INTRODUCTION AND MAP 1. SLOPE OF LAND SURFACE

HYDROGEOLOGY

By James M. Weigle and others

INTRODUCTION

This atlas describes some aspects of the geohydrology of the parts of northwestern Carroll County, Md., included in the Union Bridge and Woodsboro 7½-minute quadrangles. It is intended primarily as an aid in land-use planning and decision making, assessing potential environmental problems, and locating ground-water supplies. Land use in these quadrangles is agricultural and to some extent woodland; but Union Bridge, several small communities, dispersed residential housing, and a large operating stone quarry occupy part of the land.

The climate is typical of the humid Piedmont region of Maryland. Average annual precipitation is approximately 43 inches. Precipitation is distributed fairly evenly throughout the year, although it is somewhat greater in summer and less in fall and winter.

The Carroll County parts of the Union Bridge and Woodsboro quadrangles are drained by tributaries of the Monocacy River, chiefly Big Pipe and Little Pipe Creeks. Topography is rolling to undulatory north and northwest of Union Bridge, and hilly to the east and southeast. Maximum relief is approximately 390 feet. The greatest relief occurs east and southeast of Union Bridge.

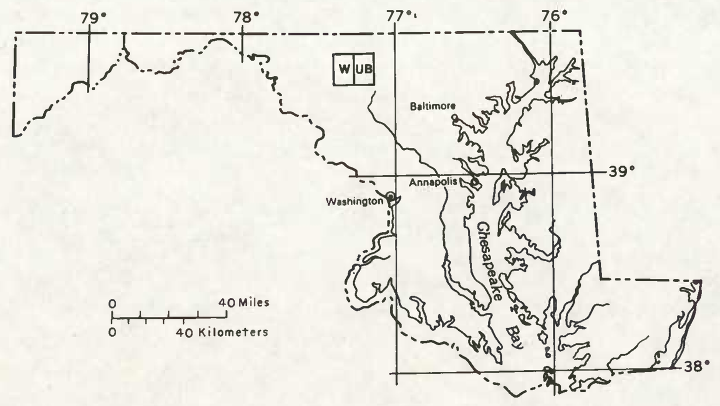

Figure 1.-- Location of Union Bridge and Woodsboro Quadrangles.

HYDROLOGY

Precipitation recharges the local ground-water reservoirs, which consist of pore spaces in the weathered rock (saprolite) and fractures in the unweathered rock. Ground-water runoff from seeps and springs sustains the flow of streams during periods of no rain. The water table is the top of the zone of saturation in the rocks. It rises and falls in response to changes in ground-water storage resulting from imbalance between ground-water recharge and discharge. Rock that is in the saturated zone and can yield water to wells and springs is termed an aquifer. Some of the Piedmont crystalline rocks, such as marble, tend to be more productive aquifers than others, such as schist or phyllite. Well yield is related to some degree to topographic position (often, valley sites are more productive than others), nature and thickness of the weathered zone, and extent to which the rocks have been fractured.

GEOLOGY

Those areas of Carroll County in the Union Bridge and Woodsboro quadrangles are underlain to the northwest by sedimentary rocks of Triassic age, and to the southeast chiefly by metamorphosed sedimentary rocks of early Paleozoic age. The rocks are considerably jointed and faulted, and the Paleozoic rocks are folded in addition.

The rocks are overlain chiefly by soil and weathered rock, which together are referred to here as overburden. In some places, as along steep slopes, the overburden is thin or absent. Well records show that above the Triassic rocks, its thickness averages 13 feet and may exceed 40 feet. Above the older (Paleozoic) rocks, the thickness of the overburden averages about 33 feet, and may exceed 110 feet.

The reader is referred to Cleaves, Edwards, and Glaser (1968) for additional information on the geology. Recently, detailed geologic mapping on a scale of 1:24,000 was completed in Carroll County, by the Maryland Geological Survey.

MAPS INCLUDED IN ATLAS

Map 1. Slope of Land Surface, by Photo Science, Inc.

Map 2. Depth to Water Table, by John T. Hilleary and James M. Weigle.

Map 3. Availability of Ground Water, by James M. Weigle.

Map 4. Constraints on Installation of Septic Systems, by James M. Weigle.

Map 5. Locations of Wells and Springs, by John T. Hilleary and James M. Weigle.

LIMITATIONS OF MAPS

Interpretation of available data, and some degree of judgment were required in preparing the maps in this atlas. The information shown on the maps does not eliminate the need for tests and detailed evaluation at specific sites.

WOODSBORO QUADRANGLE SLOPE MAP NOT AVAILABLE

SLOPE OF LAND SURFACE
Prepared by
Photo Science, Inc.

EXPLANATION

Four slope categories are shown on this map. Terrain having the maximum slope (greater than 25 percent) currently (1980) exceeds the maximum land slope permitted for the installation of domestic sewage-disposal systems (septic tanks) by the Carroll County Health Department. Other terrain categories are useful in planning certain construction activities involving local roads and drains, and in planning airport locations.

This map was prepared using topographic contour negatives by a process developed by the U.S. Geological Survey, Topographic Division. The process uses a semiautomated photomechanical process, which translates the distance between adjacent contours into slope data. The slope zones on the map are unedited. Proximity of the same contour or absence of adjacent contours may produce false slope information at small hilltops and depressions, on cuts and fills, in saddles and drains, along shores of open water, and at the edges of the map.

SELECTED REFERENCES

Cleaves, E. T., Edwards, Jonathan, Jr., and Glaser, J. D. (compilers and editors), 1968, Geologic map of Maryland: Maryland Geological Survey.

Meyer, Gerald, 1958, The ground-water resources in The water resources of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources 1/ Bulletin 22, p. 1-228.

Nutter, L. J., 1974, Well yields in the bedrock aquifers of Maryland: Maryland Geological Survey Information Circular 16, 24 p.

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Otton, E. G., and others, 1979, Hydrogeologic atlas of Westminster quadrangle, Carroll County, Maryland: Maryland Geological Survey Atlas No. 9, 5 maps.

Stose, A. J., and Stose, G. W., 1944, Geology of the Hanover-York district, Pennsylvania: U.S. Geological Survey Professional Paper 204, 84 p.

_______1946, Geology of Carroll and Frederick Counties, in The physical features of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources 1/ p. 11-128.

University of Maryland, Maryland State Roads Commission, U.S. Bureau of Public Roads, 1963, Engineering soil map of Carroll County (1 sheet).

U.S. Department of Agriculture, Soil Conservation Service, 1969, Soil survey, Carroll County, Maryland: 92 pages, 55 photomaps, 1 index.

_______1971, Soils and septic tanks: 12 p.

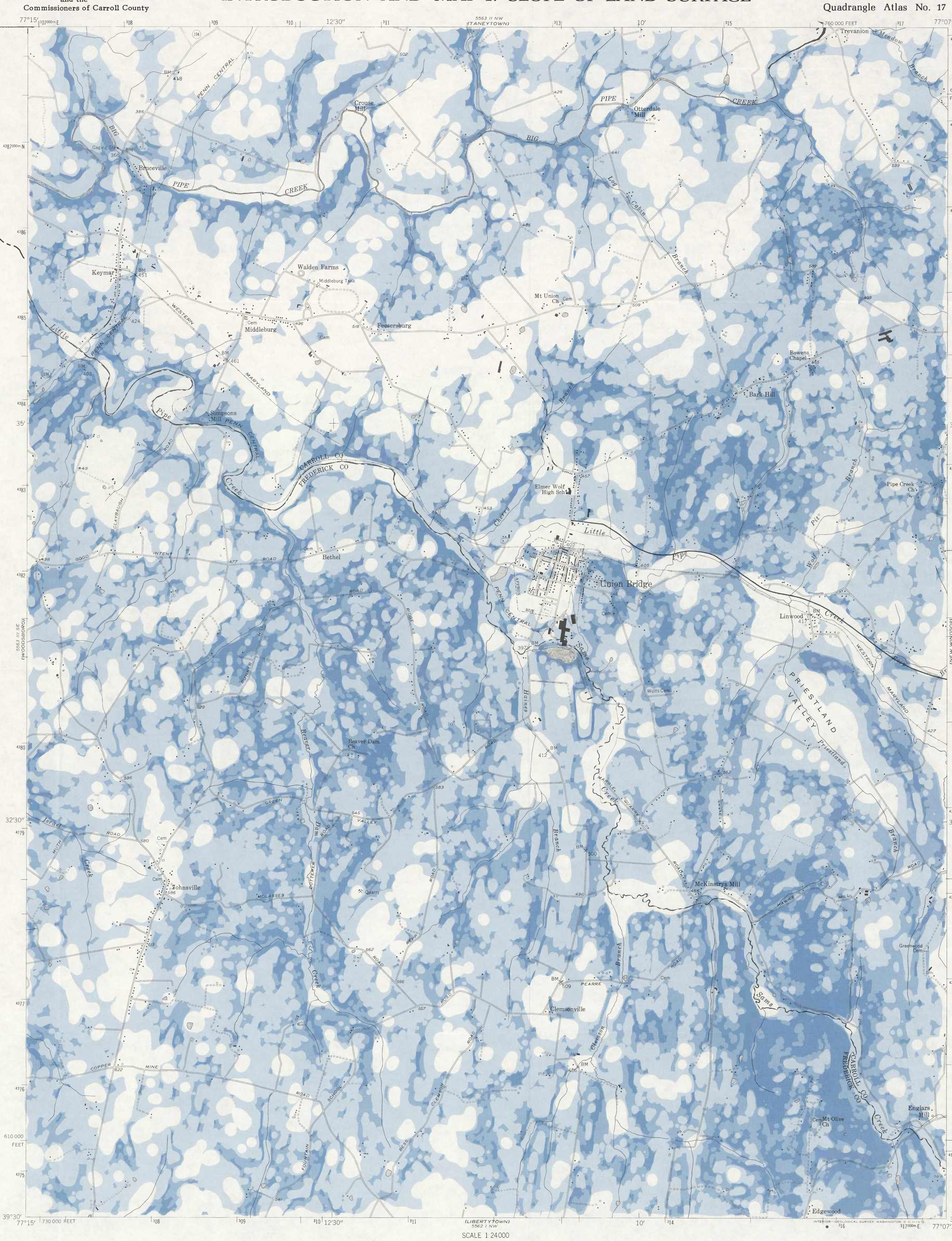
U.S. Public Health Service, 1967, rev., Manual of septic-tank practice: 92 p.

1/ The name of this agency was changed to the Maryland Geological Survey in June 1964.

CONVERSION FACTORS

In this atlas, figures for measurements are given in inch-pound units. The following table contains the factors for converting these units to metric (System International or SI) units:

Inch-pound unit	Symbol	Multiply by	Metric unit	Symbol
inch	(in.)	25.40	millimeter	(mm)
foot	(ft)	0.3048	meter	(m)
mile	(mi)	1.609	kilometer	(km)
square mile	(mi^2)	2.590	square kilometer	(km^2)
U.S. gallon	(gal)	3.785	liter	(L)
U.S. gallon per minute	(gal/min)	0.06309	liter per second	(L/s)
U.S. gallon per minute per foot	[(gal/min)/ft]	0.2070	liter per second per meter	[(L/s)/m]



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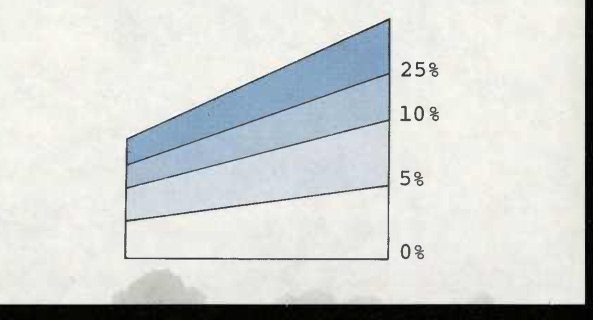
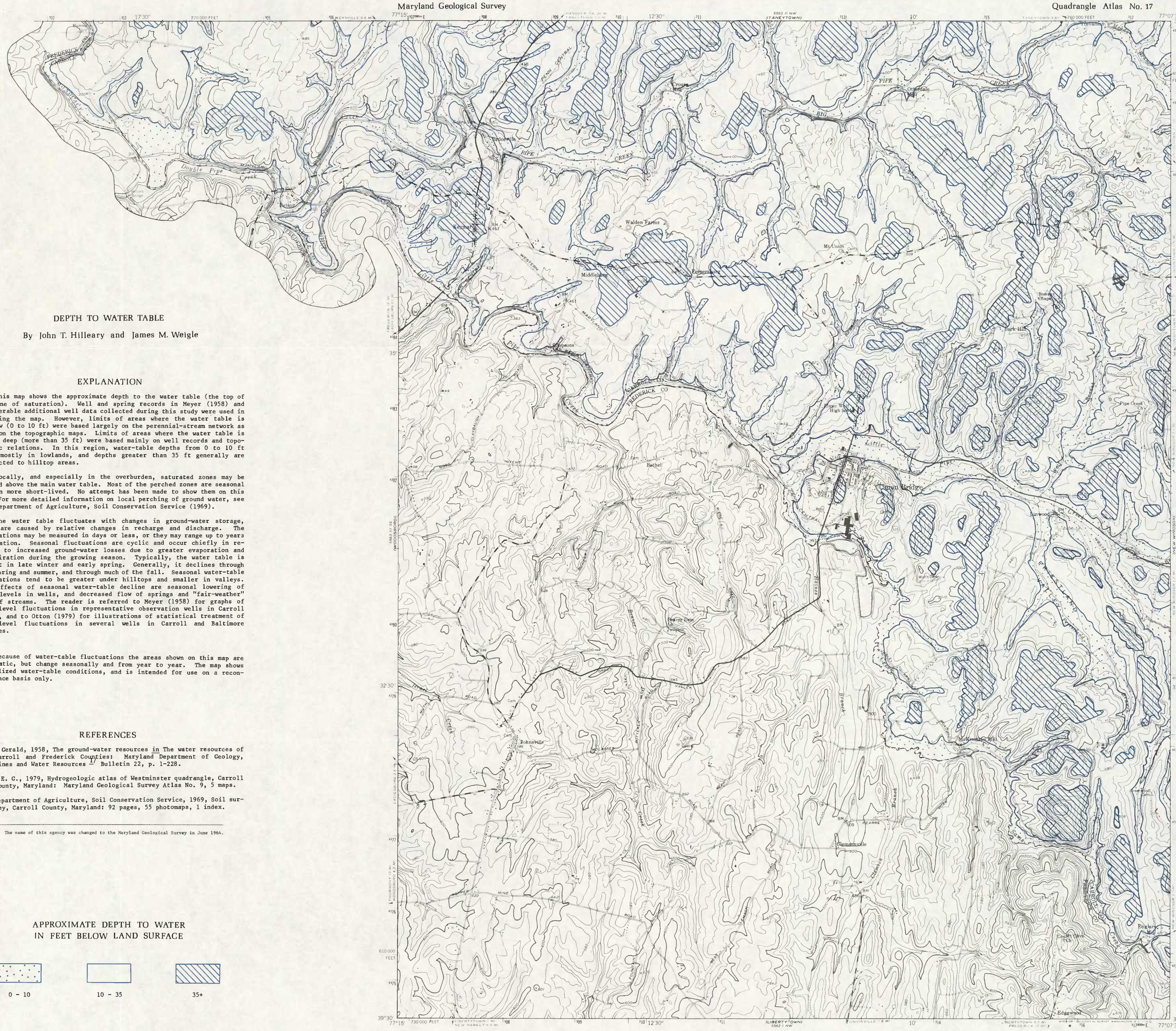


MAP 2. DEPTH TO WATER TABLE

Maryland Geological Survey

Quadrangle Atlas No. 17



DEPTH TO WATER TABLE

By John T. Hilleary and James M. Weigle

EXPLANATION

This map shows the approximate depth to the water table (the top of the zone of saturation). Well and spring records in Meyer (1958) and considerable additional well data collected during this study were used in preparing the map. However, limits of areas where the water table is shallow (0 to 10 ft) were based largely on the perennial-stream network as shown on the topographic maps. Limits of areas where the water table is fairly deep (more than 35 ft) were based mainly on well records and topographic relations. In this region, water-table depths from 0 to 10 ft occur mostly in lowlands, and depths greater than 35 ft generally are restricted to hilltop areas.

Locally, and especially in the overburden, saturated zones may be perched above the main water table. Most of the perched zones are seasonal or even more short-lived. No attempt has been made to show them on this map. For more detailed information on local perching of ground water, see U.S. Department of Agriculture, Soil Conservation Service (1969).

The water table fluctuates with changes in ground-water storage, which are caused by relative changes in recharge and discharge. The fluctuations may be measured in days or less, or they may range up to years in duration. Seasonal fluctuations are cyclic and occur chiefly in response to increased ground-water losses due to greater evaporation and transpiration during the growing season. Typically, the water table is highest in late winter and early spring. Generally, it declines through late spring and summer, and through much of the fall. Seasonal water-table fluctuations tend to be greater under hilltops and smaller in valleys. Some effects of seasonal water-table decline are seasonal lowering of water levels in wells, and decreased flow of springs and "fair-weather" flow of streams. The reader is referred to Meyer (1958) for graphs of water-level fluctuations in representative observation wells in Carroll County, and to Otton (1979) for illustrations of statistical treatment of water-level fluctuations in several wells in Carroll and Baltimore Counties.

Because of water-table fluctuations the areas shown on this map are not static, but change seasonally and from year to year. The map shows generalized water-table conditions, and is intended for use on a reconnaissance basis only.

REFERENCES

Meyer, Gerald, 1958, The ground-water resources in The water resources of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources [1] Bulletin 22, p. 1-228.

Otton, E. G., 1979, Hydrogeologic atlas of Westminster quadrangle, Carroll County, Maryland: Maryland Geological Survey Atlas No. 9, 5 maps.

U.S. Department of Agriculture, Soil Conservation Service, 1969, Soil survey, Carroll County, Maryland: 92 pages, 55 photomaps, 1 index.

1/ The name of this agency was changed to the Maryland Geological Survey in June 1964.

APPROXIMATE DEPTH TO WATER IN FEET BELOW LAND SURFACE

0 - 10

10 - 35

35+

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

1981

Prepared in cooperation with the
United States Geological Survey
and the
Commissioners of Carroll County

Maryland Geological Survey

MAP 3. AVAILABILITY OF GROUND WATER

Quadrangle Atlas No. 17

AVAILABILITY OF GROUND WATER

By James M. Weigle

INTRODUCTION

Ground water in the area shown on this sheet occurs chiefly in joints, faults, and other fractures in metamorphic and sedimentary-rock aquifers, and in intergranular spaces in the saturated part of the overburden.

Availability of water increases with the number of interconnected fractures in the saturated zone (fig. 1). High yields and specific capacities [1] sometimes result where wells penetrate fracture zones associated with faults (fig. 2).

Complexly folded, faulted, and jointed metamorphic rocks underlie the southeastern half of the area. They are primarily phyllite, and lesser amounts of slate, marble, limestone, and metabasalt. The northwestern half of the area is underlain by sedimentary rocks, most of which are sandstone, siltstone, and shale. Faults, and especially joints are numerous. The mantle of soil and weathered rock that overlies the metamorphic rocks tends to be thicker than that overlying the sedimentary rocks. The stratigraphic nomenclature follows the usage of the Maryland Geological Survey.

The rocks in the area shown on this map are assigned to four geohydrologic units, based on differences in water-bearing properties as indicated by available well records and comparative lithologies of the rocks.

Units 1, 2A, and 4 are omitted from the explanation because they do not occur in this quadrangle. They are present elsewhere in Carroll County or nearby counties.

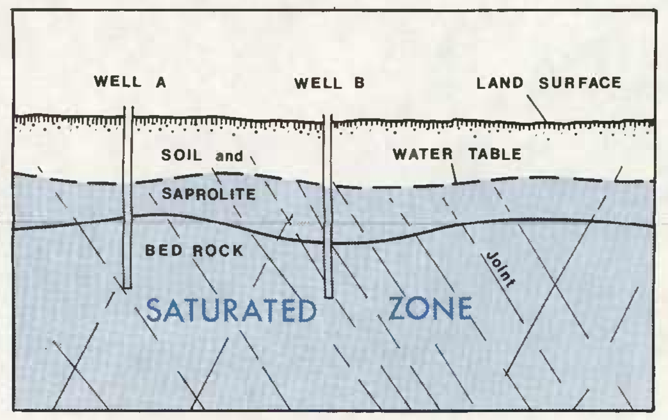


Figure 1.--Well B intersects more joints and has a larger yield than well A.

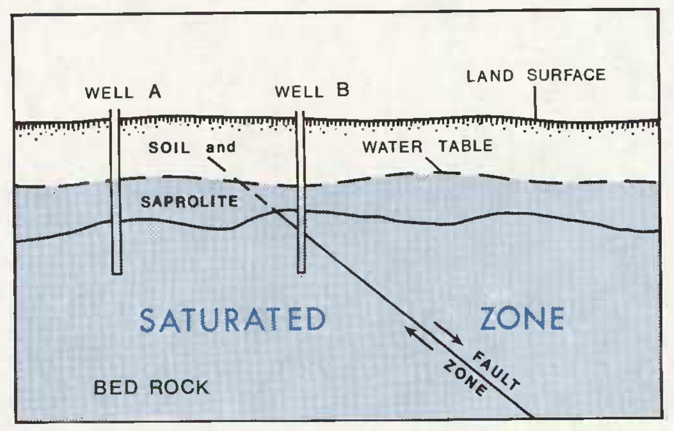


Figure 2.--Well B penetrates fault zone and yields more water than well A.

SELECTION OF UNITS

The Wakefield Marble is the most productive aquifer in the area included on this map. Brecciated zones that occur in the Wakefield Marble may explain in part the productivity of this aquifer. The Wakefield Marble is assigned to Geohydrologic Unit 2B.

Well data available for the Wakefield Marble, the limestone of the Silver Run Formation, and the Sams Creek Formation are too scanty to justify drawing yield graphs for the individual units. However, comparative lithology and the available well data suggest similar water-bearing characteristics in the latter two geologic units and dissimilarity with those of the Wakefield Marble. The limestone of the Silver Run Formation, and the Sams Creek Formation are less productive than the Wakefield Marble and are assigned to Geohydrologic Unit 2C.

The Marburg Formation and the Ijamsville Phyllite, both of former usage (Ijamsville Phyllite of Fisher, 1978), are predominantly phyllite and include lenticular bodies of quartzite up to 10 ft or more in thickness. The "Marburg" and "Ijamsville" are similar in ground-water productivity. They, and the phyllite of the Silver Run Formation are placed in Geohydrologic Unit 3.

The sedimentary rocks in the northwestern half of the area belong to the New Oxford Formation, the most extensive aquifer in this area. The rocks are primarily sandstone, shale, siltstone, and mudstone, and some conglomerate. The matrix of the sandstone and conglomerate is generally clayey or silty. Joints are especially common in the shales and mudstones, enhancing potential ground-water productivity. The rocks of the New Oxford Formation are included in Geohydrologic Unit 5.

SELECTED REFERENCES

Cleaves, E. T., Edwards, Jonathan, Jr., and Glaser, J. D. (compilers and editors), 1968, Geologic map of Maryland: Maryland Geological Survey.

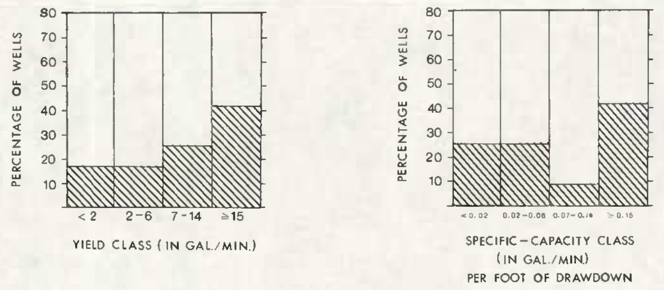
Fisher, G. W., 1978, Geologic map of the New Windsor quadrangle: U.S. Geological Survey Map I-1037.

Meyer, Gerald, 1958, The ground-water resources in The water resources of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources [2] Bulletin 22, p. 1-228.

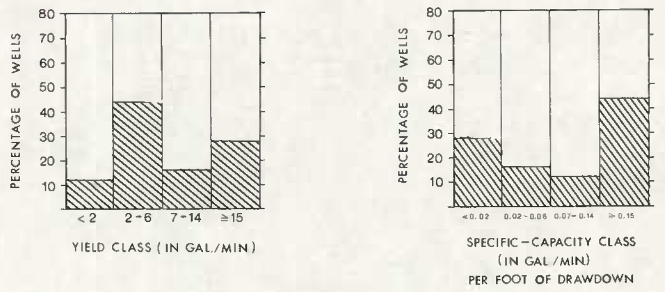
Nutter, L. J., 1974, Well yields in the bedrock aquifers of Maryland: Maryland Geological Survey Information Circular 16, 24 p.

Nutter, L. J., and Otton, E. G., 1969, Ground-water occurrence in the Maryland Piedmont: Maryland Geological Survey Report of Investigations 10, 56 p.

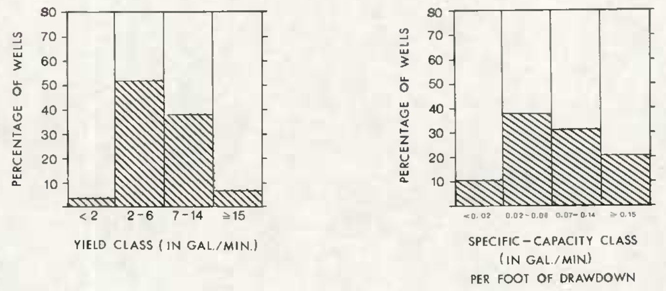
Stose, A. J., and Stose, G. W., 1946, Geology of Carroll and Frederick Counties, in The physical features of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources [2] p. 11-128.



Yields and specific capacities of wells in unit 2C.



Yields and specific capacities of wells in unit 3.



Yields and specific capacities of wells in unit 5.

EXPLANATION

2B — GEOHYDROLOGIC UNIT 2B: This unit includes the Wakefield Marble. Well yields [3] (7 wells) range from 0 to 100 gal/min. Specific capacities [3] range from 0.00 to 7.7 (gal/min)/ft.

2C — GEOHYDROLOGIC UNIT 2C: This unit includes the limestone of the Silver Run Formation (6 wells) and the Sams Creek Formation (6 wells). Yields of the 12 wells range from 0 to 50 gal/min. Specific capacities range from 0.00 to 1.0 (gal/min)/ft.

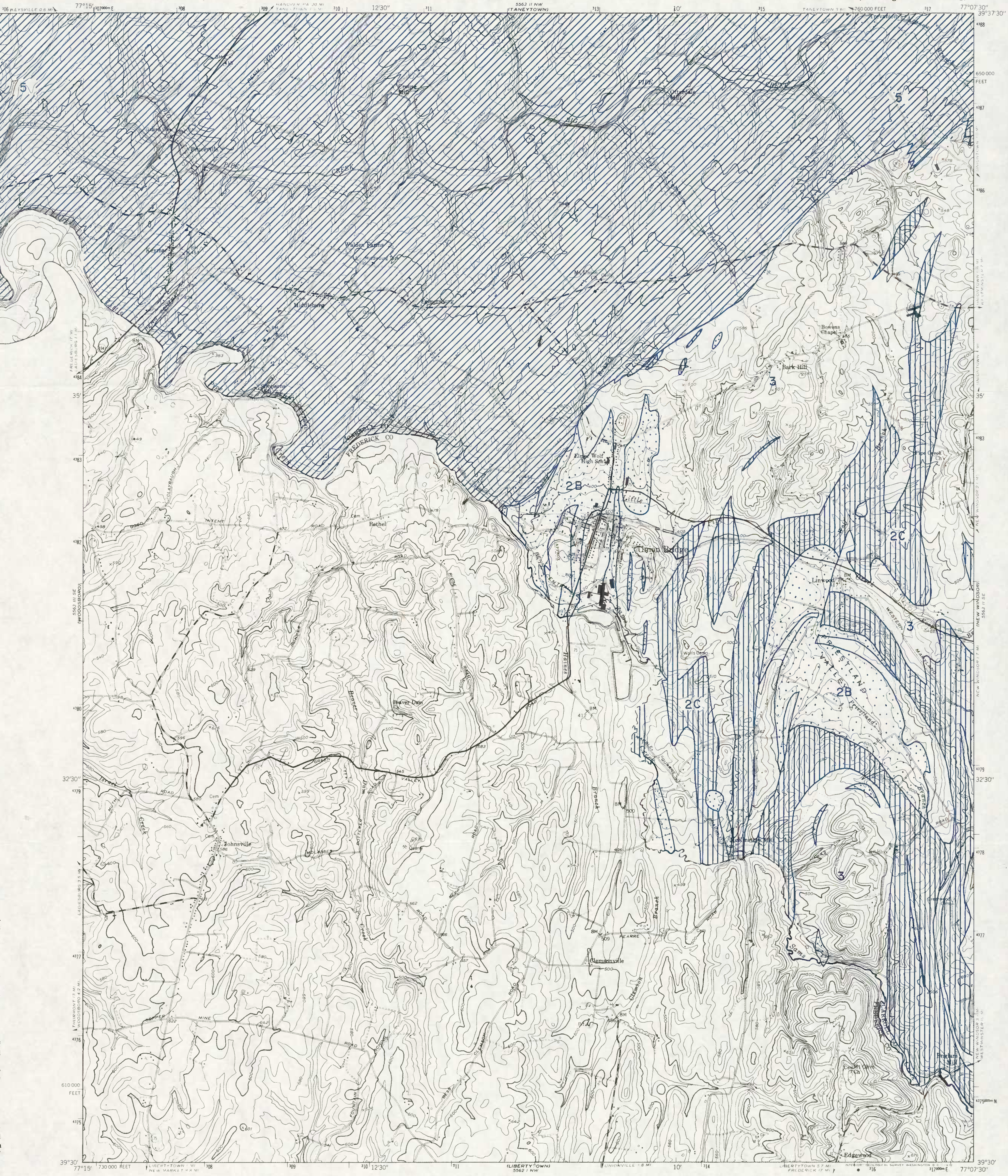
3 — GEOHYDROLOGIC UNIT 3: This unit includes the Marburg Formation of former usage (11 wells), the Ijamsville Phyllite (14 wells), and the phyllite of the Silver Run Formation. Yields of the 25 wells range from 1 to 80 gal/min, and the median yield is 6 gal/min. Specific capacities range from 0.01 to 4.0 (gal/min)/ft, and the median value is 0.08 (gal/min)/ft.

5 — GEOHYDROLOGIC UNIT 5: This unit includes the New Oxford Formation (29 wells). Yields of those wells range from 1 to 24 gal/min, and the median yield is 6 gal/min. Specific capacities range from 0.01 to 1.6 (gal/min)/ft, and the median value is 0.07 (gal/min)/ft.

1/ Specific capacity of a well is the yield per foot of drawdown of the water level in the well, and is commonly expressed in gallons per minute per foot of drawdown. For many domestic wells, the period of measurement ranges from 2 to 6 hours.

2/ The name of this agency was changed to the Maryland Geological Survey in June 1964.

3/ Well yields and specific capacities are based on yield tests by the well driller. The use of yield information in this atlas is limited to that obtained from tests at least 2 hours long, unless specified otherwise.



UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

MARYLAND
QUADRANGLE LOCATION

1981

Prepared in cooperation with the
United States Geological Survey
and the
Commissioners of Carroll County

MAP 4. CONSTRAINTS ON INSTALLATION OF SEPTIC SYSTEMS

Maryland Geological Survey Quadrangle Atlas No. 17

CONSTRAINTS ON INSTALLATION OF SEPTIC SYSTEM

By James M. Weigle

EXPLANATION

Selection of Units

The areas in the four units shown on this map differ widely in suitability for locating domestic liquid-waste disposal systems because of differences in land slope, depth to the water table, and thinness and differences in infiltration characteristics of the overburden.

The following shows the range in hydrogeologic limitations or constraints, for domestic septic systems in the various units.

MAXIMUM CONSTRAINTS	MARGINAL TO VARIABLE CONSTRAINTS		MINIMUM CONSTRAINTS
I	II	III	IV

FACTORS CONSIDERED, AND THEIR SOURCE OF EVALUATION

1. Steep slopes are considered to be a major contributing cause of failure of underground sewage-disposal systems (U.S. Public Health Service, 1967, p. 18; and U.S. Department of Agriculture, Soil Conservation Service, 1971, p. 8). Maryland Department of Health regulations (July 1964, Section 1, definitions, part 1.9) do not permit, as of 1980, the installation of underground domestic sewage-disposal systems where the slope of the land surface exceeds 25 percent. Land slopes were obtained from a slope map prepared by Photo Science, Inc. (Map 1).

2. Shallow depth to the water table is a major limiting factor in considering construction of a liquid-waste disposal system. In areas where the depth to the water table is less than 10 ft, the risk of failure of such a system is high. In addition, the chances of polluting the ground-water supply are greater where the water table is shallow than where it is fairly deep. The 10-ft minimum depth was determined in the following manner: (a) The recommended depth to the bottom of the tile field is at least 3 ft below the land surface (U.S. Department of Agriculture, Soil Conservation Service, 1971, p. 3); (b) a minimum depth of 4 ft between the base of the tile field (absorption trench) and the underlying water table is recommended (U.S. Public Health Service, 1967, p. 11); and (c) a 3-ft additional depth is suggested to allow for seasonal variations in position of the water table, which commonly fluctuates through a 3-ft range in the Piedmont valleys. The extent of the areas having a shallow water table was taken from map 2.

3. Where bedrock crops out or occurs near land surface, construction of underground disposal systems is not feasible. Those areas generally occur where land-surface slopes are steep, and are included in unit I.

4. Infiltration rates also are a limiting factor in considering construction of liquid-waste disposal systems. Overburden having low permeability may not accept the effluent of a normal household. Where the permeability is high, the effluent may be inadequately renovated. Infiltration rates were determined primarily on the basis of data collected by Carroll County sanitarians during percolation tests conducted according to standardized procedures established by the Maryland Department of Health 1/.

5. Floods can cause dispersal of sewage and possible physical damage to disposal systems. Most valleys in the Union Bridge and Woodsboro quadrangles are subject to periodic flooding. In these quadrangles, the flood-prone areas lie entirely within the areas of shallow water table (map 2) and are therefore included in unit I on map 4.

SELECTED REFERENCES

Cleaves, E. T., Edwards, Jonathan, Jr., and Glaser, J. D. (compilers and editors), 1968, Geologic map of Maryland: Maryland Geological Survey.

Fisher, G. W., 1978, Geologic map of the New Windsor quadrangle: U.S. Geological Survey Map I-1037.

Meyer, Gerald, 1958, The ground-water resources in The water resources of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources 2/ Bulletin 22, p. 1-228.

Otton, E. G., and others, 1979, Hydrogeologic atlas of Westminster quadrangle, Carroll County, Maryland: Maryland Geological Survey Atlas No. 9, 5 maps.

University of Maryland, Maryland State Roads Commission, U.S. Bureau of Public Roads, 1963, Engineering soil map of Carroll County (1 sheet).

U.S. Department of Agriculture, Soil Conservation Service, 1969, Soil survey, Carroll County, Maryland: 92 pages, 55 photomaps, 1 index.

______1971, Soils and septic tanks: 12 p.

U.S. Public Health Service, 1967 rev., Manual of septic-tank practice: 92 p.

1/ The percolation test conducted in Carroll County (1979) is performed as follows: A 2- to 3-ft-wide pit is dug to the depth to be tested, and a 1-ft-square hole is hand-dug 1-ft deep in the floor of the pit. The 1-ft hole is filled with water, and the time required for the water level to drop the second inch of a 2-inch decline is measured. For the test to be rated "passing", the time required for the water-level to drop the second inch must be between 2 and 30 minutes.

2/ The name of this agency was changed to the Maryland Geological Survey in June 1964.

MAP UNITS

I — UNIT 1 includes areas where the depth to the main water table ranges from 0 to 10 ft (map 2) and areas where the land slope exceeds 25 percent (map 1). This unit includes valley areas subject to periodic flooding and most of the areas where the overburden is thin or absent.

Very few (7) percolation tests have been made in unit 1. Of those tests, only one failed. The percolation rates for those which passed averaged 9.5 min/in., and the test pits averaged 6.3 ft in depth. The test results suggest that permeability, in unit I, may be less of a limiting factor than are steep slopes, susceptibility to flooding, and shallow water table.

II — UNIT II includes areas underlain by rocks of the New Oxford Formation, consisting of reddish-brown shale, siltstone, sandstone, and some conglomerate. Thickness of overburden averages 13 ft and ranges from 2 to 40 ft, as compared with an average of 33 ft and a range of 3 to 110 ft for the overburden on the crystalline rocks. Land surface is rolling to undulating. Depth to the water table is greater than 10 ft, and is more than 35 ft in some places.

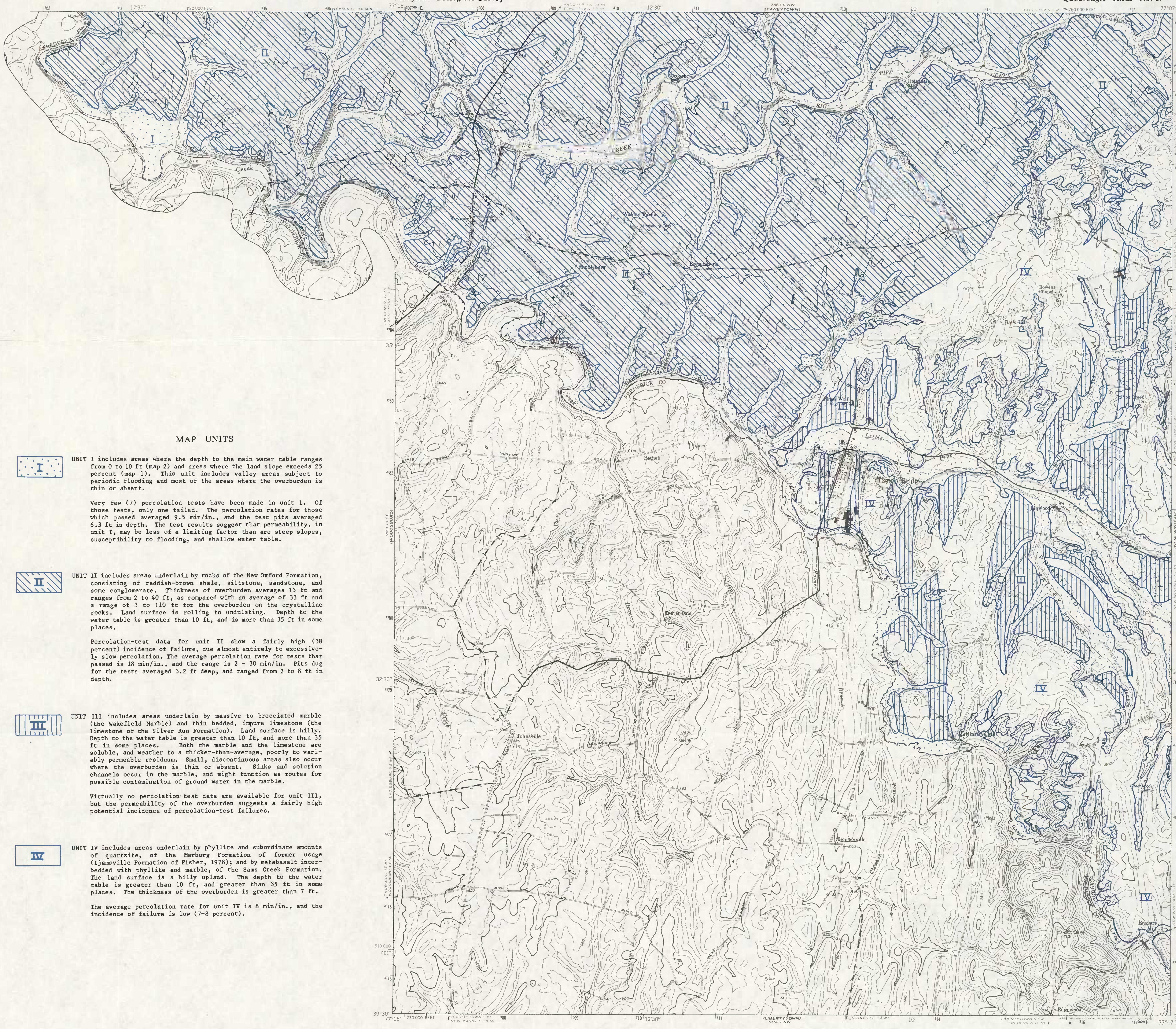
Percolation-test data for unit II show a fairly high (38 percent) incidence of failure, due almost entirely to excessively slow percolation. The average percolation rate for tests that passed is 18 min/in., and the range is 2 - 30 min/in. Pits dug for the tests averaged 3.2 ft deep, and ranged from 2 to 8 ft in depth.

III — UNIT III includes areas underlain by massive to brecciated marble (the Wakefield Marble) and thin bedded, impure limestone (the limestone of the Silver Run Formation). Land surface is hilly. Depth to the water table is greater than 10 ft, and more than 35 ft in some places. Both the marble and the limestone are soluble, and weather to a thicker-than-average, poorly to variably permeable residuum. Small, discontinuous areas also occur where the overburden is thin or absent. Sinks and solution channels occur in the marble, and might function as routes for possible contamination of ground water in the marble.

Virtually no percolation-test data are available for unit III, but the permeability of the overburden suggests a fairly high potential incidence of percolation-test failures.

IV — UNIT IV includes areas underlain by phyllite and subordinate amounts of quartzite, of the Marburg Formation of former usage (Ijamsville Formation of Fisher, 1978); and by metabasalt interbedded with phyllite and marble, of the Sams Creek Formation. The land surface is a hilly upland. The depth to the water table is greater than 10 ft, and greater than 35 ft in some places. The thickness of the overburden is greater than 7 ft.

The average percolation rate for unit IV is 8 min/in., and the incidence of failure is low (7-8 percent).



CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

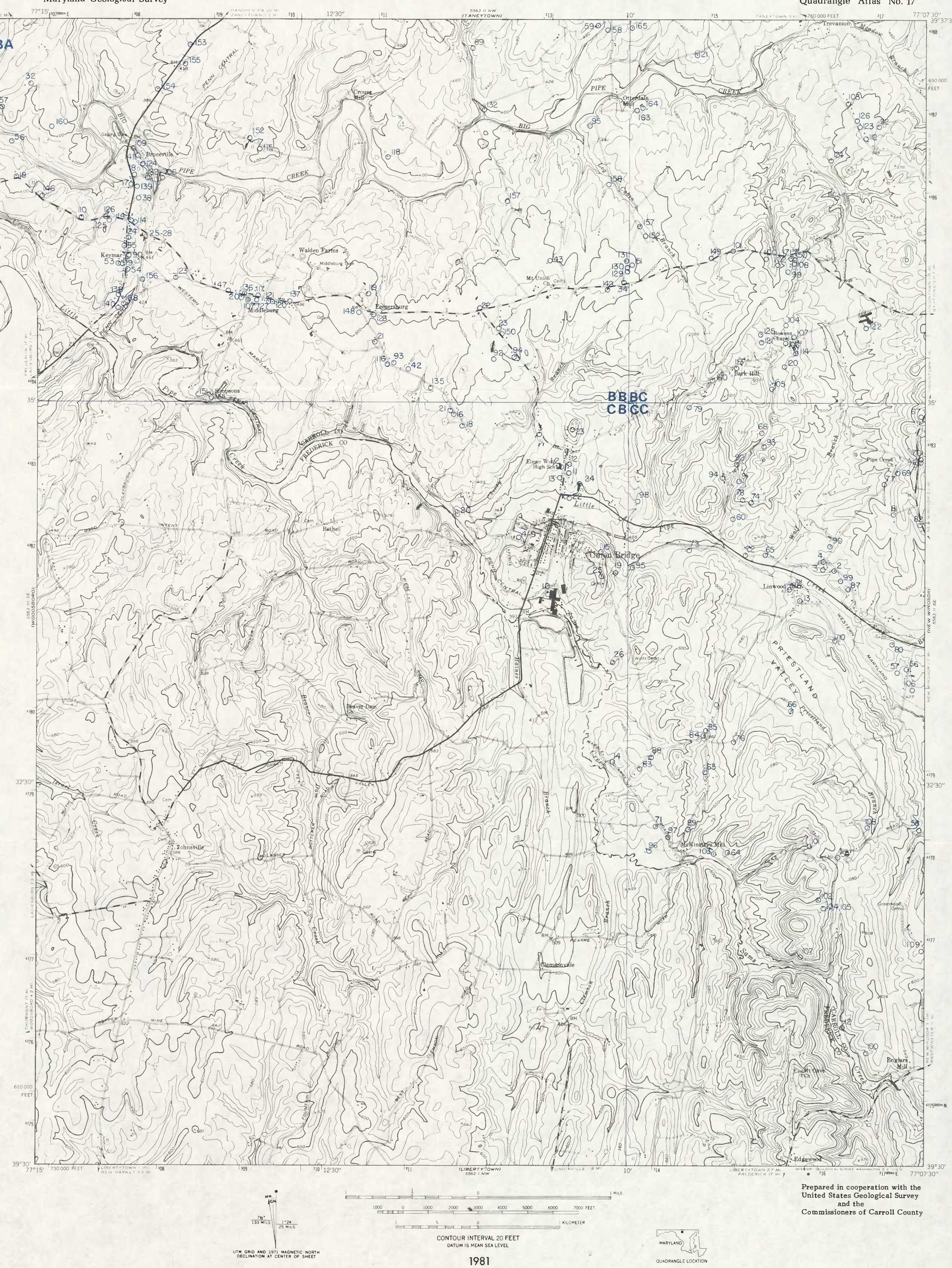
1981

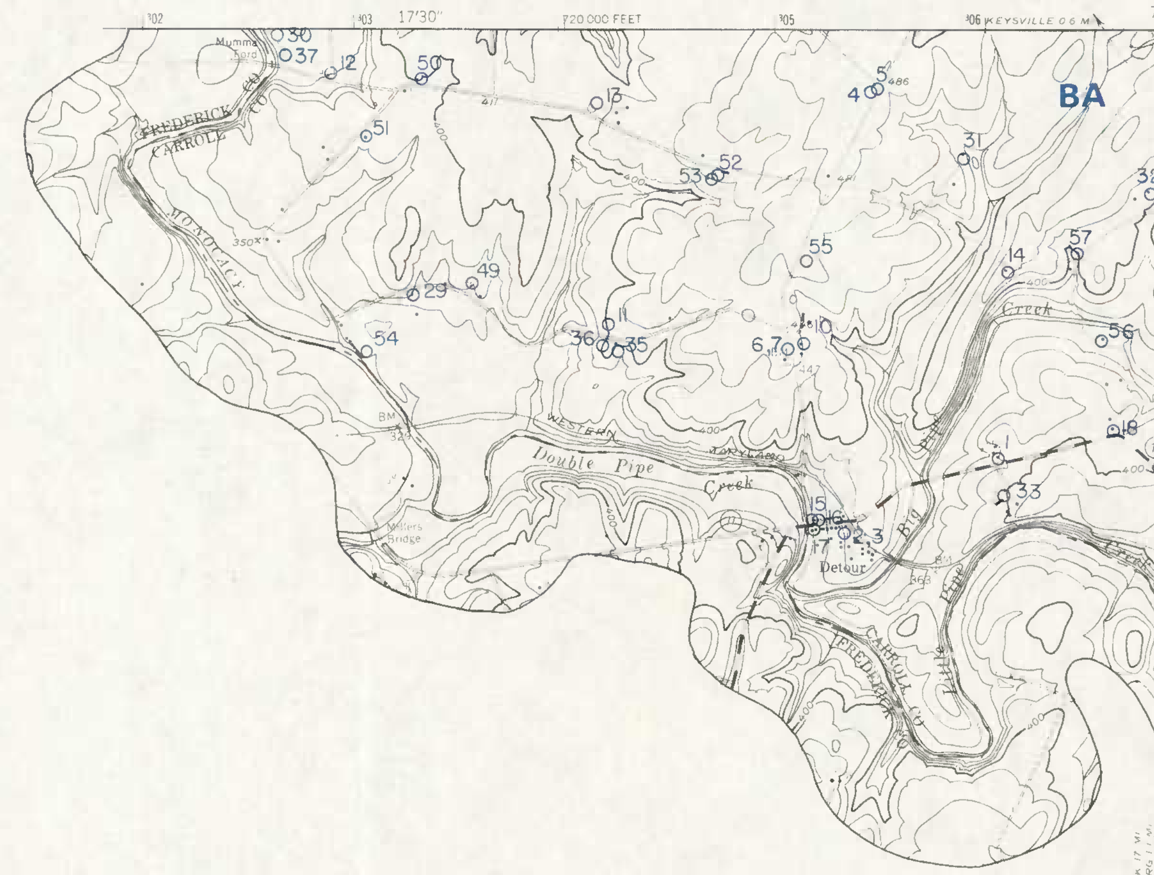
UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION

Prepared in cooperation with the United States Geological Survey and the Commissioners of Carroll County

MAP 5. LOCATIONS OF WELLS AND SPRINGS





LOCATIONS OF WELLS AND SPRINGS

By John T. Hilleary and James M. Weigle

EXPLANATION

Information for wells and springs shown on this map is given by Meyer (1958), or is on file with the U.S. Geological Survey, Towson, Md., and the Maryland Geological Survey, Baltimore, Md. Logs and well-construction records are available for most wells shown. In addition, a report of basic ground-water data available for Carroll County is being prepared.

The wells and springs are numbered according to a coordinate system by which each Maryland county is divided into 5-minute quadrangles bounded by lines of latitude and longitude. The first letter of the well number identifies a 5-minute section of latitude; the second letter identifies a 5-minute section of longitude. The pairs of letters are followed by numbers assigned serially to wells. The letter-number term designates the well with respect to the 5-minute quadrangle, and is preceded by an abbreviation of the county name. Thus, well CL-BB 17 is the 17th well inventoried in 5-minute quadrangle BB in Carroll County. In reports describing wells in only one county, the county prefix letters frequently are omitted from the well-designation term. The numbering system currently in use (1980) differs slightly from that used in earlier published reports, such as that by Meyer (1958). In the 1958 report, well CL-BB 17 was designated as Car-Bb 17. The use of lowercase letters in well designation was discontinued because of a changeover in 1970 to a computer system for storing and retrieving well information.

O 8

WELL AND NUMBER

O 4

SPRING AND NUMBER

SELECTED REFERENCES

Cleaves, E. T., Edwards, Jonathan, Jr., and Glaser, J. D. (compilers and editors), 1968, Geologic Map of Maryland: Maryland Geological Survey, scale 1:250,000.

Meyer, Gerald, 1958, The ground-water resources in The water resources of Carroll and Frederick Counties: Maryland Department of Geology, Mines and Water Resources [1] Bulletin 22, p. 1-228.

1/ The name of this agency was changed to the Maryland Geological Survey in June 1964.

ADDITIONAL NOTE

Records of wells shown on this map are contained in:
Hilleary, J.T. and Weigle, J.M., 1982, Carroll County ground-water information: Well records, spring records and chemical quality data: Maryland Geological Survey, Basic Data Report No. 12, 252 p.

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

1981

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