchc 100 Tchs
31	36-26478	10 Tb 16 Tchc 41 Tchs 68 Tchc 79 Tchs 95 Tchc 115 Tchs
32	E201506123	14 Tb 68 Tchs 79 Tchc 110 Tchs
33	36-16930	25 Tb 40 Tchc 55 Tchs 85 Tchs+Tchc 103 Tchs
34	36-20123	15 Tb 45 Tchs 80 Tchc 140 Tchs
35	36-27177	20 Tb 26 Tchs 50 Tchc 160 Tchs
36	36-24414	10 Tb 20 Tchs 40 Tchc 80 Tchs
37	36-25089	20 Tb 60 Tchs 100 Tchc 147 Tchs
38	36-29266	9 Tb 52 Tchs 54 Tchc 90 Tchs
39	36-24437	30 Tb 47 Tchs 54 Tchc 98 Tchs
40	36-29270	17 Tb 75 Tchs
41	36-26267	25 Tb 75 Tchs 80 Tchc 95 Tchs 120 Tchc 150 Tchs
42	36-30211	10 Tb 60 Tchs 75 Tchc 90 Tchs
43	36-31966	12 Tb 60 Tchs 74 Tchc 95 Tchs
44	E201205483	40 Tb+Tchs 76 Tchs
45	36-13511	40 Tb+Tchs 78 Tchs 128 Tchc 185 Tchs
46	36-13965	75 Q+Tchs 105 Tchs+Tchc 120 Tchs
47	36-09663	20 Tb 60 Tchs 70 Tchc 110 Tchs
48	36-09925	40 Tb+Tchs 60 Tchs 65 Tchc 117 Tchs 120 Tchc
49	P200907821	20 Tb 75 Tchs
50	36-23726	24 Tb 38 Tchs 60 Tchc 167 Tchs
51	36-23674	10 Tb 15 Tchc 40 Tchs 48 Tchc 60 Tchs 75 Tchc 88 Tchs
52	36-25699	64 Tchs 74 Tchc 110 Tchs
53	P200900823	100 Tchs 106 Tchc 125 Tchs 136 Tchc 145 Tchs 148 Tchc 173 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
54	36-24401	16 Tb 52 Tchs 80 Tchc 115 Tchs
55	36-26426	20 Tb 120 Tchs
56	36-29960	10 Tb 90 Tchs 95 Tchc 125 Tchs
57	E201118717	20 Tb 70 Tchs 85 Tchc 100 Tchs
58	E201205518	60 Q+Tchs 117 Tchs
59	36-25783	20 Tb 133 Tchs
60	36-30347	60 Q+Tchs 80 Tchc 90 Tchs
61	36-24256	14 Qcm2 33 Tchs 39 Tchc 75 Tchs
62	36-24183	20 Q+Tchs 40 Tchc 89 Tchs
63	36-25362	15 Q 20 Tchs 25 Tchc 95 Tchs
64	36-27575	18 Qtl 23 Tchc 60 Tchs 68 Tchc 85 Tchs
65	36-26711	20 Qcm2 32 Tchs 37 Tchc 71 Tchs
66	36-25021	8 Qcm2 60 Tchs
67	36-26860	5 Q 20 Tchs 200 Tchs+Tchc 400 Tkw
68	36-26411	20 Q+Tchs 40 Tchc 60 Tchs+Tchc 80 Tchs
69	E201202623	20 Qcm2 30 Tchs 40 Tchc 75 Tchs 77 Tchc 110 Tchs
70	36-13330	12 Qcm2 21 Tchs 30 Tchc 42 Tchs 50 Tchc 50 Tchs 62 Tchc 74 Tchs 76 Tchc 100 Tchs
71	36-22053	10 Qcm2 14 Tchc 32 Tchs 40 Tchc 52 Tchs 74 Tchc 80 Tchs 84 Tchc 100 Tchs
72	E201415958	15 Tb 25 Tchs 50 Tchs+Tchc 100 Tchs 110 Tchc 150 Tchs
73	36-24086	26 Tb 32 Tchc 100 Tchs
74	36-32020	20 Tb 35 Tchc 40 Tchs 50 Tchc 80 Tchs
75	36-11106	8 Tb 15 Tchs 22 Tchc 46 Tchs 62 Tchc 86 Tchs
76	E201714331	25 Tb 87 Tchs
77	36-22073	13 Tb 40 Tchs 55 Tchc 88 Tchs 118 Tchs+Tchc 133 Tchs
78	36-21051	18 Tb 40 Tchs 48 Tchc 90 Tchs 107 Tchc 118 Tchs
79	36-23131	18 Tb 25 Tchc 50 Tchs 65 Tchc 74 Tchs 80 Tchc 90 Tchs
80	36-23097	40 Tb+Tchs 119 Tchs 125 Tchc 154 Tchs
81	36-24112	23 Q+Tchs 40 Tchs 53 Tchc 100 Tchs
82	36-25677	20 Q+Tchs 74 Tchs 78 Tchc 104 Tchs
83	P201000539	10 Tb 20 Tchs 30 Tchc 70 Tchs+Tchc 80 Tchc 100 Tchs
84	P200915357	20 Q+Tchs 68 Tchs 78 Tchc 120 Tchs 134 Tchc 153 Tchs
85	36-24076	18 Tb 20 Tchc 36 Tchs 45 Tchc 58 Tchs 64 Tchc 105 Tchs
86	36-23932	12 Tb 25 Tchc 40 Tchs 48 Tchc 64 Tchs 84 Tchc+Tchs 98 Tchs
87	36-25321	5 Tb 40 Tchs 45 Tchc 130 Tchs 140 Tchc 183 Tchs
88	36-25865	15 Tb 75 Tchs 80 Tchc 110 Tchs
89	36-09890	20 Tb 40 Tchs 60 Tchc 160 Tchs

Well Number	Identifier[1]	Formations Penetrated[2]
90	36-26125	14 Tb 34 Tchs+Tchc 104 Tchs

1) Numbers of the form 28-xxxxx, 36-xxxxx, 56-xxxxx, Pxxxxxxxxx or Exxxxxxxxx are N. J. Department of Environmental Protection well-permit numbers. A "G" following the identifier indicates that a gamma-ray log is available for the well, an "R" indicates that a Single Point Resistance log is available.

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, "15 Tchs 45 Tchc 82 Tchs" indicates Tchs from 0 to 15 feet below land surface, Tchc from 15 to 45 feet, and Tchs from 45 to bottom of hole at 82 feet. Abbreviations are: Q = yellow, white, and gray sand and gravel surficial deposits of Pleistocene and Holocene age (units Qtu, Qtl, Qals, Qe, Qcm1, Qcm2, Qcm3); Qcm2f = gray to light gray silt, clay, and minor sand found only in subsurface; Tb = orange, red, yellow, brown clayey sand and gravel to gravelly clay (Bridgeton Formation); Tchs=white, yellow, gray, brown (minor red, orange) fine, medium, and coarse sand and minor fine gravel (sand of the Cohansey Formation); Tchc=yellow, white, gray (minor red, orange) clay, silty clay, and sandy clay (clay of the Cohansey Formation); Tkw=gray and brown clay, silt and sand (Kirkwood Formation). A "+" sign indicates that units are mixed or interbedded. TD=the total depth of well. Units are inferred from drillers' lithologic descriptions on well records filed with the N. J. Department of Environmental Protection, 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.
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 or are of poor quality. 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.