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

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

SURFICIAL GEOLOGIC MAP OF THE BLOOMSBURY QUADRANGLE
WARREN AND HUNTERDON COUNTIES, NEW JERSEY
OPEN-FILE MAP OFM 152
Pamphlet containing table 1 to accompany map.

INTRODUCTION

Industrial, commercial, and residential expansion in New Jersey have promoted the increased use of surficial geologic data for land use planning, identification, management, and protection of groundwater resources, siting for solid waste disposal, development of geologic aggregate, contaminant remediation, and delineation of geologic hazards. Surficial materials in the Bloomsbury quadrangle are highly variable, cover most of the bedrock surfaces, and are found in many types of landscape settings. They include: 1) weathered bedrock derived from dolomite, shale, gneiss, granite, and quartzite fanglomerate that formed throughout the Quaternary and possibly during the Neogene; 2) glacial drift of early Pleistocene age (older than 788 ka; ka = thousand years ago); 3) colluvium of middle and late Pleistocene age (780 ka to 11 ka) and chiefly laid down during the latter part of the Quaternary; and 4) alluvium of late Pleistocene and Holocene age (125 ka to present). Surficial deposits are depicted on the map based on their physical characteristics, readily distinguishable boundaries, and location on the landscape. They are further delineated by genetic and morphologic criteria. This provides a connection between materials, geologic processes, and depositional environments, and promotes a better understanding of the surficial geology of the study area. Thickness is less than 30 feet for alluvium and as much as 30 feet for glacial sediment, 50 feet for colluvium, and 300 feet for weathered rock. The bedrock formations that underlie these surficial deposits are described in Monteverde and others (2023).

Over the last two million years, the Bloomsbury landscape has been shaped by multiple periods of glacial and periglacial weathering related to the growth and decay of the Laurentide ice sheet in North America. Braun (1989) estimates that there may have been as many as ten glaciations of a magnitude sufficient to introduce a periglacial climate to eastern Pennsylvania and New Jersey. During these periods, much cooler temperatures and increased precipitation enhanced the break-up and fragmentation of rock largely by frost shattering and mass-wasting of slope materials brought about by a change to a shallow-rooted vegetative cover. Colluvium, a major weathering product of periglacial climate, was shed off uplands onto the lower parts of hillslopes and onto the floor of narrow valleys and heads of drainage basins. This material was later partly eroded during interglacial periods by fluvial action. Remnant deposits of a glaciation older than 788 ka are found throughout the quadrangle in areas where they have been protected from mass wasting and fluvial erosion. Although the effects of glaciation in modifying the landscape are pronounced, these modifications have been largely masked by subsequent periods of periglacial modification. Since the Bloomsbury area was last glaciated, streams have cut as much as 100 feet into the older landscape. This renewed period of incision and etching of the land was probably caused by the drop in sea level due to growth of ice sheets in the northern hemisphere during the middle to late Pleistocene. Isostatic uplift related to Pleistocene erosion on land and sediment loading offshore may have also contributed to erosion on land.

PHYSIOGRAPHY AND BEDROCK GEOLOGY

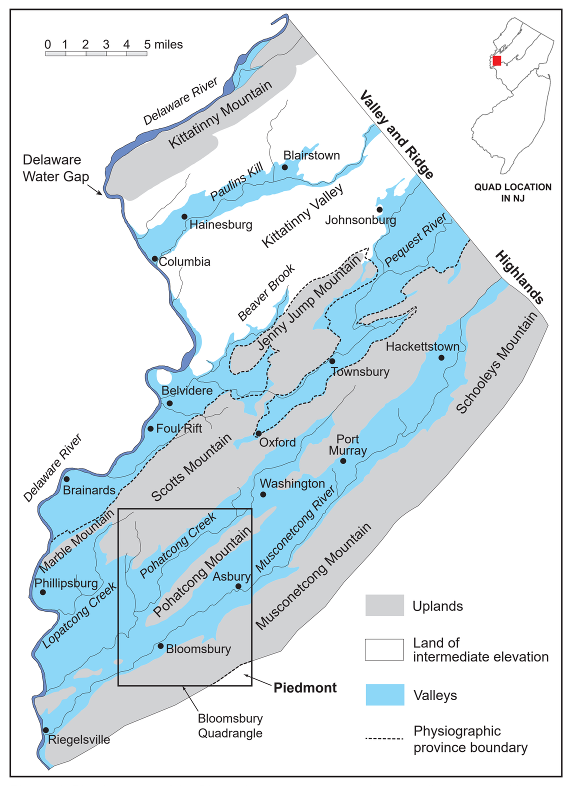

Figure 1. Physiography of the Bloomsbury quadrangle and surrounding area, and location of places named in text.

The Bloomsbury quadrangle (fig. 1) lies in the New Jersey Highlands except for its southeastern corner, which lies in the Piedmont physiographic province. The area is largely a rural setting, its landscape marked by patchwork woodlands, cultivated land, and larger forested areas covering parts of the mountains. The highest point is approximately 1,093 feet (331 m) above sea level on Scotts Mountain in the northwestern corner of the quadrangle, and the lowest point is approximately 250 feet (76 m) above sea level on the Musconetcong River in the southwestern corner of the quadrangle. Major landform elements define a pronounced southwest topographic grain. Scotts Mountain and Musconetcong Mountain bound the northwestern and southeast sides of the quadrangle respectively. Pohatcong Mountain in the central part of the quadrangle forms a narrow ridge that separates the Pohatcong and Musconetcong Valleys. These uplands, which rise between 400 feet (122 m) and 800 feet (244 m) above the valley floors, are chiefly underlain by gneiss and granite of Middle Proterozoic age (fig. 2). Topography here is rugged and the landscape is deeply dissected. Ridge lines chiefly follow layering in the bedrock, although discordant trends are common. Rock outcrops are few because in many places the rock surface is covered by thick saprolite and colluvium. In Musconetcong Valley, a ridge underlain by slate and siltstone (fig. 2) forms an area of intermediate elevation that divides the valley near Asbury.

The quadrangle lies mostly in the Delaware River drainage basin. The small area that lies in the Piedmont and adjacent parts of Musconectong Mountain are part of the Raritan River drainage basin. The larger tributaries of the Delaware River, the Musconetcong River and Pohatcong Creek, drain the central and northern parts of the quadrangle and flow southwestward through broad strike-valleys that are underlain by Cambro-Ordovician dolomite, and Ordovician shale, and siltstone (fig. 2). In most places the streams flow along belts of carbonate rock, their course forming a rectilinear drainage pattern that suggests some control by cross joints in the local rock. Both Pohatcong Creek and Musconetcong River are deeply incised. The modern river valley is very narrow and cut down in rock as much as 100 feet (30 m). In many places the older floors of the valleys are covered by a mantle of Pre-Illinoian till.

Mulhockaway Creek and Hakihokake Creek drain the southeastern part of the quadrangle. Mulhockaway Creek flows southeastward to the Raritan River. Hakihokake Creek flows southward to the Delaware River. In this area Triassic fanglomerate (fig. 2) forms a rugged upland next to Musconectcong Mountain.

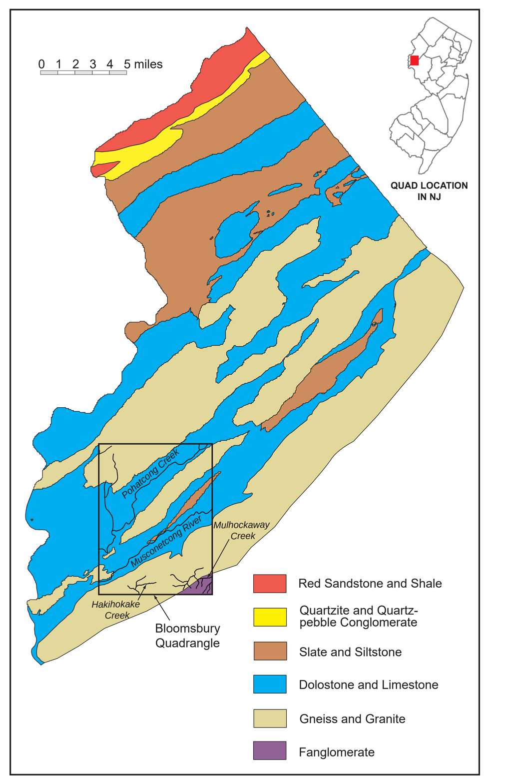

Figure 2. Simplified bedrock geology of the Bloomsbury quadrangle and surrounding area. Data simplified from Drake and others (1996).

PREVIOUS INVESTIGATIONS

The surficial geology of the Bloomsbury quadrangle and surrounding area was first discussed by Cook (1880). He discussed the distribution of quartzose boulders and scattered patches of thin gravelly drift in the Pohatcong and Musconetcong valleys. Most of this material was thought to be "modified glacial drift" that was possibly deposited by meltwater and reworked later by weathering and fluvial erosion. On greater inspection (Salisbury, 1893) this "modified glacial drift" was determined to be of glacial origin and called extra-morainic drift because of its distribution south of the Wisconsinan terminal moraine. Salisbury (1902) assigned the drift a Kansan age because of its deeply weathered appearance, which suggested it was the product of a glaciation that was much older than the Wisconsin glaciation. Salisbury also mentioned that the drift outside of the terminal moraine in a few places looked much less weathered than most of the extra-morainic drift. Bayley and others (1914) divided the extra-moranic drift into "early glacial drift" that was largely till deposited during the Jerseyan stage and "extra-morainic drift" that consisted of a mix of Wisconsin and early drift. In Pennsylvania, Leverett (1934) also assigned a Wisconsinan age to the terminal moraine and the glacial drift north of it, and suggested that the pre-Wisconsinan drift was laid during the Illinoian and Kansan glaciations. MacClintock (1954) divided the glacial deposits into Olean drift of early Wisconsinan age, and the Binghamton drift of late Wisconsinan age, based on the depth of carbonate leaching in glacial stream sediments. Crowl and Sevon (1980) suggested that glacial deposits in eastern Pennsylvania consisted of the late Wisconsinan Olean drift, and that the older glacial deposits were represented by the Warrensville drift of early Wisconsinan age and the Muncy drift of Illinoian age. Cotter and others (1986) indicated the youngest glacial deposits in Pennsylvania and New Jersey are late Wisconsinan age and are correlative with the Olean drift in Pennsylvania. Ridge and others (1990) showed that older, weathered drift in the Delaware Valley north of Marble Mountain, which is located northwest of the Bloomsbury quadrangle, is late Illinoian in age. Gardner and others (1994) showed that the pre-Illinoian drift in central Pennsylvania is older than 788 ka, based on the reversed magnetic polarity of glacial lake-bottom deposits preserved near Antes Fort in the West Branch Susquehanna River valley. Braun (1989), Witte and Stanford (1995), Stone and others (2002) indicated that the youngest glacial deposits in eastern Pennsylvania and New Jersey are late Wisconsinan age, and that the two older drifts are Illinoian, and pre-Illinoian age.

PREGLACIAL DRAINAGE AND GEOMORPHOLOGY

The primary drainage routes in the quadrangle and surrounding area were probably established well before the Pleistocene. Transverse gaps in the Highlands are possibly relicts of an earlier Raritan River drainage system that flowed in a southeasterly direction (Witte, 1997b). The Delaware River, through headward erosion and stream capture, has enlarged its drainage area chiefly by extending its tributaries upvalley along the strike of less resistant rock. In response to the overall lowering of sea level during the Pleistocene, the drainage has further evolved by incision, which along the larger tributaries of the Delaware River, has resulted in the formation of a much lower, narrower, river valley. Extensive headward erosion by first and second-order streams has also resulted in the dissection of the older valley floor, and the surrounding Highlands. The location of Illinoian glaciofluvial deposits in the Delaware Valley (Ridge, 1983; Witte and Stanford, 1995) suggests that the river valleys in the study area had been lowered or nearly lowered to their present levels by the time of the Illinoian glaciation.

The physiography of the Bloomsbury quadrangle reflects a composite landscape, chiefly periglacial, modified by glacial processes (pre-Illinoian) and fluvial erosion under a temperate climate. The Bloomsbury quadrangle consists of an assemblage of landforms that form uplands and valleys. These landforms may be grouped into geomorphic terrains based on their differences in elevation and topography. It is convenient to do this in order to discuss the history of the Bloomsbury landscape in reference to erosional processes and lithotype. This methodology was successively applied to the Lehigh Valley and surrounding area, which are similar to the Bloomsbury quadrangle, by Germanowski (1999).

Upland terrains consist of: 1) broad, relatively undissected areas of low relief < 60 feet (< 18.2 m), underlain by gneiss and granite. Surficial materials include weathered rock (thin to thick saprolite, scattered rubbly regolith), thin colluvium, and thin patches of older drift including scattered erratics; 2) narrow ridges and hills in areas of deeply dissected moderate to high relief (100 feet to 400 feet or 30.4 m to 121.9 m) underlain by gneiss and granite. This terrain consists of narrow ridge crests, extensive slopes, and deep, very narrow valleys with fairly common rock outcrops. Surficial materials include thin to thick colluvium and thin weathered rock (saprolite and rubbly regolith).

Valley terrains consist of: 1) the modern valley floor, which is deep (100 feet or 30 m), narrow, rock walled, and underlain by carbonate rock. Includes dissected areas of the old valley floor. Surficial materials include alluvium and colluvium; 2) old valley floor, which are broad areas of low relief (< 40 feet or < 12 m) and gentle slopes typically underlain by carbonate rock. Surficial materials include thin pre-Illinoian till < 30 feet (< 9 m) thick, till stone lag, weathered dolomite and limestone (solution residuum), and thin colluvium. In places carbonate bedrock is deeply weathered to depths exceeding 300 feet (91 m); 3) areas of intermediate elevation, which are rolling hills and narrow ridges underlain by shale that are 100 feet to 200 feet (30 m to 61 m) higher than older valley floors (valley terrain 2). Surficial materials include shale-chip residuum and shale-chip colluvium.

Comparison between geomorphic terrains and bedrock clearly shows that rocks more resistant to weathering form areas of higher elevation. An idea presented by Hack (1960) and summarized here indicates that "topography is largely the result of differential erosion of rocks that have varying degrees of resistance to erosion." Carbonate rock underlies the lower areas, shale underlies areas of intermediate elevation, and gneiss and granite hold up the mountains.

QUATERNARY GEOLOGY

The position and difference in weathering characteristics of glacial drift in New Jersey indicate that continental ice sheets reached New Jersey at least three times (Salisbury, 1902; Witte and Stanford, 1995; Stone and others, 2002; Stanford and others, 2021). The action of each ice sheet modified the landscape. Valleys underlain by weathered rock were deeply scoured, and bedrock ridges, hills, and slopes were worn down by abrasion and plucking, smoothing and streamlining the bedrock surface. The many unweathered and lightly weathered bedrock outcrops that lie north of the terminal moraine show that most of the pre-existing weathered bedrock and surficial material had been removed by glacial erosion, although outcrops of saprolite observed behind the late Wisconsinan border (Ridge, 1983; Witte, 2021) show that some preglacial materials were not eroded. Most of the debris entrained by the ice sheets was deposited as till and meltwater sediment. The youngest glacial deposits laid down during the late Wisconsinan substage provide the clearest record of glaciation. The glacial record, indicated by the Illinoian and especially the pre-Illinoian deposits, is less clear due to an extensive and complex weathering history.

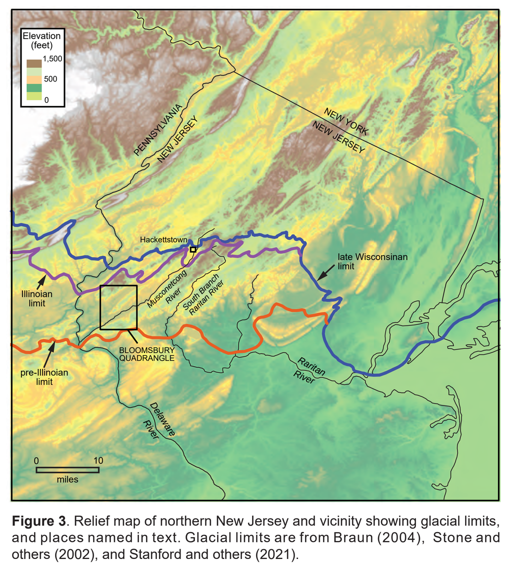

Figure 3. Relief map of northern New Jersey and vicinity showing glacial limits, and places named in text. Glacial limits are from Braun (2004), Stone and others (2002), and Stanford and others (2021).

The oldest glaciation is represented by the Port Murray Formation (Stone and others, 2002) and covered all of the Bloomsbury quadrangle (glacial limit shown with orange line in fig. 3). The Port Murray drift appears to be chiefly till. It is highly and deeply weathered, and it lies on weathered bedrock. Constructional topography is not preserved, and the drift lies as much as 100 feet (30 m) above modern valley floors in areas that are protected from mass wasting and fluvial erosion. The age of this glaciation is uncertain. Samples collected from a silty-clay bed in a deeply weathered fluviatile deposit in the Pohatcong Creek valley, downstream from the quadrangle, show that these sediments were laid down during a period of reversed magnetic polarity (Stanford and others, 2021). This places the age of the deposits at older than 788 ka. Based on correlation to dated tills in the Missouri River Valley this deposit may have been laid as early as 2.4 Ma (Ma = Million years ago) (Boellstorff, 1978; Balco and Rovey, 2010). If the deposit is not outwash, but rather older alluvium laid down by Pohatcong Creek or the Delaware River, its position within the belt of older glacial drift shows that this older drift is the same age or older than the suspected outwash. Work on "older" glacial lake-bottom deposits in the West Branch Susquehanna River valley by Gardner and others (1994) and in eastern Pennsylvania (Braun, 2004) show that these deposits were also laid down during a period of reversed magnetic polarity.

The second ice sheet (glacial limit shown with purple line in fig. 3) reached just the far northwest corner of the quadrangle. It deposited a terminal moraine across the Pohatcong Valley near the town of Washington just northeast of the quadrangle (fig. 1) during the Illinoian stage, about 135 ka. This glaciation is represented by the Lamington and Flanders Formations (Stone and others, 2002). These deposits are moderately weathered, and the underlying bedrock is not as weathered as it is beneath the Port Murray deposits. The deposits lie in modern valleys and constructional topography is preserved, although it is subdued, and the drift in many places has not been eroded off hillslopes.

The distribution of Port Murray till shows that the overall character of the Port Murray surface is similar to present time. It is doubtful if the overall height of the mountains above the older valley floors (valley terrain 2) was much greater than it is now. Since the pre-Illinoian glaciation the Delaware River and its tributaries have cut down as much as 100 feet (30 m) in the older valley floor. The position of Illinoian glaciofluvial deposits in the Delaware River valley suggests that most of the erosion took place well before the onset of the Illinoian glaciation. The narrow, rock-walled valleys that the Delaware River, Musconetcong River, and Pohatcong Creek flow through support the above hypothesis. Consequently, streams have renewed their attack on surrounding uplands, which is reflected by incision and retreat of hillslopes (formation of narrow ridges and hills as described above for upland terrain 2). In places, streams lie as much as 200 feet to 300 feet (30 m to 91 m) below ridge tops and terrain 1 flats and saddles.

The youngest ice sheet reached the northern part of Warren County during the late Wisconsinan substage of the Wisconsinan stage, approximately 25 to 24 ka (Cotter and others, 1986; Stanford and others, 2021). Its furthest advance (glacial limit shown with blue line in fig. 3) is generally marked by the terminal moraine (Salisbury, 1902). The deposits of this glaciation are lightly weathered, exhibit well-preserved constructional topography, generally lie on non-weathered rock, and lie in the modern drainage. Remnants of this glaciation exist in this quadrangle only as valley-train deposits and form terraces that flank the course of the Musconetcong River.

The terrestrial (Fullerton, 1986) and oceanic records (Shackleton and Hall, 1984) show that the growth and decay of continental ice sheets in the northern hemisphere during the Pleistocene was cyclic. In response to the growth and decay of the Laurentide ice sheet, the climate in the study area varied between temperate to boreal. During the warm interglacials, such as the Sangamon (135 to 70 ka), the relative rate of chemical weathering increased and an extensive cover of deeper-rooted vegetation helped reduce the rate of mass wasting. During this period thick soils were formed and bedrock was deeply weathered forming saprolite and decompostion residuum. In contrast, during the colder periglacial and glacial periods, there was a relative increase in the rate of physical weathering. This slowed pedogenic activity and because of a less extensive, and more shallow-rooted vegetative cover, the rate of mass wastage was greatly enhanced.

Braun (1989) suggested that erosion due to periglacial weathering could be on the order of a magnitude greater than fluvial erosion in modifying the landscape during the Pleistocene. Glacial/periglacial periods in New Jersey were short-lived and marked by intense physical weathering where large volumes of colluvium was produced. Colluvium in the Bloomsbury area is chiefly a monolithic diamict derived from weathered bedrock (chiefly by fragmental disintegration of outcrop and regolith by frost shattering) and transported downslope largely by creep. Over time it accumulated at the base of slopes, forming an apron of thick material, and it also collected on the floors of narrow valleys and first-order drainage basins. In places, it is greater than fifty feet thick and covers large parts of the landscape. Rates of sedimentation appear to be very high, typically overwhelming the capacity of the "fluvial system" to remove sediment. During periods of temperate climate, sediment production by periglacial processes presumably decreased, resulting in an increased rate of fluvial erosion. However, the total volume of material removed by fluvial erosion (gullying of slopes, incision of colluvially-filled valleys and first-order drainage basins, and alluvial fans, sapping by springs, lateral erosion of toe slopes) during temperate periods was probably less than it was during periglacial periods.

Following the late Wisconsinan glaciation, cold and wet conditions, and sparse vegetative cover enhanced erosion of hillslope material by solifluction, soil creep, and slope wash. The mechanical disintegration of rock outcrops by freeze and thaw provided additional sediment, some of which formed aprons of talus at the base of large cliffs in the New Jersey Highlands. A few small boulder fields were formed where boulders, transported downslope by creep, accumulated at the base of hillslopes and in first order drainage basins. These fields, and other concentrations of boulders formed by glacial transport and meltwater erosion, were further modified by freeze and thaw, their stones reoriented to form crudely shaped stone circles. Gradually as climatic conditions warmed, vegetation spread and was succeeded by types that further limited erosion. Between 14,250 and 11,250 years before present (Cotter, 1983) lacustrine sedimentation, which had been dominated by clastic material, became enriched in organic material. This transition represents a warming of the climate such that subaquatic vegetation could be sustained and it also marked a change in terrestrial vegetation from herb (tundra) to spruce and hemlock parkland, and eventually to a closed forest of spruce and hemlock. Forests of oak and mixed hardwoods started to populate the landscape around 9,700 yr B.P. (Cotter, 1983).

SURFICIAL DEPOSITS

Surficial materials in the Bloomsbury quadrangle include alluvium, swamp and bog deposits, colluvium, glacial drift, and weathered bedrock. They are defined by their lithic characteristics (composition, texture, color, and structure), and bounding discontinuities. Their ages are based on a modified Midwestern nomenclature from Stone and others (2002).

Non-Glacial Deposits

Stream deposits (alluvium, stream-terrace deposits, and alluvial-fan deposits)

Alluvium is chiefly Holocene age and it includes both channel (sand and gravel) and overbank (sand and silt) sediment laid down by streams in sheet-like deposits on the floors of modern valleys. Stream-terrace deposits include both channel and flood-plain sediments that lie 5 to 10 feet (2 to 3 m) above the modern flood plain and below meltwater-terrace deposits. Alluvial-fan deposits are scattered throughout the quadrangle with most of them in the Musconetcong and Pohatcong valleys. They lie at the base of valley slopes where streams emerge from the adjacent uplands, and their surfaces are entrenched by the modern drainage. These erosional channels show that the fan is not presently forming and that their formation is cyclic; influenced chiefly by climate and its effects on weathering, sediment supply, and amount and type of vegetative cover.

Hillslope sediment

Hillslope deposits include colluvium, and undifferentiated alluvium and colluvium. These deposits are derived from underlying and upslope materials transported downslope by soil creep, solifluction, earth and debris flows, and rock fall. Colluvium in the quadrangle is very widespread and is chiefly derived from weathered bedrock. It typically forms a monolithic diamict that mantles most slopes and forms thick aprons of material on their lower parts. It also collects in small first-order drainage basins in upland areas. In places colluvium includes thin beds and lenses of sorted, stratified sheet- and rill-wash sand and gravel. Undifferentiated alluvium and colluvium consists of a mixture of alluvium and colluvium that has accumulated in narrow valleys in the upper parts of first-order drainage basins. In places, these deposits also include the toe slopes of small colluvial aprons. In the Musconetcong and Pohatcong valleys, colluvium of Wisconsinan age overlies weathered colluvium of presumably pre-Wisconsinan age, and a truncated red soil marks the contact between the two. This stratigraphy supports the hypothesis that colluviation is cyclic.

Glacial Materials

Till

Till is a poorly sorted, nonstratified to very poorly stratified mixture of clay- to boulder-sized material deposited directly by or from a glacier. In the Bloomsbury quadrangle till is represented by the Port Murray Formation and a small area of Flanders Till in the far northwestern corner. The Port Murray till is highly weathered, has a clayey matrix, is oxidized and leached of carbonate material, and lies on weathered bedrock. It is only found in places where it has been protected from erosion, generally 60 to 100 feet (18 to 30 m) above the modern drainage where it is typically found on the "old" valley floors of the Pohatcong and Musconetcong valleys, and to a much lesser extent on flat upland surfaces. It was formerly much more extensive. In places, it is represented by a till- stone lag consisting of pebbles and cobbles of quartzite, chert, and quartzose siltstone. In most places, the till appears to be in place, although extensive surface and near-surface modification by cryoturbation, and minor colluviation is presumed based on the till's antiquity. The Flanders Till is sandier and much less weathered and eroded than the Port Murray till.

Deposits of glacial meltwater streams

Sediment carried by glacial meltwater streams was chiefly laid down at and beyond the glacier margin in valley-train deposits (Qwf) in the Musconetcong Valley when late Wisconsinan outwash deposits formed terraces of lightly weathered gravel and sand. These terraces are likely remnants of an extensive valley train that extended downstream from the terminal moraine at Hackettstown (fig. 3). Weathered deposits of sand and gravel in the Musconetcong Valley occur as scattered patches that sit well above the modern drainage. Based on their elevation and degree of weathering they appear to be of early Pleistocene age. Because the upper part of these stratified deposits are weathered to a round-stone diamict, they are often difficult to distinguish from the Port Murray till in places. The older stratified deposits are probably under-mapped, and in places may be interglacial stream sediment.

Due to the scant distribution and poor preservation of the Port Murray deposits, and lack of recognizable recessional deposits, the history of the pre-Illinoian deglaciation is problematic. If deglaciation proceeded as it did in the late Wisconsinan, then ice-recessional positions may have been marked by the heads-of-outwash of glaciofluvial deposits laid down in the Musconetcong and Pohatcong valleys.

Weathered bedrock

Weathered bedrock consists of saprolite, decomposition and solution residuum, and rock rubble. It was formed during the Pleistocene over a long and complex history of weathering and erosion where the climate varied between boreal conditions during glacial periods to temperate and subtropical conditions during interglacial periods. Weathered bedrock materials in the quadrangle were chiefly derived from gneiss and foliated granite, slate and siltstone, and dolostone.

Weathered gneiss and foliated granite consist chiefly of saprolite, grus and rock rubble. Structured saprolite extends deeply into bedrock along joints, fractures and foliations. Grus and rock rubble generally form a surface cover of varying thickness. Bedrock outcrops are few and generally lie only along ridge crests and very steep hillslopes. Outcrops form tors, subtors, and disorganized masses of irregularly-spaced joint-block boulders that generally denote areas of subcrop. The surface of most outcrops is granular, and deeply etched.

Weathered slate and sandstone (graywacke) consist chiefly of decomposition residuum (Richmond and others, 1991), and shale-chip rubble. Bedrock does not generally crop out. The surface of the weathered material is a mix of shale chips, soil, and a few glacial erratics.

Weathered carbonate rock consists chiefly of solution residuum (Richmond and others, 1991), and karst-fill materials. Weathering extends deeply in the subsurface along fractures, joints and bedding planes. In many places the weathered bedrock alternates in the subsurface with nonweathered bedrock. Bedrock outcrops are widely scattered, most are marked by a pile of irregularly-shaped boulders along the crest of a ridge or on a hillslope. The rock surface is very irregular and deeply etched along joints and fractures.

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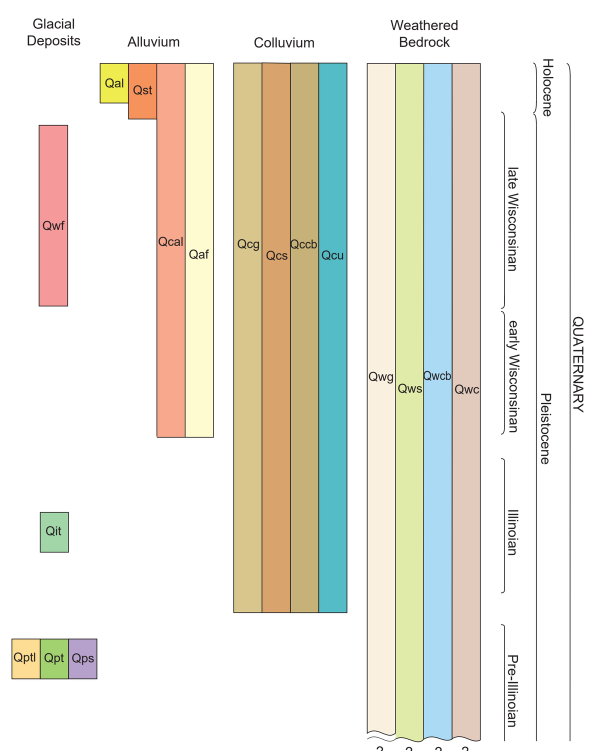
CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Map units denote unconsolidated materials more than 5 feet (1.5 m) thick. Color designations, based on Munsell Color Company (1975), were determined from naturally moist samples.

HOLOCENE AND LATE WISCONSINAN

Postglacial Deposits

af — **ARTIFICIAL FILL** - Rock waste, gravel, sand, silt, and manufactured materials emplaced by humans. As much as 200 feet (61 m) thick. Not shown beneath roads, and railroads where it is less than 10 feet (3 m) thick.

Qal — **ALLUVIUM** - Stratified, moderately to poorly sorted sand, gravel, silt, and minor clay and organic material. Locally bouldery. As much as 25 feet (8 m) thick. Includes planar to cross bedded gravel and sand in channel deposits, and cross bedded and rippled sand, massive and parallel laminated fine sand, and silt in flood plain deposits. In places, overlain by and interlayered with thin organic material and colluvium.

Qst — **STREAM TERRACE DEPOSITS** - Stratified, well to moderately sorted, massive to laminated, and minor cross bedded fine sand, and silt in terraces flanking present or former stream courses. As much as 15 feet (4 m) thick. Overlies planar to cross bedded cobble pebble gravel and pebbly sand; as much as 20 feet (6 m) thick.

Meltwater Deposits

Qwf — **VALLEY TRAIN DEPOSITS** - Stratified, well to moderately sorted sand, boulder cobble to pebble gravel, and minor silt deposited by meltwater streams beyond the glacier margin in Musconetcong Valley. As much as 30 feet (10 m) thick. The proximal part of the deposit consists of massive to horizontally bedded and imbricated coarse gravel and sand, and planar to tabular and trough cross bedded, fine gravel and sand in bars, and channel lag deposits with minor cross bedded sand in channel fill deposits. Clasts generally are smaller downstream, sand is more abundant, and trough and planar cross bedding, and graded beds are more common. Overbank deposits of massive to laminated fine sand and silt are rare. Includes meltwater-terrace deposits down valley.

HOLOCENE AND WISCONSINAN

Qaf — **ALLUVIAL-FAN DEPOSITS** - Stratified, moderately-to poorly sorted, brown to yellowish-brown, gray sand, gravel, and silt in fan-shaped deposit; as much as 35 feet (11 m) thick. Includes massive to planar-bedded sand and gravel and minor cross-bedded channel-fill sand. Bedding dips as much as 30 degrees toward the trunk valley. Locally interlayered with unstratified, poorly sorted, sandy-silty to sandy gravel.

Qcal — **ALLUVIUM AND COLLUVIUM, UNDIFFERENTIATED** - Stratified, poorly to moderately sorted, brown to yellowish-brown, gray sand, silt and minor gravel; as much as 20 feet (6 m) thick. Interlayered with or overlying, massive to crudely layered, poorly sorted sand, silt, and minor gravel.

MIDDLE PLEISTOCENE TO HOLOCENE

Qcg — **GNEISSIC AND GRANITIC COLLUVIUM** - Massive to crudely layered, slightly compact, poorly sorted yellowish-brown (10YR 5/4-8) to dark yellowish-brown (10YR 4/4), brown (10YR 5/3), strong brown (7.5YR 5/6) silty sand and sandy silt, containing as much as 60 percent lightly to moderately weathered angular to subangular cobbles, pebbles, and boulders of gneiss and foliated granite; as much as 50 feet (15 m) thick. Matrix consists of a varied mixture of quartz sand, weathered feldspar, mica, amphibole, heavy minerals, silt, and clay.

Qcs — **SLATE, SILTSTONE, AND SANDSTONE COLLUVIUM** - Crudely to moderately layered, noncompact, poorly sorted light yellowish-brown (10YR 6/4) to brownish-yellow (10YR 6/6) or light olive-brown (2.5Y 5/4) silty sand and clayey silt, containing as much as 80 percent lightly to moderately weathered angular to subangular slate chips, tabular pebbles and cobbles of siltstone and sandstone, as much as 30 feet (9 m) thick. Matrix consists of a varied mixture of rock fragments, quartz sand, silt, and clay.

Qccb — **CARBONATE ROCK COLLUVIUM** - Massive to crudely layered, slightly compact, poorly sorted dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/4), reddish-yellow (7.5YR 6/8) to strong-brown (7.5YR 5/6-8) clayey silt containing as much as 5 percent angular to subangular fragments and pebbles of leached carbonate rock, chert, and minor quartzite; as much as 20 feet (6 m) thick. Matrix consists of a varied mixture of clay, quartz sand, rock fragments, and silt.

Qcu — **UNDIFFERENTIATED COLLUVIUM** - Poorly sorted, brown to yellowish-brown, gray sand, silt, and minor gravel derived from a mixture of weathered bedrock and till; as much as 10 feet (3 m) thick.

ILLINOIAN

Qit — **FLANDERS TILL** - Massive, compact, poorly sorted, strong-brown (7.5YR 5.6), pale-brown (10YR 6/3), yellow (10YR 7/6) to yellowish-brown (10YR 5/4-6) clayey silt and sandy silt that typically contains 5 to 15 percent gravel as much as 60 feet (18 m) thick. Locally reddish till rich in weathered carbonate rock. Clasts consist of gneiss, foliated granite, quartzite, quartz-pebble conglomerate, slate, sand-stone, chert, and carbonate rock. Crystalline clasts have thick to thin weathering rinds (0.5 in.); carbonate clasts are generally decomposed to depths exceeding 10 feet (3 m). Other clasts have thin weathering rinds (0.1 in.), and pitted surfaces. Matrix is a varied mixture of quartz, rock fragments, silt, clay, weathered feldspar, minor mica, and heavy minerals. Subvertical joints moderately developed to depths of at least 10 feet (3 m). Iron and iron-manganese stain the surface of clasts, sand grains, and joints to depths of at least 10 feet (3 m).

PRE-ILLINOIAN

Qpt, Qptl — **Port Murray Formation: TILL** - Deeply weathered, compact, massive to crudely layered reddish-yellow (7.5YR 6/6-8) to strong-brown (7.5YR 5/6-8) to yellowish-brown (10YR 5/6-8), or reddish-brown (5YR 4/3) to weak-red (2.5YR 4/3) sandy silt and clayey silt that typically contains 2 to 5 percent gravel; as much as 30 feet (9 m) thick. Gravel consists of pebbles and cobbles of quartzite, gneiss, quartzose sandstone and siltstone, shale, dolostone, and chert, and a few boulders of quartzite and gneiss. Gneiss clasts have thick weathering rinds or are completely decomposed; carbonate clasts are fully decomposed. Quartzite, sandstone, and chert pebbles and cobbles have pitted surfaces and thin weathering rinds. Matrix contains clay, quartz weathered rock fragments, minor weathered mica, and few heavy minerals. Subvertical joints are poorly to moderately developed to depths exceeding 10 feet (3 m). Clasts and joints are commonly coated with red iron and black iron-manganese oxide. In places where resistant clasts (quartzite and chert) form a thin stony lag on weathered rock, the unit is labelled Qptl.

Qps — **Port Murray Formation: STRATIFIED DRIFT** - Reddish yellow (7.5 YR 6/6-8) to strong brown (7.5 YR 5/6-8) sand and gravel, and sand. Clasts are subrounded to well-rounded quartzite, quartzose sandstone and siltstone, chert, slate, and gneiss. Gneiss clasts are decomposed to depths exceeding 15 feet. Quartzite and chert clasts have weathering rinds < 0.1 in., and are coated with a brown iron-manganese stain. Sandstone and quartzite clasts have pitted surfaces. Planar bedding with minor cross-stratification. Soils developed on these deposits form diamict sediments that may resemble the Port Murray till.

NEOGENE (?) TO QUATERNARY

Qwg — **WEATHERED BEDROCK DERIVED FROM GNEISS, FOLIATED GRANITE, AND MINOR QUARTZITE** - Massive to layered, noncompact to compact brown (10YR 5/3), yellowish-brown (10YR 5/6-8), strong-brown (7.5YR 5/6), white (5YR 8/1), and red (2.5YR 5/8) silty sand to clayey silt saprolite consisting of clay, quartz, minor mica and heavy minerals; and sandy, blocky rock rubble. As much as 67 feet (20 m) thick as seen in well 36. Includes thin stony and blocky colluvium on hillslopes, and bouldery to cobbly mantle of angular to subangular gneiss, granite, and minor quartzite on very gentle hillslopes; as much as 10 feet (3 m) thick. Weathered zone grades downward through a bouldery zone of joint blocks into underlying unweathered bedrock, and extends deeply along joints, fractures, and bedrock layers. Joint blocks and rock rubble typically have thick weathering rinds. On steep slopes, weathered material is thin or absent and fractured-rock rubble with scattered outcrop is abundant (mapped as "Qwgt" or "sr" on adjacent quadrangles).

Qws — **WEATHERED BEDROCK DERIVED FROM SLATE, SILTSTONE, AND SANDSTONE** - Massive to layered, noncompact to slightly compact reddish-brown (5YR 4/3-2.5YR 4/4) silty clay or sandy silt decomposition residuum of clay, quartz, and rock fragments; and slate-chip gravel containing flat pebbles of slate, tabular pebbles of siltstone, and sandstone; as much as 30 feet (9 m) thick (estimated). Locally includes thin shaly colluvium on hillslopes; as much as 10 feet (3 m) thick. Weathered zone typically grades downward through a zone of fractured rock into underlying unweathered bedrock.

Qwcb — **WEATHERED BEDROCK DERIVED FROM DOLOSTONE AND LIMESTONE** - Massive, compact light-red (2.5YR 6/6) to red (2.5YR 5/6), reddish-yellow (7.5YR 7/8) to strong-brown (7.5YR 5/6) to yellowish-brown (10YR 5/6), or yellow (10YR 7/6), locally highly variegated, clay and silty-clay solution residuum of clay, quartz, and iron oxide; generally containing less than 5 percent chert, vein quartz and minor quartzite; thickness is highly variable, typically less than 15 feet (5 m), but locally as much as 110 feet (34 m) as shown in well 8. Locally includes thin colluvium as much as 5 feet (1.5 m) thick on gentle hillslopes. Also may include sand, gravel, silt, and clay washed into sinkholes and solution cavities from overlying colluvial, alluvial, and glacial sediment. Weathered zone typically ends at an abrupt, very irregular contact with unweathered bedrock and also extends deeply along joints and fractures.

Qwc — **WEATHERED BEDROCK DERIVED FROM QUARTZITE FANGLOMERATE** - Yellowish-brown (10 YR 6/4 and 6/6), reddish-brown (5 YR 4/3) sandy silt decomposition residuum containing 10 to 50 percent pebbles and cobbles of quartzite and sandstone, and fanglomerate; as much as 70 feet (21 m) thick (estimated). Locally includes thin colluvium less than 5 feet (2 m) thick. Weathered zone typically grades downward through a zone of fractured rock into underlying unweathered bedrock.

EXPLANATION OF MAP SYMBOLS

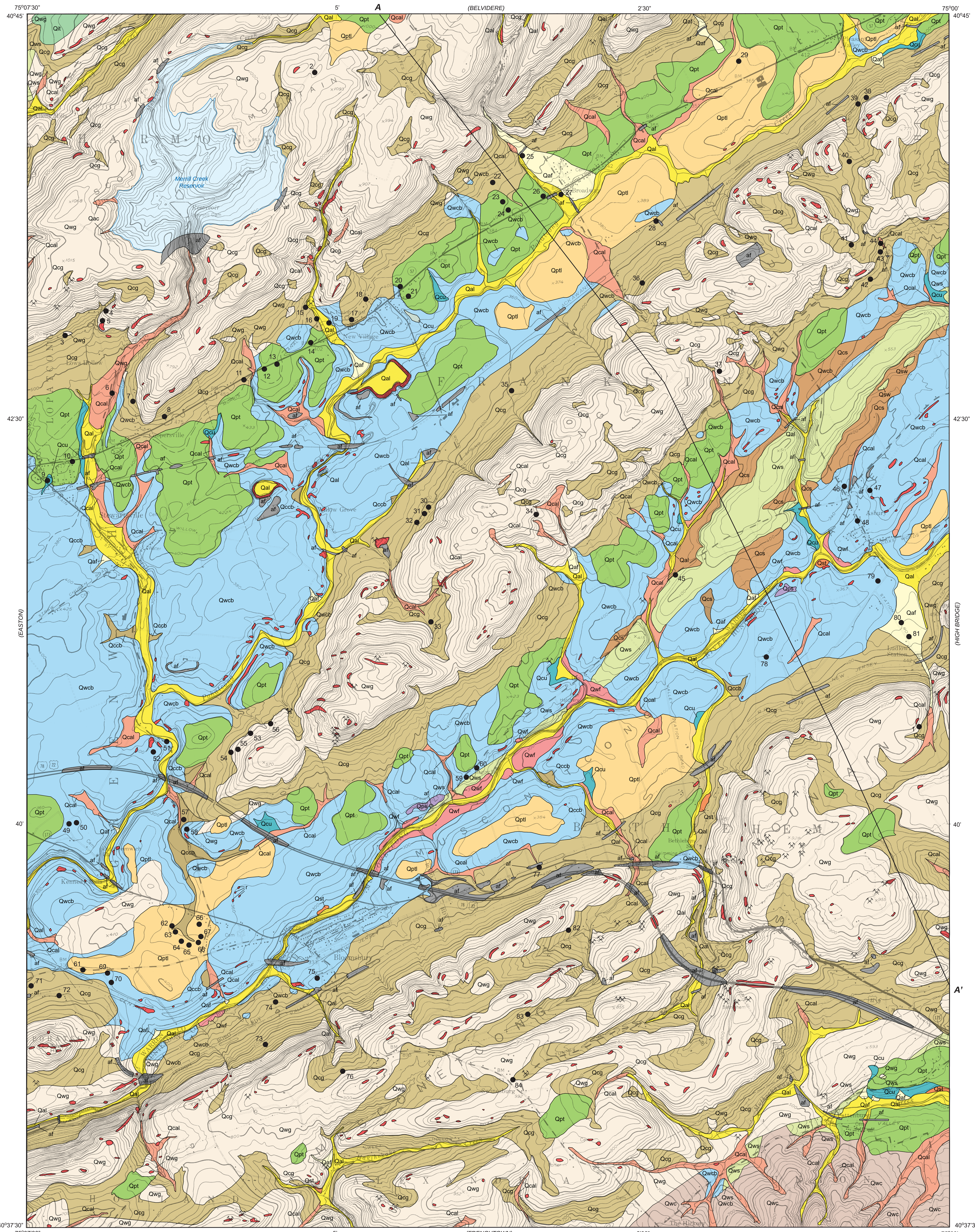
Geologic contacts - dashed where concealed.

73 — Location of well or boring - location accuracy and geologic log listed in table 1 (in pamphlet).

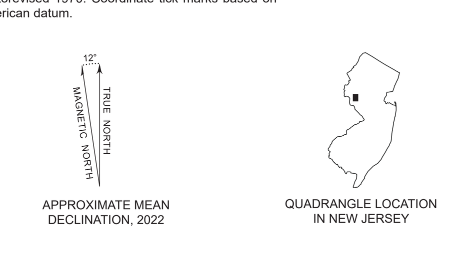
Inactive quarry - inactive in 2022.

Rock outcrops.

Merrill Creek Reservoir - not shown on basemap.



Basemap edited and published by the U.S. Geological Survey. Compiled from aerial photographs taken 1942. Field checked 1955. Map photorevised 1970. Coordinate tick marks based on 1927 North American datum.



SCALE 1:24000

1 1/2 0 1 mile

1000 0 1000 2000 3000 4000 5000 6000 7000 feet

1 1/2 0 1 kilometer

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Surficial geology mapped by R.W. Witte, 1991-1995, 2007-2008, and 2014.

GIS application by Mike Girard, New Jersey Geological and Water Survey. Digital cartography by R.W. Witte, New Jersey Geological and Water Survey.

Research supported by the U. S. Geological Survey, National Cooperative Geologic Mapping Program, under USGS award number 00HQAG-0110. 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.

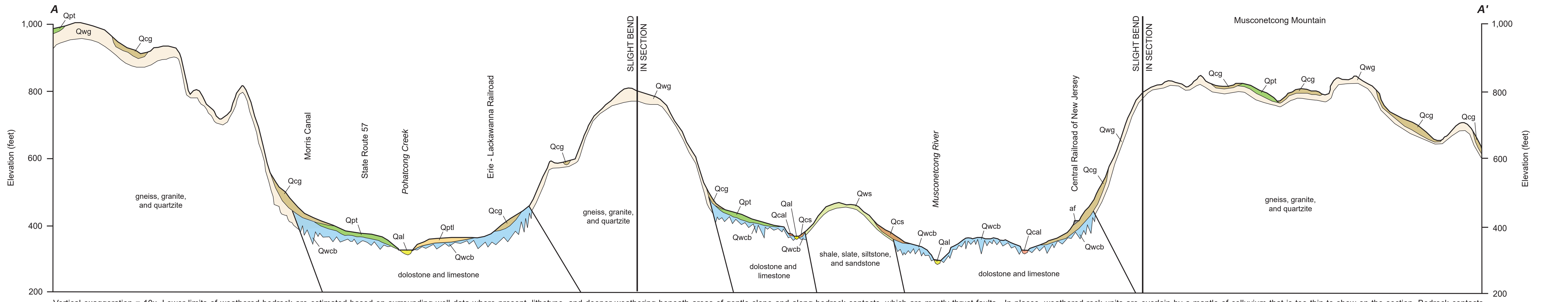
SURFICIAL GEOLOGIC MAP OF THE BLOOMSBURY QUADRANGLE
WARREN AND HUNTERDON COUNTIES, NEW JERSEY

By

Ron W. Witte[1]

[1] Retired, New Jersey Geological and Water Survey

2023



Vertical exaggeration = 10x. Lower limits of weathered bedrock are estimated based on surrounding well data where present, lithotype, and deeper weathering beneath areas of gentle slope and along bedrock contacts, which are mostly thrust faults. In places, weathered rock units are overlain by a mantle of colluvium that is too thin to show on the section. Bedrock contacts corrected for vertical exaggeration. Bedrock geology from Drake (1967), Drake and others (1996), and Monteverde and others (2023).

Surficial Geologic Map of the Bloomsbury Quadrangle
Warren and Hunterdon Counties, New Jersey

New Jersey Geological and Water Survey
Open-file Map OFM 152
2023

Pamphlet containing Table 1 to accompany map.

Table 1. Selected records of wells in the Bloomsbury quadrangle, Warren and Hunterdon counties, New Jersey. The wells listed below were drilled for private and public water supply and are on file at the New Jersey Department of Environmental Protection (NJDEP). The location of these wells are based on property maps. Location accuracy designated by letters “s”, “f”, and “t” are generally accurate to within 200 feet, 500 feet, and 1,000 feet, respectively, of the actual well location.

Well Number	NJDEP Permit Number	Accuracy of Location	Discharge Reported by Drillers (gpm)	Depth Below Land Surface (ft)	Driller’s Log
1	24-08904	f-t	30	0-30 30-155	Overburden Sandstone
2	24-16287	s	8	0-15 15-30 30-205	Clay and sand Sandstone Granite
3	24-15519	s	5	0-80 80-158 158-225	Brown soil and rock Sand and soil mixture Gray granite
4	24-14902	s-f	2	0-15 15-45 45-325	Brown soil mixture Brown mixture of clay Gray granite
5	24-15526	f	15	0-40 40-115 115-185	Sand and clay Broken sandstone Granite
6	24-10108	f-t	20	0-20 20-40 40-200 200-225	Overburden Sand Brown clay and gravel Limestone and clay
7	24-16422	f	4	0-80 80-265	Sand and clay Granite
8	24-04782	f	10	0-50 50-150 150-260	Yellowish brown clayey sand Yellowish brown clayey sand with limestone fragments Yellowish brown weathered limestone
9	24-15635	f-t	20	0-21 21-168 168-213 213-275	Brown soil Brown clay Brown soil and rock mixture Limestone
10	24-16931	s	25	0-140 140-200	Overburden Limestone
11	24-15375	s-f	20	0-40 40-140 140-228	Clay Broken limestone Limestone
12	24-17803	s	30	0-30 30-180 180-208	Clay Broken limestone Limestone

Well Number	NJDEP Permit Number	Accuracy of Location	Discharge Reported by Drillers (gpm)	Depth Below Land Surface (ft)	Driller's Log
13	24-08341	f-t	20	0-140 140-165 165-182 182-203	Rotten limestone and layer of clay Clay and gravel Rotten limestone Water, rotten fractured area
14	24-18332	s-f	30	0-250 250-285	Alternating layers of dirt and rock Limestone
15	24-16195	f-t	10	0-30 30-80 80-120	Overburden Rock Gravel and mud
16	24-17008	f	5	0-5 5-214	Overburden Sand and gravel
17	24-14982	s-f	20	0-65 65-145 145-197	Clay Broken limestone Limestone
18	24-15147	s	30	0-80 80-150 150-160	Clay Broken limestone Limestone
19	24-16285	s	40	0-25 25-140 140-164	Clay Broken limestone Limestone
20	24-16285	s-f	40	0-75 75-100 100-166	Clay Broken limestone Limestone
21	24-16735	s-f	150	0-90 90-160 160-225	Clay Broken limestone Limestone
22	24-09299	s	6	0-258	Yellow clay and limestone
23	24-09563	t	30	0-15 15-113 113-115	Overburden Brown clay and gravel Gravel
24	24-12338	f-t	40	0-5 5-122	Overburden Sand and gravel
25	24-15095	f	30	0-35 35-145 145-172	Clay and sand Broken limestone Limestone
26	24-17383	s	15	0-30 30-60 60-142	Gravel Broken limestone Limestone
27	24-17162	s	40	0-20 20-45 45-142	Gravel Broken limestone Limestone
28	24-16273	f	10	0-30 30-61 61-89 89-100 100-140 140-185 185-239 239-272 272-276 276-350	Overburden Sand and boulders Yellow clay Gravel Yellow clay Gray clay Yellow clay Gray decomposed limestone Limestone and water Clay
29	24-15310	s-f	60	0-35 35-130 130-185	Clay and sand Broken limestone Limestone
30	24-15952	s	35	0-180 180-264	Clay Limestone

Well Number	NJDEP Permit Number	Accuracy of Location	Discharge Reported by Drillers (gpm)	Depth Below Land Surface (ft)	Driller's Log
31	24-16168	s	70	0-25 25-55 55-85	Sand and clay Broken sandstone Granite
32	24-27831	s	20	0-80 80-125	Clay Limestone
33	24-15959	f-t	40	0-60 60-120 120-140	Sand and clay Broken sandstone Sandstone
34	24-15055	f	10	0-30 30-95 95-188	Sand and clay Sandstone Granite
35	24-17742	f	100	0-60 60-90 90-300	Sandy clay Broken limestone Limestone
36	24-16654	t	7	0-18 18-85 85-150	Overburden with hardpan and gravel Decomposed granite Brown granite
37	24-15225	f	10	0-30 30-85 85-118 118-250	Light brown loam soil Sand and gravel Brown clay Granite
38	24-16068	s-f	7	0-60 60-148	Sandy clay Granite
39	24-17589	s	40	0-77 77-200	Overburden Limestone
40	24-12171	s	12	0-72 72-148	Clay and hardpan Gray granite
41	24-17588	f	45	0-35 35-55 35-125	Sandy clay Broken sandstone Sandstone
42	24-17215	f-t	13	0-130 130-275	Sand and gravel Limestone
43	24-16836	s-f	12	0-20 20-144	Sandy clay Granite
44	24-17715	s-f	10	0-40 40-75 75-205	Sand and clay Sandstone Granite
45	24-11692	t	254	0-115	Clay, sand, and gravel
46	24-17216	s-f	30	0-100 100-139 139-140	Clay Sand and gravel Decomposed limestone
47	24-08906	s	2	0-10 10-500	Overburden Limestone
48	24-13305	s	30	0-10 10-100	Overburden Limestone
49	24-15283	s	30	0-100 100-200	Clay Broken limestone
50	24-16367	s	10	0-80 80-228	Clay Limestone
51	24-15002	s-f	50	0-125 125-130	Clay and limestone Decomposed limestone
52	24-18425	f-t	20	0-30 30-84	Clay and limestone Limestone
53	24-10472	s	20	0-50 50-280	Sandy soil Limestone
54	24-10021	s	10	0-60 60-250	Overburden Limestone

Well Number	NJDEP Permit Number	Accuracy of Location	Discharge Reported by Drillers (gpm)	Depth Below Land Surface (ft)	Driller's Log
55	24-11295	s	20	0-70 70-300	Sandy soil Limestone
56	24-14122	f	25	0-50 50-175	Sand and clay Sandstone
57	24-14184	s	40	0-100 100-225	Decomposed limestone, sand, and clay Granite
58	24-05959	f	10	0-30 30-121	Overburden Limestone
59	24-16634	s	20	0-40 40-200	Clay Limestone
60	24-15444	f	30	0-100 100-240	Clay, gravel, and boulders Limestone
61	24-13438	f-t	none reported	0-36 36 (refusal)	Yellow clay Limestone
62	24-09040	f	15	0-44 44-80	Yellow clay Limestone
63	24-08992	s	15	0-75 75-99	Clay and limestone Limestone
64	24-16033	f	15	1-125 125-270	Clay and sand Limestone
65	24-08989	s	35	0-60 60-129	Clay and limestone Limestone
66	24-09072	s	25	0-114	Yellow clay and limestone
67	24-08970	f	56	0-28 28-204	Clay Limestone
68	24-08969	f	20	0-15 15-50 50-197	Overburden Broken rock Blue-gray limestone
69	24-11270	s	30	0-80 80-150	Overburden Limestone
70	24-11269	s	30	0-90 90-125	Overburden Limestone
71	24-15414	s	12	0-33 33-82 82-98 98-114 114-175	Brown clay Sand and gravel Brown clay Brown soil and rock mixture Limestone
72	24-15712	s	30	0-10 10-92 92-135 135-160 160-192 192-200	Brown soil Brown clay Brown soil and rock mixture Brown clay Shattered limestone Blue limestone
73	24-01551	f	20	0-25 25-57	Clay and broken granite Granite
74	24-14219	f	10	0-55 55-107 107-114 114-198	Sand, gravel, and clay Gray limestone Mud seam and gravel Limestone
75	24-09189	f	15	0-250 250-258	Overburden Soft rock
76	24-15858	f	100	0-70 70-130	Clay Decomposed limestone
77	24-07635	f	18	0-130 130-310	Overburden Broken limestone
78	24-18195	s	50	0-60 60-225	Clay Limestone

Well Number	NJDEP Permit Number	Accuracy of Location	Discharge Reported by Drillers (gpm)	Depth Below Land Surface (ft)	Driller's Log
79	24-16536	s	100	0-55 55-100	Overburden Limestone
80	24-15588	s	100	0-45 45-100	Clay, sand, and gravel Limestone
81	24-15415	s	100	0-75 75-100	Sand and gravel Decomposed limestone
82	24-13398	f	100	0-30 30-360	Sand, clay, and loose rock Granite
83	24-14499	f	50	0-53 53-200	Gravel, clay, and boulders Granite
84	24-17398	s	8	0-120 120-300	Clay and sand Granite