DEPARTMENT OF ENVIRONMENTAL PROTECTION
WATER RESOURCE MANAGEMENT
NEW JERSEY GEOLOGICAL SURVEY

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



## INTRODUCTION

Surficial deposits are unconsolidated sediments that discontinuously overlie bedrock and that are the parent material for agronomic soils. In the Allentown quadrangle, surficial deposits include artificial fill and fluvial, eolian, and hillslope sediments that overlie unconsolidated Coastal Plain bedrock formations. They are as much as 85 feet thick but are less than 30 feet thick throughout most of the quadrangle. The sediments record five main periods of deposition, separated by four episodes of valley erosion. The composition, origin, and geomorphology of the deposits are described below. Their age and relation to the episodes of valley erosion are shown in the *Correlation of Map Units*. Coastal Plain bedrock formations in the quadrangle were mapped by Owens and Minard (1966).

## GEOMORPHOLOGY

The oldest surficial deposit in the map area is the Pensauken Formation (unit Tp), a fluvial sand and gravel that forms an eroded plain that covers the northwestern two-thirds of the quadrangle, northwest of a line between Extonville and Wrightsville. The Pensauken was deposited by a large river that flowed southwesterly along the inner edge of the Coastal Plain from the New York City area to the Delmarva Peninsula. This river system included precursors of the Hudson and Raritan rivers, and, possibly, rivers from southern New England. The Allentown quadrangle is on the southeastern edge of this former river valley. Paleocurrent measurements in the quadrangle (Owens and Minard, 1975), and regionally (Owens and Minard, 1979; Martino, 1981; Stanford and others, 2002), record the southwesterly flow. The elevation of the base of the Pensauken in the quadrangle (shown by contours on the map) ranges from 120 to 130 feet on the east edge of the formation north of Interstate 195 to between 50 and 80 feet in a swale trending southwestward from Eilers Corner through New Sharon and Allentown to the Extonville area. Northwest of this swale the base rises to between 80 and 100 feet, and lowers again to between 60 and 80 feet in another swale in the northwest corner of the quadrangle. The variation in basal elevation records southwest-trending fluvial channeling into the underlying substrate of Cretaceous formations, before deposition of the Pensauken. After channeling was completed, the Pensauken aggraded to form a fluvial braidplain with a surface elevation of about 150 feet, burying the shallow valleys. Local tributary streams draining from the Coastal Plain upland to the southeast deposited sand and gravel in valleys that graded to the Pensauken plain. Today, due to post-Pensauken stream erosion, these deposits (Tg) cap interfluves and hilltops above elevations of 130 to 145 feet.

The age of the Pensauken is not firmly established. Berry and Hawkins (1935) describe plant fossils from the Pensauken near New Brunswick, New Jersey that they consider to be of early Pleistocene age. Owens and Minard (1979) assign a late Miocene age based on correlation with units in the Delmarva Peninsula. Pollen from a black clay bed within the Pensauken near Princeton, New Jersey, includes cool-temperate species and a few pre-Pleistocene taxa. This assemblage suggests a Pliocene age (Stanford and others, 2002). The Pensauken is overlain by late Pliocene or early Pleistocene till in Somerset County, New Jersey, and lies in a valley deeply eroded into middle and late Miocene marine and fluvial deposits. These relationships also indicate a Pliocene age (Stanford, 1993).

The Pensauken river was diverted southeastward to the Atlantic Ocean in the New York City area during a glaciation in the late Pliocene or early Pleistocene between 2.5 million and 800,000 years ago (Stanford, 1993). Following the diversion, a new local drainage network was established on the abandoned Pensauken plain. In the Allentown quadrangle, the earliest record of post-Pensauken streams are sand and gravel deposits capping lower interfluves and hilltops (TQg). The base of these deposits grades from an elevation of 160 to 170 feet at the southwest edge of the quadrangle, between Wrightsville and Cream Ridge, to 50 feet in the Doctors Creek valley at Allentown and in the Crosswicks Creek valley near Extonville. The westward decline of the base of the deposits, and their geographic distribution, indicate that they were laid down by west-draining precursors of the Assunpink, Doctors, and Crosswicks creeks. Their topographic position indicates that these deposits are chiefly of early Pleistocene and, possibly, latest Pliocene, age.

Continued stream erosion in the early and middle Pleistocene further deepened valleys by 20 to 50 feet. Wide plains developed within these valleys, possibly during one or more periods of higher-than-present sea level in the middle Pleistocene when streams were unable to incise. Sand and gravel capping these plains (Qtu) today form upper stream terraces with surfaces 20 to 40 feet above modern flood plains. These terraces are well developed in the Crosswicks, Doctors, and upper Assunpink creek valleys. They also extend across low, broad divides between Buckhole Creek and the New Sharon Branch of Assunpink Creek near Wrightsville, and between Assunpink Creek and the Millstone River valley in the northeastern corner of the quadrangle, east of Eilers Corner. These divides mark abandoned routes of streams that formerly flowed into the Assunpink basin before being captured by Doctors Creek and the Millstone River during the latter stages of upper terrace deposition.

In the Delaware valley, downstream from the mouths of Assunpink and Crosswicks creeks, the upper terraces grade to, or are onlapped by, the Cape May Formation, unit 2, which is an estuarine deposit of late Pleistocene age (oxygen-isotope stage 5, corresponding to the Sangamonian interglacial in North American glacial-stage terminology, about 125,000 years old). This relationship indicates that the upper terraces are contemporareous with, or older than, the Cape May 2 (Stanford, 2008).

As sea level declined after the Sangamonian highstand, streams incised again. After 20 to 40 feet of incision, sand and gravel were laid down on narrow plains (Qtl). Today these deposits form lower stream terraces with surfaces 5 to 15 feet above modern flood plains. The lower terraces grade to glaciofluvial plains in the Delaware and Millstone valleys to the west and north of the quadrangle that were deposited during maximum advance of the last glacier 25,000 to 15,000 years ago (known as the late Wisconsinan stage). The lower terraces are therefore also chiefly of late Wisconsinan age. Permafrost and tundra-boreal forest in this area during the late Wisconsinan glacial maximum led to increased overland runoff that delivered more sediment to streams, promoting terrace deposition. On flat uplands with little runoff, two areas of frost-cracked patterned ground visible on airphotos (shown by pattern on map) also are evidence of permafrost. Several small deposits of windblown sand (Qe), and more widespread but thin and patchy deposits of windblown silt (symboled on map where observed), on upper terraces and the Pensauken upland, were also probably laid down at this time, when reduced tree cover exposed more sediment to wind erosion.

Lower terraces are more extensive and better preserved, and may indicate a longer period of deposition, in the Assunpink Creek valley than in the Crosswicks and Doctors Creek valleys. This difference reflects the shorter route of Crosswicks and Doctors creeks to local base level at the Delaware River than that of Assunpink Creek. The resulting steeper Crosswicks and Doctors creeks incise more rapidly than the Assunpink during erosional episodes and limit the lateral extent of terraces during depositional periods.

In the Crosswicks Creek valley, erosional remnants of an intermediate terrace between the upper and lower terraces are preserved near Walnford, with a surface 15 to 25 feet above the modern flood plain. This terrace was laid down as Crosswicks Creek incised from the upper to the lower terrace in the late Pleistocene 125,000 to 25,000 years ago (the early and middle Wisconsinan stages).

As climate warmed between 15,000 and 10,000 years ago, forests returned, permafrost melted, and sediment loads in streams declined. Streams again incised, eroding 5 to 20 feet into the lower terraces to form modern flood plains. Channel and overbank sediments have been deposited in these flood plains for the past 10,000 years. Melting of permafrost also contributed to the formation of the many small topographic basins (known as thermokarst basins, shown by pattern on the map) on flat upland and terrace surfaces in the quadrangle.

## DESCRIPTION OF MAP UNITS

(hatched pattern) ARTIFICIAL FILL—Sand, silt, gravel, clay; gray to brown; demolition debris (concrete, brick, wood, metal, etc.), cinders, ash, slag, glass. Unstratified to weakly stratified. As much as 30 feet thick. In highway and railroad embankments, dams, and small areas of filled flood plains and ravines. Some small areas of fill, particularly along streams in suburban areas, are not mapped.

**Qal** ALLUVIUM—Sand, silt, minor clay and peat; brown, yellowish-brown, gray; and pebble gravel. Contains varied amounts of wood and fine organic matter. Sand and silt are unstratified to weakly stratified. Gravel occurs in unstratified to weakly stratified beds generally less than 2 feet thick. Sand consists chiefly of quartz with some (5-10%) glauconite and mica. Gravel consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a few (<5%) chert and ironstone pebbles. Sand and gravel beds may be locally cemented with iron. Total thickness of deposit as much as 15 feet. Deposited in modern flood plains, stream channels, and groundwater seepage areas.

**Qe** EOLIAN DEPOSITS—Fine sand, fine-to-medium sand, yellowish-brown to very pale brown. Unstratified to weakly stratified. Sand consists chiefly of quartz with minor glauconite and a trace (<1%) of feldspar. As much as 10 feet thick. These are windblown sediments eroded from underlying and adjacent surficial deposits and deposited in low dunes. Thin, patchy, light gray, very fine sand and silt as much as 8 feet thick overlie surficial deposits elsewhere in the quadrangle, particularly as accretion gleys on low-lying outcrop areas of the Pensauken Formation. These deposits are in part windblown and in part fine-grained slopewash sediments. They lack continuity and distinctive morphology and so are not mapped, but are indicated on the map by the letter “g” followed by a thickness, in feet, where penetrated by hand-auger hole.

**Qtl** LOWER STREAM-TERRACE DEPOSITS—Fine-to-medium sand, some medium-to-coarse sand, minor silt; yellowish-brown, reddish-brown, olive-yellow, pale olive, light gray; pebble gravel. Sand consists chiefly of quartz, with some glauconite, minor mica, and a trace of feldspar. Sand is unstratified to well-stratified, locally cross-bedded. Gravel occurs in thin beds and as a basal lag and consists chiefly of white, gray, and yellow-stained quartz and quartzite, with minor dark brown and reddish-brown ironstone and a trace of gray and brown chert. As much as 15 feet thick. Form stream terraces with surfaces 5 to 15 feet above modern flood plains.

**Qcl** LOWER COLLUVIUM—Silty fine-to-medium sand; brown, yellowish-brown, reddish-brown; with a few to some ironstone and quartz pebbles. Sand is quartz with some glauconite. Unstratified to weakly stratified. As much as 10 feet thick. Deposited by slopewash and mass movement on steep hillslopes, chiefly during cold climate conditions in the late Pleistocene. Forms foot-slope aprons that grade to lower stream terraces or the modern flood plain.

**Qti** INTERMEDIATE STREAM-TERRACE DEPOSITS—Fine-to-medium sand, some medium-to-coarse sand, minor silt; yellowish-brown, olive-yellow, pale olive; pebble gravel. Sand consists chiefly of quartz with some glauconite. Sand is unstratified to well-stratified, locally cross-bedded. Gravel occurs in thin beds and as a basal lag and consists chiefly of white, gray, and yellow-stained quartz and quartzite, minor dark brown and reddish-brown ironstone, and a trace of gray and brown chert. As much as 15 feet thick. Form stream terraces with surfaces 15 to 25 feet above the modern flood plain along Crosswicks Creek.

**Qtu** UPPER STREAM-TERRACE DEPOSITS—Fine-to-medium sand, minor silt, very fine sand, and coarse sand; yellow, reddish-yellow, brownish-yellow, light gray, olive-yellow; pebble gravel. Sand consists chiefly of quartz with some glauconite, minor mica, and a trace of feldspar in places. Sand is unstratified to well stratified, locally cross-bedded. Gravel occurs in thin beds and as a basal lag, and consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a trace of gray and brown chert and brown and reddish-brown ironstone. As much as 25 feet thick. Form stream terraces in the Crosswicks Creek, Doctors Creek, and upper Assunpink Creek valleys with surfaces 20 to 40 feet above modern flood plains.

**Qcu** UPPER COLLUVIUM—Silty fine-to-medium sand; reddish-yellow, brown; with a few to some quartz and ironstone pebbles. Unstratified to weakly stratified. As much as 10 feet thick. Deposited by slopewash and mass movement on steep hillslopes, chiefly during cold climate conditions in the early and middle Pleistocene. Forms perched foot-slope aprons that are on grade to upper stream terraces.

**TQg** UPLAND GRAVEL, LOWER PHASE—Fine-to-medium sand, silty fine-to-medium sand; yellow, brownish-yellow, reddish-yellow, olive-yellow; pebble gravel. Sand is chiefly quartz with some glauconite. Sand is unstratified to weakly stratified. Gravel consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a trace of brown to reddish-brown ironstone and gray to brown chert. As much as 20 feet thick. Occurs as erosional remnants of former flood plains on low interfluves and hilltops.

**Tp** PENSAUKEN FORMATION (Salisbury and Knapp, 1917)—Fine-to-coarse sand to clayey sand, minor silt and very coarse sand; reddish-yellow, yellow, very pale brown, light gray; pebble gravel. Unstratified to well stratified, commonly with tabular, planar cross-beds in sand. Pebble gravel occurs as thin layers (generally less than 3 inches thick) within the sand and as thicker, unstratified beds in places at the base of the formation, where it may include cobble gravel. Sand consists chiefly of quartz with some feldspar, mica, and glauconite, and a trace of rock fragments (chert and shale) (Bowman and Lodding, 1969; Owens and Minard, 1979). The feldspar is partially or fully weathered to white clay. Gravel consists chiefly of yellow, reddish-yellow (from iron staining), white, and gray quartz and quartzite; a few brown to gray chert and reddish-brown ironstone; and a trace of brown, reddish-brown, and gray sandstone and shale, and white-to-gray gneiss. The chert, sandstone, shale, and gneiss commonly are partially weathered or fully decomposed. On footslopes, swales, and low-lying areas of outcropping Pensauken there is a discontinuous light gray, white, to very pale brown silt, silty very fine sand, to fine-sandy silt, as much as 8 feet thick, but generally less than 3 feet thick, overlying Pensauken sand and gravel. This fine-grained material includes both windblown deposits and accretion-gley sediment transported from upslope by rillwash, sheetwash, and soil throughflow, primarily during periods of permafrost formation. It is too patchy to map but is indicated by “g” and a thickness value (in feet) where penetrated by hand-auger hole. The Pensauken is as much as 85 feet thick.

**Tg** UPLAND GRAVEL—Fine-to-medium sand, silty fine-to-medium sand; yellow, brownish-yellow; pebble gravel. Sand is chiefly quartz with some glauconite and minor mica. Sand is unstratified to weakly stratified. Gravel consists chiefly of white, gray, and yellow-stained quartz and quartzite, with a trace of brown to reddish-brown. As much as 35 feet thick. Occurs as erosional remnants of former flood plains on interfluves and hilltops.

**Qwcp** WEATHERED COASTAL PLAIN FORMATIONS—Exposed formations of Cretaceous and Paleocene age. Soil zone generally includes some lag pebbles from eroded surficial deposits. Unit includes patchy colluvial, alluvial, or eolian sediments less than 3 feet thick.

## MAP SYMBOLS

Contact—Solid where well-defined by landforms, long-dashed where approximately located, short-dashed where gradational or featheredged, dotted where projected under water.

3● Qe5/Qtu7● Material observed in exposure, excavation, or penetrated in 5-foot hand-auger hole—Number, if present, indicates thickness of surficial material, in feet. No number indicates map unit thicker than 5 feet. Where more than one surficial material was exposed, the thickness (in feet) of the upper unit is indicated next to its symbol and the lower unit is indicated following the slash.

g3● Accretion gley or eolian silt—Light gray silt and very fine-to-fine sand overlying mapped surficial unit. Penetrated in hand-auger hole, number indicates thickness in feet.

● 28-4124 / 15 Thickness of surficial material in well or boring—Location accurate to within 200 feet. Upper number is N. J. Department of Environmental Protection well permit number, lower number is thickness of surficial material in feet.

⊙ 28-17514 / 23 Thickness of surficial material in well or boring—Location accurate to within 500 feet. Upper number is N. J. Department of Environmental Protection well permit number, lower number is thickness of surficial material in feet.

16 ■ Thickness of surficial material in power-auger boring—From Owens and Minard (1966). Queried value north of Shrewsbury may be thickness of Marshalltown Formation rather than surficial material.

Shallow topographic basin—Line at rim, pattern in basin. Depth generally less than 5 feet but as much as 15 feet. Most were formed by melting of permafrost. Some may have formed from wind erosion. Drawn from air photos taken in 1979.

Excavation perimeter—Line encloses excavation. Topography within excavation may differ from that shown on base map.

Sand and gravel pit—Inactive in 2008.

Seepage scarp—Line at base of scarp, at position of groundwater emergence. Seepage drains downhill from this position.

Patterned ground—Polygonal patterns formed by ice-wedge growth during cold climate conditions. Visible on aerial photography taken in 1979.

100 Elevation of base of Pensauken Formation—Contour interval 20 feet.

Paleoflow—Arrow shows direction of former river flow, as measured on cross-beds observed at point “x”. Bar through symbol indicates measurement is from Owens and Minard (1975).

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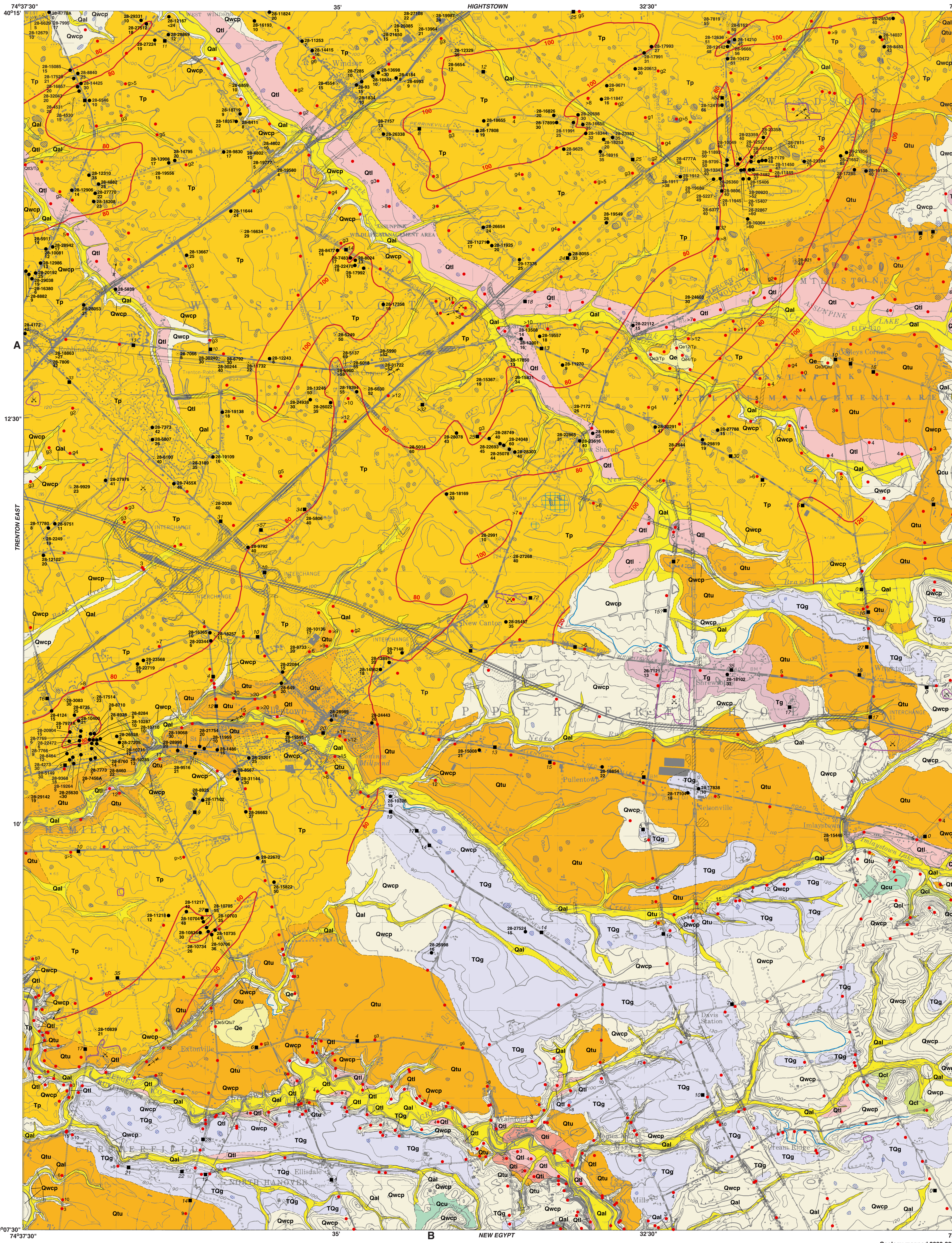
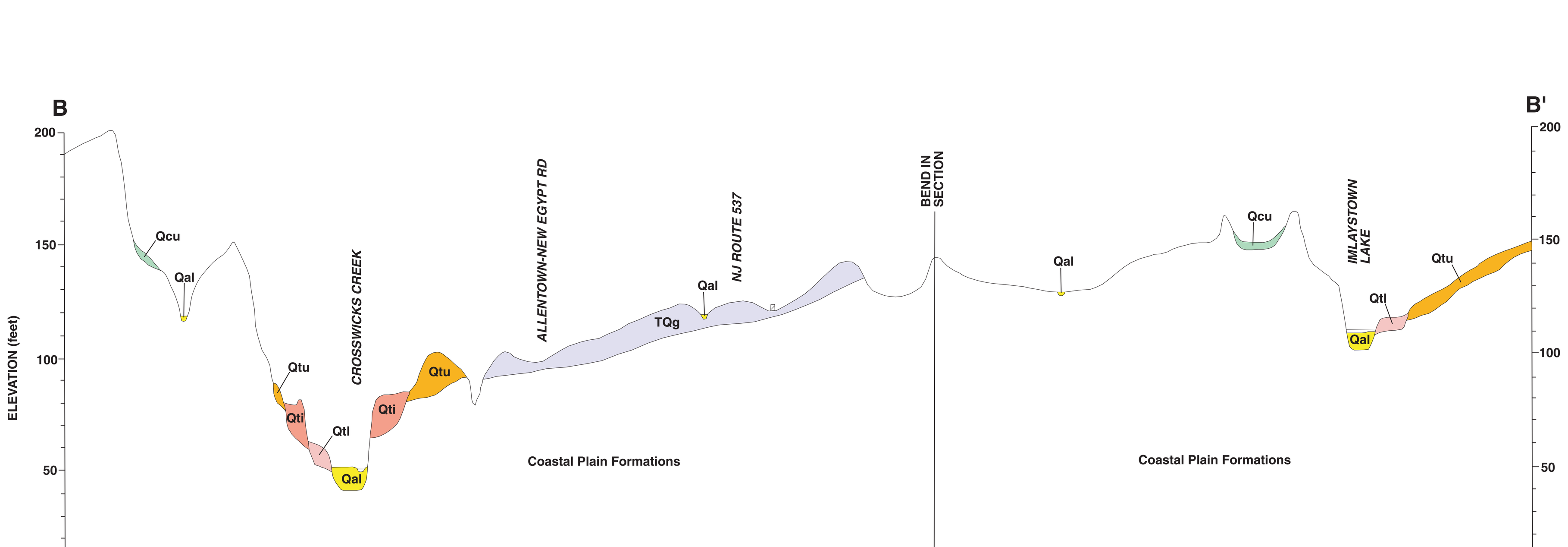


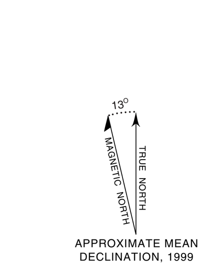

Base from U. S. Geological Survey, 1995.
North American Datum of 1927.

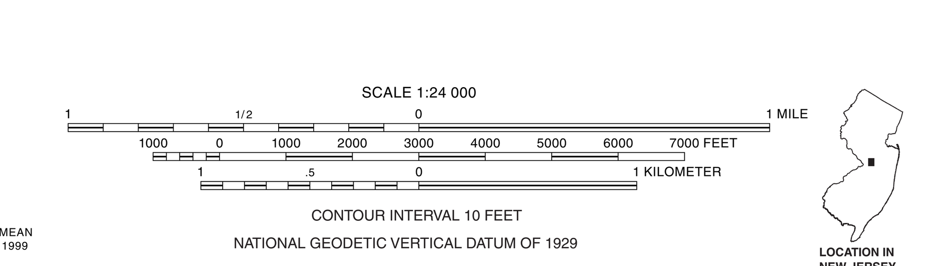
Geology mapped 2008-2009.
GIS coverages by M. Girard.
Cartography by S. Stanford.

# SURFICIAL GEOLOGY OF THE ALLENTOWN QUADRANGLE
# BURLINGTON, MERCER, AND MONMOUTH COUNTIES, NEW JERSEY

by
Scott D. Stanford
2010

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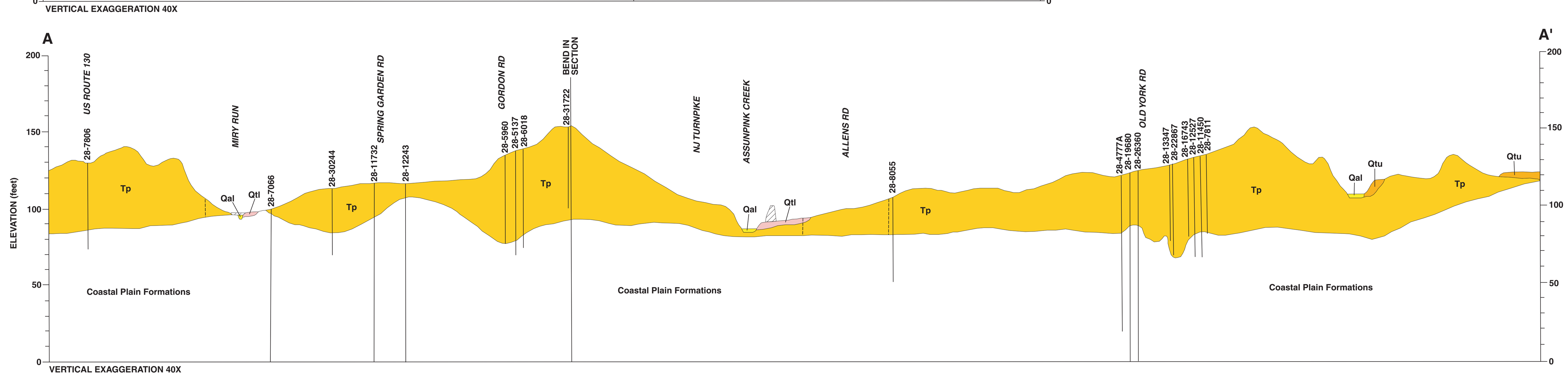


## CORRELATION OF MAP UNITS