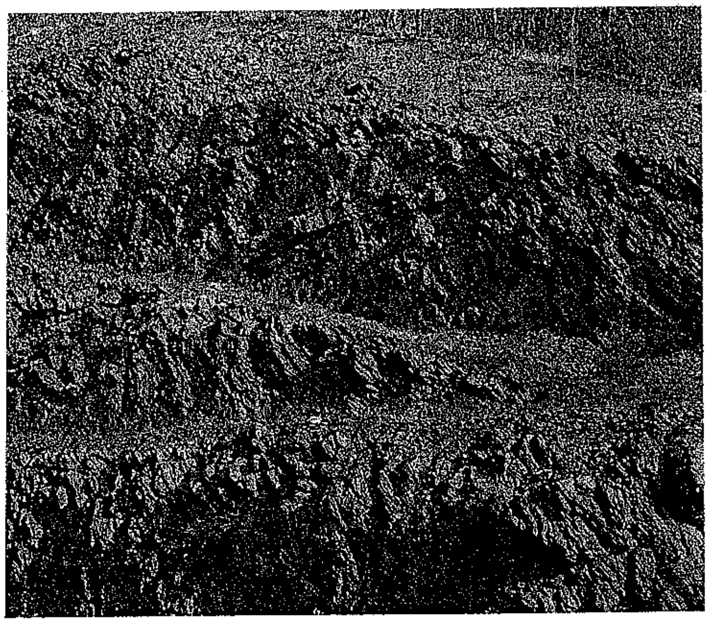
Welsh



IG: Moderately resistant; moderately weathered to moder- tural breakup in shale is hackly and chippy, and in siltstone e is flaggy, rubbly, and blocky; overlying mantle is moder-

HY: Lowland due to predominance of less resistant red stone; sandstone forms areas of low local relief.

Fair to good surface drainage; trellis to angular drainage

ND PERMEABILITY: Joint-, cleavage-, and bedding-plane vide a secondary porosity of moderate to low magnitude; sity in sandstone may be moderate; low permeability.

TER: Sandstones are best water-bearing units; may be un- conditions; near-maximum potential is 35 gal/min; water erally good; water may be high in iron.

XCAVATION: Shale and siltstone are moderately easy; difficult; moderate drilling rate.

STABILITY: Good in sandstone and siltstone; only fair in

FOUNDATION STABILITY: Good if shales and siltstones are kept water free; should be excavated to sound bedrock.

CONSTRUCTION MATERIALS: Good source of random fill; potential for flagstone, structural clay products, and lightweight aggregate.

CATTARAUGUS FORMATION (SEE VENANGO FORMATION)

CHADAKOIN FORMATION (Dch) (Chemung)

DESCRIPTION: Medium-gray shale, light-gray to brownish siltstone, fine-grained sandstone, and conglomerate; marine fossils are common; includes "pink rock" of drillers; included in Conneaut Group and "Chemung" of earlier geologists; maximum thickness is about 300 feet; type section is in brick quarries at Jamestown, New York.

BEDDING: Well developed in most places; generally less than 2 inches thick; flaggy and platy.

FRACTURING: Joints are well developed; closely spaced in shale and siltstone; most form a blocky or platy pattern; open and steeply dipping or vertical.

WEATHERING: Shale disintegrates rapidly when exposed to moisture; results in small, platy, triangular fragments; sandstone and siltstone are moderately resistant, and break up into small to medium blocks; mantle is variable in thickness; in glaciated areas of northwestern Pennsylvania, mantle is thick.

TOPOGRAPHY: Plateau of low to medium relief; bedrock topography is masked by glacial material.

DRAINAGE: Surface drainage is moderate to good; in glaciated regions, drainage is poor.

POROSITY AND PERMEABILITY: Interstitial porosity is low in coarser rocks; joint development creates a moderate total effective porosity; low permeability.

GROUNDWATER: Median yield is 4 gal/min; wells greater than 100 feet for most domestic supplies; salt water and pockets of natural gas are common; yields in Erie County range from 0.1 to 50 gal/min.

EASE OF EXCAVATION: Moderately difficult; drilling rate is moderate.

CUT-SLOPE STABILITY: Fair to good; fairly steep cuts can be maintained in sandstone; siltstone and shale disintegrate rapidly; undercutting of resistant beds can cause poor-quality slopes and result in rockfalls; drainage maintenance is required.

FOUNDATION STABILITY: Good; shale and siltstone should be kept water free; must be excavated to sound bedrock.

CONSTRUCTION MATERIALS: Fair source of brick raw material and fill.

ROCK TEST DATA:
Shale
Unconfined compressive strength = 1,465 to 4,680 lb/in^2

REMARKS: Compressive strength data from John H. Robinson Engineering Inc.

CHAMBERSBURG FORMATION (Oc)

DESCRIPTION: Dark-gray limestone at the top, gray argillaceous limestone in the middle, and dark-gray cobbly limestone at the base; occurs only southwest of the Susquehanna River; maximum thickness is about 770 feet; reference section is along spur of railroad northwest of Kauffman, eastern Franklin County.

BEDDING: Well bedded; thin to flaggy.

FRACTURING: Joints have a platy pattern; well developed; highly fractured; moderate distance between fractures; steeply dipping and open.

WEATHERING: Moderately resistant; moderately to highly weathered to a moderate depth; weathers to pencil-like, jagged fragments up to medium size, elongate plates, and blocks; overlying mantle is thin.

TOPOGRAPHY: Rolling valleys of low relief; natural slopes are gentle

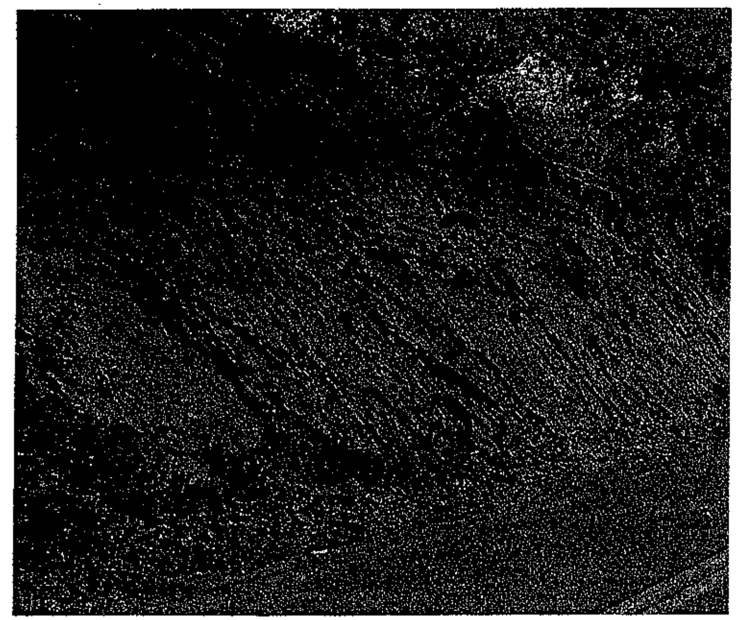
DRAINAGE: Good surface and minor subsurface drainage.

POROSITY AND PERMEABILITY: Joint and solution open
a secondary porosity of low magnitude; low permeability.

GROUNDWATER: Median yield is 5 gal/min; low median
that solution openings are not common; water can be relative

EASE OF EXCAVATION: Moderately easy; difficult at c
rock is unweathered; moderate drilling rate.

CUT-SLOPE STABILITY: Fair, due to disintegration when
moisture for a relatively short time.



FOUNDATION STABILITY: Good; should be excavated to
rial; should be investigated thoroughly for sinkholes.

CONSTRUCTION MATERIALS: Good source of road mate

CHEMUNG FORMATION (SEE CHADAKOIN TION, GIRARD SHALE, NORTHEAST SHAI LOCK HAVEN, SCHERR, AND FOREKNOBS

Lobins, Craig

From: Winschuh, Charles
Sent: Monday, February 02, 2009 9:45 AM
To: Lobins, Craig
Subject: RE: Water Supply sampling

My address is RR 1 Box 18 Springville PA 18844(Rural mail delivery address - I actually reside in Dimock Township) Home phone number is 570 -278-3365. Thank You.

-----Original Message-----
From: Lobins, Craig
Sent: Monday, February 02, 2009 9:38 AM
To: Winschuh, Charles
Cc: Bedrin, Michael; O'Donnell, Michael; Oprendek, Anthony; Kucsma, Paul; Ansell, Mark
Subject: Water Supply sampling

Mr. Winschuh -

Unfortunately the Department doesn't routinely perform this service. Last year we issued 8,000 drilling permits so you can imagine the huge expense and workload the department would have in sampling water supplies near drilling locations.

However, the gas drilling operator typically samples water supplies within 1000 feet before the gas well is drilled. This sampling is not required but 99% of the Operators do this. The Oil and Gas law presumes that a well operator is responsible for pollution of a water supply that is within 1,000 feet of the oil and/or gas well, where pollution occurred within 6 months after completion of drilling or alteration of such well. Unless the Operator can demonstrate the pollution existed prior to the drilling/alteration activity, i.e., predrill water sample.

With all that said, please send me your address & phone number and if you are located within our investigation area we will contact you to schedule a sample.

Sincerely,
Craig Lobins
Regional Oil & Gas Mgr

-----Original Message-----
From: Winschuh, Charles
Sent: Friday, January 23, 2009 8:21 AM
To: EP, Contact Us
Subject: Dimock PA gas well tests.

Dear DEP, My name is Charles Winschuh. I live in Dimock Township PA. The media has reported that DEP is testing residential water wells in my Township due to suspected problems related to natural gas drilling. A gas well drilling pad has been constructed adjacent to my property/residence. My property is not under lease with any gas company due to my concerns about environmental impact. Can DEP test my well water so that I have a benchmark test before they start drilling this well? Thank you

WEATHERING: Moderately resistant; moderately weathered to a shallow depth; small elongate and triangular fragments result from rapid hydration of minerals in exposed rock; overlying mantle is moderately thick.

TOPOGRAPHY: Rolling hills of medium relief; natural slopes are moderately steep and stable.

DRAINAGE: Good surface drainage.

POROSITY AND PERMEABILITY: Joint openings provide a secondary porosity; both weathered and unweathered rock have a low porosity; low permeability.

GROUNDWATER: Average yield is 35 gal/min; lithology is an important factor in well yield.

EASE OF EXCAVATION: Upper few feet may be excavated moderately easily; unweathered bedrock is difficult; slow to moderate drilling rate.

CUT-SLOPE STABILITY: Good.

FOUNDATION STABILITY: Good; should be excavated to sound material; may need grouting for extremely heavy loads.

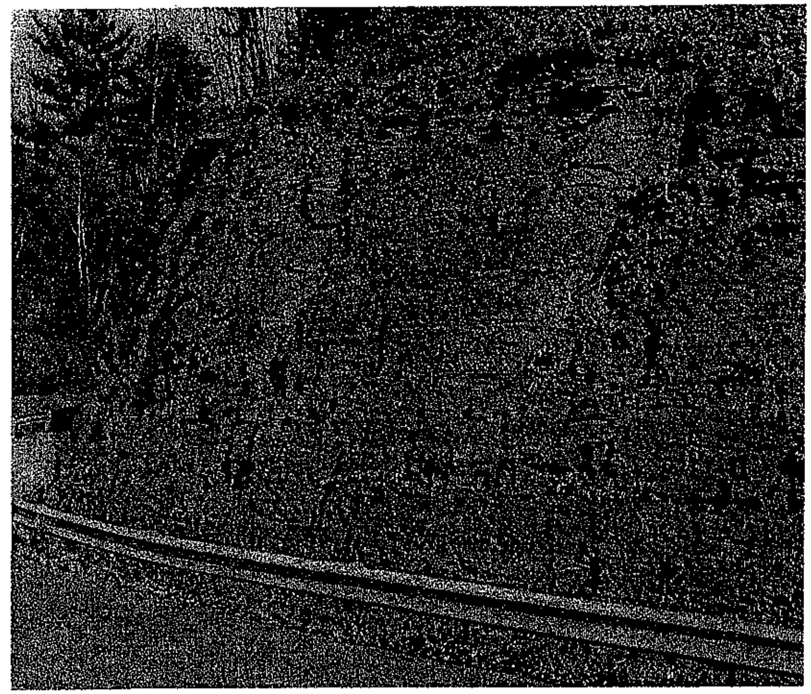
CONSTRUCTION MATERIALS: Good source of fill.

LOCK HAVEN FORMATION (Dlh)

DESCRIPTION: Interbedded light-olive-gray, very fine grained, fossiliferous sandstone, light-gray siltstone, and gray silty shale; locally hematitic; contains angular shale pebbles; a few conglomerate beds occur near top; "Chemung" of earlier workers; approximately 4,000 feet thick; reference section is along the east side of Pa. Route 44 at Torbert, Lycoming County.

BEDDING: Sandstone is thin and medium bedded; crossbedded in some places; lenticular in many places; siltstone is very thin to medium bedded; shale is thin to very thick bedded.

FRACTURING: Joints are poorly to well developed and have a moderate to wide spacing; nearly vertical; open



WEATHERING: Moderately resistant; weathered to a shallow mantle is thin to moderately thick.

TOPOGRAPHY: Forms hills and ridges of moderate relief; fairly to steep natural slopes; slopes are stable.

DRAINAGE: Good surface drainage.

POROSITY AND PERMEABILITY: Joint- and bedding-plane ope provide a secondary porosity of low magnitude; low permeability.

GROUNDWATER: Reported yields range from 2 to over 300 ga water-quality problems include brackish water and hydrogen sulfide

EASE OF EXCAVATION: Moderately difficult; highly fractured near surface is easily excavated.

CUT-SLOPE STABILITY: Fair to good; sandstone, siltstone, an glomerate have good stability; shale breaks down rapidly and ha fair stability.

rately resistant; moderately weathered to a shal-
jate and triangular fragments result from rapid
n exposed rock; overlying mantle is moderately

ıg hills of medium relief; natural slopes are
table.

face drainage.

ΛEABILITY: Joint openings provide a secondary
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Y: Good.

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ERIALS: Good source of fill.

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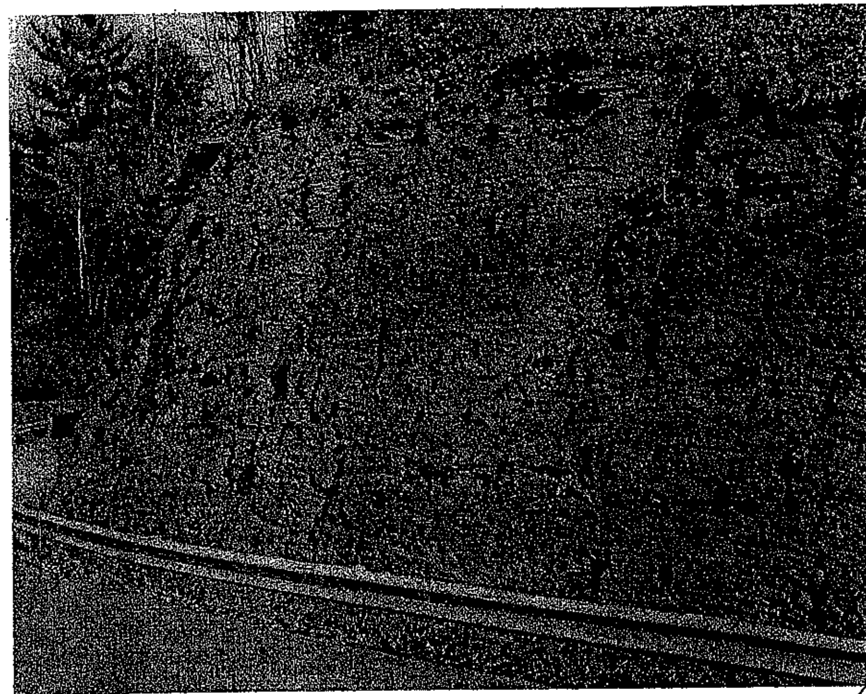


WEATHERING: Moderately resistant; weathered to a shallow depth; mantle is thin to moderately thick.

TOPOGRAPHY: Forms hills and ridges of moderate relief; fairly steep to steep natural slopes; slopes are stable.

DRAINAGE: Good surface drainage.

POROSITY AND PERMEABILITY: Joint- and bedding-plane openings provide a secondary porosity of low magnitude; low permeability.

GROUNDWATER: Reported yields range from 2 to over 300 gal/min; water-quality problems include brackish water and hydrogen sulfide.

EASE OF EXCAVATION: Moderately difficult; highly fractured shale near surface is easily excavated.

CUT-SLOPE STABILITY: Fair to good; sandstone, siltstone, and conglomerate have good stability; shale breaks down rapidly and has only fair stability.

several freshwater limestone
rclay), and several thin, non-
1 lower part; thickness varies
y to about 525 feet in Somer-
iver valley in Berlin syncline,

ss of beds varies with lithol-
veral feet; sandstone is thick
issile; limestone varies from
claystone.

ately well formed; moderate
open and vertical.

limestone are moderately re-
extensively and deeply; dis-
small plates and small, irregu-

and hills of medium relief;
ay deeper, narrower stream
sided divides; more resistant
1 relief and direction of topo-
al slopes are stable, except

y porosity of sandstone is low
through secondary porosity

ole depending on local effec-
om sandstone; mining oper-
urrence; care should be exer-
mination of groundwater sup-
producing areas; water is of

ed coal, shale, and claystone
to moderate.

slumps, and landslides; cuts in thick-bedded to massive sandstone can be nearly vertical.

FOUNDATION STABILITY: Fair to good; should be excavated to sound material; heavy structures should not be located on or near claystone because of tendency to deform under load when wet.

CONSTRUCTION MATERIALS: Good source of road material and fill; claystone may provide refractory material; sandstone provides building stone and embankment facing if not platy and thin bedded.

ROCK TEST DATA:
Upper Clarksburg shale
Unconfined compressive strength = 3,674 lb/in^2

REMARKS: Test data from USCE.

CATSKILL FORMATION (Dck)

At Surface to 250' depth at 'site' near town of Dimock

DESCRIPTION: Complex unit consisting of shale, siltstone, sandstone, and conglomerate; thickness of exposed rocks decreases to west; relative amount of red beds decreases to almost zero in northwestern Pennsylvania.

BEDDING: Well developed in most places; thicknesses range from less than 1 foot to 10 to 16 feet in coarser beds; crossbedding is common; sedimentary features are common.

FRACTURING: Well developed; closely spaced and regular in shale and siltstone; forms a blocky or platy pattern in most places; open and steeply dipping or vertical.

WEATHERING: Shale disintegrates rapidly when exposed to moisture, weathering to small, platy, triangular fragments; sandstone, siltstone, and conglomerate are moderately resistant and break up into medium and large blocks; mantle is thick in glaciated areas of northern Pennsylvania, and variable in thickness elsewhere.

TOPOGRAPHY: Plateaus of medium relief; natural slopes are stable at fairly steep angles.

POROSITY AND PERMEABILITY: Interstitial porosity is low in coarser rocks; joints create a secondary porosity of moderate magnitude; low to moderate permeability.

GROUNDWATER: Yields in excess of 300 gal/min have been reported; water quality is good to excellent.

EASE OF EXCAVATION: Difficult; relative drillability is moderate.

FOUNDATION STABILITY: Good; shale and siltstone should be kept water free; must be excavated to sound bedrock.

CUT-SLOPE STABILITY: Good; steep cuts can be maintained in sandstone and conglomerate; siltstone and shale disintegrate rapidly; undercutting of resistant coarser beds can cause poor-quality slopes and result in rockfalls; drainage maintenance is required.

CONSTRUCTION MATERIALS: Good source of flagstone and brick raw material, aggregate, roof granules, and fill.

ROCK TEST DATA:
Permeability = 0.2 ft/day in solid rock and 5.0 ft/day in weathered rock.
Red shale
- Compression (unit load at failure) = 2,203 to 2,859 lb/in^2
- Field water content = 0.8 to 1.5%
- Unit dry weight = 169.6 lb/ft^3

Red siltstone
- Compression (unit load at failure) = 5,041 lb/in^2
- Field water content = 0.8%
- Unit dry weight = 169 lb/ft^3
- Modulus of rupture = 63 lb/in^2

Gray-brown sandstone (fine-grained; few shale chips)
- Compression (unit load at failure) = 9,728 lb/in^2
- Field water content = 0.4%
- Unit dry weight = 166.5 lb/ft^3
- Modulus of rupture = 3,308 lb/in^2

REMARKS: Test data from USCE.

CATSKILL FORMATION, BEAVERDAM RUN MEMBER (Dcbr)

DESCRIPTION: Light-olive-gray, very fine to fine-grained sandstone

1.1 miles north of center of Lehighton
Route 209, Carbon County.

BEDDING: Moderately well bedded; 0.
spersed massive beds; massive and fissil

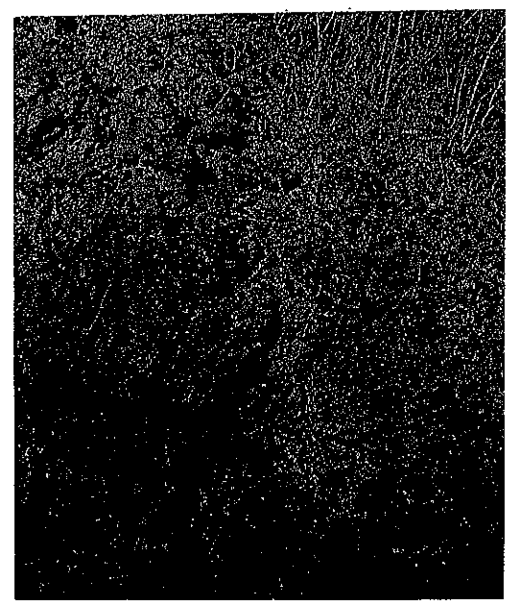
FRACTURING: Massive beds have
slabby, closely spaced fracture pattern;
oped fracture pattern, breaking along clo
fracture surfaces into shaly fragments.

WEATHERING: Moderately resistant;
ered to a shallow depth and has a soil c
ered surfaces are rough, yielding small
fragments and shaly rubble.

TOPOGRAPHY: Ridges of medium relie
steep and stable.

DRAINAGE: Good surface drainage.

POROSITY AND PERMEABILITY: Jo
openings provide a moderate secondar
erate.



Drilled Wells in Schuylkill County—Continued

Location [1]	Owner or tenant	Topographic situation	Altitude above sea level [2] (feet)	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute)	Use of water [3]	Remarks
1½ miles north of Pine Grove	Ed. Britz	Hillside	560	82	5⅝	Yellow shale	do	16	18±	15	D	
1¼ miles north of Pine Grove	Pennsylvania Power & Light Co.	do	560	260	8	Sandstone	Hamilton	------	30±	26+	do	Supplies 20 homes and drinking water at plant; see analysis 911; temperature 56° F., Sepber 2, 1931.
1½ miles east of Pine Grove	M. Clements	Hilltop	800	180	6	Gray sandstone	Portage	------	50	2	do	Sandstone overlain by shale.
½ mile southeast of Pine Grove	Nick C. Donofrio	Hillside	560	30.8	24	Black shale	do	30.8	23.6	------	N	Dug well; depth to water level measured October 21, 1931; see pl. 4 and fig. 3.
1 mile south of Pine Grove	Elias Hope	do	580	82	5⅝	do	Marcellus	12½	35	10	do	
¼ mile west of Beuchler	Paul Fiedler	do	640	75½	5⅝	Yellow shale	Portage	12¼	30	15	do	
¾ mile west of Outwood	George Boyer	Canyon	600	53	6	Hard blue sandstone	Catskill	15	50±	------	do	Depth to water level 5± feet in wet seasons, 50± feet during summer of 1930.
½ mile south of Suedberg	George Doubert	Valley	500	68½	5⅝	Sandstone	Hamilton	11	20	25	do	Small draw-down pumping 25 gallons a minute; sandstone overlain by yellow shale.

[1] If no distance is given well is located in town.
[2] Generally estimated from nearest contour line or bench mark on topographic map.
[3] C—Cooling; D—Domestic; I—Industrial; N—None; PS—Public supply.

Welsh

SUSQUEHANNA COUNTY

GENERAL FEATURES

[Area 824 square miles, population 33,806]

Susquehanna County is at the north end of the area described in this report and lies between Bradford and Wayne Counties on the New York State line. It is the second largest county in the area. The population is largely rural, as most of the villages have less than 1,000 inhabitants and Forest City, with a population in 1930 of 5,209, is the only borough in the county with 5,000 or more. In 1930 there were 3,170 farms in Susquehanna County, which is more than in any other county covered by this report. Most of them are small dairy farms scattered along the valleys and gently rounded hills, for there are very few large areas of flat land. There were only 41 manufacturing establishments in the county in 1929 whose annual products were valued at $5,000 or more each.

SURFACE FEATURES

The highest point in the county is in the southwest corner of Herrick Township, where North Knob of the Elk Hills reaches an altitude of 2,684 feet above sea level. Most of the county is high and rolling. The greater part of the county lies above 1,500 feet in altitude, and near the Wayne County line altitudes above 2,000 feet are not uncommon. The lowest part of the county is in the vicinity of Great Bend, where Susquehanna River enters New York State. The Great Bend station is 884 feet above sea level. The maximum relief is therefore about 1,800 feet. The greatest local relief occurs along streams, such as Martins Creek, which have cut through the hard sandstones of the New Milford formation. In striking contrast to this is the broad valley of Susquehanna River, flowing through the softer Chemung rocks. There are a few patches of flat land on terraces along the Susquehanna.

Susquehanna County is drained entirely by the North Branch of Susquehanna River and by its tributaries. Susquehanna River enters from New York near the northeast corner of the county and reenters New York just north of the town of Great Bend, Pa. The river does not again reenter Susquehanna County but comes within 4 miles of the southwest corner. As the county lies entirely north of the glacial border, there are numerous undrained areas occupied by lakes and swamps.

GEOLOGY AND GROUND WATER

GENERAL SECTION

Susquehanna County lies well to the north of the Wisconsin terminal moraine and, with the exception of the summit of Elk Hills, was entirely covered by ice. Deposits of glacial drift of variable thickness cover the whole county except where they have been removed by erosion.

The rock formations exposed in Susquehanna County range from the Post-Pottsville down to the Chemung. The youngest formations—the Post-Pottsvile and Pottsville formations, Mauch Chunk shale, and Pocono sandstone—are exposed only in the southeast corner of the county. The oldest rocks are exposed along the western and northern boundaries.

Generalized section for Susquehanna County

Geologic formation	Maximum thickness exposed (feet)	Character of rocks	Ground-water conditions
Glacial drift (Wisconsin)	200±	Till (boulders, clay, sand, and gravel) and outwash (clay, sand, and gravel).	Till yields small supplies of potable water to numerous dug wells. Outwash yields large supplies of very soft potable water, but not extensively utilized as source of water.
Post-Pottsville and Pottsville formations	200+	Conglomerate, sandstone, slate, and coal.	
Mauch Chunk shale	0—170	Hard gray sandstone, pebbly white sandstone, dark and reddish shale.	Unimportant as source of ground water; small area of outcrops; no wells reported.
Pocono sandstone	605±	Pebbly conglomerate, sandstone, and buff sandy shale.	
Catskill group	1,800±	Chiefly red shale and gray cross-bedded sandstone, with some conglomerate, red, green, and white sandstone, gray and olive-green shale, a few thin streaks of coal; contains fish remains.	Sandstone beds yield moderate supplies of good water. Most important water-bearer in county.
Chemung formation	380±	Olive-green, fossiliferous shale, red, green, and purple shale, and red, olive-green and green sandstone.	Yields small to moderate supplies of fair water. Deeper wells may encounter salty water.

STRUCTURE

The geologic structure of Susquehanna County is relatively simple compared to that of most of the other counties covered by this report. The major structural feature of the region is the Lackawanna syncline or coal basin, which terminates in the southeast corner of the county but whose axis turns and runs due north along the Wayne County line. To the northwest of this synclinal axis the strata dip rather steeply to the southeast, but they flatten out to a nearly horizontal plane within 4 or 5 miles. Then comes a reversal of dip toward Tunkhannock Creek, to the northwest on the axis of an anticline that continues southwestward as far as Union and Clinton Counties. This anticline dies out to the northeast in about the center of Herrick Township. The rocks in the remaining part of the county lie almost horizontal but are folded locally into minor anticlines. Several folds entering Susquehanna County from Bradford County flatten out and disappear to the east. The Wilmot anticline enters at the southwest corner of the county and extends across Auburn Township. Its southward dips are rarely more than 50 to 75 feet to the mile, so that the strata in the southern part of the county are nearly horizontal. The Towanda or Rush anticline of Bradford County crosses Rush Township and fades, and the Rome anticline of Bradford County extends through Friendsville to Hallstead.

WATER-BEARING FORMATIONS

[See pp. 41-54 for further description]

Glacial drift.—Susquehanna County was almost entirely covered by ice during the last glacial stage. The general direction of ice movement was about S.28°W., but bare rock surfaces were observed bearing striae

trending S.28°W. to S.60°W. White[98] placed the upper limit of glaciation in this region at 2,200 feet, so that the Elk Hills stood out as islands. Over the remainder of the county the highlands were planed off, many valleys were gouged out, and a great quantity of glacial drift was deposited over the rock surface. Several wells are reported with casing lengths of more than 100 feet. The glacial drift consists of both till and stratified outwash.

Glacial till yields small quantities of water to numerous dug wells, and probably supplies more wells than any other formation in the county. It is also the source of many small springs, some of which are utilized (p. 264). The stratified drift containing lenses of water-bearing sand or gravel yields larger supplies than the till.

The larger valleys as well as some of the smaller ones are filled in most places with glacial outwash deposits. Susquehanna River flows over a buried valley through most of its course within the county, and there is an abandoned channel about 1½ miles east of Great Bend and another about 1 mile east of Hickory Grove. Very few well records are available along the valley, but it was reported that the valley fill in the vicinity of Binghamton, N. Y., ranges in depth from 190 to 300 feet. Broad terraces line Susquehanna River in most places, and many conical mounds of stratified drift are found on the terraces. (See pl. 6-B.)

In a small area of the county along the Susquehanna River Valley and to a lesser extent along the smaller streams such as Tunkhannock and Martins Creeks the outwash sand and gravel of the glacial drift are potential sources of ground water. Their importance has not yet been fully realized, however, as there are very few drilled wells that end in sand or gravel, and most of the wells are cased through the glacial drift into the underlying bedrock. The drilled well of the Oakland Water Co. (well 8) is the only drilled well recorded along the Susquehanna River Valley that obtains water from the sand and gravel in the glacial drift. This well is only 22 feet deep and 4 inches in diameter. It ends with an open finish in gravel and yields 164 gallons a minute. This is by far the strongest well recorded in the county, but it is probable that with more modern methods of finishing such wells by means of screens or strainers much larger yields could be obtained. This method of developing wells is also applicable in some places where layers of fine sand would render an ordinary open-finished well unsatisfactory if not a complete failure. The use of well screens and strainers is further discussed on pp. 33-35.

Post-Pottsville, Pottsville, Mauch Chunk and Pocono formations.—The post-Pottsville, Pottsville, Mauch Chunk and Pocono formations crop out only in a small triangular area at the southeast corner of the county, and are unimportant as sources of ground water owing to their small areal extent, to the coal mining in the post-Pottsville and to the rugged, forested outcrops of the other three formations.

Catskill continental group.—With the exception of small areas in the southeastern, northern and western parts, all of Susquehanna County is underlain by rocks of the Catskill continental group. The Mount Pleasant, Elk Mountain, Cherry Ridge, Honesdale and Damascus formations crop out in the southeastern part of the county. The Honesdale and

[98] White, I. C., Geology of Susquehanna County and Wayne County: Pennsylvania Geol. Survey, 2d ser., Rep. G5, p. 25, 1881.

Damascus also crop out at Montrose, and by far the larger part of the county is underlain by the New Milford formation.

The Catskill group contains numerous beds of water-bearing sandstone and sandy shale, which can be reached by drilled wells of moderate depth. The water generally occurs in fractures and bedding planes. (See pl. 5-A.) Nearly all the drilled wells in Susquehanna County obtain water from sandstones and to a lesser extent from shales of the Catskill, and most of these wells are in the New Milford formation. Moderate supplies are usually obtained from the Catskill at depths ranging from 50 to 100 feet, but many of the industrial wells obtain somewhat larger supplies at depths of from 200 to 500 feet. The water obtained from the Catskill is generally entirely satisfactory for most purposes.

Chemung formation.—In Susquehanna County only about the upper 380 feet of the marine Chemung formation is exposed, and the outcrops are limited to small areas along the northern and western parts of the county. A few drilled wells obtain adequate supplies of water from the sandstones and shales of this formation. The water is generally of less desirable quality than that from the overlying formation, and deep wells are likely to encounter salt water. (See well 4.)

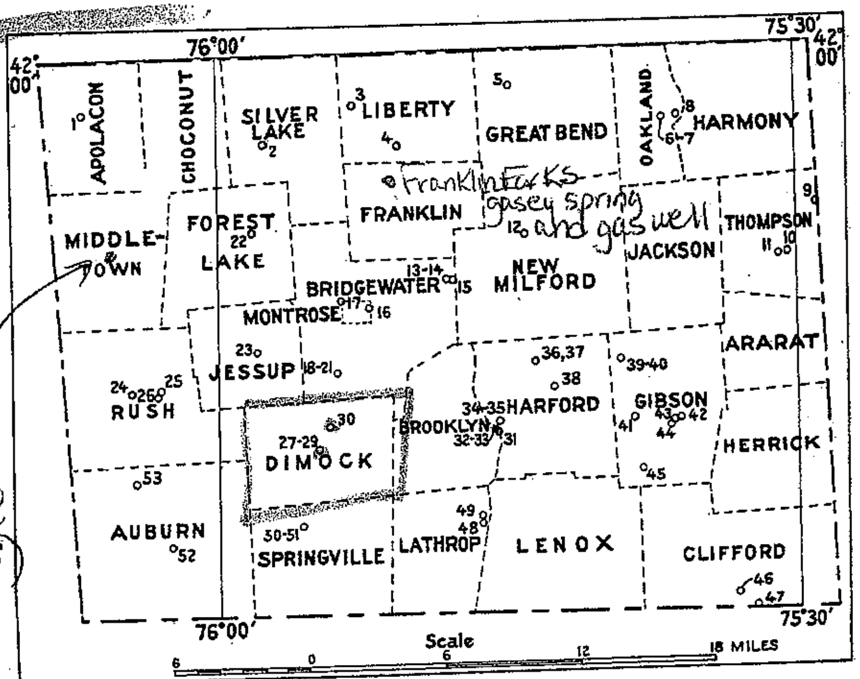


Figure 16. Map of Susquehanna County showing location of water wells.

ARTESIAN CONDITIONS

The structure of the rocks in Susquehanna County is relatively simple, but artesian pressure sufficient to cause the water to rise some distance above the level where water was first encountered is found in many of the bedrock wells. The well of the Gibson Dairy Association (well 40)

is the only one recorded in the county in which the artesian pressure is sufficient to cause the well to flow. It is possible that flowing wells might be obtained along the southeastern slope of Lackawanna Mountain above Forest City, as the structure there is very similar to that farther south, in Lackawanna and Luzerne Counties, where numerous flowing wells have been drilled.

QUALITY OF WATER

Fourteen samples of water were collected in Susquehanna County, the analyses of which are tabulated on page 272. The water collected from 11 wells and springs in the hard-rock formations contained an average of 130 parts per million of total dissolved solids and had an average hardness of 96 parts per million. The three samples of water collected from wells and springs in the glacial drift contained an average of only 62 parts per million of total dissolved solids and had an average hardness of 38 parts per million. Only one sample contained an excess of iron. (See analysis 22.)

A well in Lawsville Center (well 4) obtains very salty water from the Chemung formation. The water is used for washing milk cans but it is too salty for drinking.

A spring on the bank of a small stream about 1 mile west of Franklin Forks yields about 10 gallons a minute from thin-bedded sandstone in the Chemung formation. The water is very salty and deposits iron at the overflow. Bubbles of inflammable gas rise to the surface and can be ignited with a match, and a gas well about 200 feet from the spring supplies a farm house with gas for cooking. It seems probable that the gas is methane (CH_4), as this gas is known to come from gas wells in the Chemung formation in several of the counties in the north-central part of Pennsylvania. Near the center of Middleton Township a test hole for oil was drilled to a depth of 680 feet[60]. No oil was obtained, but gas and salt water were found in the Chemung formation at a depth of 300 feet. A nearby well 300 feet deep supplied brine for the manufacture of salt. The old county reports mention salt springs in Apolacon, Auburn and Franklin Townships that were used by early settlers as sources of salt.

Except for these occurrences of salt water in beds of the Chemung formation, the ground waters of Susquehanna County are entirely satisfactory for most purposes.

PUBLIC SUPPLIES

The subjoined table shows that there are only six public supplies in Susquehanna County using ground water. Forest City, Montrose, Susquehanna Depot, and Great Bend are all supplied by surface water, and in the remaining villages the inhabitants are supplied by individual springs and wells. Thus although more places use ground water than surface water, the largest boroughs, Forest City and Montrose, are supplied by surface water, and therefore the consumption of surface water far exceeds that of ground water. All the boroughs using ground water obtain their supplies from one or more springs, and four of the six have one or more auxiliary wells for use during exceptionally dry seasons. Chlorination is required only at two of the ground-water public supplies.

[60] White, I. C., op. cit., p. 20.

Some of the public supplies from springs are unreliable during prolonged dry seasons. New Milford uses some surface water when the springs get low, but most of the villages resort to auxiliary wells. It is probable that future demands will be best met by drilling additional wells.

INDUSTRIAL SUPPLIES

The largest industrial users of ground water in Susquehanna County are the creameries that are scattered all over the county. Most of the creameries obtain water from drilled wells, but a few of them are supplied by springs. The water is used for washing milk cans and bottles, for boiler use, and at some plants for cooling.

DOMESTIC SUPPLIES

Most of the domestic water supplies in Susquehanna County utilize dug wells, which obtain small quantities of water from the glacial drift. Some of these wells are reported to go dry during the summer. Although there are at present relatively few drilled wells in the county, they are becoming increasingly popular because they are less subject to contamination and are more reliable during dry seasons. Numerous small springs are utilized for domestic supply.

Well 51, on a hillside in Springville, is dug about 4 feet deep into glacial drift and provided with an overflow pipe about 3 feet below the surface of the ground. The overflow on July 14, 1930, just after a heavy rain, measured 9.1 gallons a minute. On July 22d, after a brief dry spell, the overflow was remeasured and found to be only 3.17 gallons a minute. This shows that in a region of shallow water-table, the water level may rise appreciably very shortly after a heavy rain.

SPRINGS

There are many small springs in Susquehanna County, some of which are provided with overflow pipes so that their yield could be measured by means of a 1-gallon measure and a stop watch, but most of them have no such improvements, and the yield could only be estimated. Although most springs are reported to have constant yields the year around, actual flow measurements show that they fluctuate considerably and usually decrease during the dry summer.

The Half Way Spring House, about half a mile north of Hopbottom, has three springs that are used to supply passing motorists with drinking water. The water in all three of these springs appears to come from bedding planes in Catskill sandstone and on July 10, 1930, they flowed 3.8, 4.4, and 2.4 gallons a minute respectively. The spring yielding 2.4 gallons a minute was remeasured on July 21, 1930, and the flow had decreased to 1.3 gallons a minute. (See analysis 1217.)

The Spencer Spring, owned by the Thompson Borough Water Co., probably obtains its water from the glacial drift. On July 9, 1930, the spring flowed 9.3 gallons a minute and when measured again on July 21, 1930, the flow had decreased to 7.6 gallons a minute. (See analysis 1215.)

Public water supplies in Susquehanna County derived from ground water

Borough and Owner	Population 1930 [1]	Source	Geologic source	Storage (gallons)	Average daily consumption	Treatment	Remarks
Brooklyn Mr. Rayknap	----------	6 or 8 springs and 1 dug well (auxiliary)	Glacial drift	22,000±	----------	None	Dug well 18 feet deep, 6 feet to water.
Hopbottom Hopbottom Water Co.	354	7 springs and 1 drilled well (auxiliary)	Springs, glacial drift; well, Catskill	200,000±	63	Chlorine gas (well)	Supply decreasing from year to year. See well 49.
Kingsley A. J. Masters	----------	1 spring	Catskill	900	24 consumers	None	See analysis 1216. Decreases in summer but gives adequate supply.
New Milford New Milford Water Co.	782	11 springs	----------	248,000±	36,000± gallons	Chlorine gas	Used by 50 percent of inhabitants. In dry seasons springs get low. Some surface water used.
Oakland Oakland Water Co.	1,040	15 springs and 3 drilled wells (auxiliary)	Springs and 1 well, glacial drift; 2 wells Chemung	33,850	242 consumers	None	About 2 percent used for manufacturing. See wells 6 to 8; analysis 8.
Thompson Thompson Borough Water Co.	321	3 springs (1 auxiliary) and 1 drilled well (auxiliary)	Springs, glacial drift; well Catskill	53,000	----------	do	Serves 90 percent of inhabitants. See analysis 1215, also well 11.

[1] Figures available only for incorporated places.

Drilled wells in Susquehanna County—Continued

No.	Location [1]	Owner or tenant	Topographic situation	Altitude above sea level (feet) [2]	Depth (feet)	Diameter (inches)	Character of water-bearing material	Geologic horizon	Depth of casing (feet)	Depth to water level (feet)	Yield (gallons a minute).	Use of water [3]	Remarks
21	South Montrose	A. L. Lake	Upland		20		Drift	Glacial drift		4		D	Adequate supply.
	Forest Lake Twp.												
22	½ mile north of Forest Lake	Rosedale Dairy Co.	Edge of valley		90±	4		Catskill				I	Adequate supply; see analysis 22.
	Jessup Twp.												
23	Fairdale	Woodlawn Farm Dairy	do		157	8	Sandstone(?)	do		26	large	do	Somewhat low in summer.
	Rush Twp.												
24	¾ mile northeast of Lawton		do		24±		Drift	Glacial drift				D	Low in summer.
25	Rush	Mr. VanDyke	do		70			Chemung				do	Adequate supply.
26	⅜ mile southwest of Rush	H. J. Light	Hillside		166	6		do		50-60		do	Do
	Dimock Twp.												
27	Dimock	Mr. Norris			452	6		Catskill		180±		do	
28	do	Creamery			385	8		do	20±	70		I	
29	do				579	8		Chemung(?)	20±	70		do	
30	2½ miles south of South Montrose	P. Ballyntine	Near hilltop		598	8		do			40±	I&D	Pump at 200-foot depth; also uses two other drilled wells and several springs; see analysis 30; temperature 52° F., July 22, 1930.
	Brooklyn Twp.												
31	Kingsley	P. Wilmarth	Steep hill side		198	6	Blue-gray sandstone	Catskill	1-2(?)		10	I	Small draw-down pumping 25 gallons a minute; first water at 100 feet; 90 feet of 4-inch pump pipe; see analysis 31; temperature 50° F., July 21, 1930.
32	do	Delaware Lackawanna & Western R. R.	Hillside		450	12	Red and green sandstone	do		58½	34	R	Small draw-down pumping 34 gallons a minute for 9 hours; see log. Well was later deepened to 668 feet without appreciable change.
33	do	do	do		500	12	do	Chemung			50	N	Abandoned because the water causes foaming in boilers; see log; later deepened to 627 feet without change.
	Harford Twp.												
34	Kingsley	do	do		318	10	do	Catskill	150	60±		R	Used only as auxiliary to surface supply.
35	do	Mary Engate	do		90	6	Blue-gray sandstone	do	14	40		D	Adequate supply; drift 14 feet, red shale 14 feet; blue-gray sandstone 62 feet.
36	Near Tingley Lake	A. J. Masters	Lakeside		50	6		do		5	Very small	do	Large draw-down; water reported to be cloudy.
37	do	A. W. Crossman	do		265			do		5		do	
38	Harford	Rosedale Dairy Co.	Hillside		175	6		do		5	13	I	Can be pumped dry at 13 gallons a minute; see analysis 38; temperature 50° F., July 21, 1930.
	Gibson Twp.												
39	Gibson	F. W. Barret			25			do		20±		D	Dug well.
40	do	Gibson Dairy Association	Valley		120	6		do	30	Flows	30	I	Flowed 1.1 gallons a minute; water level 18 inches above surface, July 15, 1930; draw-down 20± feet pumping 30 gallons a minute all day; temperature 51° F.
41	Union Hill (?)				420	6		do	20	70		D	

Log of Delaware, Lackawanna & Western Railroad Co.'s wells at Kingsley

Well 32	Feet	Well 33	Feet
Glacial drift (?)	0- 22	Glacial drift	0 - 13.5
Broken sandstone	22- 37	Red shale	13.5- 17.5
Green sandstone	37-112	Green sandstone	17.5-106
Red sandstone	112-144	Gray sandstone	106 -128
Red shale	144-146	Red sandstone	128 -150
Green sandstone	146-256	Green sandstone	150 -258
Red sandstone	256-300	Red sandstone	258 -298
Green sandstone	300-336	Green sandstone	298 -343
Red sandstone	336-358	Red sandstone	343 -366
Green sandstone	358-372	Green sandstone	366 -373
Red sandstone	372-383	Red sandstone	373 -386
Green sandstone	383-450	Green sandstone	386 -435
		Gray sandstone	435 -500

Analyses of waters in Susquehanna County

[Analyst, K. T. Williams. Parts per million. Numbers less than 1200 correspond to numbers on map and in the table of well data]

	5	8	15	16	18	22	[illegible]
Silica (SiO_2)	22	10	--	--	--	13	--
Iron (Fe)	.10	.04	--	--	--	3.71	--
Calcium (Ca)	38	10	12 [1]	18 [1]	26	26	28
Magnesium (Mg)	7.5	2.7	--	--	8.0	9.2	8.8
Sodium (Na)	9.6	3.1	8 [2]	15 [2]	6 [2]	13	9 [2]
Potassium (K)	.8	.4				1.8	
Carbonate (CO_3)	0	0	0	7.9	0	0	4.9
Bicarbonate (HCO_3)	159	28	55	126	102	116	127
Sulphate (SO_4)	4.8	14	9 [1]	8 [1]	12 [1]	24	4 [1]
Chloride (Cl)	5.0	1.9	8.0	8.0	4.0	8.0	4.0
Nitrate (NO_3)	.10	.90	2.2	4.2	4.2	1.5	8.3
Total dissolved solids	162	57	74 [2]	148 [2]	119 [2]	151	131 [2]
Total hardness as $CaCO_3$ (calculated)	126	86	50 [3]	106 [3]	98	103	106
Date of collection (1930)	July 21	July 21	July 22	July 22	July 22	July 22	July 22

	31	38	51	52	1215 [4]	1216 [4]	1217 [4]
Silica (SiO_2)	--	--	--	--	--	--	--
Iron (Fe)	--	--	--	--	--	--	--
Calcium (Ca)	20 [1]	35	16 [1]	50	12 [1]	16 [1]	20 [1]
Magnesium (Mg)	--	8.6	--	12	--	--	--
Sodium and Potassium (Na and K)	23 [2]	7 [2]	11 [2]	15 [2]	4 [2]	11 [2]	7 [2]
Carbonate (CO_3)	5.9	0	0	8.9	0	8.9	0
Bicarbonate (HCO_3)	110	153	55	218	26	42	29
Sulphate (SO_4)	26 [1]	10 [1]	24 [1]	12 [1]	10 [1]	14 [1]	28 [1]
Chloride (Cl)	6.0	1.0	1.0	1.0	1.0	1.0	2.0
Nitrate (NO_3)	.10	.60	4.3	.10	4.2	1.5	2.4
Total dissolved solids	148 [2]	144 [2]	87 [2]	215 [2]	43 [2]	73 [2]	70 [2]
Total hardness as $CaCO_3$ (calculated)	86 [3]	123	51 [3]	174	28 [3]	42 [3]	42 [3]
Date of collection (1930)	July 21	July 21	July 22	July 22	July 21	July 21	July 21

[1] By turbidity. [2] Calculated. [3] Determined.
[4] 1215. Spring in Thompson; glacial drift; temperature 50°F. 1216. Spring in Kingsley; sandstone of Catskill group; temperature 50°F. 1217. Spring at Halfway Spring House, ½ mile north of Hopbottom; Catskill group; temperature 49°F.

WAYNE COUNTY

GENERAL FEATURES

[Area 739 square miles, population 28,420]

Wayne County occupies the extreme northeast corner of the State and of the area covered by this report and is bounded on the north and east by New York State. The population is largely rural, as the entire county is covered with small farms, and there are only two communities with 1,000 or more inhabitants—Honesdale, 5,490, and Hawley, 1,811. Wayne County had 2,908 farms in 1930, and in 1929 there were only 65 manufacturing establishments in the county whose annual products were valued at $5,000 or more each. Numerous summer resorts have been built along Delaware River and around the glacial lakes, and Wayne County has become a popular playground for people from New York and New Jersey.

SURFACE FEATURES

The highest part of Wayne County is a narrow strip along the Susquehanna and Lackawanna County lines, where the Moosic Mountains, formed by Pottsville sandstone, rise in several places to altitudes of more than 2,300 feet. Mount Ararat, the second highest peak in northeastern Pennsylvania, is 2,654 feet and Sugarloaf Mountain is 2,541 feet above sea level. Both of the peaks are in the southwest corner of Preston Township. The Moosic Mountain divide continues northward at an altitude of about 2,000 feet. The remainder of the county slopes gently eastward and southeastward toward Delaware River in the northern part and toward Lackawaxen River in the southern part. The lowest point in the county is where Delaware River crosses the Pike County line, at an altitude of about 600 feet. The maximum relief is therefore about 2,050 feet. Locally the greatest relief is found along the deeply incised valleys of Delaware River and its tributaries, which in many places are more than 500 feet deep.

With the exception of small areas along the northern part of the western border, Wayne County is drained entirely by Delaware River, which flows along its eastern border. Lackawaxen River, a tributary of the Delaware, drains the southern part of the county through Pike County, and the northern part drains directly into the Delaware by a number of small streams. Parts of Scott and Preston Townships are drained by Starrucca Creek, a tributary of the North Branch of Susquehanna River; and parts of Preston, Mount Pleasant, Clinton, and Canaan Townships are drained by the Lackawanna. In flowing a distance of 37 miles from Hancock, N. Y. to Milanville, Pa., Delaware River drops 200 feet—a gradient of about 5.4 feet to the mile.

GEOLOGY AND GROUND WATER

GENERAL SECTION

With the exception of the summits of Sugarloaf Mountains and Mount Ararat, Wayne County, was entirely covered by ice during the last glacial stage. Deposits of glacial drift are found all along the streams, cover much of the highlands, and remain on many of the hill slopes

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SURFICIAL GEOLOGY OF THE SPRINGVILLE 7.5-MINUTE QUADRANGLE SUSQUEHANNA AND WYOMING COUNTIES, PENNSYLVANIA

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PENNSYLVANIA GEOLOGICAL SURVEY
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SURFICIAL GEOLOGY OF THE SPRINGVILLE 7.5-MINUTE QUADRANGLE

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EXPLANATION OF MAP UNITS

L **LAKE**

d **SANDSTONE QUARRY DUMP**
Piles of broken sandstone (bluestone) dimension stone blocks tens of feet thick.

Rp **BEDROCK PIT OR QUARRY**
Excavation tens of feet deep in bedrock; provides aggregate for construction purposes.

Qa **ALLUVIUM:**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; usually underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) thick in headward tributary valleys, somewhat thicker in larger valleys.

Qat **ALLUVIAL TERRACE**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; the deposits form benches running parallel to and a few feet above the present floodplain; usually underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) thick in head ward tributary valleys, somewhat thicker in larger valleys.

Qaf **ALLUVIAL FAN:**
Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; having a fan shaped landform; usually underlain by other unconsolidated material glacial deposits 6 feet (2 meters) or more thick.

Qp **PEAT:**
Wetland underlain by peat, thickness variable, usually less than 6 feet (2 meters) thick in localized upland sites and up to 30 feet (10 meters) thick in valley floor settings; usually underlain by other unconsolidated material (glacial deposits).

Qw **WETLAND:**
Area with standing water for part of each year; usually underlain by peat, clay, silt, sand, or some combination of those materials beneath which is other unconsolidated material (glacial deposits); thickness of peat usually less than 1.5 feet (0.5 meter),

overall thickness of unconsolidated material is usually greater than 6 feet (2 meters).

Qwic **WISCONSINAN ICE-CONTACT STRATIFIED DRIFT:**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with a few closed depressions; typically deposited in valley side kames; generally not more than 30 feet (10 meters) thick.

Qwt **WISCONSINAN TILL:**
Stratified sand and gravel with some boulders; often chaotic stratification; some internal slump structures; gently sloping upper surfaces with a few closed depressions; typically deposited in valley side kames; generally not more than 30 feet (10 meters) thick.

R **SANDSTONE AND SHALE BEDROCK:**
Bedrock outcrops or clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and gray sandstone, and shale; reddish brown to yellowish brown, clayey silt to sandy silt matrix; clasts are typically matrix-supported with lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a down slope directed orientation within the upper 1.5 feet (0.5 meters) of the material; less than 6 feet (2 meters) to bedrock; on greater than 25 percent slopes, typically less than 3 feet (1 meter) thick.

BEDROCK LEDGE OUTCROP

2 **STRIATION:**
Site number is above the arrow. Location and orientation are given in Table 2. Point of the head of the arrow marks the location of the striation site.

ISOCHORES AT 30, 100, AND 150 FEET:
An isochore is the thickness of a deposit measured in a vertical borehole or in an excavation with a vertical face. The isochores drawn on the map sometimes pass from one surficial deposit to another, like from till to ice-contact-stratified-drift. That indicates that a 30 foot thickness of till is next to a 30 foot thickness of ice-contact-stratified-drift.

DISCUSSION

Mapping Technique - Surface Distribution of Deposits

The 1:24,000-scale detailed reconnaissance surficial geology map (map of unconsolidated materials overlying consolidated bedrock) of the Springville quadrangle was produced in four phases. In the first phase, a preliminary surficial deposit map was made by Duane Braun using existing soil mapping (Eckenrode, 1982; Reber, 1973), bedrock mapping (White, 1881, 1883), and landform analysis from the 1:24,000-scale topographic map and aerial photographs. In the second phase, the preliminary surficial deposit map was verified and/or corrected during ten to twenty person-days of field-work by Elaine Gustis (geologist assistant) and Duane Braun (surficial geologist). In the third phase, the field verified/corrected preliminary surficial geology map was finalized, drafted onto three mylar overlays, and had the text added by Duane Braun. In the fourth phase, the map was digitized and produced in three digital files, the contacts, the isochores, and the outcrops by Jerry Mitchell (GIS consultant). Further digital work, editing, enhancements, and final digital production were done by Bureau of Topographic and Geologic Survey personnel.

The distribution and type of units on the preliminary surficial geology map is primarily a combined parent material and topographic position classification of the soil survey map units. The classification of all soil series by surficial deposit map unit is given in Table 1. Many soil series are common to more than one surficial deposit type. The landform of a specific area is used to decide which surficial deposit type the soil series is most likely related to at that site on the preliminary surficial geology map. The soil series boundaries are manually transferred from the 1:20,000-scale soil survey maps to the 1:24,000-scale topographic map. Positions of the boundary lines are estimated by eye using natural and human features that are identifiable on both the soil survey aerial photographs and the topographic map. Expectable line location error is on the order of 50 to 100 feet on the ground where there are distinct features to tie the boundaries to. Where boundaries go across extensive featureless areas of forest, line placement error is in the range of 100 to as much as 200 feet on the ground. During the field verification and correction phase many contacts are moved to reflect conditions directly observed in the field.

Mapping Technique - Thickness of Deposits

The thickness of surficial deposits is divided into four thickness categories: less than 6 feet (2 meters) overlying the bedrock [the contact of the bedrock (R) unit with all other surficial units], 30 feet (10 meters), 100 feet (30 meters), and 150 feet (50 meters). The 30, 100, and 150 feet thickness contours are drawn to be a conservative estimate of thickness (at least that thickness present). The thicknesses are determined from sparse water well data and outcrops of the surficial deposits. In most areas the thickness is interpreted on the basis of soil-landform associations and a reconstruction of the preglacial drainage. This reconstruction indicates that most stream valleys have segments partly to entirely filled with glacial deposits. In a few places streams have a deranged pattern where the streams turn abruptly and enter or exit valley segments that are markedly narrower or wider than adjacent segments. These changes are the result of burial of parts of the original dendritic drainage pattern (Braun, 1997).

Quaternary History

During the Quaternary, the Springville 7.5-minute quadrangle area has been affected by a climate that alternated between cold, glacial-periglacial conditions and warm, humid temperate interglacial conditions. About ten such alternations have affected northeastern Pennsylvania during the last one million years (Braun, 1989, 1994). There is evidence for at least three different glacial advances across the Springville area in that there are three glacial limits of distinctly different age to the southwest of the area (Braun, 1994). The farthest to the southwest and oldest glacial limit is considered to be of pre-Illinoian-G age (850 Ka) or older. The next distinct glacial limit is considered to be of either late Illinoian (150 Ka) or pre-Illinoian-B (450 Ka) age and is only about 10 miles (15 km) beyond the most recent, late Wisconsinan (20 Ka) aged glacial limit. Other glacial advances have approached the area and caused severe periglacial activity (Braun, 1989, 1994).

The earlier glacial advances across the Springville area should have accomplished some erosional work. The trend of the glacial limits and glacial striations of the older glaciations is similar to that of the late Wisconsinan glacier (Braun, 1994). This indicates that the older glaciers moved across the region in about the same direction as the late Wisconsinan ice and the older glaciers should have eroded and deposited in a pattern generally like that of the late Wisconsinan. Preglacial valleys oriented parallel to ice flow would tend to be significantly scoured and partly back filled in each glaciation. Valleys oriented perpendicular to ice flow would have the least scour and be the most back-filled, sometimes becoming completely buried (Braun, 1997). The late Wisconsinan glacier advanced and retreated across the region in a general S20°W to S30°W direction (Braun, 1997). Within the quadrangle, a single glacial striation site indicates that ice flow was towards S32°W (Table 2).

Only late Wisconsin-aged deposits and landforms have been observed in the Springville quadrangle. Most of the material was deposited in the quadrangle over a few decades to centuries of ice recession (probably centered around 17 - 18 Ka for this quadrangle). The last glacial advance and retreat was quite effective in removing older glacial deposits from the landscape. The Wisconsinan till deposits are dominated by fresh clasts of the local bedrock indicating considerable erosion of the bedrock during the last glaciation.

On the Springville quadrangle the overall pattern of deposits is one of bedrock knobs separated by valleys partly filled with 30 to more than 150 feet of glacial till (as delineated by the thickness contours on the map). The original dendritic drainage pattern has been little modified by glacial erosion but has been markedly modified by glacial deposition. Masses of till, often in excess of 100 feet in thickness, form knobs that partly to entirely block individual valleys. Coates and King (1973) and Coates (1981) described such knobs in New York State adjacent to Pennsylvania and noted from well data and limited surface exposures that the knobs are composed of till. In the map area a few outcrops also showed the knobs to be composed of till. A series of such knobs form "beaded valleys" that have a series of narrower and wider segments. Today the wider segments are often wetlands or human dammed lakes. The best examples of such "beaded" valleys are the Thomas Creek valley near the village of Springville and several unnamed tributaries on the west side of White Creek on the northwestern part of the map. That northwestern area also has an exceptionally large area of greater than 30 feet of till cover that produces a map pattern of isolated bedrock knobs surrounded by a "sea" of glacial till. During and immediately after deglaciation there were short-lived proglacial and paraglacial (immediately post-glacial) lakes in essentially all such wide spots dammed by glacial till. There are still two small till dammed lakes (with low human made dams raising their levels slightly), Lake Crystella on the north-central part of the map and Thomas Pond near the village of Springville. Most such till dams were breached by water flow in only tens of years to at most a few thousand years until only wetlands remained. Up to the present time beavers have repeatedly re-dammed such sites.

The southwest moving glacier also deposited thick till "shadows" (Coates, 1966) on many of the south and southwest facing sides of valleys that trend transverse to the glacial flow. Often the till shadows make such valleys distinctly asymmetric with a gentler till mantled north side (south facing side) and a steeper exposed bedrock south side (north facing side). On the Springville map the main streams drain southwesterly and only the smallest tributary valleys are transverse to ice flow. So the till shadow effect is minimal in the Springville area.

As the glacier continued its recession north of Pennsylvania, cold periglacial climate conditions prevailed in the area for several thousand years. At that time exposed sandstone ledges were frost shattered and the blocks transported downslope by various processes collectively known as gelifluction (Coates and King, 1973; Coates, 1981; Braun, 1997). The glacial till deposits themselves have been "mobilized" on the slopes by gelifluction. On the upper to middle parts of the slopes, the upper 1.5 to 3 feet (0.5 to 1 meter) of material is a till-derived colluvium material. That material often shows a well developed downslope fabric (tabular clasts near parallel to the surface slope). On the lower parts of the hillslopes the till derived colluvium often reaches a 3 to 6 feet (1 - 2 meters) thickness (Braun, 1994).

In the latest Pleistocene, after 13,000 BP (Dalton and others, 1997) and throughout the Holocene, vegetation became well established and organic matter started accumulating in wetlands and lakes in the region. All the lakes and wetlands in the region are the result of glaciation. Larger wetlands and all the natural lakes are dammed on one or two sides by glacial deposits, a situation noted by Cameron (1970) and confirmed locally in the Springville area. A few of the smaller wetlands on top of Moosic Mountain are entirely scoured out of bedrock. In the larger wetlands, peat thickness often approaches 30 feet (10 meters) (Edgerton, 1969).

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Description of Map Units

Sandstone Quarry Dump

Piles of broken sandstone (bluestone) dimension stone blocks, tens of feet thick.

Bedrock Pit or Quarry

Excavation tens of feet deep in bedrock; provides aggregate for construction purposes

Lake

Alluvium

Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; usually underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) thick in headward tributary valleys, somewhat thicker in larger valleys.

Alluvial Terrace

Stratified silt, sand, and gravel, with some boulders; subrounded to rounded clasts; contains localized lenses of silty or sandy clay; the deposits form benches running parallel to and a few feet above the present floodplain; usually underlain by other unconsolidated material (glacial deposits); 6 feet (2 meters) thick in headward tributary valleys, somewhat thicker in larger valleys

Alluvial Fan

Stratified silt, sand, and gravel, with some boulders, subrounded to rounded clasts; having a fan shaped landform; usually underlain by other unconsolidated material glacial deposits 6 feet (2 meters) or more thick

Wetland

Area with standing water for part of each year; usually underlain by peat, clay, silt, sand, or some combination of those materials beneath which is other unconsolidated material (glacial deposits); thickness of peat usually less than 1.5 feet (0.5 meter), overall thickness of unconsolidated material is usually greater than 6 feet (2 meters).

Peat

Wetland underlain by peat, thickness variable, usually less than 6 feet (2 meters) thick in localized upland sites and up to 30 feet (10 meters) thick in valley floor settings; usually underlain by other unconsolidated material (glacial deposits).

Wisconsinan Ice-Contact Stratified Drift

Stratified sand and gravel with some boulders; often chaotic stratification, some internal slump structures; gently sloping upper surfaces with a few closed depressions; typically deposited in valley side kames; generally not more than 30 feet (10 meters) thick.

Wisconsinan Till

Glacial or resedimented till, texturally a diamict with a clayey, silty, or sandy matrix depending on the local source bedrock; poor to multimodal sorting; unstratified to crudely stratified with a clast fabric; striated cobble and boulder clasts are common; rare clasts are far traveled crystalline erratics; typically occurs as a fairly smooth landform with a bouldery surface and little distinct constructional (knob and kettle) topography on hillslopes; upper 3 feet (1 meter) is often colluviated, displaying a downslope-oriented fabric; thickness is greater than 6 feet (2 meters), is typically 15 feet (5 meters), and can be greater than 200 feet (60 meters) in buried to partly infilled valleys

Sandstone and Shale Bedrock

Bedrock outcrops or clast-rich diamict of residual and colluvial material derived from the directly underlying bedrock of interbedded red and grey sandstone, and shale; reddish brown to yellowish brown, clayey silt to sandy silt matrix; clasts are typically matrix-supported with lenses of clast-supported material with or without matrix; tabular clasts generally exhibit a down slope directed orientation within the upper 1.5 feet (0.5 meter) of the material; less than 6 feet (2 meters) to bedrock; on greater than 25 percent slopes, typically less than 3 feet (1 meter) thick.

Symbols

Contours of Total Thickness of Surficial Deposits in Feet
Hachure lines sometimes pass over more than one surficial deposit, indicating total thickness of all of deposits encountered

Striations
Site number above arrow. Location and striation orientation in Table 2, listed by site number. Arrow point marks site location

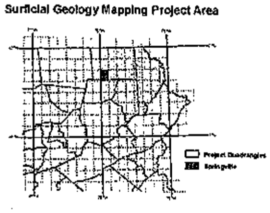
Bedrock Outcrop Ledge

Surficial Geology of the Springville 7.5-minute Quadrangle Susquehanna and Wyoming Counties, Pennsylvania

Geologic Mapping by
Duane D. Braun, Bloomsburg University, 2002

Digital Map Production by
Theodore J. Conley, Student Intern, and
Thomas G. Whitfield, Bureau of Topographic and Geologic Survey, 2006

Surficial Geology Mapping Project Area



Commonwealth of Pennsylvania
Department of Conservation and Natural Resources
Bureau of Topographic and Geologic Survey
and
Bloomsburg University
2006

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Table 1. Classification of soil series by surficial geology map unit.		
Surficial geology unit	**Lackawanna and Wyoming Co. Soil Series**	**Susquehanna Co. Soil Series**
FILL (f)		Cut and fill land (Cu)
WETLAND (Qw)	Haplaquents (HA), Norwich and Chippewa (Nc, Nx), Volusia (Vo, Vx)	Norwich and Chippewa (Nc, Nx), Volusia (Vc, Vs)
PEAT (Qp)	Medihemists and Medifibrists (MK)	Peat (Pt)
ALLUVIUM (Qa) & ALLUVIAL TERRACE (Qat) & ALLUVIAL FAN (Qaf)	Fluvents and Fluvaquents (FA), Holly (Hm, Ho), Philo (Ph), Pope (Po, Pp)	Barbour (Ba), Basher (Bc), Holly (Hm, Ho), Mixed alluvial (Mn), Unadilla (Us), Wyalusing (Wy)
WISCONSINAN ICE CONTACT STRATIFIED DRIFT (Qwic)	Braceville (Bc), Rexford (Re), Wyoming (Wy)	Chenango (Cn)
WISCONSINAN TILL (Qwt)	Bath (Ba, Bb), Lackawanna (La, Lb), Mardin (Mc, Mf, Mh), Morris (Mr, Ms, Mx), Norwich and Chippewa (Nc, Nx), Swartswood (Sw, Sx), Volusia (Vc, Vf, Vx), Wellsboro (Wc, Wf, Wg) Wurtsboro (Wk, Wx)	Bath (Be, Bf, Bs), Lackawanna (La, Lf,Lg), Mardin (Mc, Mf, Mg), Morris (Mo, Mr, Ms), Norwich and Chippewa (Nc, Ns) Volusia (Vc, Vf, Vs), Wellsboro (We, Wl, Ws)
RED AND GRAY SANDSTONE AND SHALE BEDROCK (R)	Arnot (Ar, As, ASE), Lackawanna (LCE), Lordstown (Le, Lf, Lx) Mardin (Mh), Morris (Mx), Oquaga (Oa, Ox, Oy), Swartswood (Sx), Wellsboro (Wg), Wurtsboro (Wx)	Lackawanna (Lf), Lordstown and Oquaga (Lk, Lo, Ls) Mardin (Mf), Morris (Mr), Volusia (Vf), Wellsboro (Wl)

Table 2 Springville quadrangle glacial striations				
Site	Location		Direction	Topographic Position
	Latitude	Longitude		
1	41° 41' 17"	75° 53' 51"	S 32°W	East-west saddle

PRINTING INSTRUCTIONS

All pages of the document except the geologic plate are 8.5 x 11 inches. The geologic plate is 30 inches wide and 36 inches high. To print the entire document on letter paper, simply execute the print command in Adobe Acrobat Reader or Adobe Acrobat. The geologic plate should automatically be reduced to fit on the letter-sized paper.

If you wish to plot the map at its published size of 30 x 36 inches, open the Acrobat file and display the map. Next, execute the File/Print command. When the print dialog opens click the radio button for "Current Page." Next, make sure the plotting device is selected as the current printer and open the properties for that device. Navigate to the page setup and select a paper size that is at least 30 x 36 inches. Your plotting device may include the ability to specify the exact dimensions of the paper. If you select paper that is smaller than 30 x 36 inches, the Acrobat Print dialog provides a "fit to page" option that will automatically resize the map to fit on the paper selected. Just keep in mind that the verbal scale will only be correct when the map is printed at its published size of 30 x 36 inches.