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WATER RESOURCES MANAGEMENT
NEW JERSEY GEOLOGICAL AND WATER SURVEY

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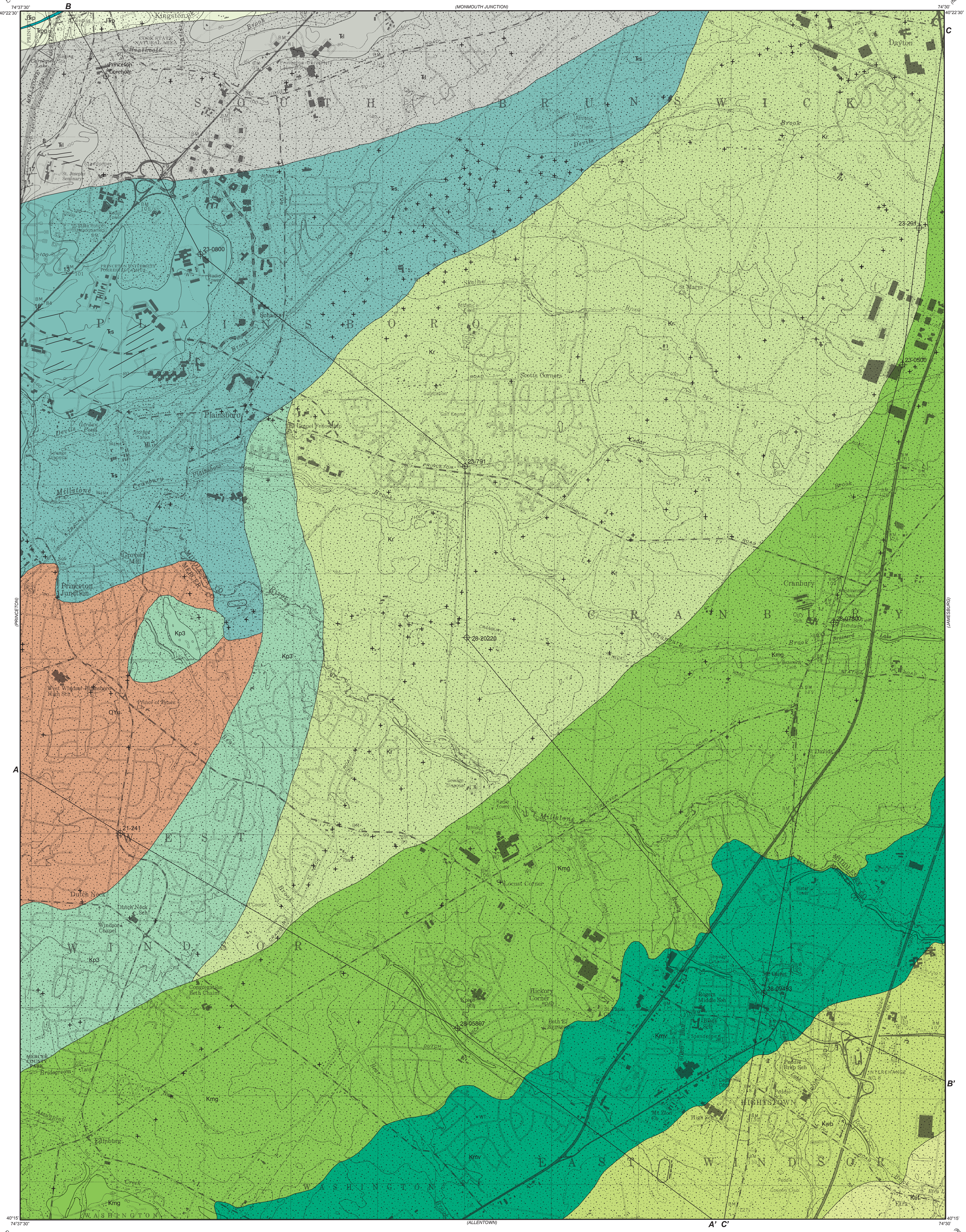


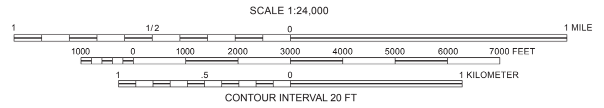
Topography compiled 1942. Planimetry derived from imagery taken 1995 and other sources. Survey control current as of 1954.

North American Datum of 1983 (NAD 83). Projection and 1,000-meter grid: Universal Transverse Mercator, zone 18 2,500-meter ticks: New Jersey Coordinate System of 1983.

North American Datum of 1927 (NAD 27) is shown by dashed corner ticks. The values of the shift between NAD 83 and NAD 27 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software.

There may be private inholdings within the boundaries of the National or State reservations shown on this map.

Landmark buildings verified 1987.



Bedrock geology mapped by P.J. Sugarman, S.D. Stanford, D.H. Monteverde, and R.A. Volkert in 2014.
Digital cartography by N.L. Malerba.

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Bedrock Geologic Map of the Hightstown Quadrangle Middlesex and Mercer Counties, New Jersey

by
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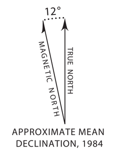
2015



INTRODUCTION

Bedrock of the Hightstown quadrangle includes unconsolidated formations of the New Jersey Coastal Plain Province, as well as sedimentary rocks of the Newark Basin and metamorphic rocks of the Trenton Prong, which comprise the Piedmont Province. The Coastal Plain formations include gravel, sand, clay, and glauconite sand deposited in fluvial, deltaic, coastal, and continental shelf settings between 95 and 80 million years ago. The Newark Basin sedimentary rocks were laid down in lakes and alluvial plains in a continental rift basin between 233 and 200 million years ago (Olsen and others, 2011). The metamorphic rocks include a heterogeneous assemblage of gneiss, schist and granite that ranges in age from Mesoproterozoic to Paleozoic. They were later compressed and deformed during Proterozoic and Paleozoic orogenies. The lithology and age of the formations are provided in the Description of Map Units. Age relations are also summarized in the Correlation of Map Units. Cross sections A-A', B-B', and C-C' show the subsurface configuration of the formations along the line of section. Information on the wells used in the cross sections is given in Table 1. Further detail on the regional stratigraphy of the Coastal Plain formations is provided by Owens and others (1998). Regional relationships of the metamorphic basement rocks are described by Volkert and others (1996) and geophysical data on their extent and depth are provided by Sandberg and others (1996). The elevation of the base of the Coastal Plain formations is shown in Figure 1. Surficial deposits of Pliocene and Quaternary age overlie the Piedmont rocks and Coastal Plain formations in most of the quadrangle. Because of the thick surficial cover, bedrock outcrops are limited. The surficial deposits were mapped by Stanford (2002).

DESCRIPTION OF MAP UNITS

Ket **Englishtown Formation** - Quartz sand, fine-to-medium grained, minor coarse sand, with thin beds of clay and silt. Sand is white, yellow, and light gray where weathered, light gray where unweathered. Clay and silt are light gray to brown where weathered, dark gray to black where unweathered. Very fine-to-fine sand, silt, and clay are commonly thinly bedded to laminated; fine-to-coarse sands are commonly cross bedded. Sand contains common lignite and mica and minor glauconite; mica, lignite, and pyrite are common in the clays. Flat, irregular shaped pyrite cemented sand concretions are found throughout the formation (Owens and Minard, 1966). In the adjacent Allentown quadrangle to the southwest, siderite concretions in the basal few feet contain casts of small gastropods and pelecypods (Owens and Minard, 1966). Basal part of the formation is only present in the very southeast of the quadrangle. Maximum thickness 100 feet in adjacent Jamesburg quadrangle (Stanford and Sugarman, 2008). Late Cretaceous (early Campanian) in age based on pollen (Wolfe, 1976) and ostracodes (Gohn, 1992). Grades downward into the Woodbury Formation. In wells, transition to Woodbury is placed at a change from gray sand, or gray sand and clay, to gray clay. On geophysical well logs, transition to Woodbury is marked by increased gamma-ray intensity.

Kwb **Woodbury Formation** - Silty clay with minor thin beds of very fine quartz and glauconite sand. Dark gray and black where unweathered, yellowish brown to brown where weathered. In more weathered beds, joints and layers are commonly crusted with iron-oxides. Silt is composed of quartz, mica, and feldspar. Pieces of fine grained pyrite and lignite are dispersed throughout. Siderite concretions (6 inches maximum) are present in the upper part (Owens and Minard, 1966). As much as 50 feet thick. Late Cretaceous (early Campanian) based on pollen (Wolfe, 1976) and ostracodes (Gohn, 1992). Grades downward into the Merchantville Formation. In wells, transition to Merchantville is placed at report of change from gray silty clay to green clay or marl.

Kmv **Merchantville Formation** - Glauconite sand, glauconite silt and sand to clayey silt. Olive, dark gray, black where unweathered, olive brown to yellowish brown where weathered. Beds are generally thick, massive, and intercalated. Iron cementation is common. Glauconite and quartz are the major sand components. Quartz sand is chiefly very fine to fine grained. Many of the glauconite grains are accordion form (Owens and Minard, 1966). Minor feldspar, mica (colorless), and pyrite, except in the clayey silt beds where mica is more common. As much as 60 feet thick. Late Cretaceous (early Campanian) in age based on ammonite fossils (Owens and others, 1977).

Kmg **Magothy Formation** - Quartz sand and thin to thick interbeds of clay. Sand is white to yellow where weathered, light gray where unweathered. Silt and clay are white, yellow, pink where weathered, gray to black where unweathered. Sand is fine-to coarse grained, includes minor lignite, pyrite, mica (clear), and feldspar. Pyritic cemented sands can locally form thin beds. Clay is commonly micaceous and lignitic. Sand is cross bedded to laminated. Silt and clay are interlaminated or thinly interbedded with very fine-to-fine sand, or, less commonly, in beds and lenses up to 3 feet thick. The gamma-ray geophysical log from the Borough of Hightstown (Sections B-B', C-C') has a high intensity 25 ft thick interval interpreted as clay-silt above the Magothy sand that is included in the Magothy as a possible equivalent of the Amboy Stoneware Clay, Morgan, or Cliffwood members. Owens and others (1998) maps this 25 ft bed as the Cheesequake Formation, a slightly glauconitic, micaceous clayey silt (Sugarman and others, 2005) (Litwin and others, 1994) that is located unconformably above the Magothy to the northeast of Hightstown (e.g. the South Amboy quadrangle). This interval in question is shown with a diagonal pattern on cross sections B-B' and C-C'. As much as 150 feet thick. Late Cretaceous (Turonian-Coniacian) in age based on pollen (Christopher, 1979, 1982; Miller and others, 2004). Unconformably overlies the Raritan Formation. In wells, contact with Raritan placed at report of change from light sand to clay. On geophysical logs, contact with Raritan marked by increased gamma-ray intensity and decreased resistance.

Kr **Raritan Formation** - Includes two informal members in this quadrangle: the Woodbridge Clay and the Farrington Sand. In the outcrop, the members are not mapped owing to sparse exposures. Another member, the "Raritan fire and potter's clay" of Cook (1878) and Ries and others (1904), underlies the Farrington Sand in the New Brunswick area. This unit includes a lower clay (the "potter's clay") which is predominantly a red, white, and gray clay derived from weathering of shale and mudstone (Stanford and others, 1998), and is included with the Stockton Formation on this map, and an upper, discontinuous, gray sandy clay (the "fire clay") which is near the base of the Farrington Sand and is included in that member, or with the underlying Potomac Formation, on this map. Total thickness of the Raritan Formation in the quadrangle is about 180 feet. Thins to the southwest, where it pinches out in West Windsor Township.

Krw **Woodbridge Clay Member** - Interbedded sequence of unconsolidated clays and sands. Clay is gray to black where unweathered, white to brown to pale red where weathered. Sand is white, yellow, and light gray. Sand is micaceous and feldspathic, and occasionally contains gravel. Clay is lignitic and contains pyrite. As much as 95 feet thick. Grades downward into the Farrington Sand. In wells, transition to Farrington is placed at report of change from gray clay and sand to coarse sand or sand and gravel. On geophysical well logs, transition to Farrington is marked by decreased gamma-ray intensity and increased resistance. The Woodbridge Clay is Late Cretaceous (late Cenomanian) in age based on pollen (Christopher, 1979) and ammonites (Cobban and Kennedy, 1990). Shown in cross section only.

Krf **Farrington Sand Member** - Quartz sand, fine-to-coarse grained, with some thin beds of angular very coarse quartz sand to very fine pebble gravel. Minor clay and silt in beds and lenses up to 3 feet thick. Sand is white, yellow, pink, and red where weathered, gray where unweathered. Clay and silt are white and yellow where weathered, gray where unweathered. As much as 75 feet thick. In wells, contact with Potomac is placed at report of change from sand and gravel to interbedded sand and clay. On geophysical well logs, contact with Potomac is marked by slightly increased gamma-ray peaks and slightly decreased resistance. The Farrington Sand is Late Cretaceous (Cenomanian) in age based on pollen (Christopher, 1979). It is similar in age to the Potomac Formation, unit 3, and it is possible that some of the Farrington beds could be included in the Potomac Formation. Shown in cross section only.

Kp3 **Potomac Formation, Unit 3** - Quartz sand, fine-to-medium grained, and beds of clay and silt. Sand is white, yellow, light gray where weathered, gray where unweathered. Clay and silt are white, yellow, brown, reddish yellow where weathered, gray to black where unweathered. As much as 100 feet thick in southwestern part of quadrangle, pinches out to north near Plainsboro Township. Sand includes some lignite, and minor feldspar and mica. Silt and clay beds include abundant mica and lignite. The Potomac Formation in the map area is equivalent to the Potomac Formation, unit 3 (Doyle and Robbins, 1977), based on pollen (Owens and others, 1998), and is of Late Cretaceous (early Cenomanian) age. Unconformably overlies Piedmont rocks.

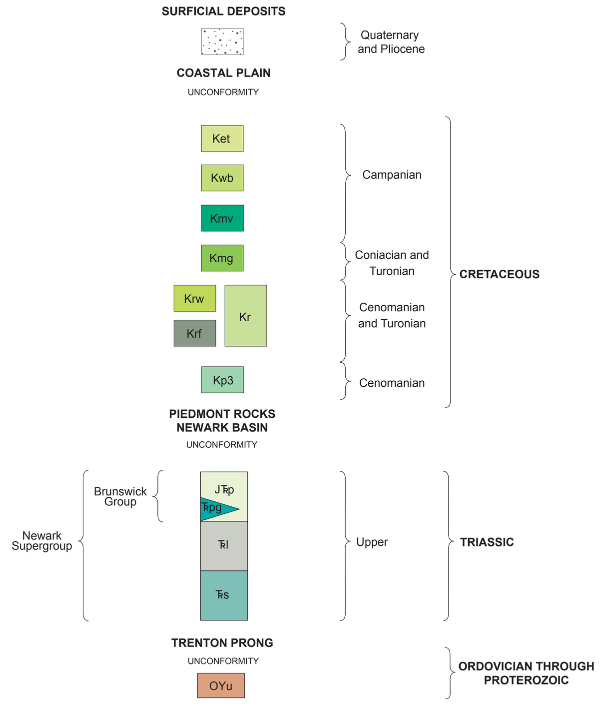
J̄Trp, Trpg **Passaic Formation** - Interbedded sequence of reddish-brown to maroon and purple, fine-grained sandstone, siltstone, shaly siltstone, silty mudstone and mudstone, separated by interbedded olive-gray, dark-gray, and/or black siltstone, silty mudstone, shale and lesser silty argillite. Reddish-brown siltstone is medium- to fine-grained, thin- to medium-bedded, planar to cross-bedded, micaceous, and locally contains mud cracks, ripple cross-lamination, root casts and load casts. Shaly siltstone, silty mudstone, and mudstone form rhythmically-fining-upward sequences as much as 15 feet thick. They are fine-grained, very thin- to thin-bedded, planar to ripple cross-laminated, fissile, locally bioturbated, and locally contain evaporite minerals. Gray bed sequences (Trpg) are medium- to fine-grained, thin- to medium-bedded, planar to cross-bedded siltstone and silty mudstone. Gray to black mudstone, shale and argillite are laminated to thin-bedded, and commonly grade upward into desiccated purple to reddish-brown siltstone or mudstone. Thickness of gray-bed sequences ranges from less than a foot to several feet. Unit is approximately 11,000 feet thick in the vicinity of the map area. Due to the redefinition of the Triassic-Jurassic boundary the Passaic is now entirely Late Triassic, Norian to Rhaetian, (Olsen and others, 2011).

Trl **Lockatong Formation** - Cyclically deposited sequences of mainly gray to greenish-gray, and in upper part, locally reddish-brown, siltstone to silty argillite and dark-gray to black shale and mudstone (Fig. 2). Siltstone is medium- to fine-grained, thin-bedded, planar to cross-bedded, with mud cracks, ripple cross-laminations and locally abundant pyrite. Shale and mudstone are very thin-bedded to thinly laminated, platy, locally containing desiccation features. Lower contact into Stockton Formation defined in drill core samples of the Princeton corehole (Fig. 2; Olsen and others, 1996) and placed at base of lowest continuous black siltstone bed (Olsen, 1980). Due to limited outcrop exposures borehole logs were used to define the basal contact of the Lockatong. Maximum thickness of unit regionally is about 2,200 feet (Parker and Houghton, 1990). Lockatong is Late Triassic (Norian) in age (Olsen and others, 2011).

Trs **Stockton Formation** - (Upper Triassic) - Unit is interbedded sequence of gray, grayish-brown, or slightly reddish-brown, medium- to fine-grained, thin- to thick-bedded, poorly sorted to clast-imbricated conglomerate (Fig. 2), planar to trough cross-bedded, and ripple cross-laminated arkosic sandstone, and reddish-brown clayey fine-grained, sandstone, siltstone and mudstone. Coarser units commonly occur as lenses and are locally graded. Fining upwards sequences are common, the finer grained beds are bioturbated. Conglomerate and sandstone layers are deeply weathered and more common in the lower half; siltstone and mudstone are generally less weathered and more common in upper half. Lower contact is an erosional unconformity. Thickness is approximately 4,500 feet. Stockton is Late Triassic, Carnian to Norian (Olsen and others, 2011).

OYu **Pre-Mesozoic Rocks, Undivided** - (Mesoproterozoic to Ordovician) – Heterogeneous assemblage of medium-grained gneiss, granite and schist that include a wide variety of lithologies. Not exposed in the map area but known to be present in the subsurface based on logs of borings and water-well records and the projection of crystalline rocks from the Princeton quadrangle (Monteverde and others, 2012). The contact of these crystalline rocks and the sedimentary rocks of the Newark Supergroup are shown by a purple line (Fig. 1; modified from Sandberg and others, 1996) where buried beneath Coastal Plain sediments.

CORRELATION OF MAP UNITS



EXPLANATION OF MAP SYMBOLS

Contact - Approximately located.

Formation covered by surficial deposits – Surficial deposits of Pliocene and Quaternary age continuous and generally more than 5 feet thick.

15 **Strike and dip of inclined beds**

Bedrock-controlled strike ridge – Low ridge parallel to strike of bedrock (from Stanford, 2002).

\+ **Well showing formations beneath surficial deposits** – Location accurate to within 500 feet. From Stanford (2002). Lithologic logs on file at NJ Geological & Water Survey. Lithologic and geophysical logs for a few of these wells are provided by Gronberg and others (1989).

Gamma-ray log – On sections, vertical line shows location and depth of penetration of well. Gamma intensity increases to right. Location accurate to within 500 feet. Identifiers of the form 23-xxx, 21-xxx, and 25-xxx are U. S. Geological Survey Ground Water Site Inventory identification numbers. Identifiers of the form 28-xxxx are N. J. Department of Environmental Protection well permit numbers.

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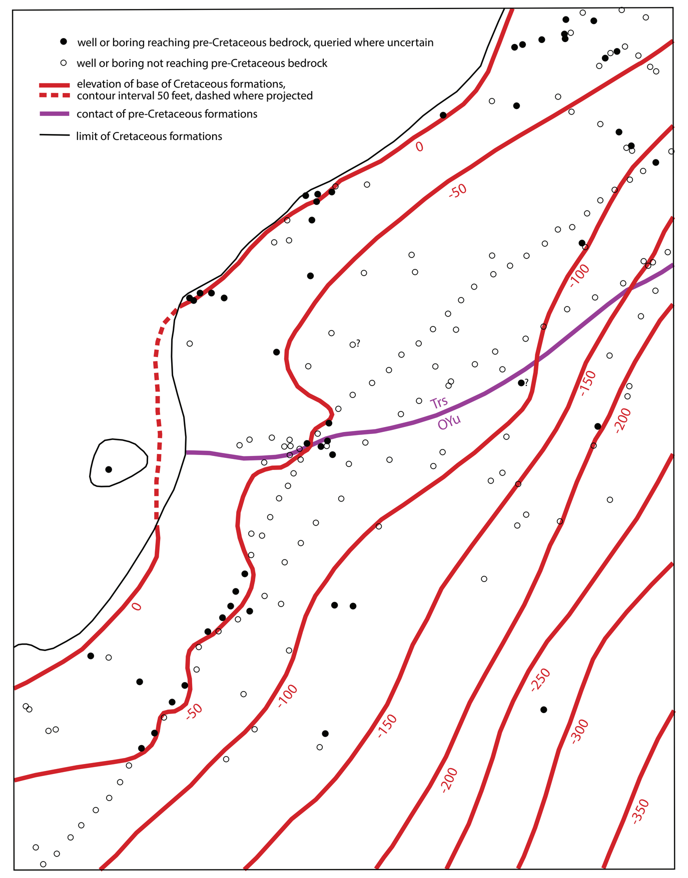

Figure 1. Elevation of the base of Cretaceous formations in the Hightstown quadrangle (red contours). Purple line shows contact of Stockton Formation (Trs) and pre-Mesozoic metamorphic rocks (OYu) beneath Cretaceous formations.

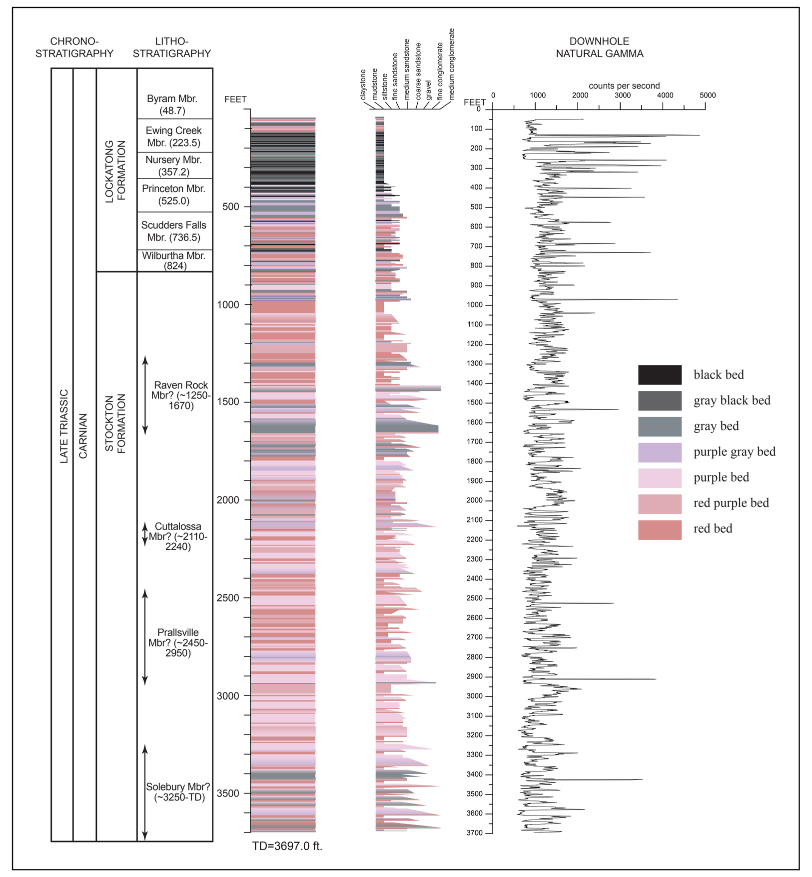

Figure 2. Stratigraphic column and gamma log of the Princeton corehole, it was drilled as part of the Newark Basin Coring Project (Olsen and others, 1996), which used offset corehole locations to sample from just above the Orange Mountain Basalt to near the base of the Stockton Formation. It intersected the oldest units, from the lower Lockatong Formation through the basal Stockton Formation without penetrating into basement. Modified from Olsen and others, (1996). Member (Mbr).

New Jersey Well Permit No.	Latitude (ddmmss)	Longitude (ddmmss)	Elevation (ft)	Total Depth (ft)
28-09493	401624.5	743128.22	98	403
28-05897	401606	743356.1	95	265
21-0241*	401727	743640	100	122
28-20220	401837	743359	105	191
23-791*	401940	743353	80	150
28-16120	402058	743559	96.8	110
N/A	402209	743649	120	3697
28-07800	401842	743056.1	96.5	260
28-10532	402018	743021.1	105	196
28-04849	402109	743013	107	212

Table 1. New Jersey well permit number and total depth of wells used in cross-sections. * USGS Ground Water Site Inventory number (ddmmss = degrees, minutes, seconds)

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