HOWARD CO.

UNITED STATES DEPARTMENT OF THE INTERIOR
Geological Survey

in cooperation with
THE MARYLAND DEPARTMENT OF GEOLOGY, MINES AND WATER RESOURCES
Baltimore, Maryland

MEMORANDUM DESCRIBING THE GEOLOGY AND GROUND-WATER CONDITIONS IN THE VICINITY OF SIMPSONVILLE, MARYLAND

By

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8-31-72: Well number How-Ce 21 changed to Ce 39 to avoid duplication of already-published number.

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Introduction and Purpose

This memorandum summarizes briefly the result of a study of the ground-water conditions of a small area near Simpsonville, Maryland, underlain chiefly by the Guilford granite (granite-pegmatite) of early Paleozoic or late Precambrian age. The records of 15 wells and 5 springs are given, as are the sample-study logs of 3 test wells drilled at the site of a planned industrial laboratory. A geologic map revised somewhat from a published map by Cloos and Broedel is included (fig. 1).

The study of the hydrology in the vicinity of Simpsonville was undertaken as a part of the ground-water investigations in cooperation with the Maryland Department of Geology, Mines and Water Resources. It provides ground-water data in addition to those already available, as a basis for a decision by the Maryland Water Resources Commission in regard to the application of an industrial laboratory to appropriate 200,000 gallons of ground water a day at a site about half a mile northwest of Simpsonville (approximately 12 miles southwest of Baltimore). Also, it supplements existing information on the occurrence of ground water in crystalline rocks of the type underlying the site, which are widespread in the Piedmont of Maryland and other States.

Previous Reports

Ground-water conditions in Howard County are described briefly by Clark and others (1918), and are discussed in much greater detail by Dingman and Meyer (1954, p. 1-139) in Bulletin 14 of the Department of Geology, Mines and Water Resources. That report describes the occurrence of ground water in the crystalline rocks and indicates that the average yield of three wells ending in the Guilford granite in Howard County is 13 gpm. The average depth of the wells, however, is only 46 feet, and their yields probably are below the average yield that could be obtained from wells drilled to greater depths.

Geology and Hydrology

Simpsonville lies in the Piedmont of Maryland about three miles southeast of Clarksville and at the intersection of Maryland Route 32 with the Middle Patuxent River. The area is underlain by the Guilford granite and the Wissahickon formation of probable early Paleozoic age. The granite is commonly coarse grained and highly pegmatitic, and is stated by Cloos and Broedel (1940) to be a "structureless biotite-muscovite granite closely associated with pegmatite." The associated Wissahickon formation (southeastern facies of Cloos and Broedel) is an oligoclase mica schist commonly rich in garnet and kyanite. Examination of the sample cuttings obtained from three test wells drilled by the Davison Chemical Co. shows that the granite-pegmatite and the schist in the Simpsonville area are interlayered with one another in a complex manner (fig. 2). Figure 1, showing the geology and the locations of wells and springs in the area, was compiled from a field examination of more than 25 outcrops present throughout an area of about 1½ square miles.

Almost all the exposures consisted of granite and granite-pegmatite, which is believed to be the major rock type underlying the area and is so shown on figure 1. However, four exposures of the highly micaceous, coarsely crystalline Wissahickon formation were examined; their locations are shown on figure 1. The description of the cuttings from the wells appears to verify the correctness of the geologic mapping, as approximately three-fourths of the rock logged consisted of granite-pegmatite. The two reliable strike and dip measurements obtained indicated a strike of the rock cleavage in the granite-pegmatite of about N 25° E. The cleavage planes dip northwest at angles of 60° to 90° from the horizontal.

Both the granite and the schist are weathered to varying degrees, the amount of weathering being the greatest on the upland areas and the least along the valley of the Middle Patuxent River, which (at least near Simpsonville) flows mainly along a surface of bare rock. A rough index of the amount of weathering is given by the depths of the well casings. Commonly the casings are driven through the soil, clay, and rotted rock to a point of resistance in the firmer rock. The length of casing in five wells in the locality ranges from 18 to 53 feet and averages 36 feet. Dingman and Meyer (1954, p. 32) indicate that 35 feet constitutes the average depth of strong weathering in 102 wells in the crystalline rocks in Howard and Montgomery Counties. As a matter of fact, a lesser degree of weathering undoubtedly has taken place in both the granite and the schist to greater depths, at least several tens of feet. It is probable that much of the deeper rock weathering occurs along parting planes, or zones of fracture which, in this locality, dip at steep angles from the horizontal.

This probably explains the zone of caving mud encountered at a depth of 86 to 87 feet in well How-Ce 23 (Davison Chemical Co. no. 3). Hard rock was encountered at a depth of 53 feet and the well casing was driven to resistance at this depth. However, the fluid mud and rock encountered in a 1-foot zone some 33 feet deeper forced the abandonment of the well, although an initial penetration was made by the drill to a total depth of 102 feet. A weathered zone was reported by the driller in well How-Ce 22 (Davison Chemical Co. no. 2) at a depth of 150 feet. This zone was free of mud and may contribute some water to the well.

Ground water occurs in the crystalline rocks chiefly in the weathered zone, in joints or other small crevices, and along faults. Water occurring within the zone of saturation (the top of which is the water table) but not confined under hydraulic pressure is said to exist under water-table conditions. Most of the ground water in the upper part of the crystalline rocks is under water-table conditions. Ground water in the deeper fractures and weathered zones in the crystalline rocks is confined under hydraulic pressure between bodies of impermeable rock and is said to occur under artesian conditions. In most of the deeper drilled wells in the area of this report where ground water is encountered at depths below a few tens of feet it is, by definition, under artesian head, but the confining bodies of rock, or other earth material, commonly terminate within a short distance of the well, so that water-table conditions commonly prevail in the area as a whole. Thus, local precipitation is the source of all ground water in the area of this report; some of this precipitation, chiefly in the form of rainfall, moves downward through the soil and into the zone of saturation in the rocks where it is in slow, though continuous, motion from points of high elevation to points of lower elevation. The ground water from the zone of saturation thus supplies water to the stream channels during periods of no rainfall. The springs and seeps along the small drains and watercourses mark the visible points of ground-water discharge. In the Simpsonville area several springs were inventoried; these occurred at an altitude of 380 to 400 feet above sea level. Most of these springs were of the contact type and issued near the base of the weathered granite-pegmatite. The abundance of such springs suggests that much of the ground water stored in the crystalline rocks is in the weathered rock material.

Domestic Wells and Springs

Dug and drilled domestic wells in the area (table 6) range in depth from 26½ feet (well How-Ce 7) to 127 feet (well How-Ce 27). Data concerning the yields of most of these wells are meager, but apparently their yields range from 1/2 to 10 gpm. The best well is about 1,300 feet southeast of the Davison Chemical Co. well no. 1 (How-Ce 21) and was drilled in 1953 for R. E. Woodall. A number of springs were observed in the vicinity, and data concerning five of them were obtained. The estimated or measured flow of the springs during late October and early November 1955 ranged from less than 1 to about 20 gpm. The largest spring (How-Ce 35) is about 2,300 feet southeast of well How-Ce 21, and its discharge on October 21, 1955 was estimated to be 10 to 20 gpm. This spring consists of a zone of seeps and smaller springs present along the floor of a flat depression just south of Maryland Route 32 and a few hundred feet ~~east~~ west of the Middle Patuxent River. No information is available concerning the variability of the discharge of these springs.

Test Wells at the Laboratory Site

During September, October, and November, 1955, four test wells were drilled by the Davison Chemical Co. at the laboratory site. The wells were drilled by the cable-tool, or percussion, method and three of them were cased in the upper part with 6-inch casing. The third well (How-Ce 23) was originally cased with 6-inch casing but was later reamed and recased with 8-inch casing. A zone of flowing mud was encountered in this well at a depth of 86 to 87 feet, and as this mud could not be effectively sealed off the well was abandoned and left as an observation well, after clogging below to a depth of 63 feet with mud and rock debris.

The first well drilled, How-Ce 21, was completed at a depth of 127 feet and yielded 30 gpm when tested with a cylinder pump. Sample cuttings were not collected from this well above a depth of 80 feet, but the cuttings between depths of 80 and 125 feet show that the well ends in the granite-pegmatite. The sample-cutting descriptions of wells How-Ce 22, -Ce 23, and -Ce 37 are given in table 1, which follows:

Table 1.--Sample-cutting description of wells near Simpsonville, Md.

Material	Thickness (feet)	Depth (feet)
How-Ce 22 (Altitude: 380.9 feet)		
Clay, yellowish brown, sandy, highly micaceous........	5	5
Clay, grayish orange, micaceous, sandy, with fragments of quartz up to 0.5 inch in diameter...............	5	10
Clay, grayish orange, micaceous, with abundant quartz fragments..	5	15
Sand, color as above, clayey, micaceous, quartzose and feldspathic................................	5	20
Clay, color as above, silty, less micaceous, quartzose	5	25
Clay, color as above, silty, highly micaceous, abundantly quartzose...................................	10	35
Schist, dark yellowish brown, rotted, soft, highly quartzose, micaceous (base of weathered zone at 39 feet)...	5	40
Schist, dark yellowish brown, quartzose, micaceous; feldspar grains abundant...........................	5	45
Schist, as above, quartzose..........................	15	60
Granite, yellowish brown, weathered, micaceous; pink feldspar common; biotite abundant (pegmatite-granite)	5	65
Granite, as above, but grayish orange at base, quartzose; pink and white feldspar abundant, mica and biotite common................................	55	120
Granite, grayish orange, micaceous, feldspathic, quartzose...	20	140
Granite, light grayish orange, micaceous as above, quartzose...	25	165
Schist, light olive gray, finely quartzose, highly micaceous..	5	170
How-Ce 23 (Altitude: 368.7 feet)		
Clay, yellowish orange, gritty, silty, with coarse mica flakes; grades downward into silty clay........	15	15
Granite-pegmatite, weathered to sand, grayish orange, silty, coarse mica abundant, quartzose.............	5	20
Granite-pegmatite, yellowish gray, weathered to silty sand, finely micaceous, quartzose.................	40	60
Schist, yellowish gray to light olive gray, quartzose, fine biotite and mica grains.......................	5	65
Schist, mottled indeterminate gray, highly quartzose, mica flakes very coarse............................	5	70
Granite-pegmatite, grayish orange to pale yellowish orange, pink and white feldspars; biotite and mica common..	5	75
Granite-pegmatite, yellowish gray, weathered, finer ground, micaceous, slightly schistose..............	5	80
Granite-pegmatite, yellowish gray, fresher, coarser sized, less silty, quartzose......................	5	85

Table 1.--Sample-cutting description of wells near Simpsonville, Md. (continued)

Material	Thickness (feet)	Depth (feet)
How-Ce 37 (Altitude: 392.8 feet)		
Clay, yellowish brown, micaceous, silty (mica flakes up to 1/2 inch diameter)................	5	5
Clay, light olive gray, silty, highly micaceous; grades downward to silty clay, olive brown.....	15	20
Sand, light olive gray to dusky yellow, very clayey and silty, micaceous....................	10	30
Granite, yellowish orange, weathered, micaceous, quartzose..................................	5	35
Granite-pegmatite, very pale orange, fresh, micaceous, feldspathic..........................	5	40
Schist and granite, light olive gray, micaceous, quartzose..................................	5	45
Schist, grayish olive, micaceous, quartzose......	10	55
Schist and granite, dark greenish gray to olive gray, micaceous...............................	10	65
Granite-pegmatite, grayish orange, micaceous; pink and white feldspar common; black minerals rare..	40	105
Granite and schist mixed, mottled light olive gray, micaceous...............................	5	110
Schist, olive gray, quartzose...................	5	115
Schist, olive gray, mottled, quartzose as above..	5	120
Granite-pegmatite, grayish orange to pinkish, coarsely micaceous; feldspars abundant.........	30	150

The second test well, How-Ce 22, was completed at a depth of 171 feet, and it yielded an average of 53 gpm during a 12-hour period on November 17, 1955. The discharge during the first few minutes of this test ranged from 44 to 103 gpm. Within the first 30 minutes the discharge was stabilized at 55 gpm, but it subsequently declined to about 52 gpm near the end of the 12-hour period. The description of the sample cuttings from this well is given in table 1.

The fourth test well, How-Ce 37, was drilled to a depth of 156 feet and yielded about 15 gpm in a 7-hour test on November 18, 1955. The well reportedly yielded 35 gpm during a bailer test run after completion of the drilling. The sample cuttings from this well also are described in table 1.

The yield tests and specific capacities of the three successful wells drilled by the Davison Chemical Co. are given in table 2. The specific capacity of a well furnishes a rough index of its hydraulic efficiency and may be defined as the yield divided by the drawdown required to furnish that yield. It is generally expressed in gallons per minute per foot of drawdown. As the drawdown increases slowly with time, the specific capacity changes and should be given in reference to a definite time unit.

Table 2.--Yields and specific capacities of the test wells

Well	Yield (gpm)	Drawdown (feet)	Time interval used for dd. (minutes)	Specific capacity (gpm ft.)
How-Ce 21	30	67	120	0.4
-Ce 22	52	34	714	1.5
-Ce 37	15	114	90	.1

Well Characteristics

The energy necessary to move the water through a permeable formation to a pumped well is furnished by the head differential existing in the cone of depression surrounding the well. The pumping level in a well continues to decline and the zone of depression continues to expand until the recharge to the aquifer is increased or the discharge from the aquifer is decreased by an amount equal to the withdrawal from the well. Under water-table conditions, so long as no recharge occurs, all the water is derived from storage in the formation. Thus, the cone of depression must continue to expand indefinitely and the water level to decline as long as the well is pumped, until and unless recharge is induced or natural discharge is reduced.

In the Piedmont area of Maryland much of the ground water is believed to be stored in the permeable zone of weathered rock lying above the denser, more impervious crystalline rock. Because of the comparative thinness of the weathered material (in some places only a few feet) the overall storage capacity of the rocks is low. Thus, as pumping continues and the cone of depression expands horizontally and vertically, the thickness of the zone transmitting the water to the well decreases and the amount of water able to enter the well decreases. Thus, unless the pump capacity is increased, the yield of the well declines. If the pump capacity is increased, this increase is compensated for by a further decline in the pumping water level, and thus the "vicious circle" is continued to a point where the permeable saturated, weathered zone is almost completely dewatered in the vicinity of the pumped well or wells. At this point the yield of the well will fall off sharply (or cease entirely) until enough water has moved toward the well from points farther out in the cone of depression to permit pumping to resume. During the drought period in September and October 1954, instances where such a condition prevailed were reported from some localities in the Maryland Piedmont.

It is therefore pertinent to evaluate the drawdown in a pumping well to determine the rate of decline of the cone of depression in the granite-pegmatite under the hydraulic gradients existing during the 7-hour test made on well How-Ce 22 on October 17, 1955. The drawdown and specific-capacity values obtained during this test are shown in figure 3 for a 94-minute period during the early part of the test, when the rate of pumping averaged about 55 gpm. A projection of the drawdown slope obtained for 94 minutes (approximately 1½ hours) shows that at the end of 1,000 minutes (0.69 day) the drawdown would have increased to about 48 feet (pumping level of 60 feet), and at the end of 10,000 minutes (6.9 days) the drawdown would have increased to about 59 feet (pumping level of 71 feet). As both these levels are below the base of the water-bearing zone at a depth of 50 feet, it is unlikely that the well could continue to deliver at a rate of 55 gallons a minute for even 0.69 day. As a matter of fact, the yield had actually declined to 52 gpm by the end of the 7-hour test. Nevertheless, figure 3 is useful in that it shows the general trend to be expected in the well with continued pumping.

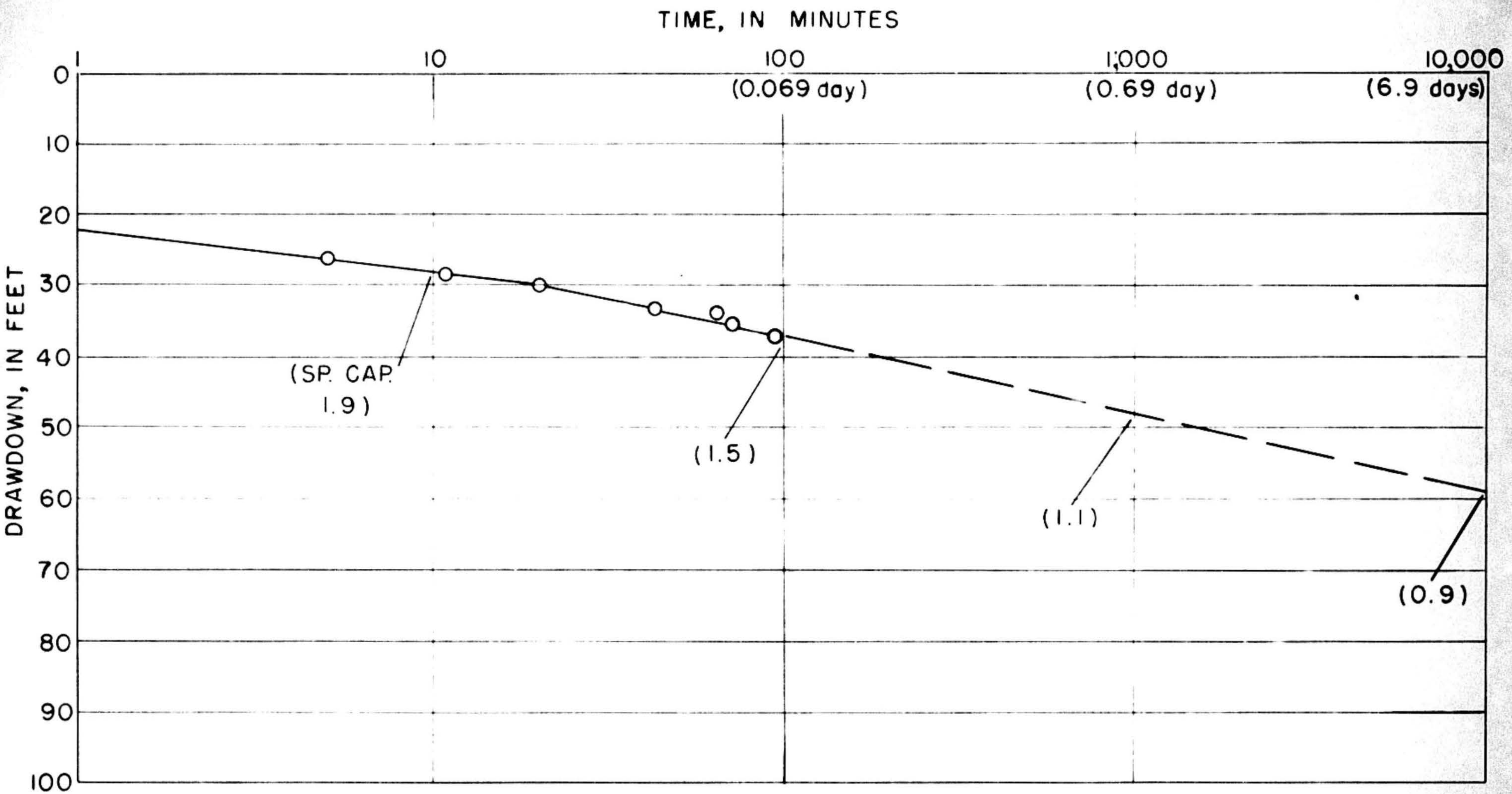

FIGURE 3. EXTRAPOLATION OF DRAWDOWN AND CHANGE IN SPECIFIC CAPACITY IN WELL How-Ce 22, YIELDING 55 GPM FOR 94 MINUTES ON OCTOBER 17, 1955.

Tests of the Aquifer

The physical properties of a water-bearing formation that govern its capacity to transmit and store water are the coefficients of transmissibility and storage. These terms are commonly expressed by the letters T and S and are known as formation constants. The coefficient of transmissibility may be defined as the quantity of water, in gallons per day, that flows through a 1-foot section of the aquifer under a hydraulic gradient of unity (loss of head of 1 foot for each foot the water travels). The transmissibility is the product of the field coefficient of permeability, (P_f), multiplied by the saturated thickness of the aquifer, in feet (m). The coefficient of storage is the volume of water released from or taken into storage, per unit surface area of the aquifer per unit change of the component of head normal to that surface. Obviously, in nature the coefficients of transmissibility and storage differ widely from place to place as a result of differences in the lithology and thickness of the rocks.

Determination of the coefficients of transmissibility and storage are useful in predicting the behavior of the water level in wells in response to changes in the withdrawal of water from or addition of water to a water-bearing formation. These coefficients are commonly determined by means of aquifer tests in which wells ending in a water-bearing formation are pumped for known periods of time and the drawdowns in a pumped well and in one or more observation wells are measured. The theory and the basis for analysis used in the tests are described by Theis (1935), Wenzel (1942), and others. Tests were run on the Guilford granite at the well field of the Davison Chemical Co. on September 28, October 17, and November 17, 1955. The results of these tests can be used to determine the hydraulic coefficients of the aquifer, but only with some qualifications. The reason for this is that the geologic conditions at the site of the well field seemingly are so complex that the theoretical assumptions on which the analysis of the test information is based are partially vitiated. The geology at the site of the well field is shown by the well logs in figure 2. As the schist and granite presumably have somewhat different permeabilities, the interlayering of the two rock types probably means that the movement of ground water in the vicinity of the test site is more devious than it would be if the geology were less complex. Such complexity is suggested also by the somewhat random occurrence of the water-bearing zones in the wells (fig. 2).

The analysis of the aquifer-test data seems to confirm that the hydrologic and geologic conditions are complex. In the test of October 17, 1955, well How-Ce 22 (Davison Chemical Co. no. 2) was pumped for 7 hours and the drawdown measured by means of a water-stage recorder on well How-Ce 21, 247 feet from the pumped well. Plotting of the drawdown data showed that the drawdown curve[2/] obtained from the water levels in well How-Ce 21 failed to match the type curve except for one small segment of the plotted curve. Use of this segment gave a coefficient of transmissibility of about 110,000 and a storage coefficient of 0.05. This is believed to be an unreasonably high value for the coefficient of transmissibility and not consistent with the low yields of wells tapping the aquifer and with the results obtained in other crystalline-rock tests. A similar high value of about 170,000 gpd per foot for the coefficient of transmissibility was obtained from the drawdowns in well How-Ce 37

2/ Theis, C. V. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground-water storage: Am. Geophys. Union Trans., p. 519-524, 1935.

measured during the test of November 17, 1955.

Data obtained from aquifer tests in other areas in the Maryland Piedmont have given values for the coefficient of transmissibility of the crystalline rocks (schist, gneiss, gabbro, and granite) that range from about 2,000 to 20,000 gpd.[3/] It is significant that computations of the transmissibility utilizing the recovery curves obtained from the pumped wells in the tests gave values much lower than those obtained from the drawdowns. The values obtained are tabulated below:

Table 3.--Coefficients of transmissibility obtained from the curve of recovery of the water levels in wells pumping from the Guilford granite

Well	Date of test	Pumping rate (gpm)	T	Method of analysis
How-Ce 21	9/28/55	30	2,600	Theis (Cooper-Jacob modification)
-Ce 22	10/17/55	53	8,700	do
-De 16	2/4/53	17	5,100	do

An average of the three values of the coefficient of transmissibility given above is about 5,500 gpd per foot. Using the value of the coefficient of storage of 0.05 obtained from the type-curve analysis, which is a reasonable value for rocks of this character, and the average trans-

3/ Unpublished data in the files of the U. S. Geological Survey, Baltimore, Md.

missibility of 5,500 gpd per foot, computations[4/] were made of the drawdown to be expected in observation wells 247 and 218 feet, respectively, from a well pumping at a rate of 53 gallons per minute for 12 hours (1/2 day). Wells How-Ce 21 and -Ce 37 are actually these distances from well How-Ce 22, which was pumped at the rate of 53 gpm for 12 hours. The calculated drawdowns and the measured drawdowns after 12 hours of pumping are as follows:

Well	Calculated drawdowns (feet)	Observed drawdowns (feet)
How-Ce 21	0.05	0.24
-Ce 37	.11	.06

It seems likely, therefore, that the coefficient of transmissibility of 5,500 gpd per foot is of the correct order of magnitude, and that the coefficient of storage also is in the correct range, but it must be emphasized that, because of the variability of the physical character of the rocks and corresponding changes in their hydrologic properties, the coefficients are limited in their applicability to field conditions.

4/ The Theis equation in Geological Survey units is commonly written as:

$$s = \frac{114.6\,Q}{T} \int_{1.87r^2S/Tt}^{\infty} \frac{e^{-u}}{u}\,du \ldots$$

where
- s = drawdown, in feet, in an observation well near the pumped well
- T = transmissibility, in gallons per day per foot
- S = coefficient of storage as a decimal fraction
- Q = discharge of the pumped well, in gallons per minute
- u = $1.87r^2S/Tt$
- r = distance, in feet, from the pumped well to the observation well
- t = time, in days, since pumping began
- e = natural logarithm base

Effects of Withdrawal of Water from the Aquifer

The validity of calculations of the effect of ground-water withdrawal from an aquifer using the Theis equation are subject to certain conditions which are fulfilled only in part in the vicinity of the laboratory site. These are:

1) The aquifer must be isotropic and homogeneous -- that is, capable of transmitting water equally well in all directions. The variations of the character of the earth materials at the laboratory site have been described.

2) The formation should have an indefinite areal extent. This requirement is fulfilled to some extent, although the hydraulic effect of differences in lithology that are reflected in topographic irregularities may be the same as that of nearby boundaries of the formation.

3) The discharging well penetrates the entire thickness of the aquifer. This condition is probably essentially complied with, inasmuch as the chief water-bearing zones lie above a depth of 100 feet, and most wells in the locality penetrate beyond this depth.

4) The water is released instantaneously from storage with a decline in head. This condition is not fulfilled, although for calculations of drawdown over a period of time beyond a few days it is not significant.

5) The discharging well is of an infinitesimally small diameter. This factor is not an important source of error in most calculations.

In addition to the above limitations, the calculations of the drawdown in the vicinity of a pumped well (or wells) are made on the assumption that no recharge is added to the aquifer during the period of predicted drawdown.

At the laboratory site the nearest perennial stream (a small westward flowing tributary of the Middle Patuxent River) is about 700 feet north of well How-Ce 22 (Davison no. 2). This stream and the Middle Patuxent River, which is approximately 1,300 feet east of well How-Ce 22 undoubtedly receive ground water from the vicinity of the wells, some of which may be salvaged by pumping from wells. The streams may even contribute some water to the aquifer, if they are intercepted by the expanding cone of depression created by pumping at the laboratory well field. Furthermore, the condition of no recharge to the aquifer will seldom be fulfilled for long periods of time, as drought periods lasting longer than a few months are uncommon in the Piedmont of Maryland.

If allowance is made for the limitations described above, the following calculations of the drawdown in wells in the vicinity of the Davison Chemical site may be regarded as the maximum which can occur, but most likely they will not occur under the existing field conditions. They nevertheless serve as the best guide available.

Therefore, if 200,000 gallons a day is pumped from the wells at the laboratory site under the theoretical conditions described above, the maximum drawdowns in nearby wells are estimated as follows:

Table 4.--Calculation of drawdown in wells in the vicinity of a well (or wells) pumping 200,000 gallons a day (140 gpm)

Time, in days	Distance, in feet, from pumped well (or wells)			
	218	247	1,000	2,000
0.5	0.29	0.09	---	---
1	.91	.61	---	---
10	5.9	5.2	0.22	---
30 (1 mo.)	8.9	7.3	1.4	0.1
100 (3.3 mos.)	12.4	11.7	4.0	1.0

Effects of Natural Fluctuations in the Position of the Water Table

It is likely that any lowering of the water table in the Simpsonville area caused by the pumping from wells at the laboratory site may be masked by the effect of natural changes in the volume of water stored in the rock aquifers. The magnitude of the changes in water level resulting from changes in the recharge-discharge balance in the aquifer can best be shown by evaluating the records of water levels in observation wells in the area.

As a part of the cooperative ground-water investigations, measurements have been made of the static (nonpumping) water level in three wells (How-Bd 1, Mont-Be 1, and Mont-Cf 1) ending in the crystalline rocks within 17 miles of the laboratory site. Records of the water-level fluctuations in these wells cover periods of time ranging from 6½ to 8½ years. The water levels have been measured approximately monthly since the beginning of the observations. The water levels in these wells have fluctuated through a range of 14.0, 15.5 and 22.4 feet, respectively. Pertinent data on these wells are summarized below:

Table 5.--**Summary of fluctuation of water levels in three observation wells in the crystalline rocks in Howard and Montgomery Counties**

Well	Length of record (years)	Location	Maximum fluctuation during period of record (feet)	Maximum decline during a 100-day interval (feet)
How-Bd 1	$8\frac{1}{2}$	Slacks Corner	15.5	3.8
Mont-Be 1	$6\frac{1}{2}$	Damascus	22.4	11.1
Mont-Cf 1	$6\frac{1}{2}$	Mount Zion	14.0	6.3
			Aver. 17.3	Aver. 7.1

The maximum decline in the water level in the three wells during a 100-day period averages 7.1 feet.

It is probable that declines in the position of the water table (reflecting changes in ground-water storage) near the laboratory site will equal or nearly equal the average decline noted in the three observation wells. Thus, a 7-foot decline in the water level in a well 1,000 feet from the pumped well could occur in a 100-day period solely as a result of natural causes; this is nearly twice the predicted decline of 4.0 feet caused by pumping 200,000 gpd for 100 days (table 4). It is significant, however, that the two effects probably would be cumulative, and the net result during a 100-day drought period might be a decline of the water level in the well of more than 10 feet.

The data in table 5 show that the average range in fluctuation in the three observation wells over a period of $6\frac{1}{2}$ to $8\frac{1}{2}$ years is 17.3 feet. Inasmuch as the average saturated thickness of the weathered crystalline rock in the vicinity of the laboratory site is estimated to be only about 20 feet, and as most of the ground water available from storage is believed to be contained in the weathered portion of this rock, it would appear that, at the end of a period of decline of the water table to its maximum low (drought), nearly all the stored ground water would have been lost through natural discharge, even if no withdrawals had been made as a result of pumping. For this reason, if for none other, it would appear necessary to maintain continuous and accurate records of the water levels in both pumping and nonpumping wells in the vicinity of the well field. Accurate records of the ground-water pumpage also should be maintained to serve as a guide in interpreting the observed water-level fluctuations and as an index of the demand for water.

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Table 6.--Record of Wells in the Vicinity of Simpsonville, Md.

Well	Approx. distance and direction from well How-Ce 21	Name	Date compl.	Approx. alt. (ft.)	Depth (ft.)	Diam. (ft.)	Rept'd. yield (gpm)	Static water level (ft.)	Remarks
How-Ce 7	2300 ft. S.E.	Harry Saumenig	1951	280	26½	36	--	21.6	Dug well. Water level meas. 8/22/52.
-Ce 17	2200 ft. S.E.	C. G. Melin	1942	280	50	6	--	--	
-Ce 18	3600 ft. W.	Charles Shaw	1947	460	75	6	1/2	41.2	Water level meas. 8/25/51.
-Ce 21 (P20,931)	---	Davison Chem. Co.	1955	401.7	127	6	30	31.8	Csg. to 31 ft.; s.w.l. on 10/7/55. Owner's well 1.
-Ce 22 (P21,089)	200 ft. N.	do	1955	380.9	171	6	53	11.7	Csg. to 39 ft.; s.w.l. on 10/14/55. Owner's well 2.
-Ce 23 (P21,211)	295 ft. N.	do	11/55	368.7	---	8	---	9.6	Csg. to 53 ft. Well abandoned because of caving mud below csg. Owner's well 3.
-Ce 24	620 ft. S.E.	do	before 1900	410	53	36±	---	50.2	Old dug well at farmhouse; s.w.l. on 10/19/55.
-Ce 25	800 ft. W.	do	---	380	---	---	1±	---	Unimproved spring near frame tenant house.
-Ce 26	1700 ft. W.	R. H. Wood, Jr.	1955	430	98	6	5	---	
-Ce 27	1300 ft. S.E.	R. E. Woodall	9/53	390	127	6	10	---	Rock rept. at depth 18 ft.
-Ce 28	1200 ft. E.	do	---	360	---	---	2-3	---	Unimproved spring.
-Ce 29	3100 ft. W.	E. Wollach	---	460	75	---	---	---	Dug well-domestic supply; depth rept. by owner.
-Ce 30	3150 ft. W.	Mrs. Wm. Walker	6/55	460	98	6	---	---	About 75 ft. E. of -Ce 18.
-Ce 31	3000 ft. S.	J. N. Baines	6/55	350	75	6	---	30	Water level rept. by owner.
-Ce 32	2300 ft. S.	Mr. Boyer	---	425	55.6	36(?)	---	53	Dug well at abandoned house.
-Ce 33	1800 ft. S.W.	John W. Phillips	---	410	85	6	4-5	---	Drilled well near barn.
-Ce 34	1500 ft. S.W.	do	---	395	---	---	3-5	---	Improved spring; flow est. on 10/21/55.
-Ce 35	2300 ft. S.E.	Mr. Vogel	---	395	---	---	10-20	---	Zone of springs; flow est. on 10/21/55.
-Ce 36	3300 ft. W.	V. J. Gallagher	---	400	---	---	3-6	---	Unimproved spring; flow est. 11/2/55.
-Ce 37 (P21,446)	220 ft. W.	Davison Chem. Co.	11/55	392.8	156	6	15-35	15.2	Csg. to 35½ ft.; Davison Chem. well 4.
-De 16	2 miles S.	J.H.U. Applied Phys. Lab.	1952	420	62	8	18	4	Owner's well 2.

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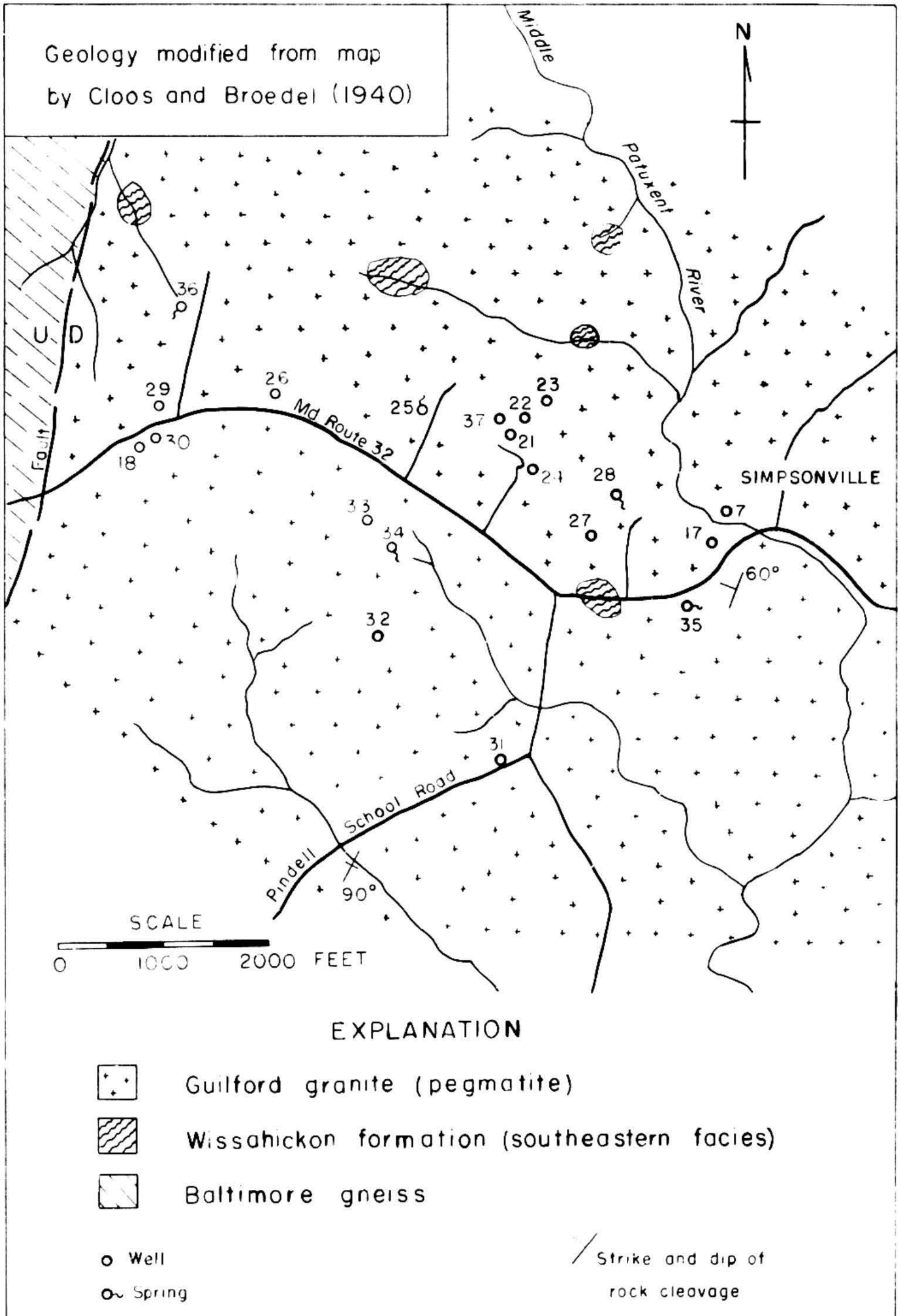

FIGURE 1. MAP SHOWING THE GEOLOGY AND LOCATION OF WELLS AND SPRINGS IN THE VICINITY OF SIMPSONVILLE, MARYLAND.

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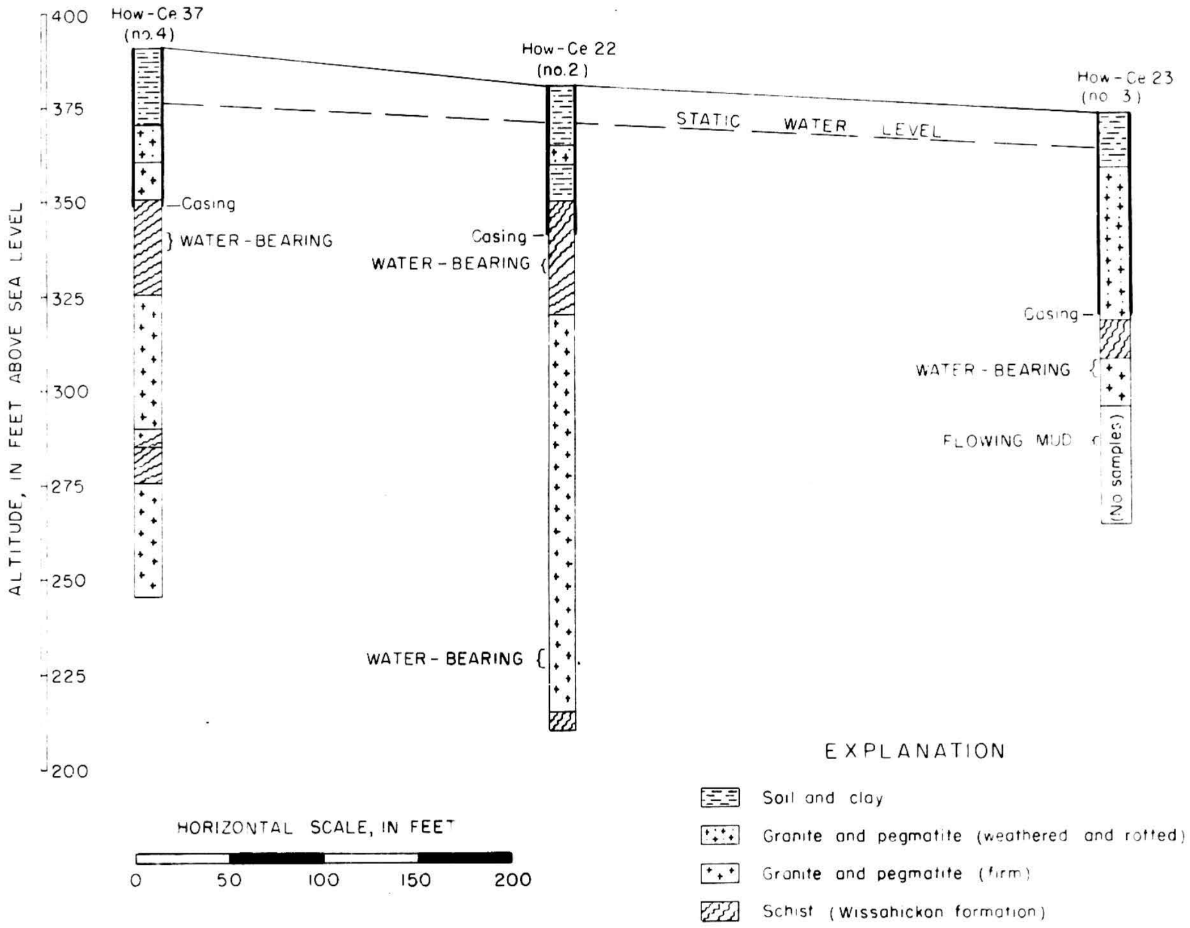

FIGURE 2. GEOLOGIC SECTION ACROSS THE WELL FIELD AT THE LABORATORY SITE.