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SURFICIAL GEOLOGY OF THE MENDHAM QUADRANGLE
MORRIS AND SOMERSET COUNTIES, NEW JERSEY
OPEN-FILE MAP OFM 94

Pamphlet containing tables 1 and 2 accompanies map

INTRODUCTION

The Mendham quadrangle is located in the Highlands province in north-central New Jersey. Surficial deposits in the quadrangle include glacial, stream, hillslope, wetland, and man-made sediment and weathered-rock material. Glacial sediments were laid down during three glaciations: the late Wisconsinan glaciation (about 25,000 years ago), an intermediate glaciation of pre-Wisconsinan age (most likely the late Illinoian glaciation, about 150,000 years ago), and an older glaciation of pre-Illinoian age (possibly as old as 2.5 million years ago). Hillslope and alluvial-fan and some of the stream sediments were laid down primarily under cold-climate conditions during the glacial periods. Wetland and flood-plain sediments are primarily of postglacial age. Weathered-bedrock materials are produced continuously under both cold and temperate climate by mechanical and chemical breakdown of bedrock.

The accompanying map and sections show the surface extent and subsurface relations of these deposits. Their composition and thickness, and the events they record, are described in the *Description of Map Units* (below). Well and boring data used to construct bedrock-surface elevation contours, and to infer the thickness and subsurface distribution of the deposits, are provided in tables 1 and 2 (in pamphlet). Figure 1 shows geomorphic and glacial features in the quadrangle, and figure 2 shows the thickness of surficial deposits and weathered bedrock. The chronologic relationships of the deposits and episodes of erosion are shown in the *Correlation of Map Units* (below). The hydrology of the surficial deposits and the history of geomorphic and glacial events in the quadrangle and adjacent areas are briefly described in the two following sections. Bedrock was mapped by Volkert (2008).

HYDROLOGY OF SURFICIAL DEPOSITS

Illinoian sand and gravel deposits (Qis) are productive glacial aquifers in valley fills in the Lamington River valley and the downstream reach of the Mill Brook valley. In these valleys, the sand and gravel is overlain by silt, clay, and fine sand of late Wisconsinan age (Qsl, Qdol; sections AA', CC'), which are confining or semiconfining beds. Sand and gravel beds in these valley fills are important regional aquifers and are tapped by public-supply wells to the north and west of the Mendham quadrangle (Canace and others, 1993; Schaefer and others, 1993; Nicholson and others, 1996). Only a few wells draw from the valley fills in the Mendham quadrangle (L1, L2, L3, L10, L12 in table 1). Elsewhere in the quadrangle, surficial deposits are generally too thin or insufficiently permeable to be aquifers, although several domestic wells draw from Illinoian sand and gravel beneath, or interbedded with, till in the moraine at the head of Shongum Lake (wells L18, L22), or from weathered bedrock beneath the moraine (well L20). A few other wells draw from granular weathered gneiss (Qwg, wells L26, 109) where it is sufficiently thick.

Hydraulic conductivities of surficial deposits may be estimated from aquifer-test and laboratory data on similar deposits in New Jersey (Stanford, 2000; Mennel and Canace, 2002). Sand and gravel deposits (units Qso, Qaf, Qis, Qst, and parts of Qal) are highly permeable, having estimated hydraulic conductivities that range from 10^1 to 10^3 feet per day (ft/d). Weathered rock, colluvium, and till with silty sand matrix (parts of Qwg, Qcg, and Qf) are also permeable, having estimated hydraulic conductivities from 10^{-1} to 10^2 ft/d. Glaciolacustrine silt and clay (Qsl, Qdol, Qpml, Qisl, and Qpsl) and weathered rock with clayey silt to silty clay matrix (parts of Qwcb, Qws, and Qwb) are of low permeability, having hydraulic conductivities of 10^{-5} to 10^{-3} ft/d. Fine sand and silt alluvial deposits (parts of units Qal, Qcal, and Qaf), silty to sandy silt till (parts of Qpt and Qf), and silty weathered rock and colluvium (parts of Qwcb, Qws, Qwb, Qwg, Qcg, and Qcs) are somewhat more permeable, having estimated hydraulic conductivities of 10^{-3} to 10^{-1} ft/d. Wetland deposits (Qs) and fill have variable hydraulic conductivities that depend on their clay and silt content. Peat with little mineral soil, and fill composed of sand, cinders, gravel, demolition debris, slag, and trash, may be highly permeable.

GEOMORPHIC AND GLACIAL HISTORY

The highest elevations in the quadrangle are the plateau-like summit areas of uplands, including terrain above an elevation of about 850 feet in the northern half of the quadrangle and a smaller area between about 650 and 720 feet in elevation near the southern edge of the quadrangle (fig. 1). These uplands have about 150 feet of local relief and are as much as 700 feet above main valley floors. They are part of a regional low-relief upland erosion surface, termed the "Schooley peneplain" by Davis and Wood (1889), and "Kittatinny base level" by Salisbury (1898). They interpreted the feature as the product of fluvial erosion during a long period of stable base level. When base level lowered, the plain was incised by rivers, leaving upland remnants on resistant bedrock like the gneiss and granite in the Mendham quadrangle. Later studies in the Appalachian region proposed different origins for similar upland surfaces, and the peneplain hypothesis fell into disfavor. More recently, improved data on global sea level, and on the age of fluvial and marine sediments in New Jersey, indicate that a revised version of the peneplain hypothesis is plausible in this region. These data suggest that the upland erosion surface reached its final form in the middle to late Miocene (15-10 million years ago (Ma)) and was isolated on resistant-rock uplands by river incision in the late Miocene and early Pliocene (10-4 Ma) (Stanford and others, 2001). Erosion on moderate to gentle slopes has subsequently modified the surface, but it has done so at a rate much slower than that in the valleys, preserving its general form.

Lowering sea level between 10 and 4 Ma due to growth of glaciers in Antarctica led to river incision along belts of erodible bedrock, including carbonate rock and micaceous, foliated gneiss. Carbonate rock includes Paleozoic dolomite in the Lamington River and North Branch of the Raritan River valleys, and marble in the Whippany River valley. Micaceous, foliated gneiss crops out in the Whippany River, Den Brook, and Mill Brook valleys. This incision lowered valley floors as much as 500 feet below the former base level on the Schooley surface.

The pre-Illinoian glacier advanced into this landscape, perhaps as early as 2.5 Ma. It covered the entire quadrangle and advanced as far south as the Somerville area, 15 miles south of Mendham Borough. Magnetically reversed pre-Illinoian sediment (Ridge, 2004), weathering properties, erosional preservation, and pollen in basal lake sediment of probable pre-Illinoian age in Budd Lake (Harmon, 1968; Stanford and others, 2001), all indicate that the pre-Illinoian glaciation occurred in the early Pleistocene, between 2.5 and 0.8 Ma. Today, remnants of deeply weathered pre-Illinoian till (Qpt) crop out in only two small patches on flat uplands near Mendham Borough and Mount Freedom (Randolph Township). Additional deposits may be preserved beneath colluvium in similar topographic positions. Scattered erratic pebbles, cobbles, and boulders of purple conglomerate, gray to white quartzite, and gray chert (shown by symbols on the map) indicate that the pre-Illinoian till was formerly more widespread, but has been eroded from most of its original extent.

Very fine sand, silt, and clay of possible pre-Illinoian glacial origin were observed under colluvium at two locations: 1) in a headwater valley in Mendham Borough and 2) along Primrose Brook in Jockey Hollow (both sites labeled "Qpsl" on map). A small deposit of deeply weathered sand and gravel (Qps) near Glen Alpin (Harding Township) may also be pre-Illinoian. These deposits may have been laid down in glacial lakes. The silt and fine sand at Mendham is in a small north-draining valley that would have been dammed by the glacier margin. The deposits at Glen Alpin and Primrose Brook may have been laid down in glacial Lake Watchung, a large ice-dammed lake that filled the upper Passaic River basin during the pre-Illinoian glaciation. More extensive deposits in this lake occur just south of the quadrangle, in the Bernardsville and Basking Ridge area (Stanford, 2008).

A long period of weathering and erosion followed the pre-Illinoian glaciation. Almost all of the pre-Illinoian deposits were eroded away, and rivers deepened their valleys by several tens of feet below the pre-Illinoian land surface.

A second glacier entered this landscape during the middle Pleistocene, probably during the late Illinoian glaciation about 150,000 years ago. It advanced to position M1 (fig. 1). This glaciation cannot be directly dated, but its deposits are much less weathered and eroded than those of the pre-Illinoian, indicating a significantly more recent age. It is older than late Wisconsinan, as indicated by a radiocarbon date of 36,070+/-280 yrs. BP (41,650-40,840 calibrated yrs. BP) (Beta 309763) on peat overlying Illinoian sand and gravel, and overlain by six feet of colluvium, at Dalrymple Pond (latitude 40º51'09", longitude 74º34'50"). Deposits of this glacier include till (Flanders Till of Stone and others, 2002, unit Qf), sand and gravel (Qis), and silt and clay (Qisl). The sand, gravel, silt, and clay were laid down by meltwater in glacial lakes. The distribution of these sediments shows that lakes formed in the Lamington River, Jackson Brook, Wallace Brook, Mill Brook, and Den Brook valleys. These valleys all drained northward and so were dammed by the glacier to create lakes.

Before it was filled with glacial sediment, the upper Lamington River valley drained to the north as a tributary to the Rockaway River (Stanford, 1989). During the Illinoian glaciation, this valley was dammed by the ice front to form glacial Lake Ironia (Stone and others, 2002). Lake Ironia was controlled by a spillway draining southward across the former drainage divide into the Raritan basin at an elevation of about 680 feet near Chester Borough (5 miles west of Mendham Borough). The northwest corner of the quadrangle includes a small part of this lake. The lake drained when the retreating ice front uncovered the Rockaway River valley at Dover, permitting eastward flow down the Rockaway.

Smaller lakes occupied the Jackson, Wallace, Mill, and Den Brook valleys, all of which are also north-draining tributaries to the Rockaway River (fig. 1). In the Jackson and Wallace Brook valley, high and intermediate lake stages (JB1 and JB2, respectively, on fig. 1) were controlled by spillways at 950 and 870 feet in elevation that drained west into the Lamington River valley. A series of temporary, lowering spillways operated during the drop from the high to intermediate stage. The intermediate stage was succeeded by a low stage (JB3 on fig. 1) controlled by a spillway at 840 feet that drained southward into the Mill Brook valley. The low stage drained as ice uncovered the Rockaway valley at Dover, about 0.5 mile north of the quadrangle boundary.

The Den and Mill Brook valleys were occupied by glacial Lake Shongum. The high stage of Lake Shongum (SH1 on fig. 1) was controlled by a spillway on the Den Brook drainage divide at an elevation of 850 feet that drained southward into the Whippany River valley. The high stage extended westward into the Mill Brook valley when the ice front retreated from a gap west of Shongum Lake. Before this retreat, a small lake was ponded in the headwaters of Mill Brook south of the present site of Dalrymple Pond (DP on fig. 1). This lake drained along the ice front banked against the hillslope to the east. The high stage of glacial Lake Shongum lowered to the intermediate stage (SH2 on fig.1) when the rereating ice front uncovered a lower gap at an elevation of 800 feet just south of the present alignment of Route 10, which allowed eastward drainage into the Whippany valley. Shortly thereafter, continued retreat exposed a gap at an elevation of 700 feet just to the north, along the present Route 10, and the lake lowered to its low stage (SH3 on fig. 1). Both the intermediate and low stages extended into the Mill Brook valley. The low stage lowered again and then drained as the retreating ice front uncovered the Rockaway valley north of Mount Tabor, about 1.5 miles northeast of the northeast corner of the quadrangle. Illinoian glacial deposition in the Mendham quadrangle ended at this time.

In glacial lakes Ironia and Shongum, sand and gravel were deposited in lacustrine fans and deltas, and small volumes of silt and clay (symboled "Qisl" where observed) were deposited on lake bottoms, during both advance and retreat of the glacier. At and north from the terminal position (M1 on fig. 1), advancing ice overrode the advance-phase lake sediments and emplaced till atop them. This overriding action built a moraine in the Den and Mill Brook valleys (between margins M1 and M2 on fig. 1). This moraine is especially prominent at the north end of Shongum Lake, where it is more than 150 feet thick. Till overlying lacustrine deposits was observed in a pipeline trench here and in the Lamington valley, and in a former gravel pit west of Openaka Lake (symboled on map).

A period of weathering, and stream and hillslope erosion, followed the Illinoian glaciation. During periods of cold climate, primarily during the early and late Wisconsinan, forest cover was reduced and permafrost developed, impeding soil drainage and thereby waterlogging the surficial material during thaws. Weathered-rock material and glacial sediment on hillslopes became unstable and moved downslope to form aprons of colluvium (Qcg, Qcs). Where the material was transported downslope into steep tributary channels, streams flushed it into main valleys to form alluvial fans (Qaf). North of the Illinoian limit, till on moderate-to-steep hillsides was eroded away, exposing the underlying weathered rock. Along footslopes, particularly in the Mill Brook valley, colluvium accumulated on top of lacustrine deposits and till (sections AA', CC'). Exposures where lacustrine sediment was observed beneath colluvium are indicated by symbols on the map.

Most colluvium at the surface is lightly weathered and probably of Wisconsinan age. The 36,070+/-280 yrs. BP date on peat beneath six feet of colluvium at Dalrymple Pond (cited above) indicates that colluvium here was deposited during the late Wisconsinan. South of the Illinoian limit, older, weathered colluvium, deposited during earlier periods of cold climate, likely occurs in the subsurface of thick aprons. Older colluvium containing weathered and decomposed gneiss clasts, and showing soil development, was observed in two exposures (symboled with "Qcgo' on map) beneath fresh-clast colluvium.

The most-recent glacier, known as the late Wisconsinan, reached its southernmost position by about 25,000 years ago (21,000 radiocarbon years ago), based on radiocarbon dates of pre-advance organic material in a sediment core from Budd Lake (Harmon, 1968; Stanford and Witte, 2002) and on Long Island, New York (Sirkin and Stuckenrath, 1980). The glacier advanced to within two miles of the northern and eastern edge of the Mendham quadrangle, but did not enter the map area. At its maximum position, and during retreat, this glacier impounded lakes in the Lamington valley (glacial Lake Succasunna, SC on fig. 1), in the Rockaway valley (glacial Lake Dover, DO on fig. 1), and in the Passaic valley (Moggy Hollow stage of glacial Lake Passaic, MH on fig. 1).

In Lake Succasunna, which was similar to Illinoian glacial Lake Ironia, a large delta filled the northern reach of the lake. This delta was built outward from the terminal position (about one mile north of the northwest corner of the quadrangle) and consists of sand and gravel (Qso) topset and foreset beds overlying silt, fine sand, and clay bottomset and lake-bottom beds (Qsl on section AA').

In the Mendham quadrangle, deposition in Lake Dover was exclusively lake-bottom silt, fine sand, and clay (Qdol on section CC'). Glaciofluvial sand and gravel (Qr) was laid down atop the Lake Dover sediments by meltwater draining down the Rockaway valley after Lake Dover drained (Stanford, 1989).

Lake Passaic was a large lake that filled the upper Passaic basin and had three glacial-phase stages (Stone and others, 2002). Only the highest, known as the Moggy Hollow stage, extended into the Mendham quadrangle. It was controlled by a spillway on the Passaic-Raritan drainage divide near Far Hills, 7 miles south of Mendham Borough. In the quadrangle, it flooded the Whippany and Passaic valleys to an elevation of 350 to 360 feet. Silt, clay, and fine sand (Qpml) accumulated on the lake bottom (fig. 3). In the Whippany valley, colluvium accumulating on footslopes along the lakeshore became interbedded with lake clay. Places where lake clay was observed within colluvium are symboled on the map.

A cut along Interstate Route 287 near Glen Alpin (Harding Township) exposed a thin deposit of rounded gneiss gravel with a few quartzite, chert, and siltstone erratics, and laminated to cross-bedded coarse sand, within colluvium at an elevation of about 350 feet (symboled "Qpmb" on map). Because there is no fluvial source for this material, it is most likely a beach deposit, with ice-rafted erratics, deposited by wave action on the shoreline of the Moggy Hollow stage.

After the Moggy Hollow stage lowered, sand and gravel (Qst) was laid down atop the lake clays in places by the Whippany River and its tributaries. Sand and gravel under colluvium along Primrose Brook near Glen Alpin (symboled on map) are also post-Moggy Hollow stream deposits. These deposits are between 300 and 340 feet in elevation, and may be graded to the Great Notch stage of Lake Passaic, which was at 290 to 300 feet in elevation in this area (Stanford, 2006). Today, these deposits form terraces several feet above the modern flood plain.

Radiocarbon dates on postglacial organic material in New Jersey and adjacent areas indicate that glacial lakes had drained, and late Wisconsinan glacial deposition in the Mendham quadrangle had ended, by 19,000 radiocarbon years ago (Stone and others, 2002). As climate warmed, forest cover returned and hillslopes stabilized. Deposition of colluvium and alluvial fans ceased and streams and groundwater seepage eroded and incised the colluvial aprons and alluvial fans in places. The seepage and stream erosion formed cobble-to-boulder lags and flood plains (Qcal, Qal). Seepage and slopewash also laid down clayey silt at the foot of some gently sloping colluvial aprons. A radiocarbon date of 1290+/-30 yrs. BP (1290-1170 calibrated yrs. BP) (Beta 309792) on plant material under four feet of clayey silt at one such site near Mendham (latitude 40º46'16", longitude 74º34'47") indicates that the silt here accumulated within the past 1300 years, perhaps chiefly from agricultural clearing during European colonization. Wetland sediment (Qs) accumulated in poorly drained areas. Flood-plain and wetland deposition continues today.

DESCRIPTION OF MAP UNITS

Postglacial Deposits—These include man-made fill, stream deposits in fans (Qaf), modern channels and flood plains (Qal, Qcal), and low terraces (Qst), and wetland deposits in swamps and marshes (Qs).

▨ aft ARTIFICIAL FILL—Artificially emplaced sand, gravel, silt, clay, and rock fragments, and man-made materials including cinders, ash, brick, concrete, wood, slag, asphalt, metal, glass, and trash. Color varied but generally dark brown, gray, or black. In highway and railroad fills, dams, dikes, made land, waste-rock disposal piles, and trash fills (aft). As much as 50 feet thick, generally less than 20 feet thick. Many small areas of fill are not mapped.

Qal ALLUVIUM—Sand, silt, pebble-to-cobble gravel, cobble-to-boulder gravel, minor clay and peat; fine sediment is dark brown, brown, yellowish-brown, gray; moderately to well-sorted, stratified. Contains varied amounts of organic matter. Sand and gravel are deposited in active channels. Sand, silt, clay and peat are deposited in back channels, overbank areas, and groundwater seepage areas, chiefly on broad flood plains. In places, alluvium includes cobble-to-boulder lags from erosion of weathered gneiss and colluvium. As much as 15 feet thick.

Qaf ALLUVIAL FAN DEPOSITS—Pebble-to-cobble gravel, cobble-to-boulder gravel, sand, silt; brown, yellowish-brown, gray; moderately sorted, stratified. As much as 25 feet thick (estimated). Some small alluvial fans are included with units Qal and Qcal.

Qst STREAM TERRACE DEPOSITS—Fine-to-medium sand, silt, pebble-to-cobble gravel; brown, very pale brown, yellowish-brown, light gray; moderately to well sorted, stratified. As much as 10 feet thick. Form terraces with surfaces 3-10 feet above the modern flood plain.

Qs SWAMP AND MARSH DEPOSITS—Peat and organic silt, clay, and minor fine sand; black, dark brown, and gray. As much as 10 feet thick (estimated).

Qcal ALLUVIUM AND COLLUVIUM, UNDIVIDED—Interbedded colluvium as in unit Qcg, and alluvium consisting of dark brown to yellowish-brown or reddish-yellow silty sand, sandy silt, to clayey silt, with some organic matter and beds and lag veneers of subangular to subrounded cobbles and boulders of gneiss, and rounded erratic cobbles and boulders of conglomerate and quartzite (adjacent to unit Qf). As much as 15 feet thick. Lag deposits are dominant in steeper reaches of valleys. Fine sediment, with organic matter, discontinuously overlies and infills lag deposits in gently sloping reaches. In some steep, narrow valleys, lags have moved downvalley to accumulate as bouldery lobes.

Glacial Deposits—These include till and meltwater sediments laid down during the late Wisconsinan, Illinoian, and pre-Illinoian glaciations. Till is a poorly sorted, nonstratified sediment containing gravel and boulders, deposited directly from glacial ice (units Qf and Qpt). The meltwater sediments are moderately to well-sorted and stratified and include sand and gravel laid down in glacial lakes (Qso, Qis, Qps) and glaciofluvial plains (Qr), and silt, clay, and fine sand laid down in glacial lakes (Qsl, Qdol, Qpml).

Deposits of late Wisconsinan age

Qso GLACIAL LAKE SUCCASUNNA DELTAIC DEPOSITS—Fine-to-medium sand, minor coarse sand and pebbly sand; very pale brown to light gray. As much as 40 feet thick. Deposited in glacial Lake Succasunna. Extensively mined in quadrangle, may have been mostly removed from mined areas.

Qsl GLACIAL LAKE SUCCASUNNA LAKE-BOTTOM DEPOSITS—Silt, clay, fine sand; light gray; laminated to thinly bedded. As much as 120 feet thick. In subsurface only (section AA'). Deposited in glacial Lake Succasunna.

Qr ROCKAWAY RIVER OUTWASH—Sand and pebbly sand; light gray to very pale brown. As much as 20 feet thick. Deposited by meltwater flowing down the Rockaway River after draining of glacial Lake Dover.

Qdol GLACIAL LAKE DOVER LAKE-BOTTOM DEPOSITS—Silt, clay, fine sand; light gray; laminated to thinly bedded. As much as 100 feet thick. Deposited in glacial Lake Dover. In subsurface only (section CC').

Qpml GLACIAL LAKE PASSAIC, MOGGY HOLLOW STAGE, LAKE-BOTTOM DEPOSITS—Silt, clay, very fine sand; light gray to very pale brown; laminated to thinly bedded (fig. 3). As much as 70 feet thick. Deposited in Moggy Hollow stage of glacial Lake Passaic.

Deposits of Illinoian age

Qf FLANDERS TILL—Brown, brownish-yellow, and very pale brown silty sand to sandy clayey silt with some (5-10% by volume) to many (10-40%) subrounded to subangular pebbles and cobbles and few (1-5%) to some subrounded boulders. Till matrix is generally compact, nonplastic, nonsticky, weakly jointed, and may have a weak to moderate subhorizontal fissility. Gravel consists chiefly of gray and white gneiss, some purple conglomerate and purple quartzite, and a little gray mudstone, sandstone, chert, and white-to-gray quartzite. Boulders are chiefly gneiss, purple conglomerate, and purple quartzite, with few to some white-to-gray quartzite. Gneiss clasts have weathered rinds generally more than 0.25-inch thick. Some mudstone and sandstone clasts are also weathered or fully decomposed. As much as 80 feet thick.

Qis ILLINOIAN STRATIFIED DEPOSITS—Pebble-to-cobble gravel, fine-to-coarse sand, silty sand, minor cobble-to-boulder gravel. Sand and silty sand are yellowish-brown to brown. Gravel consists chiefly of gray and white gneiss, some purple conglomerate and purple quartzite, and minor gray sandstone and mudstone, quartzite, and chert. Gneiss clasts, and some sandstone and mudstone clasts, have weathered rinds or are partially decomposed. Sand is unstratified to plane- and cross-bedded. As much as 130 feet thick. Deposited in glacial lakes in the Lamington, Jackson, Mill, and Den Brook valleys. Commonly interbedded or overlain by Flanders Till (Qf).

Deposits of pre-Illinoian age

Qpt PRE-ILLINOIAN TILL—Yellowish-brown to reddish-yellow sandy silt to sandy clayey silt, with some subrounded to subangular pebbles and cobbles, and few subrounded boulders. Gravel consists chiefly of gray and white gneiss, some purple conglomerate and quartzite, and a little gray to white quartzite, gray mudstone and sandstone, and dark-gray chert. Boulders are chiefly gray gneiss, purple conglomerate, and gray to white quartzite. The mudstone, sandstone, and gneiss gravel clasts have weathered rinds or are completely decomposed. As much as 10 feet thick. Equivalent to the Port Murray Formation, till facies, of Stone and others (2002).

Qps PRE-ILLINOIAN STRATIFIED DEPOSIT—Reddish-yellow to yellowish-brown clayey silty sand to clayey silt with some to many pebbles and fine cobbles. Gravel consists chiefly of gray and white gneiss, some red shale and siltstone, and a little gray, white, and red quartzite. Gneiss, shale, and siltstone clasts are deeply weathered to fully decomposed. As much as 20 feet thick (estimated). In erosional remnant of a lacustrine deposit near Glen Alpin (Harding Township).

Hillslope Deposits—Nonstratified, poorly sorted sediment deposited at the foot of hillslopes by downslope movement of material.

Qcg GNEISS COLLUVIUM—Yellowish-brown, reddish-yellow, brown sandy silt, silty sand, sandy clayey silt with some to many subangular gneiss pebbles and cobbles, in places underlain by, or interbedded with, thinly layered reddish-yellow to pinkish-white clayey sand and sandy clay with few angular pebbles and cobbles. Long dimensions of clasts typically are aligned parallel to the hillslope. Upper blocky colluvium (fig. 4) is derived from downslope movement of fractured, weathered bedrock; lower, layered colluvium is derived from downslope movement of saprolite. Within the limit of pre-Wisconsinan glaciation (M1 on fig. 1), colluvium includes few to some erratic pebbles and cobbles of purple conglomerate, gray to white quartzite, and gray sandstone and mudstone from erosion of Flanders Till. Elsewhere, colluvium may include rare (<0.1%) conglomerate, quartzite and chert erratics from erosion of pre-Illinoian till. Colluvium on moderate-to-gentle slopes includes cobble-to-boulder lags formed by seepage erosion of weathered gneiss, alternating with, or overlain by, clayey-silty material. As much as 50 feet thick.

Qcs SILTSTONE AND CONGLOMERATE COLLUVIUM—Brown, yellowish-brown, light gray sandy clayey silt with some subangular pebbles and cobbles. Gravel is weathered from conglomerate bedrock and consists chiefly of gray quartzite and sandstone. As much as 10 feet thick.

Weathered Bedrock Material—Nonstratified, poorly sorted sediment and fractured rock formed by mechanical and chemical weathering of bedrock.

Qws WEATHERED SILTSTONE, SHALE, AND CONGLOMERATE—Reddish-brown, yellowish-brown, brown clayey silt to silty clay with some angular to subangular gray to red siltstone and shale chips and some gray and purple quartzite pebbles and cobbles. As much as 30 feet thick.

Qwb WEATHERED BASALT—Reddish-yellow to yellowish-brown clayey silt to silty clay with some to many angular to subangular pebbles and cobbles of basalt. Most clasts have reddish-yellow clayey-silty weathered rinds. As much as 15 feet thick.

Qwg **Qwgt** WEATHERED GNEISS—Yellowish-brown, yellow, very pale brown, reddish-yellow, silty sand, silty clayey sand to sandy clayey silt, locally micaceous, with few to many subangular pebbles and cobbles of gneiss. Includes mixed clast-and-matrix sediment, granular decomposed rock, fractured rock rubble, and saprolite that preserves original rock structure (fig. 5). Clasts vary from unweathered to fully decomposed. On gentle to moderate slopes, well records indicate that clast-and-matrix sediment (described by drillers as "overburden", "hardpan", "sandy hardpan", and "clay hardpan"), which is fractured rock mixed with sandy-clayey saprolitic material by colluviation, cryoturbation, and bioturbation, is generally between 5 and 30 feet thick and commonly overlies or grades downward to saprolite (described by drillers as "rotten rock", "sandstone", "rotten granite", and "soft granite") that may be as much as 100 feet thick over unweathered rock. On steep slopes, fractured-rock rubble, generally less than 20 feet thick, overlies unweathered bedrock. Total thickness of weathered material is as much as 150 feet but is generally less than 50 feet (fig. 2). The uppermost, clast-and-matrix material may contain traces of quartzite, chert, and gray sandstone and mudstone erratic pebbles and cobbles, especially within the pre-Wisconsinan glacial limit. "Qwgt" indicates areas, typically on the steepest slopes and narrow ridgetops, where weathered material is thin or absent and fractured outcrop abundant.

Qwcb WEATHERED CARBONATE ROCK—Yellow, very pale brown, reddish-yellow, light gray clayey silt to silty clay, minor sandy silt, with some to many light gray, yellow, and reddish-yellow angular chips and pebbles of carbonate rock. As much as 100 feet thick but thickness is highly variable. Crops out in one bank along India Brook; present beneath colluvium in the North Branch Raritan River valley and beneath glacial deposits in the Lamington valley (section AA').

MAP SYMBOLS

Contact—Long-dashed where approximately located, short-dashed where gradational or feather-edged, dotted where removed by excavation.

● **Material observed in hand-auger hole, exposure, or excavation**

figure 3 ● **Photograph location**

1290+/-30 ● (Beta 309762) **Radiocarbon date**—In radiocarbon years before present, with error and laboratory number.

Excavation perimeter—Line encloses excavated area. Outlines pits and quarries.

⚔ **Sand and gravel pit**—Inactive in 2009.

⚒ **Quarry or mine**—Inactive in 2009.

L15 ■ **Well with log in table 1**—Location accurate within 100 feet. Wells located from tax-parcel maps, street addresses, or distances from landmarks as reported by drillers.

L22 ⊡ **Well with log in table 1**—Location accurate within 500 feet.

433 ● **Well reporting thickness of surficial material**—Data in table 2. Location accurate within 100 feet.

427 ⊙ **Well reporting thickness of surficial material**—Data in table 2. Location accurate within 500 feet.

Qis ● **Subsurface unit exposed**—Observed in excavation or streambank, beneath mapped surface unit. "Qcgo" indicates weathered colluvium observed beneath fresh colluvium. "Qpmb" indicates beach sand and gravel of the Moggy Hollow stage of Lake Passaic. "Qpsl" and "Qisl" indicate glaciolacustrine silt, clay, and very fine sand of pre-Illinoian and Illinoian age, respectively. "Qis/Qisl" indicates Illinoian silt and clay under Illinoian sand and gravel.

◊ **Pre-Illinoian erratic**—One or more cobbles and boulders of purple conglomerate, white to gray quartzite, or gray chert, from pre-Illinoian glaciation.

Glacial ridge—Line on crest, barbs point toward glacier. Emplaced along Illinoian glacial margins.

Seepage scarp—Line at position of groundwater emergence. Water drains downslope from this position. Seepage is also common along upland margins of units Qal and Qcal.

500 **Elevation of bedrock surface**—Contour interval 50 feet. Includes top surface of weathered bedrock. Shown only where glacial deposits are more than 25 feet thick.

r **Bedrock outcrop**—Outcrops within unit Qwgt are not shown, and some small outcrops along streams or in artificial cuts are also not shown. Refer to Volkert (2008) for these outcrop locations.

Lake or pond—Obscures underlying deposits.

127 **Well on sections**—Projected to line of section. Owing to projection, depths of contacts on section may not be identical to those in well.

CORRELATION OF MAP UNITS

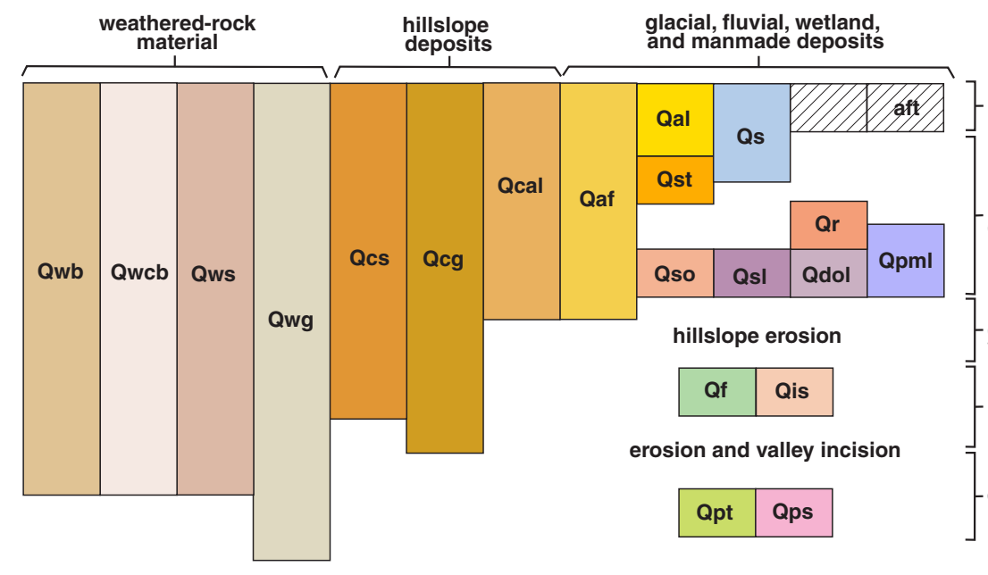

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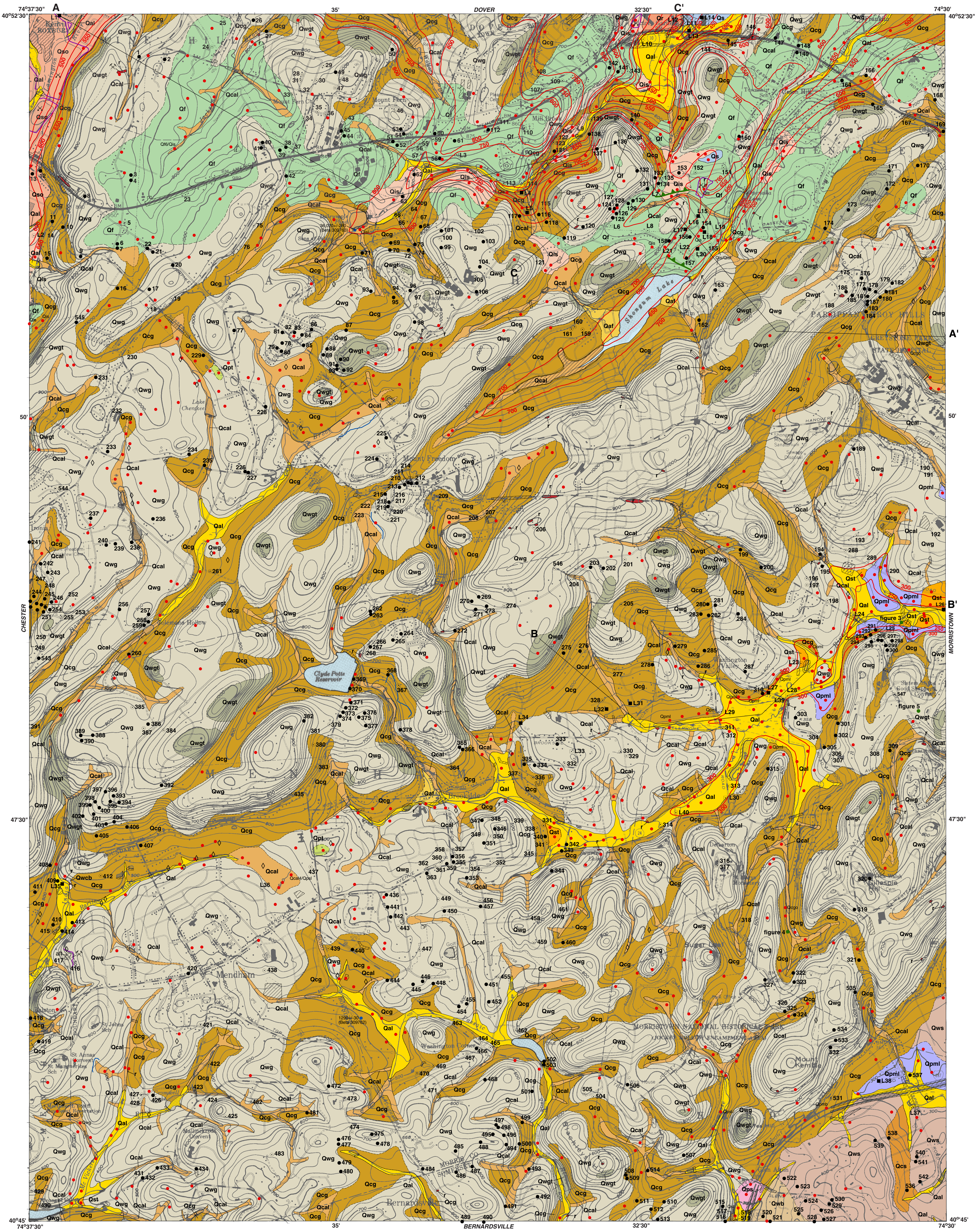
Figure 3. Lake-bottom deposits of the Moggy Hollow stage of glacial Lake Passaic. White layers are clay, deposited in winter. Thicker, brown layers are silt and very-fine sand, deposited in summer. Each pair of clay and silt beds represents a year of deposition and is known as a varve. Location shown on inset and map.

Figure 4. Blocky facies of gneiss colluvium. Note that long dimensions of clasts are generally parallel to the hillslope (marked by soil horizon at top of photo). Location shown on inset and map.



Base map from U. S. Geological Survey, 1954
Photorevised 1981
Corner ticks are on North American Datum of 1927.

Geology mapped 1988, 2010-2011
Cartography by S. Stanford

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number G10AC00387.

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.

SURFICIAL GEOLOGY OF THE MENDHAM QUADRANGLE
MORRIS AND SOMERSET COUNTIES, NEW JERSEY

by
Scott D. Stanford
2012

SCALE 1:24 000
1 MILE
7000 FEET
1 KILOMETER

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

APPROXIMATE MEAN DECLINATION, 1981

LOCATION IN NEW JERSEY

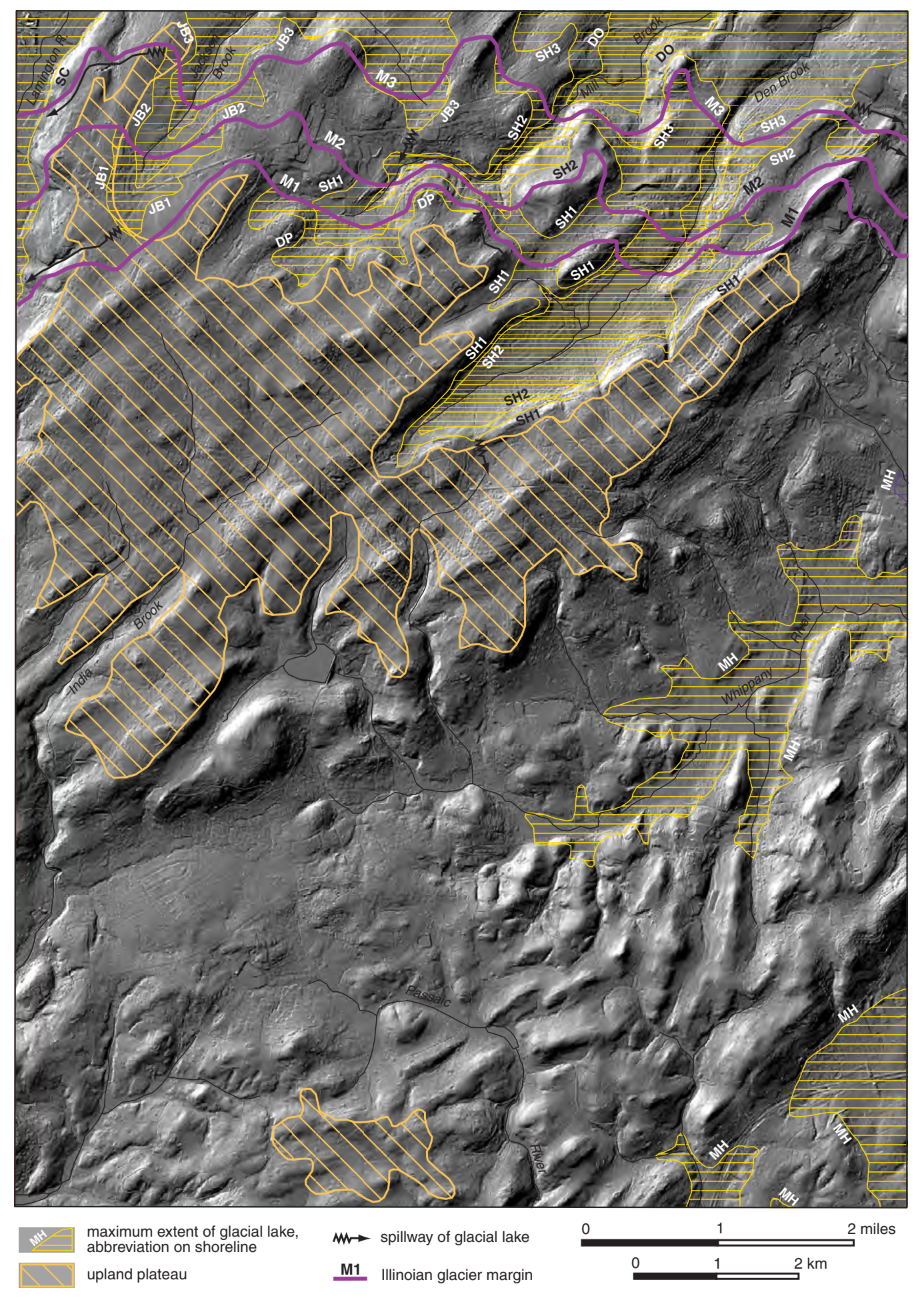


Figure 1.--Glacial and geomorphic features of the Mendham quadrangle. Abbreviations on Illinoian glacial-lake shorelines are: DP=lake in valley south of Dalrymple Pond; JB1, JB2, JB3=high, intermediate, and low stage, respectively, of lake in the Jackson and Wallace Brook valleys; SH1, SH2, SH3=high, intermediate, and low stage, respectively, of glacial Lake Shongum. Abbreviations on late Wisconsinan glacial-lake shorelines are: SC=glacial Lake Succasunna, DO=glacial Lake Dover, MH=Moggy Hollow stage of glacial Lake Passaic. Abbreviations on Illinoian glacier margins are: M1=maximum extent of Illinoian ice, lake impounded in valley south of Dalrymple Pond and high stage of Lake Shongum impounded in Den Brook valley; M2=last ice margin before Lake Shongum, high stage, and high stage of lake in Jackson Brook valley lower to their intermediate stages; M3=last ice margin before intermediate stages of Lake Shongum and lake in Jackson Brook valley lower to their low stages. Topographic image from N. J. Highlands Water Protection and Planning Council Geographic Information System LiDAR digital data with 2 m horizontal resolution.

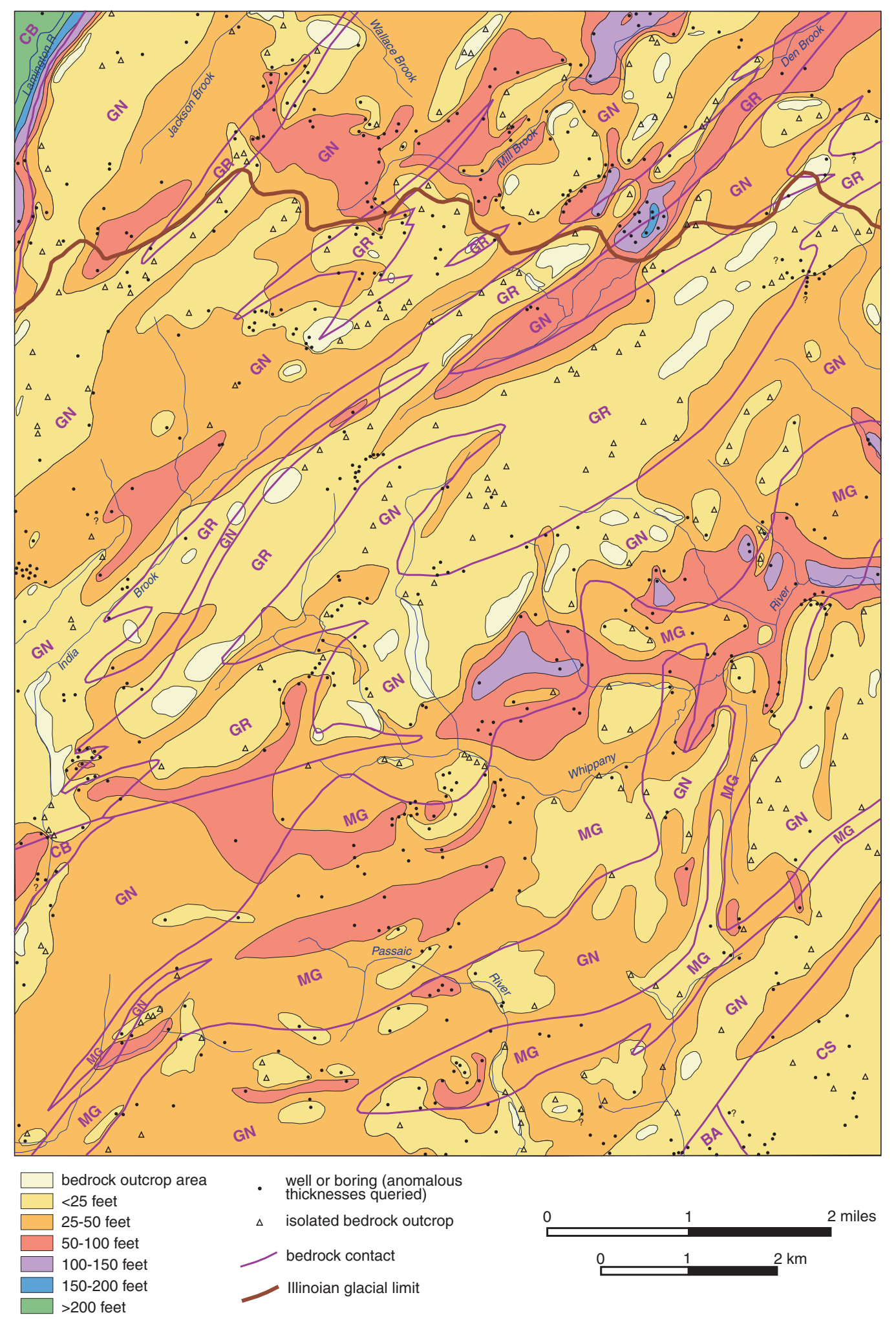
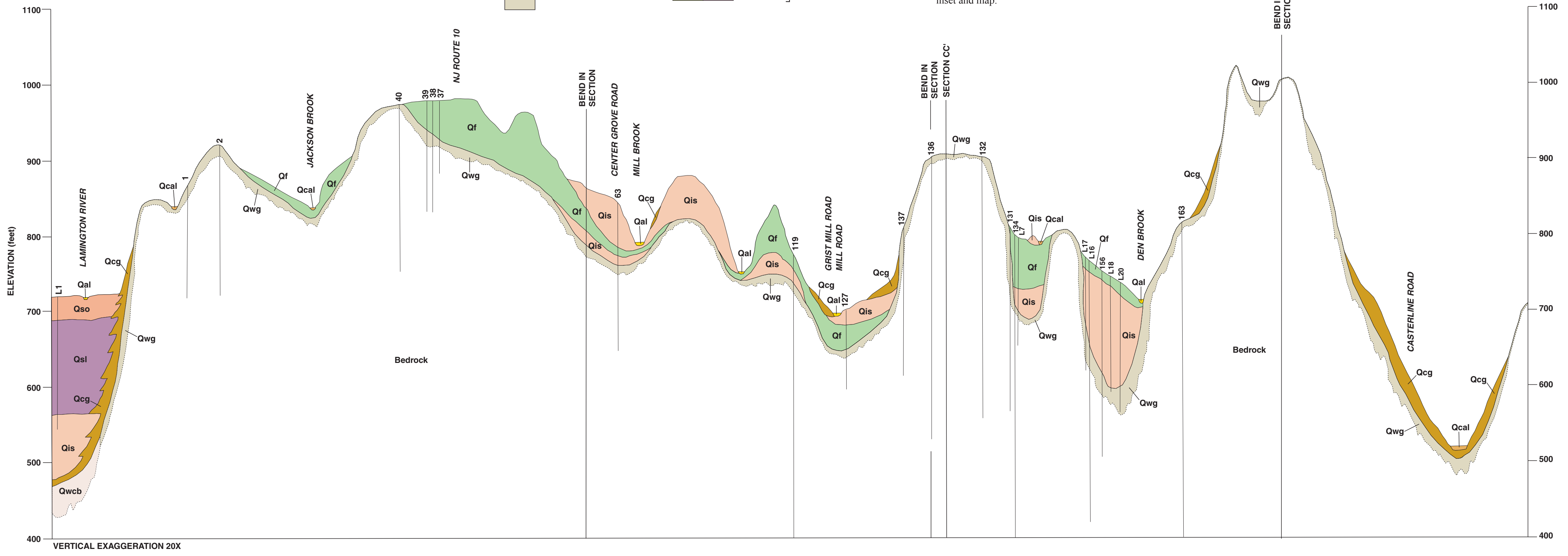
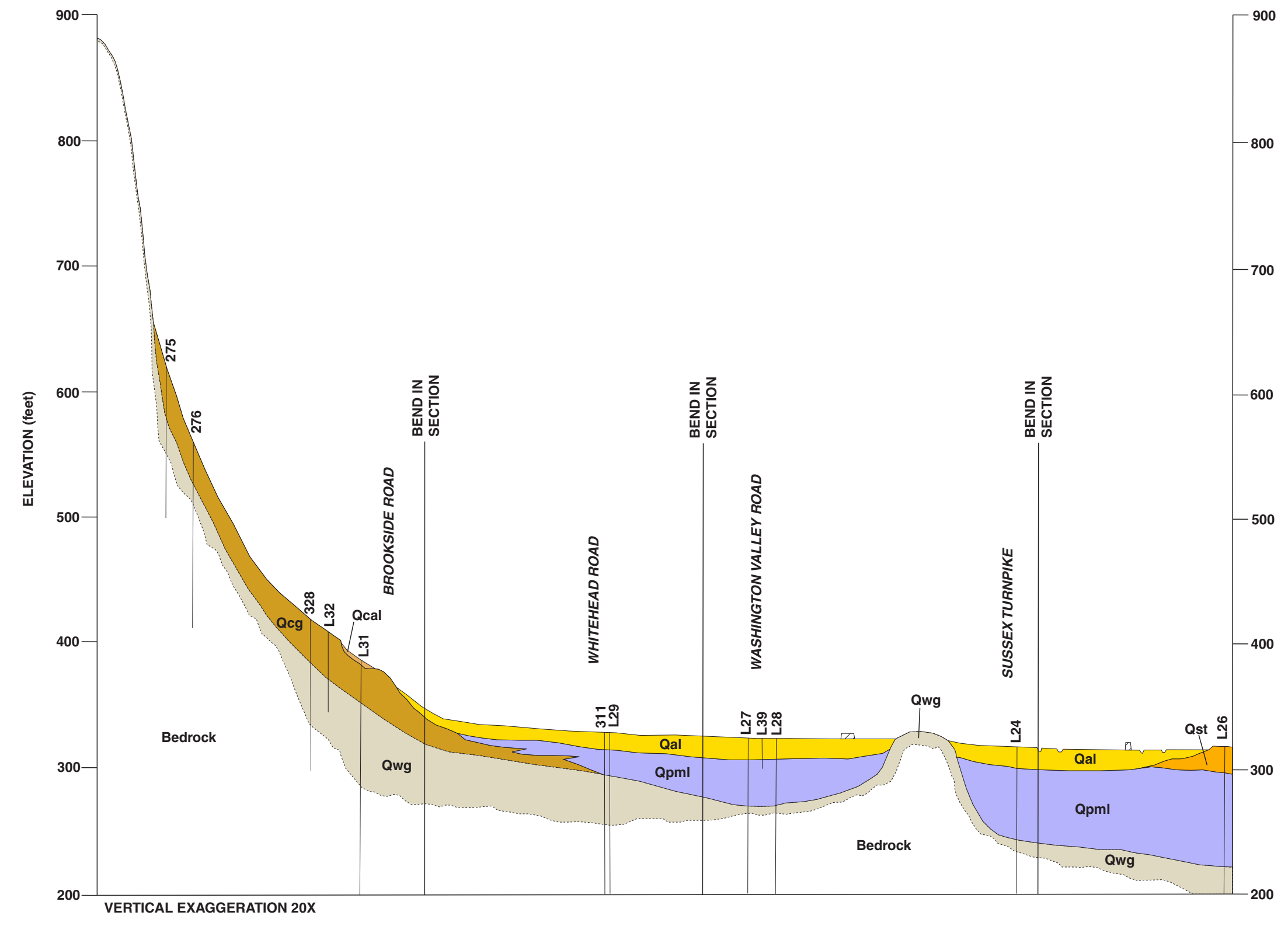
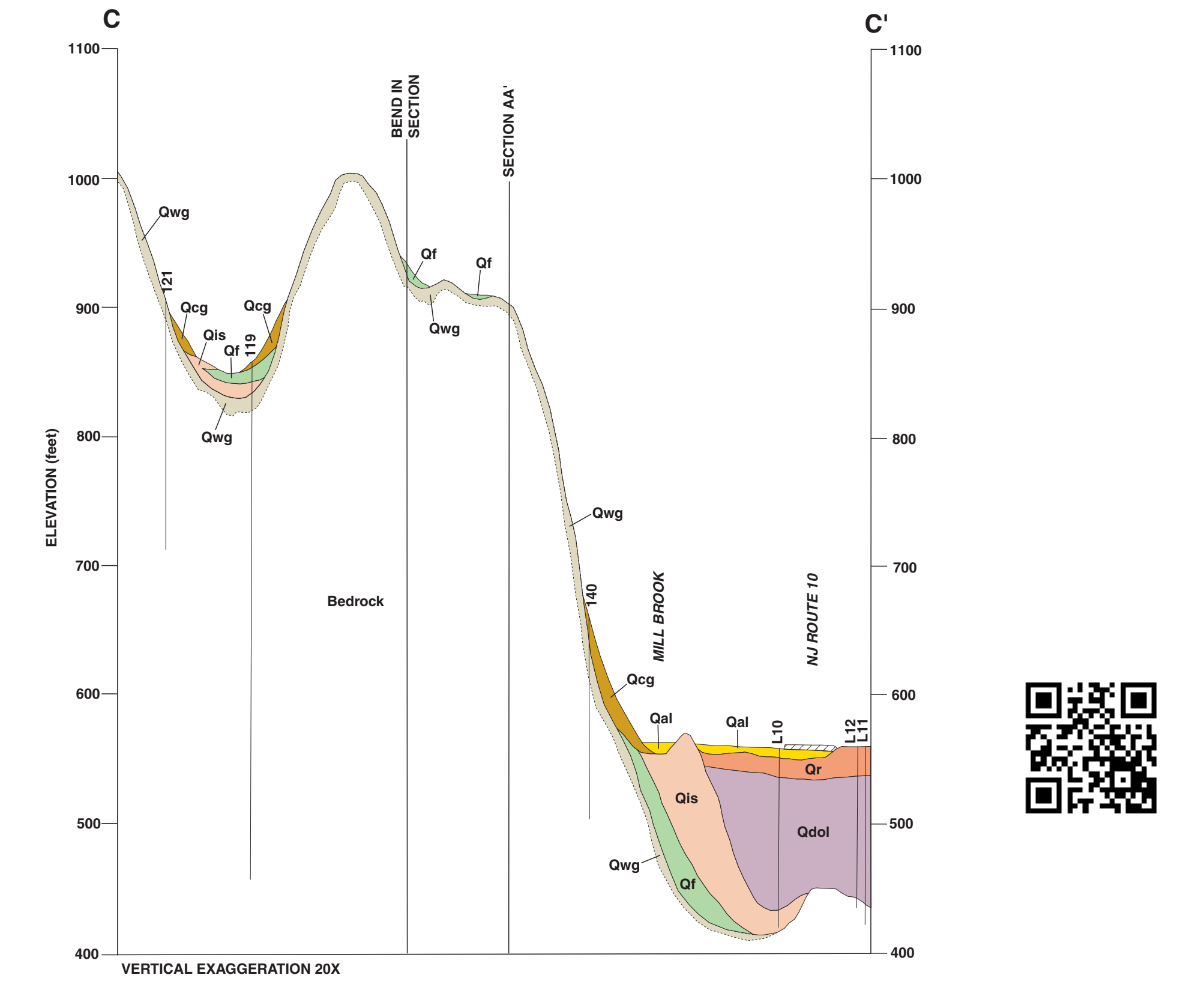


Figure 2.--Thickness of surficial material, including weathered rock, in the Mendham quadrangle. Abbreviations for bedrock lithologies are: CB=carbonate rock, GR=unfoliated, massive granite, MG=foliated, micaceous gneiss (with marble lenses in the Whippany River valley), GN=foliated, layered gneiss, CS=conglomerate and shale, BA=basalt. Bedrock contacts and lithologies based on Volkert (2008). Thick surficial materials include Illinoian and late Wisconsinan glacial deposits in the Lamington, Mill Brook, Den Brook, and Whippany valleys, colluvium at the base of escarpments and ridges, and saprolite developed on micaceous and foliated gneiss. Granite generally underlies the highest ridges and has the thinnest mantle of weathered material.

Figure 5. Weathered gneiss, showing angular fractured-rock rubble and coarse sandy saprolite. Location shown on inset and map.







Surficial Geology of the Mendham Quadrangle
Morris and Somerset Counties, New Jersey

New Jersey Geological Survey
Open-File Map OFM 94
2012

pamphlet with tables 1 and 2 to accompany map

Table 1.--Selected well and boring records.

Well No.	Identifier[1]	Driller's log with depth (ft.) and description[2]	
L1	16701	0-30	sand (Qso)
		30-155	gray clay (Qsl)
		155-157	gravel, 30+ gpm (Qis)
		157-172	yellow clay (Qwcb or Qisl)
		172-175	gravel (Qwcb or Qis)
L2	26977	abbreviated log	
		0-10	fine to medium sand (Qso)
		10-12	fine sand, coarse gravel (Qso)
		12-18	fine to medium sand (Qso)
		18-26	very fine hard-packed sand (Qsl)
		26-32	soft clay and sand (Qsl)
		32-34	clay (Qsl)
		34-38	clay with coarse sand (Qsl over Qis)
		38-40	medium to coarse sand (Qis)
		40-41	fine sand (Qis)
		41-42	clay and coarse gravel (Qcg or Qis)
		42-62	gravel, large rocks, yellow clay (Qis and Qcg)
		62-70	fine to medium gravel (Qis)
		70-79	boulders with sand and gravel (Qis)
		79-102	fine sand, clay streaks (Qisl)
		102-130	brown clay (Qisl or Qwcb)
		130-131	rock
		screened 50-75, yield 545 gpm	
L3	18704	0-20	gravel, sand (Qf and Qis)
		20-50	clay, boulders (Qf)
		50-60	clay mixed with gravel (Qf and Qis)
		60-70	red clay (Qisl)
		70-90	clay, boulders (Qf or Qcg)
		90-108	soft granite (Qwg)
		108-148	granite
L4	20423	0-20	boulders, sand (Qcg)
		20-45	sand (Qis)
		45-85	clay (Qisl)
		85-273	granite
L5	14916	0-30	overburden, big boulders (Qcg)
		30-33	boulder (Qcg)
		33-92	sand (Qis)
		92-98	granite
L6	20349	0-65	overburden, water, clay (Qf and Qisl)
		65-67	boulders (Qf)
		67-80	clay and sand (Qis and Qisl)

		80-92	sand, boulders at 80 (Qis)
		92-94	boulders (Qis or Qwg)
		94-123	granite
L7	17772	0-30	sand and clay (Qf and Qis)
		30-70	hardpan (Qf)
		70-80	sand (Qis)
		80-147	granite
L8	25601	0-80	sand and clay (Qf and Qis)
		80-110	clay and gravel (Qwg)
		110-225	granite
L9	16183	0-35	gravel, sand (Qis)
		35-109	clay (Qisl)
		109-222	granite
L10	14965	0-25	overburden with gravel (Qal over Qr)
		25-73	sand (Qdol)
		73-125	clay (Qdol)
		125-134	sand and gravel (Qis)
		cased to 133, yield 25 gpm	
L11	7044	0-95	sand and clay and hardpan (Qr over Qdol)
		95-125	blue and gray clay (Qdol)
		125-145	sandstone rock (Qwg)
L12	18073	0-20	sand (Qr)
		20-50	silt (Qdol)
		50-71	silt and gravel (Qdol)
		71-80	silt (Qdol)
		80-90	clay (Qdol)
		90-115	clay, granite (Qwg)
		115-122	granite
L13	16362	0-183	brown sand and clay (Qal over Qdol)
		183-184	brown granite and water
L14	15074	0-30	sand, gravel, and dirt (Qr)
		30-88	fine sand (Qdol)
		88-116	rotten rock (Qwg or Qis)
		116-200	solid granite
L15	20313	0-108	fine sand, some gravel (Qf over Qis)
		108-160	granite
L16	20314	0-125	fine sand, some gravel (Qf over Qis)
		125-348	granite
L17	22328	0-88	fine sand, some gravel (Qf over Qis)
		88-148	granite
L18	18409	0-71	hardpan, sand, gravel, and some large boulders (Qf over Qis)
		71-93	gray clay (Qisl)
		93-151	silty sand and gravel (Qis)
		151-155	choice water-bearing sand and gravel (Qis)
		cased to 155, yield 12 gpm	
L19	21162	0-30	sand and gravel (Qf over Qis)
		30-100	clay (Qisl)
		100-140	fine sand (Qis)
		140-197	granite
L20	20275	0-98	dirt, sand, clay (Qf)
		98-125	sand (Qis)
		125-156	rotten stone (Qwg)
		156-173	water (in Qwg)
		cased to 133, yield 20+ gpm	

L21	19809	0-72	dirt and boulders (Qf)
		72-137	sand (Qis)
		137-158	gray trap rock (gneiss)
		158-173	rotten stone (Qwg)
		cased to 135, yield 10 gpm	
L22	15276	0-50	sand, gravel, boulders (Qf)
		50-55	sand, gravel (Qis)
		55-58	gravel (Qis)
		cased to 58, yield 20 gpm	
L23	34781	0-34	clay (Qpml)
		34-47	gravel with fine material (pre-late Wisconsinan alluvium)
		47-203	granite
L24	39879	0-71	clay (Qpml)
		71-293	granite
L25	31029	0-62	clay (Qpml)
		62-81	gravel (pre-late Wisconsinan alluvium)
		81-600	granite
L26	21392	0-15	gravel (Qst)
		15-22	sand (Qst)
		22-94	clay (Qpml)
		94-120	brown soft granite (Qwg)
L27	33463	0-47	clay (Qpml)
		47-55	sand and gravel (pre-late Wisconsinan alluvium)
		55-543	granite
L28	33464	0-23	gravel, sand (Qal)
		23-51	clay (Qpml)
		51-410	granite
L29	34782	0-9	sandy soil (Qal)
		9-13	clay (Qpml)
		13-19	gravel, water (pre-late Wisconsinan alluvium)
		19-72	weathered granite (Qwg)
		72-293	granite
L30	34784	0-17	clay (Qal and Qpml)
		17-29	gravel (Qal)
		29-44	clay (Qpml)
		44-222	granite
L31	31755	0-34	clay (Qcg)
		34-45	sand and gravel (Qwg or pre-late Wisconsinan alluvium)
		45-100	weathered granite (Qwg)
		100-285	granite
L32	19997	0-65	clay, boulders, and gravel (Qcg over Qwg)
		cased to 63, yield 30 gpm	
L33	12197	0-11	hardpan, stones, and some large boulders (Qwg)
		11-62	yellow clay with some stones (Qwg)
		62-64	water-bearing sand and gravel (Qwg)
		64-84	conglomerated soft rock (Qwg)
		84-90	firm rock
L34	8315	0-151	yellow hardpan and a few boulders (Qcg over Qwg)
		151-163	soft dark gray rock (Qwg)
L35	22224	0-18	boulders and sandy soil (Qal)
		18-24	dark brown sticky clay (Qwcb)
		24-26	more boulders (Qwcb)
		26-30	dark brown sticky clay (Qwcb)

		30-75	weathered limestone (Qwcb)
		75-300	gray limestone
L36	29451	0-15	overburden (Qwg)
		15-43	clay and gravel (Qwg)
		43-57	clay with fine sand (Qwg)
		57-83	soft sandstone (Qwg)
		83-352	hard rock
L37	N25-13-835	0-10	tan clay and grits (Qal)
		10-17	hard gray clay (Qpml)
		17-24	coarse, light-brown sand with a little fine gravel (pre-late Wisconsinan alluvium and Qcs)
		24-31	soft red shale
L38	42162	0-6	gray clay (Qpml)
		6-12	sandy dry brown soil (pre-late Wisconsinan alluvium or Qcg)
		12-25	mixed granite and red shale (Qcg)
		25-130	red and gray shale
L39	42422	0-3	yellow-brown silty fine-to-medium sand (Qal)
		3-6	brown coarse-to-fine sand, little gravel (Qal)
		6-10	gray-brown clayey silt(Qpml)
		10-25	gray silt and clay, trace gravel (Qpml)
		25-27	gray clay and silt (Qpml)
L40	33467	0-14	gravel, water (Qal)
		14-17	gray clay (Qpml)
		17-37	sandy soil and gravel (pre-late Wisconsinan alluvium)
		37-193	granite

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[1] Identifiers consisting of 4 or 5 digits are well permit numbers issued by the N. J. Department of Environmental Protection, Bureau of Water Allocation. All are prefixed with “25-”. Identifiers of the form “Nxx-xx-xxx” are N. J. Atlas Sheet coordinates of well logs in the N. J. Geological Survey permanent note collection.

[2] Depth (in feet below land surface) and driller’s or logger’s description is provided. Notation “NR” indicates depth of contact is not reported. Inferred map units and author’s comments are indicated in parentheses. All descriptions are reproduced as they appear in the original source, except for minor format, punctuation, and spelling changes. Logs identified as “abbreviated” have been condensed for brevity, or have minor details omitted. Many bedrock descriptions have been condensed; these are not identified as abbreviated. Map units are inferred from the known extent of materials at the surface and from known depositional settings, in addition to the drillers’ descriptions. For wells completed in surficial material, the yield (in gallons per minute, gpm) and depth to which the well is cased, if reported, are included after the description.

Table 2.—Selected wells and borings reporting thickness of surficial material. All depths are in feet below land surface.

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
1	32251	18		150
2	21636	4	16	200
3	Healy 1961, B9	11		12
4	Healy 1961, B3	10		12
5	8857	33		82
6	27061	50		100
7	30173	40		70
8	26711	30		230
9	34110	8		200
10	40231	18	43	130
11	20219	21		173
12	23103	13	45	95
13	34534	85		275
14	20220	8	75	150
15	27586	15		225
16	22360	40	70	150
17	17853	10		400
18	26332	10	35	500
19	21567	12	22	123
20	36114	6		400
21	23819	80	89	198
22	23820	111		223
23	15125	35		97
24	13360	6		216
25	17878	15		123
26	26343	40	60	100
27	33719	11	31	122
28	3823	18		55
29	4044	5	15	48
30	8408	26		80
31	3824	50	>65	
32	19520	60		122
33	6712	26		78
34	8884	35	52	62
35	12663	4		122
36	8546	13		60
37	21154	56		98
38	22601	40		147
39	22834	61		147
40	21754	8		225
41	42003	4		250
42	27819	18		180
43	14610	36		214
44	41290	>70		
45	41188	>40		
46	10362	10		178
47	3926	6		300
48	5596	14		377
49	19470	25	60	140
50	34083	2		250
51	24249	2	30	225
52	30290	100		330
53	12387	11	75	121
54	12481	18		124

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
55	17771	50		173
56	3756	72		125
57	16565	45	50	90
58	19753	5		97
59	15248	75		170
60	43066	>42		
61	30131	>35		
62	19892	54		198
63	26688	80		198
64	16804	40		180
65	16750	40	68	147
66	16803	52		172
67	17409	27		148
68	19482	15	65	73
69	32516	5	13	148
70	26307	8		90
71	36230	3		175
72	29799	7		98
73	19053	65		123
74	4059	22		60
75	21782	22		98
76	9304	30		72
77	26040	16		100
78	26032	8	14	102
79	26306	4		225
80	21614	19		210
81	20682	8		97
82	19384	4		160
83	37136	15		150
84	27484	27		100
85	22723	17		98
86	10327	60		67
87	32056	6	21	355
88	20534	16		348
89	18192	10		523
90	15922	5		72
91	22974	3		325
92	17619	3		298
93	34505	15	40	180
94	13623	58	65	80
95	22373	20		72
96	23700	30	48	98
97	20456	12		248
98	20671	16		210
99	34111	15		300
100	20256	8		310
101	20945	35		277
102	20428	6		275
103	23610	8		200
104	28272	18		405
105	9485	22		353
106	12092	5		147
107	9056	52		95
108	19580	39	61	147
109	8298	56	>73	
110	1062	54		110
111	10022	86		105
112	13307	10	58	147

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
113	3225	36		70
114	19416	46		198
115	19437	88		123
116	21966	41		300
117	13559	71	82	89
118	44194	22		255
119	26288	35		400
120	20731	4		248
121	25720	18		195
122	15789	76		150
123	15788	55		198
124	32325	20		375
125	24392	5	86	175
126	24393	77		135
127	30556	30		108
128	42970	12		450
129	28303	73		100
130	28302	55		80
131	37521	20		245
132	21580	5		348
133	33142	34		75
134	41972	108		450
135	10298	95		135
136	22299	10	103	373
137	23742	42		197
138	32467	20	70	300
139	20547	38		197
140	23150	38		150
141	23082	25		125
142	39853	10	95	230
143	38598	7	30	225
144	6597	12		137
145	40590	15	60	405
146	19080	20		173
147	40239	10	11	25
148	42173	27	30	415
149	40581	27		58
150	18874	18	40	123
151	18253	10		123
152	21022	79		123
153	28383	3		100
154	27275	166		223
155	19285	135		298
156	26273	128		248
157	25567	140		225
158	23685	68	85	122
159	14130	23		121
160	14373	35	75	223
161	14437	35	75	223
162	24220	40		500
163	22228	8	273	448
164	36337	>27		
165	28347	48		275
166	10589	57		108
167	24111	34		173
168	40242	37		223
169	29444	14		325
170	29463	85		500

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
171	24033	5		248
172	21806	40		150
173	41675	4		300
174	28941	30	40	100
175	10268	20	42	88
176	42451	8		223
177	29255	10		170
178	27982	11		272
179	29475	17		197
180	27983	12	55	373
181	21866	60		260
182	30539	10		424
183	21066	50		150
184	21827	10		148
185	29522	10		170
186	26208	6		150
187	21067	30		300
188	15266	5		165
189	20417	8		373
190	14521	50	120	147
191	14034	50	65	155
192	34108	27		485
193	15189	8	28	313
194	19519	20	40	223
195	36565	20		305
196	6715	129		218
197	6501	90	120	192
198	25-13-255	>177		
199	22126	10	80	105
200	20944	6		197
201	25788	20		305
202	24132	18		200
203	24131	50		200
204	22710	8		148
205	23252	15		400
206	4387	10		53
207	10770	14	62	130
208	11144	11		218
209	654	5		165
210	30402	5	13	40
211	33070	17	43	47
212	31257	15	18	43
213	26991	14		43
214	31259	43		47
215	24004	15	25	150
216	18967	15		210
217	18969	20		210
218	25730	19		275
219	21116	6	12	198
220	12360	9		110
221	10620	4		70
222	19180	12		165
223	14016	22		60
224	27767	18		200
225	21611	20	68	223
226	20809	12	50	173
227	22446	18	75	123
228	35971	30	35	287

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
229	20467	28		123
230	8423	25		298
231	5669	24		174
232	7514	19	29	189
233	27892	18		130
234	25575	18		275
235	29617	12	40	248
236	27756	53		100
237	25938	6	30	205
238	24059	35	55	98
239	25863	6		150
240	39132	10	40	300
241	32768	8	32	280
242	25984	40		150
243	36254	12	15	505
244	39317	17	48	205
245	43359	15	36	300
246	37649	20		275
247	39619	16	38	205
248	38161	12	29	455
249	39908	8	35	205
250	32256	27		100
251	38324	13	42	500
252	38323	8	39	305
253	39315	21	37	505
254	33193	38		122
255	30723	30		270
256	44150	15	80	175
257	42935	6		252
258	23802	4		640
259	29408	18		430
260	30725	24		550
261	13914	22		238
262	42721	15	40	300
263	42720	12	35	330
264	40586	15	30	255
265	38432	18		405
266	22563	5		398
267	27667	12		700
268	29653	3		298
269	26735	8		250
270	26737	8		270
271	27760	27		225
272	36584	15	20	305
273	26738	8		75
274	21037	6		248
275	20391	70		125
276	34300	48		150
277	20331	46	73	173
278	31733	23		330
279	43079	12	26	730
280	25362	40	70	130
281	24686	20	45	150
282	27265	40	140	170
283	35150	14		210
284	22025	11	62	135
285	27038	70		150
286	19680	16	27	147

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
287	14027	24	30	122
288	B3 Wash. Valley	60		119
289	B2 Wash. Valley	39		78
290	B1 Wash. Valley	40		130
291	30854	70		400
292	26649	37		98
293	26424	20	60	100
294	28116	45		275
295	28214	5		275
296	23372	18		300
297	24415	40		100
298	40330	13		700
299	25474	12		372
300	43751	34		698
301	19598	50		340
302	16907	50		150
303	23715	8		199
304	34780	41		406
305	42318	24	55	300
306	40414	16	32	37
307	40418	4	20	30
308	23542	22		300
309	33010	>20		
310	39878	15		200
311	33465	19		143
312	34779	38		225
313	33466	50		168
314	34785	18		172
315	18632	53		448
316	42171	6	9	22
317	40814	30	>35	
318	25325	82	85	125
319	24165	5		325
320	B10 Healy 1960	16		33
321	15233	55	68	148
322	19486	41		73
323	18146	50		250
324	24204	40		100
325	30023	18	20	100
326	15292	12		400
327	25-13-573	12		262
328	8314	89		125
329	20987	58	80	148
330	25116	60		340
331	26241	25		660
332	4463	64		108
333	38728	45		698
334	22158	60		398
335	3927	55		97
336	10831	66		98
337	12792	64		92
338	26224	50		700
339	24126	12		300
340	24125	12	30	450
341	26240	25		700
342	34783	26		247
343	33468	25		493
344	22273	35		200

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
345	1456	47		77
346	25464	12		505
347	24521	15		600
348	24336	22		498
349	23399	14		600
350	24016	20		600
351	30001	30		300
352	19916	16		148
353	23772	12		425
354	21705	13	52	148
355	8454	42		68
356	38160	40		155
357	7296	46		85
358	9963	40		95
359	26581	17	19	21
360	6459	50		100
361	11974	45		96
362	11975	53		93
363	12358	65	83	96
364	31483	22		505
365	36551	38		805
366	36846	30		630
367	696	9		202
368	27286	16		215
369	27727	62		68
370	27729	29		38
371	25205	7		100
372	25203	5		200
373	25204	4		300
374	25206	27		300
375	39129	4	37	950
376	41041	9	14	1050
377	41036	21		595
378	25221	30		305
379	23364	16	80	122
380	27050	50		280
381	30082	5		375
382	28404	12		475
383	20346	20		200
384	25526	7		175
385	27810	22	36	305
386	27051	12	66	305
387	27761	15		375
388	25218	22		700
389	26483	8		680
390	36460	23		650
391	17831	10		305
392	41433	20	38	300
393	22620	34		320
394	40095	13	25	73
395	23683	6		300
396	26776	16		97
397	23314	40		300
398	23830	4		320
399	23829	20		340
400	23453	60		160
401	23452	40		100
402	23828	40		340

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
403	25940	15	22	350
404	27878	12		355
405	36845	12	38	305
406	24683	60		100
407	13885	25	30	157
408	20927	15		123
409	21199	86		325
410	26782	15	29	42
411	18277	95		350
412	27988	18		600
413	29450	15	23	350
414	26783	>40		
415	13191	50	120	470
416	28109	34		120
417	26779	20		60
418	30933	5	20	140
419	27358	18		230
420	26156	5	7	19
421	928	18	40	166
422	19716	5		700
423	2585	10	60	195
424	3236	21		260
425	30085	14	32	473
426	41594	18	47	305
427	29388	16		505
428	19292	70		247
429	3478	37	50	354
430	21258	14		300
431	26502	5		400
432	28332	40		400
433	24645	28		200
434	43953	17	30	640
435	8145	70		
436	42643	15	65	300
437	20938	45		173
438	24129	19		400
439	30087	31		198
440	28381	30		300
441	42642	15	50	300
442	39830	5	25	600
443	26486	30		499
444	40566	27	90	205
445	26733	40	64	198
446	26732	52		298
447	12165	25	78	96
448	42923	12		785
449	11187	40		98
450	10476	40		100
451	38695	12	58	475
452	42889	33		248
453	43940	14		298
454	43939	7	34	
455	36549	38		305
456	15297	55		195
457	13537	18	22	120
458	15060	55		325
459	19553	50		275
460	23916	25		540

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
461	22650	30		670
462	26944	10		150
463	18343	20		175
464	23104	73		98
465	933	21	62	169
466	32283	10	60	105
467	17552	97		164
468	32119	39	45	398
469	3180	15		121
470	666	15	125	180
471	3330	22		183
472	22802	8	20	425
473	2671	7		180
474	28742	62		300
475	21786	7		348
476	27023	11		373
477	29955	18	43	398
478	25377	8	70	150
479	36839	18	25	150
480	29565	18		150
481	30597	12	25	605
482	41831	18	34	700
483	22424	90		123
484	20523	18		298
485	20317	14		373
486	24738	20		150
487	21097	50		200
488	43345	14	58	305
489	20621	30		330
490	20622	20		690
491	24113	9		224
492	21165	8		222
493	40946	28		200
494	32515	27	36	248
495	43923	22	38	300
496	30726	22		630
497	33161	12		730
498	33563	10		655
499	33748	20	56	297
500	32519	27	58	723
501	28305	40		150
502	25538	25		30
503	25537	15		20
504	10091	25		64
505	14173	6	60	96
506	11771	30		150
507	33516	5		700
508	28436	4		210
509	26346	12	110	340
510	42157	53		405
511	25817	30		130
512	22661	60		150
513	22315	10		400
514	31748	30		280
515	27162	15		40
516	27007	14		230
517	26994	15		30
518	24677	22		505

Well Number	Identifier[1]	Depth (ft.) to base of surficial material[2]	Depth (ft.) to base of saprolite[3]	Total depth (ft.)
519	26995	24		30
520	32110	15		615
521	25694	2		600
522	20352	40		240
523	20303	15	21	215
524	21916	17		223
525	22351	20		298
526	22838	5		350
527	22340	13		623
528	27602	11		598
529	23665	26		248
530	19059	12		450
531	23356	25		495
532	40331	10	34	210
533	40333	6	21	305
534	40332	6	119	300
535	30584	20		700
536	23690	20		90
537	27105	12		125
538	22088	18		223
539	16193	28		295
540	41898	24		420
541	43474	24		670
542	25217	18		350
543	26576	9		175
544	16039	10		72
545	24755	14		405
546	20173	5		173
547	13373	17		187

[1] Identifiers consisting of 3, 4, or 5 digits are well permit numbers issued by the N. J. Department of Environmental Protection. All are preceded by “25-”. Identifiers of the form 25-x-xxx are N. J. Atlas Sheet coordinates of well logs in the N. J. Geological Survey permanent note collection. Identifiers of the form “Bx Healy xxxx” and “Bx Wash. Valley” are test borings on file at the N. J. Geological Survey.

[2] Described by drillers as “overburden”, “hardpan”, “clay and gravel”, “clay”, “sand and clay”, “sandy hardpan”, and “stony hardpan”.

[3] Described by drillers as “sandstone”, “rotten rock”, “rotten granite”, “soft granite”, “broken rock”, “fractured rock”, “weathered rock”, and “soft sandstone”.