GROUND-WATER APPRAISAL OF THE PINE BUSH AREA, ALBANY COUNTY, NEW YORK

by Deborah S. Snavely

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JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

U.S. Geological Survey
P.O. Box 1350
Albany, New York 12201
(518) 472-3107

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CONVERSION FACTORS AND ABBREVIATIONS

The following factors may be used to convert inch-pound units of measurement in this report to International System of units (SI).

Multiply inch-pound	by	To obtain SI units
	Length	
inch (in.)	2.54×10^{1}	millimeter (mm)
	2.54×10^{-2}	meter (m)
foot (ft)	3.048×10^{-1}	meter (m)
mile (mi)	1.609×10^{0}	kilometer (km)
	Area	
square mile (mi^2)	2.509×10^{0}	square kilometer (km^2)
	Rate	
inch per year (in/yr)	8.054×10^{-7}	millimeter per second (mm/s)
foot per day (ft/d)	3.048×10^{-1}	meter per day (m/d)
	Flow	
cubic foot per second (ft^3/s)	2.832×10^{-2}	cubic meter per second (m^3/s)
gallon per minute (gal/min)	6.308×10^{-2}	liter per second (L/s)
	Temperature	
degrees Fahrenheit (°F)	5/9 (°F-32)	degrees Celsius (°C)

Other Abbreviations Used

Concentration of chemical constituents
milligrams per liter (mg/L)

Specific conductance
micromhos per centimeter at 25° Celsius
(μmho/cm at 25°C)

National Geodetic Vertical Datum of 1929 (NGVD): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as "sea level" in this report.

GLOSSARY

Anisotropy: Condition of having different properties in different directions. With reference to hydraulic conductivity, it is the ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity.

Aquifer: A porous, water-bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.

Base flow: That part of the stream discharge that does not consist of direct runoff from precipitation or melting snow. It is usually sustained by water draining from storage in ground-water bodies, lakes, or swamps.

Cone of depression: A depression produced in a water table or other potentiometric surface by the withdrawal of water from an aquifer; in cross section, shaped like an inverted cone with its apex at the pumping well.

Confined aquifer: An aquifer surrounded by formations of less permeable or impermeable material.

Cubic feet per second: A unit expressing rate of discharge. One cubic foot per second is equal to the discharge of a stream 1 foot wide and 1 foot deep flowing at an average velocity of 1 foot per second.

Direct runoff: The runoff that enters stream channels by flow over and (or) through the ground without entering the main water table, or that part of the runoff directly associated with rainfall or snowmelt.

Drainage basin: The entire area that collects water and contributes it ultimately to a particular stream channel, lake, reservoir, or other body of water.

Drawdown: The lowering of the water table or potentiometric surface of an aquifer through the withdrawal of water from an aquifer by pumping; equal to the difference between the static water level and the pumping water level.

Effective porosity (of a rock or soil): The amount of interconnected pore space available for fluid transmission. It is expressed as a percentage of the total volume occupied by the interconnecting interstices.

Evapotranspiration: Water withdrawn from soil by evaporation and (or) plant transpiration.

Ground water: Subsurface water occupying the zone of saturation, from which wells and springs are fed. In a strict sense, the term applies only to water below the water table.

Ground-water discharge: The discharge of water from the saturated zone by (1) ground-water runoff and ground-water evapotranspiration, and (2) discharge through wells and other man-made structures.

GLOSSARY (continued)

Ground-water evapotranspiration: Ground water discharged into the atmosphere in the gaseous state either by direct evaporation or through transpiration by plants.

Ground-water recharge: Water descending from the atmosphere, through the soil, to the zone of saturation.

Ground-water runoff: That part of the runoff that consists of water that has passed into the earth and entered the zone of saturation, and has later been discharged into a stream channel as a spring or seepage. Ground-water runoff is the principal source of base flow (dry-weather flow) of streams unregulated by surface storage, and such flow is sometimes called ground-water flow.

Head, static: The height of the surface of a water column above a standard datum that can be supported by the static pressure at a given point.

Hydraulic conductivity: A measure of the ability of a porous medium to transmit a fluid. The material has a hydraulic conductivity of unit length per unit time if it will transmit in unit time a unit volume of water at the prevailing kinematic viscosity through a cross section of unit area, measured at right angles to the direction of flow, under a hydraulic gradient, or unit change in head over unit length of flow path.

Hydraulic gradient: The change in static head per unit of distance in a given direction. If not specified, the direction is generally understood to be that of the maximum rate of decrease in head.

Mean (arithmetic): The sum of the individual values of a set, divided by their total number. Also referred to as the "average."

Milligrams per liter: A unit for expressing the concentration of chemical constituents in solution by weight per unit volume of water.

Porosity: The ratio of the aggregate volume of interstices in a rock or soil to its total volume. It is usually stated as a percentage.

Precipitation: The discharge of water from the atmosphere, in either a liquid or solid state.

Runoff: That part of the precipitation that appears in streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels.

Saturated thickness: Thickness of an aquifer below the water table.

Saturated zone: The subsurface zone in which all open spaces are filled with water. The water table is the upper limit of this zone. Water in the saturated zone is under pressure greater than atmospheric.

GLOSSARY (continued)

Specific conductance: A measure of the ability of water to conduct an electrical current. A high value indicates a high concentration of dissolved minerals.

Specific yield: The quantity of water that a unit volume of permeable rock or soil, after being saturated, will yield when drained by gravity. It may be expressed as a ratio or as a percentage by volume.

Till: An unsorted, unstratified sediment deposited directly by a glacier and composed of boulders, gravel, sand, silt, and clay mixed in various proportions.

Transpiration: The process whereby plants release water vapor to the atmosphere.

Unconfined aquifer (water-table aquifer): One in which the upper surface of the saturated zone, the water table, is at atmospheric pressure and is free to rise and fall.

Water table: The upper surface of the saturated zone.

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By Deborah S. Snavely

ABSTRACT

The surficial sand aquifer of the Pine Bush in Albany County, N.Y., consists of very fine to medium sand and ranges in thickness from 5 to 150 feet. Hydraulic conductivity ranges from 65 to 70 feet per day. Finer grained silt and clay form the base of the aquifer, and discontinuous lenses of silt and clay are prevalent. In some places streams have removed the sand and are flowing in the underlying material.

Mean annual recharge, based on calculation of mean annual base flow, is estimated to be 12.7 inches. Precipitation is the only source of recharge, and approximately 38 percent of precipitation recharges the Pine Bush aquifer.

Depth to the water table is 10 to 15 feet in most of the Pine Bush and rarely exceeds 20 feet. Seasonal variation of depth to water from March 1979 through March 1981 averaged 2.4 feet at all observation wells except those near ponds, where water levels are more constant. Total precipitation has been declining since 1979; this is reflected in a decline of the water table, which was as much as 2.49 feet lower in 1981 than in 1979.

A computer model was used to simulate the drawdown that would be produced by a pumping well tapping the center of the surficial aquifer. Results indicate that a single production well could yield between 150 and 600 gallons per minute (216,000 to 864,000 gallons per day), depending on aquifer characteristics at the site. Hydraulic-conductivity values of 25, 50, and 100 feet per day were simulated, allowing a maximum drawdown of 80 percent of saturated thickness.

Streams and ground water were analyzed for a variety of constituents, especially phosphorus, nitrogen, and chloride. The highest phosphorus concentration in ground water was 0.02 mg/L (milligrams per liter) and in streams was 0.09 mg/L. The highest nitrogen (nitrite plus nitrate) concentration in ground water was 7.7 mg/L and in streams was 2.0 mg/L. Chloride concentrations ranged from 1.1 to 340 mg/L in ground water and from 26 to 150 mg/L in streams. The stream samples were collected during base-flow conditions, when the streamflow consisted entirely of ground-water discharge.

INTRODUCTION

Increasing residential and commercial development in the Pine Bush, between the cities of Albany and Schenectady, has prompted interest in the ground-water reserves of the area. The Pine Bush is covered by lacustrine sand that has locally been blown into dunes. This sand forms the water-table aquifer, which is the subject of this investigation.

To document the ground-water reserves, the U.S. Geological Survey began a study in 1979 in cooperation with the city of Albany to quantify the amount of ground water available from the surficial sand aquifer and to assess the chemical quality of ground water and surface water, especially with respect to phosphorous, nitrogen, and chloride. The purpose of the water-quality assessment was to determine whether the aquifer or streams have been contaminated by road salt, landfill leachate, or septic effluent.

Estimates of ground-water quantity were obtained from test-well drilling and pumping tests to determine the aquifer's properties and, through use of a digital simulation model of the hydrologic system, to evaluate drawdowns that would be produced by various pumping rates. Data on chemical quality of ground water and surface water were obtained through a program of sampling and laboratory analysis.

Purpose and Scope

This report describes geohydrologic properties of the Pine Bush surficial sand aquifer and presents data on the water quality. It also describes how the ground-water simulation model was used to estimate the maximum pumpage that the aquifer could sustain without excessive water-table drawdowns.

Previous Studies

A comprehensive discussion of the geology and depositional environments of the Pine Bush is given by Dineen (1982). Numerous other reports on the geology, ecology, and land uses of the Pine Bush have been published; those pertinent to the hydrology of the area are listed in the section "References Cited."

Acknowledgments

Thanks are extended to Robert J. Dineen of the New York State Geological Survey for running resistivity and seismic profiles to define the geology of the Pine Bush area. His results were published by the New York State Museum and Science Service (1982). Thanks are also extended to Thomas Reilly, David Prudic, and Edwin Weeks of the U.S. Geological Survey for technical assistance in developing the ground-water model.

DESCRIPTION OF AREA

The Pine Bush is a 40-mi^2 area between Albany and Schenectady, N.Y. (fig. 1). The area studied encompasses the central 32 mi^2 of the Pine Bush (fig. 2).

The Pine Bush takes its name from the pitch pine and scrub oak that cover its numerous sand dunes and swamps. It is actually a small segment of a dune field that extends from South Glens Falls to Delmar (Dineen, 1975) (fig. 1). The dunes developed on the bed of a former glacial lake that extended from Glens Falls to Newburgh (fig. 1) about 20,000 years ago (Connally, 1972). The blanket of dunes forms a gently rolling terrain with deeply incised stream valleys.

Most streams within the Pine Bush originate in nearby marshy areas and together form a dendritic drainage pattern (fig. 3). The northernmost streams, such as Lisha Kill and Shakers Creek, drain to the Mohawk River; the southern streams are tributary to the Normans Kill and the Hudson River.

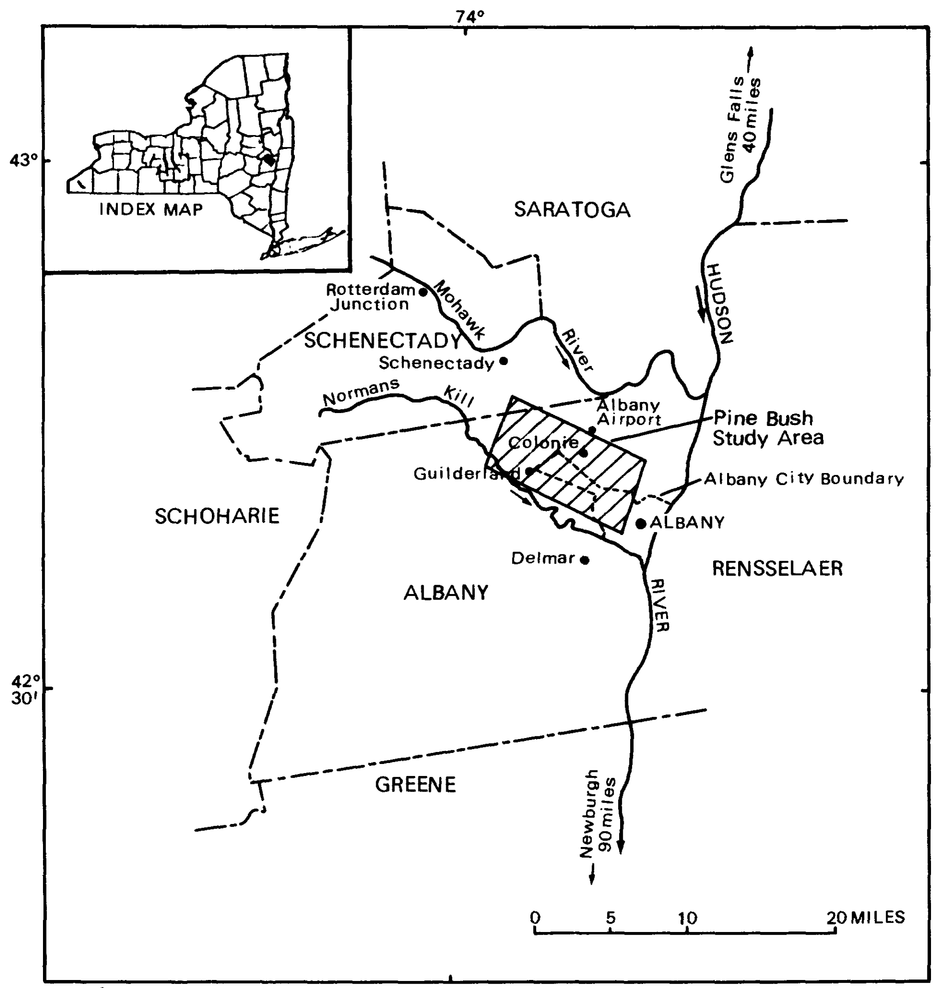


Figure 1.--Location of the Pine Bush, Albany County, N.Y.

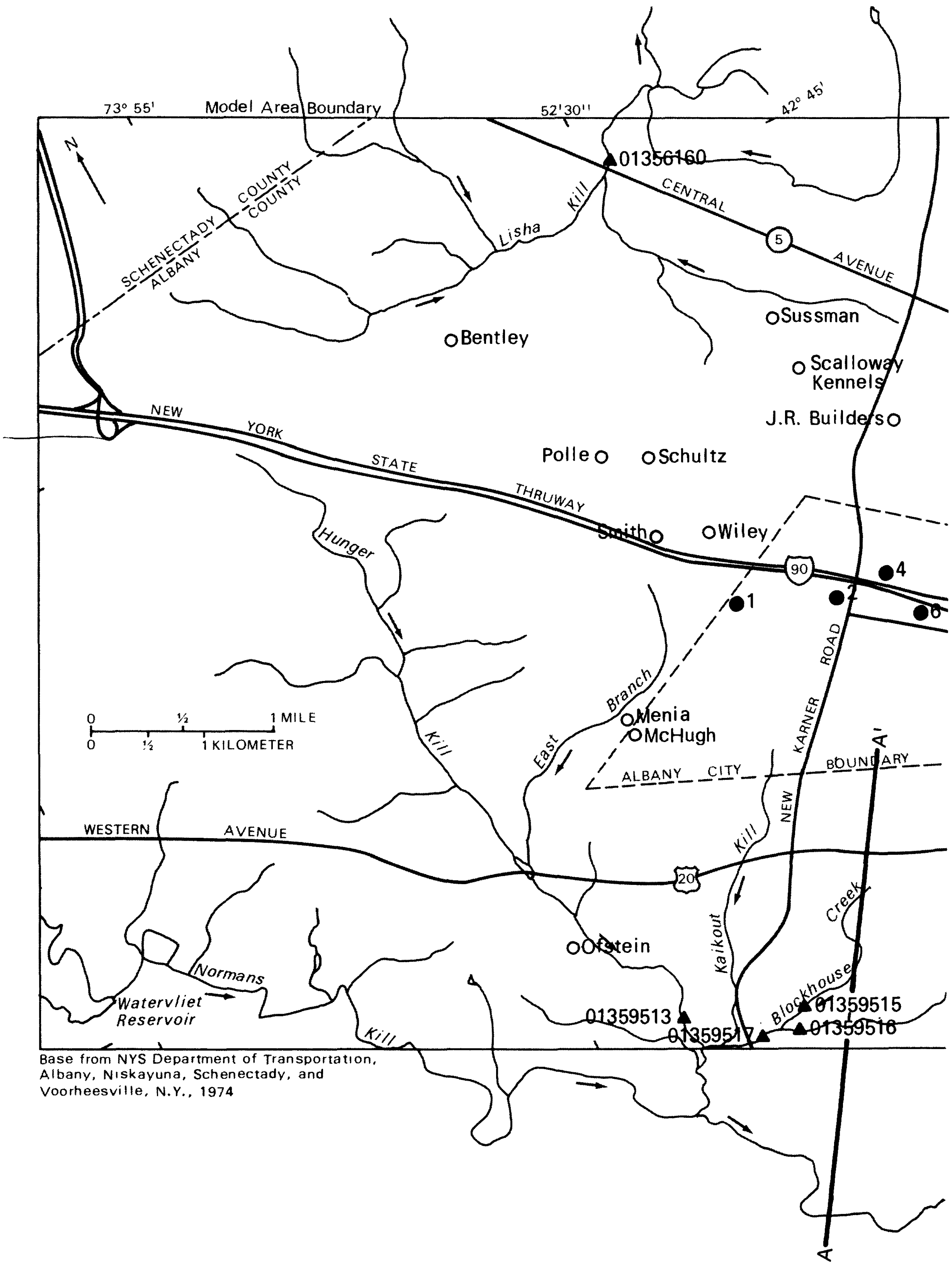


Figure 2.--Geographic features of modeled area and location of

The climate of the Pine Bush is typical of upstate New York. The average January temperature is 24°F, the average July temperature is 72°F (Dineen, 1975). Precipitation averages 37 in/yr, with maximum monthly means in June, July, and August (Arnow, 1949).

Several major highways cross the Pine Bush area; for example, the New York State Thruway (I-90), the Adirondack Northway (I-87), and Washington Avenue Extension (fig. 3). These roads connect the metropolitan areas and have promoted residential and commercial development by providing access. Pressure for increased development prompted the city of Albany to investigate the ground-water reserves and the water quality.

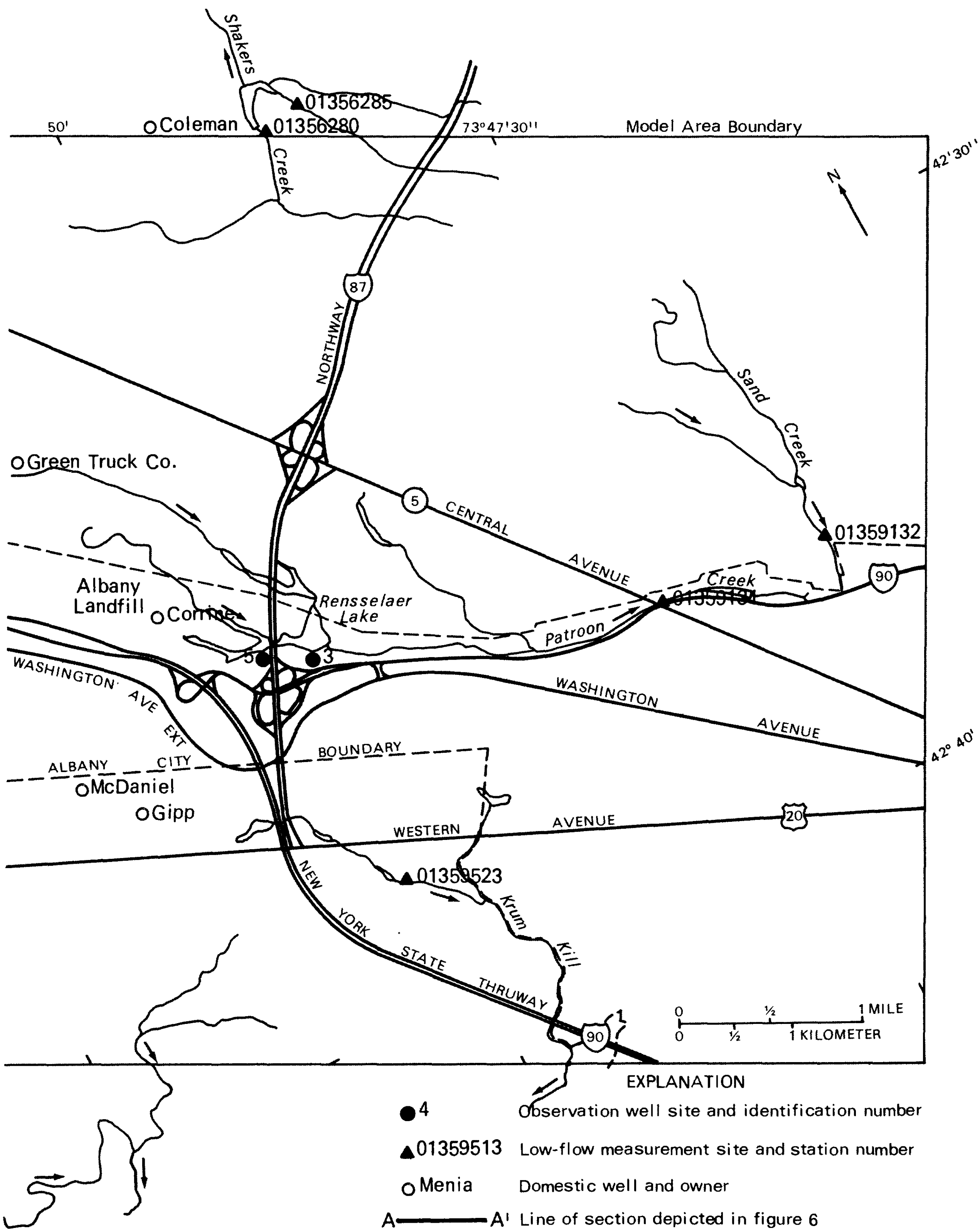
METHODS OF INVESTIGATION

All borehole, test-well, and well-log data available from Arnow (1949) and the New York State Geological Survey were compiled and analyzed to determine the extent and thickness of the aquifer. Six sites were chosen for drilling where the saturated sand was likely to be thickest. Single and multiple observation wells were installed with an 8-in. auger. Split-spoon samples were collected at 5-ft intervals, and grain-size analyses were made on nine of the samples. Two-in.-diameter polyvinylchloride (PVC) pipe was installed in each hole with continuous-slot PVC screen at the bottom. All but one well had 4 ft of screen; the exception (site 2) had 2 ft of screen. Each site was assigned a number, and each well within the site was designated by letter. Data on site and well numbers, land-surface altitude, geologic logs, dates of well completion, water level, and the screened interval of each well are given in table 6 (at end of report); site locations are indicated in figures 2 and 3.

In addition, a test well with 6-in. steel casing and 5 ft of stainless steel screen was installed at site 4 and site 6. The well at site 4 was installed by hydraulic rotary; the one at site 6 by cable tool. These sites were chosen for test drilling because they had the thickest sections of saturated sand. An observation well was installed 10 ft from each test well, and two pairs of observation wells were installed at greater distances (fig. 4). One well of each pair was screened at the top of the aquifer, the other at the base, to compensate for the effects of partial penetration during pumping tests. Each test well was developed by pumping 40 gal/min for a minimum of 4 hours. Figure 4 illustrates the relative positions of the test wells and observation wells at sites 4 and 6.

A 24-hour pumping test was made at sites 4 and 6 by pumping the 6-in. wells, and water-level measurements were made during both pumping and recovery. The drawdown data were used to calculate the hydraulic conductivity and specific yield of the aquifer. In addition, grain-size analyses were made on nine split-spoon samples to ensure that the aquifer characteristics calculated from the aquifer-test data were consistent with the grain-size distribution.

Water levels in all 17 observation wells and the two test wells were measured weekly from the time of well completion until January 1980 and were measured monthly through 1981. The test well at site 6 is equipped with a continuous analog recorder. The land-surface altitude and the top of the casing were also measured, so that the head at each well could be determined.



observation wells and stream low-flow measurement sites.

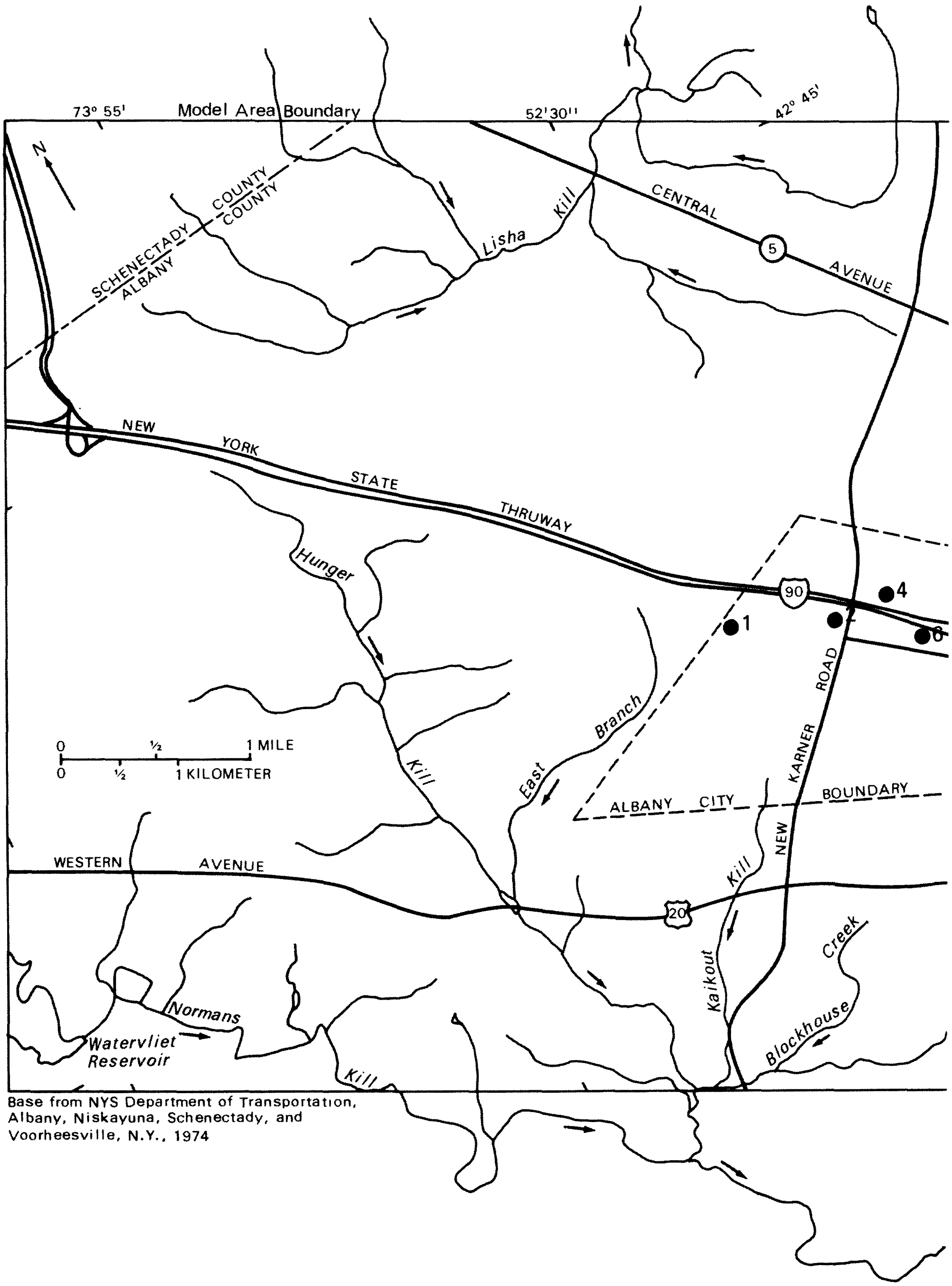
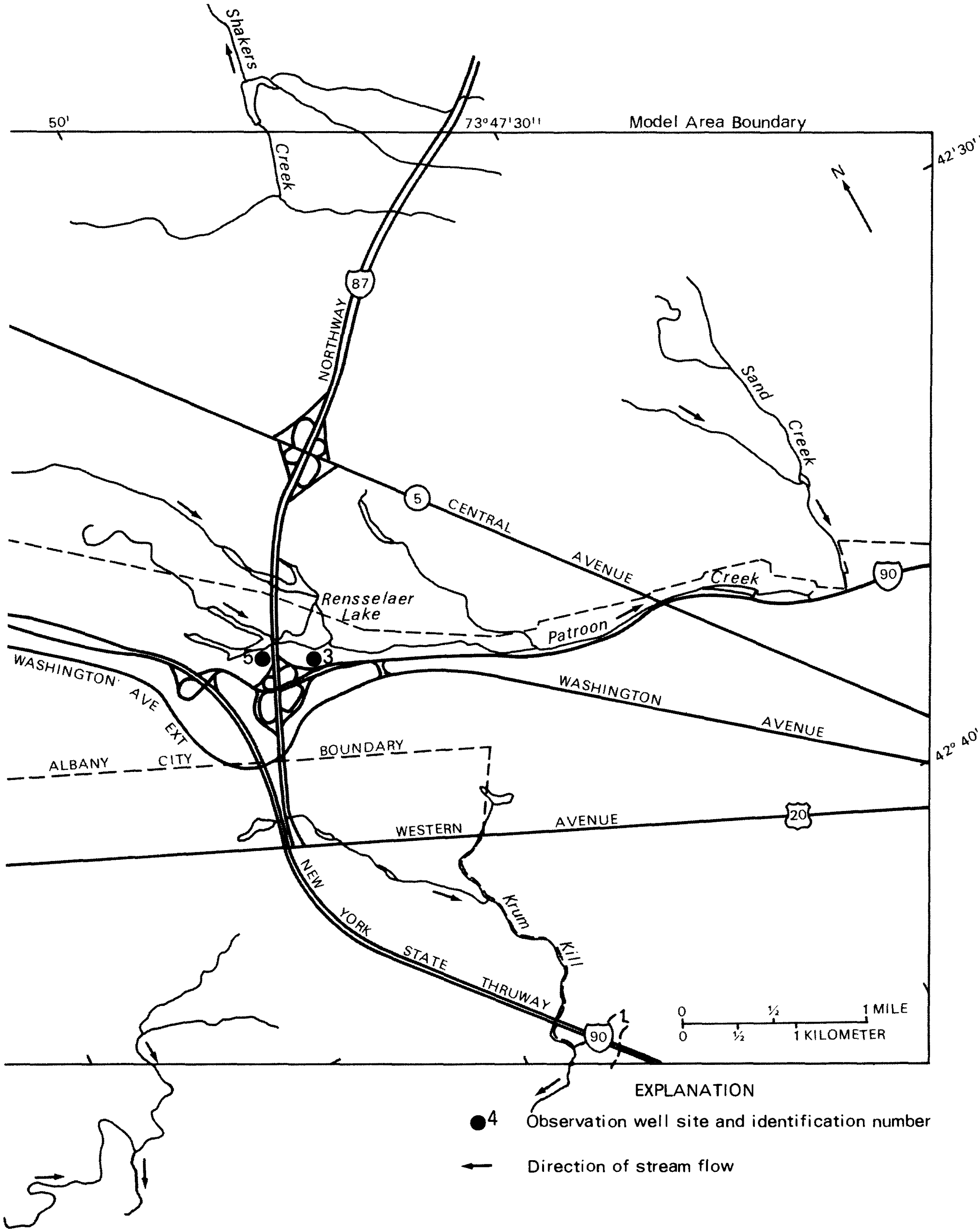


Figure 3.--Major geographic features



and streams of Pine Bush area.

Low-flow measurements were made on nine streams to determine base flow. Locations of streamflow-measurement sites are indicated in figure 2.

A total of 77 water samples were collected from private domestic wells, observation wells, and streams and were analyzed for chloride, nitrogen, and phosphorus; 27 of the samples were also analyzed for sodium, calcium, magnesium, and potassium. In addition, 14 observation-well samples were collected and analyzed for chloride only. Results of these analyses are given in tables 4 and 5 (p. 28, 29) and tables 7-9 (p. 40-47).

To aid in delineating the extent of confining layers and the depth to bedrock, 27 resistivity lines and 12 seismic survey lines were run and analyzed by the New York State Geological Survey. Results are summarized in Dineen (1982).

The hydrologic and geologic information were used to design a ground-water simulation model to estimate the maximum pumpage the aquifer could sustain without producing water-table drawdowns greater than 80 percent of the saturated thickness if one pumping well were installed at a specific location. The computer program used was written by Trescott, Pinder, and Larson (1976).

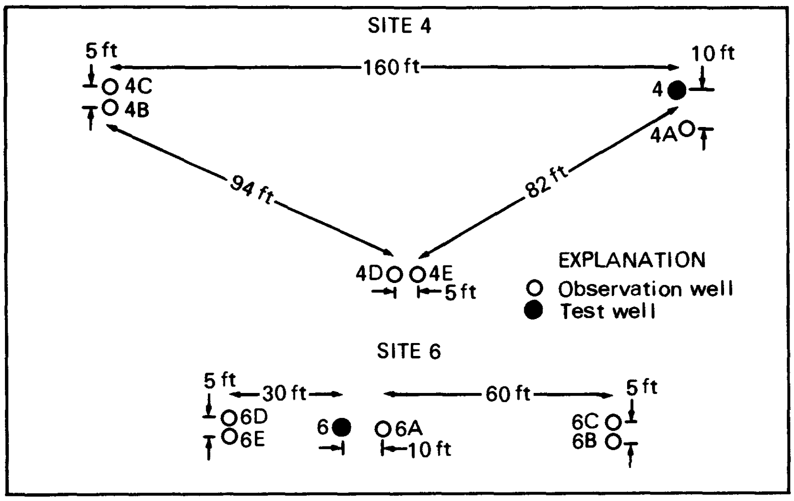


Figure 4.--Diagram showing distribution of observation wells at sites 4 and 6. (Locations are shown in fig. 2).

GEOLOGY

The Pine Bush is covered by dunes of light yellow-brown to light gray very fine to medium sand that ranges in thickness from 5 to 150 ft (Dineen, 1979). This sand was deposited by the "Glaciomohawk River," which built a large delta into glacial Lake Albany (LaFleur, 1976). Later, as the lake drained, the sand was reworked by wind and streams and is now well sorted throughout the Pine Bush. Figure 5 presents the results of grain-size analyses made on split-spoon samples from three sites; the data indicate that the grain sizes and degree of sorting are similar among the three sites.

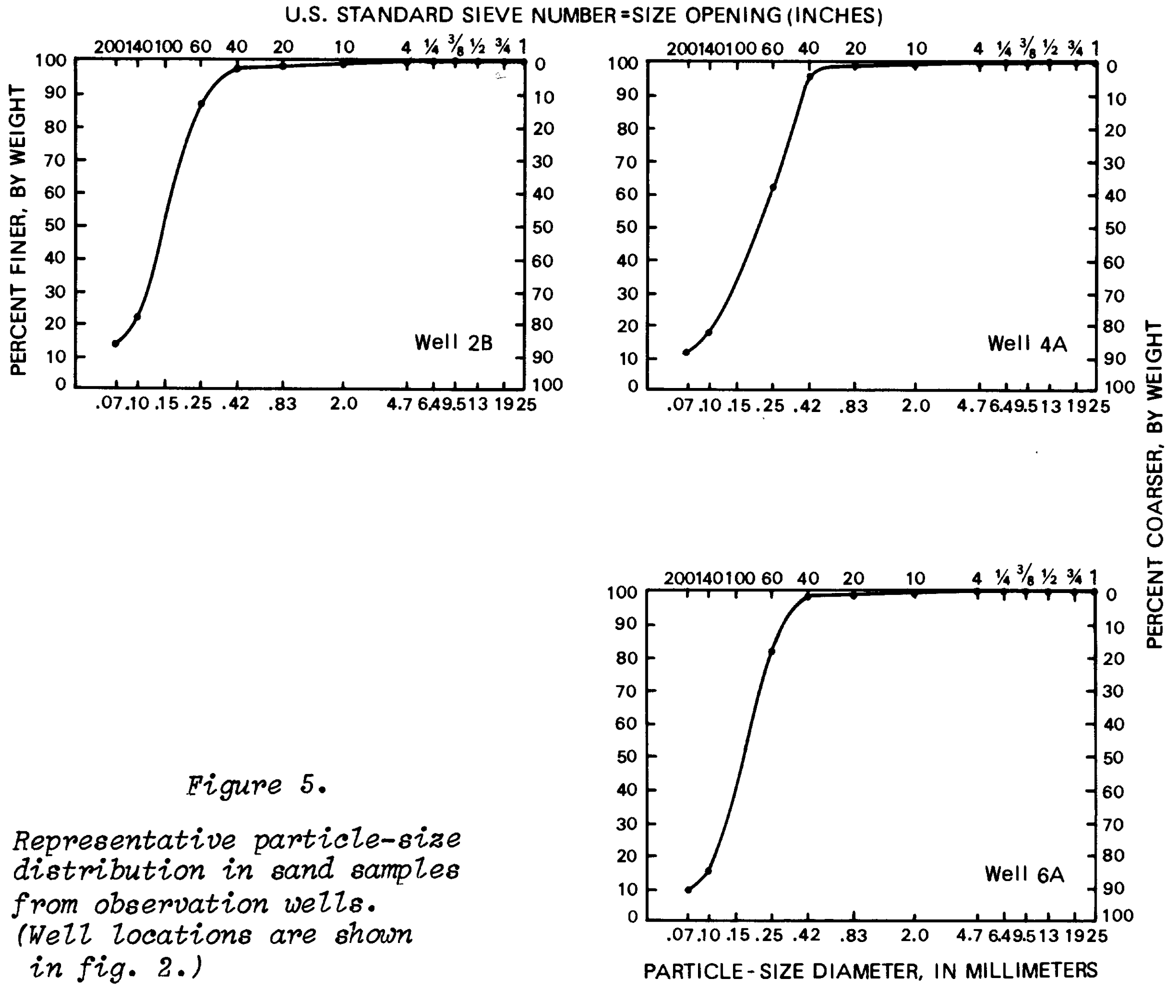


Figure 5.

Representative particle-size distribution in sand samples from observation wells. (Well locations are shown in fig. 2.)

In many places, wind-blown and lake sand grades downward into finer grained silt and clay that form the base of the sand unit (Dineen, 1979); this gradual transition makes the base of the sand aquifer difficult to define at some locations, such as site 6. At other locations, however, such as site 5, the lake clay forms a distinct lower boundary. Layers of silt are also scattered throughout the sand (Dineen, 1979). The wind-blown and lake sand blankets the entire area except along modern flood plains, where streams have eroded through the sand, exposing the silt and clay.

The lacustrine deposits are underlain by glacial deposits in preglacial river channels (Dineen, 1975, 1976, 1977). These deposits contain varying amounts of silt, till, sand, and coarser material and are overlain by silt and clay except in a few small areas where they are at or near land surface (Dineen, 1979). These lower glacial deposits are rarely in hydraulic contact with the surface sand and are not included as part of the aquifer system studied. Figure 6 is a cross section depicting the relationship between the surficial sand, the lake silt and clay, and the modern stream channels. Although part of this cross section extends south of the area studied, it is representative of the geologic units and streams of the Pine Bush. Some stream channels are incised in silt and clay where the sand is missing, such as along the Normans Kill and the South Branch of Blockhouse Creek; others fully penetrate the sand, as on the northernmost branch of Blockhouse Creek. Still others flow through the sand without fully penetrating it (not shown on the cross section).

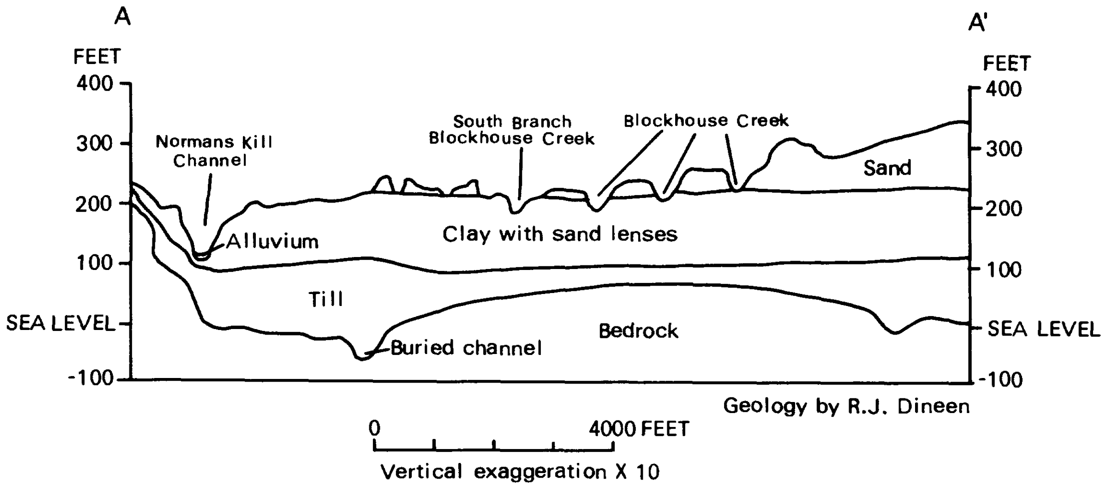


Figure 6.--Generalized geologic section of Pine Bush.

HYDROLOGY

Recharge

The surficial sand aquifer is recharged solely from precipitation, which is distributed uniformly over the area. Part of the precipitation becomes direct runoff to streams; the rest infiltrates into the soil. Of the water that enters the soil, some reaches the water table and recharges the aquifer; the rest is returned to the atmosphere through evapotranspiration. Precipitation and direct runoff may be measured easily, but evapotranspiration is relatively difficult to measure; therefore, recharge is generally calculated from other data. If discharge out of the modeled area is assumed to equal inflow into it (ground-water pumpage is negligible), recharge may be calculated from the following relationship:

Recharge = Base flow $\pm$ change in ground-water storage.

In general, storage increases or decreases seasonally, but over several years tends to balance out. For this reason, the mean discharge values of streams at base flow were used to estimate recharge.

Twelve base-flow measurements were made during 1978-80 at each of 10 sites (9 streams) within the study area (fig. 3). The Hunger Kill gaging station at Guilderland has 10 years (1968-77) of daily stream-discharge record; the 12 base-flow measurements at the other 9 sites were correlated with concurrent base-flow measurements at the Hunger Kill gage through linear regression. Regression equations were developed and used in conjunction with estimated monthly mean base flows at the Hunger Kill site to determine the monthly mean base-flow values (table 1). Monthly mean base flows at the Hunger Kill gage were estimated from hydrographs of the 10-year period of record; mean annual base-flow values were computed from the monthly values.

Mean annual base flow was computed to be 12.7 in. (30.4 ft^3/s). Mean annual (normal) precipitation (base period 1941-70) at the National Oceanic and Atmospheric Administration's station at Albany County Airport is 33.4 in. (79.7 ft^3/s). Therefore, approximately 38 percent of precipitation recharges the Pine Bush aquifer. Considering the high permeability of the soil and the significant amount of vegetation, this estimate seems reasonable.

Ground-Water Movement and Discharge

The water table in much of the Pine Bush area is 10 to 15 ft below land surface; depth to water rarely exceeds 20 ft. From March 1979 through March 1981, the seasonal fluctuation in depth to water was 2.4 ft at all observation wells except 3A and 5A (fig. 2), where it was only 0.3 ft; these wells maintain a more constant water level because of their proximity to Rensselaer Lake.

Hydrographs for wells 4A, 5A, and 6A (fig. 7) reflect a declining trend in water level during 1980-81. The highest recorded water level well 4A in 1979 was 14.60 ft below land surface; the highest in 1980 was 16.90 ft below land surface; and the highest in 1981 was 18.90 ft below land surface. At well 6A the highest recorded level in 1979 was 1.08 ft higher than in 1980 and 2.49 ft higher than in 1981. Although the water level in well 5A fell slightly during 1979-81, the fluctuations in this well are only slight because the water level in Rensselaer Lake stabilizes the water level in the aquifer near its periphery.

Because the aquifer is recharged by precipitation, the water levels respond directly to total precipitation. Table 2 lists total annual precipitation at the nearby Albany County airport during 1975-80 and monthly precipitation during January-March 1981. Except for a slight increase in 1977 and a moderate increase in 1979, total precipitation has been decreasing since 1975, and water levels are declining in response. This decline may be only relative, however. Because water-level measurements were started in 1979, when rainfall was higher than normal, water levels may have been abnormally high and may have been returning to normal levels since then.

The water table roughly parallels the land surface, although local variations may alter the direction of flow. Figure 8 is a generalized water-table map; direction of flow is perpendicular to the lines of equal head. Ground water flows downgradient, and, where the aquifer is dissected by stream channels, ground water flows into the channels. All the streams receive ground water and, during periods without precipitation or direct runoff, are sustained entirely by ground-water inflow.

Table 1.--Monthly and annual mean base flow of Pine Bush streams, Albany County, N.Y.

[Values are in cubic feet per second; locations are shown in fig. 2.]

Station Number	Station Name	Drainage Area (mi^2)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Annual Mean	Annual mean [(ft^3/s)/mi^2]
01356160	Lisha Kill at Maywood	9.64	2.65	3.53	3.92	3.41	3.44	5.22	6.07	5.02	3.41	2.46	1.88	1.85	3.57	0.37
01356280	Shakers Creek near Colonie	2.76	0.92	1.12	1.21	1.09	1.10	1.50	1.69	1.46	1.09	0.88	0.74	0.74	1.13	0.41
01356285	Shakers Creek Tributary at Colonie	0.61	0.31	0.45	0.51	0.43	0.44	0.72	0.85	0.69	0.43	0.28	0.19	0.18	0.46	0.75
01359131	Patroon Creek at Central Avenue, Albany	7.37	6.95	8.08	8.58	7.93	7.98	10.2	11.3	10.0	7.94	6.72	5.95	5.93	8.13	1.10
01359132	Sand Creek at Sand Creek Road, Albany	2.79	2.32	2.54	2.64	2.51	2.52	2.96	3.18	2.91	2.51	2.27	2.12	2.12	2.55	0.91
01359513	Hunger Kill at Guilderland	8.16	9.25	10.4	10.9	10.2	10.3	12.6	13.7	12.3	10.2	9.01	8.24	8.22	10.44	1.28
01359515	Blockhouse Creek at Westmere	1.19	1.06	1.13	1.16	1.12	1.13	1.27	1.34	1.25	1.12	1.05	1.00	1.00	1.14	0.96
01359516	South Branch Blockhouse Creek at Westmere	0.77	0.34	0.40	0.43	0.39	0.40	0.52	0.59	0.51	0.39	0.33	0.28	0.28	0.41	0.53
01359517	Blockhouse Creek near Guilderland	1.96	1.58	1.77	1.85	1.74	1.75	2.12	2.29	2.08	1.74	1.54	1.42	1.42	1.78	0.91
01359523	Krum Kill Tributary at Albany	1.43	1.26	1.47	1.56	1.44	1.45	1.87	2.08	1.83	1.44	1.21	1.07	1.06	1.48	1.04

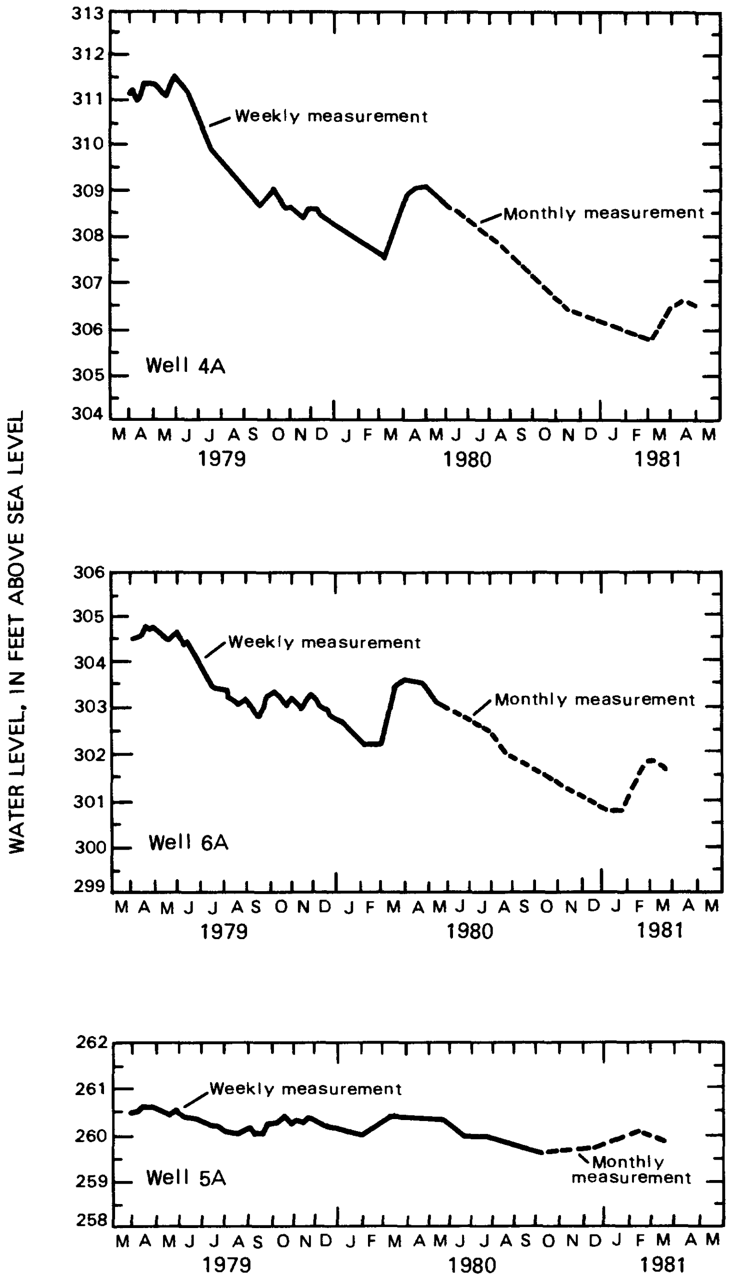


Figure 7.

Hydrographs of observation wells 4A, 5A, and 6A, March 1979 to March 1981. (Locations are shown in fig. 2.)

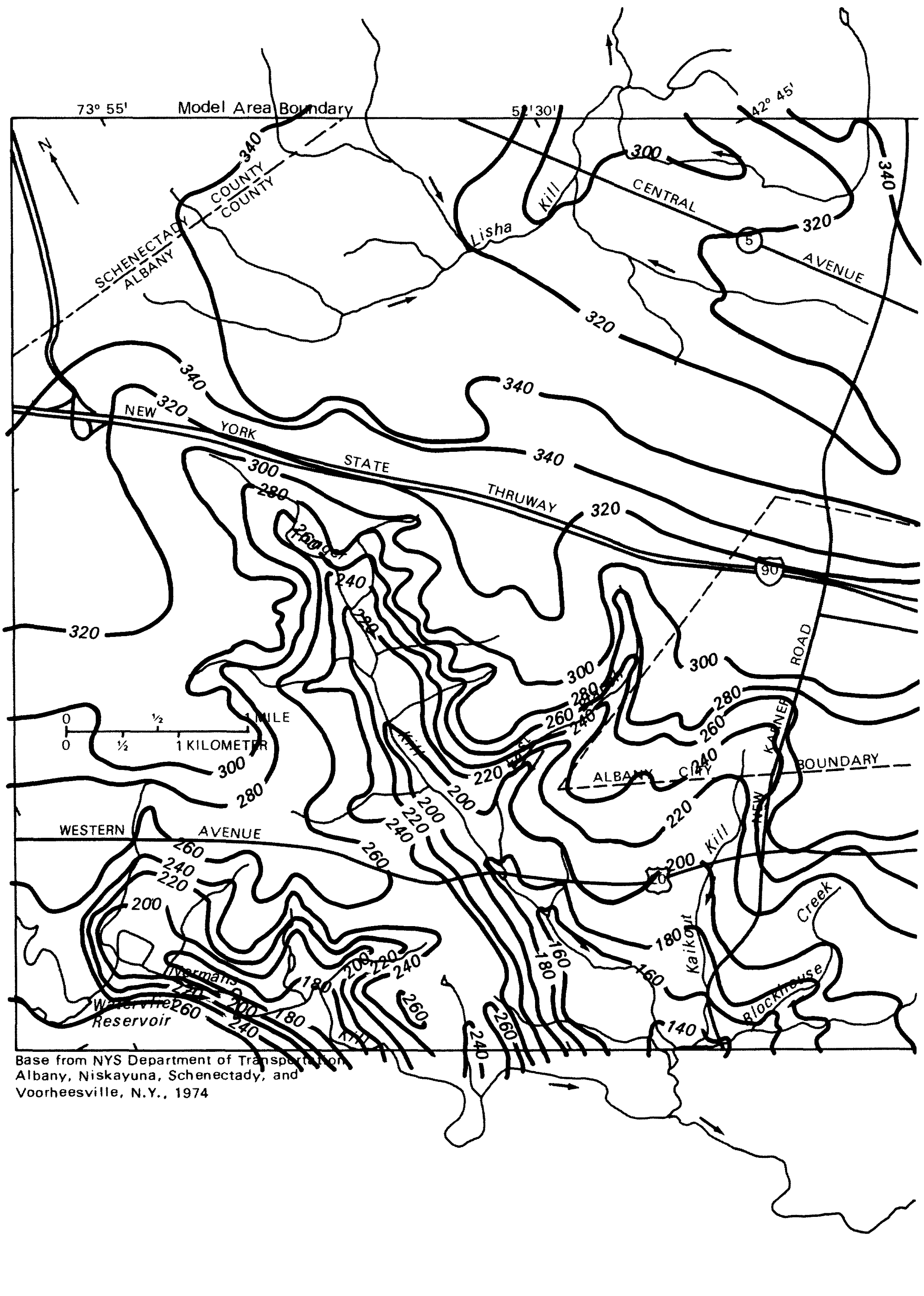


Figure 8.--Generalized water-table map of Pine Bush.

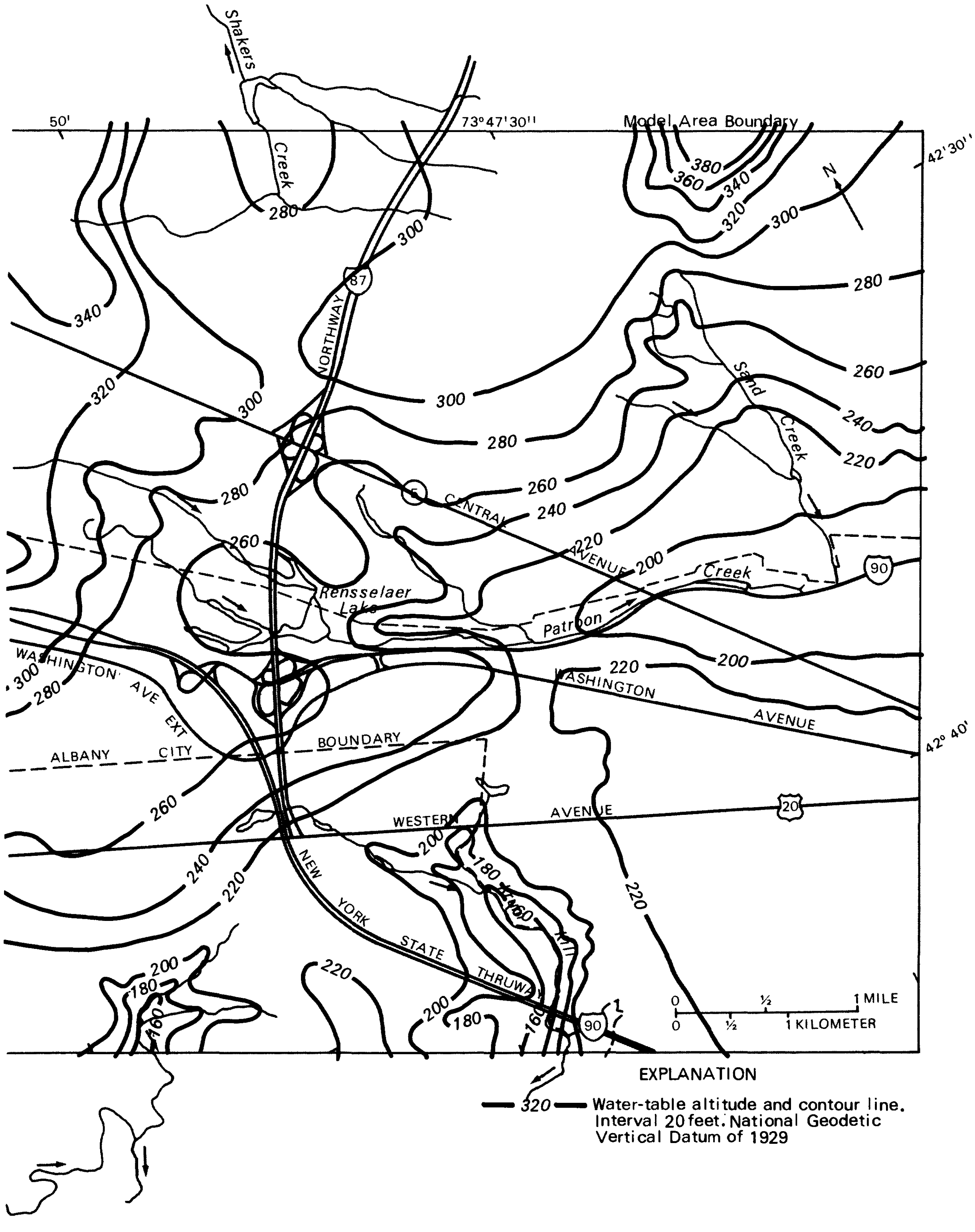


Figure 8.--Generalized water-table map of Pine Bush. (continued)

The interaction between ground water and surface water is governed by the material through which the surface water is flowing. Rensselaer Lake (fig. 2) intersects the aquifer, so that the lake level and the water level in the aquifer coincide. In contrast, the Hunger Kill flows in silt, clay, and alluvium below the aquifer and is not in direct hydraulic contact with it; therefore, water from the aquifer enters the stream only as seepage through the silt-clay unit (fig. 6). All streams in the southern part of the area (Hunger Kill, Kaikout Kill, Krum Kill, and most of Blockhouse Creek) are sustained by seepage through the clay; Patroon Creek, Lisha Kill, Shakers Creek and Sand Creek are fed directly by the surficial sand.

Table 2.--Total annual precipitation and departure from normal at Albany County Airport, in inches.

[Data from Climatological Data, annual summaries, National Oceanic and Atmospheric Administration]

Year		Total precipitation	Departure from normal
1975		47.05	+13.69
1976		42.54	+9.18
1977		44.30	+10.94
1978		33.46	+0.10
1979		37.14	+3.78
1980		32.59	-1.23
1981			
	January	0.59	-1.61
	February	5.02	+2.91
	March	0.26	-2.32

Aquifer Characteristics

The primary factors that describe how much water an unconfined aquifer contains and its ability to transmit water are its hydraulic conductivity, specific yield, and saturated thickness. The surficial aquifer ranges from 5 to 150 ft and averages about 40 ft in saturated thickness. The aquifer thins or disappears near streams that have cut through the sand and into underlying clay and is thickest in the northwestern and central parts of the Pine Bush.

Horizontal hydraulic conductivity was calculated by analyzing the drawdown data from aquifer tests at sites 4 and 6 (fig. 2). An estimate was obtained through a computer program by Edwin Weeks (U.S. Geological Survey, written commun., 1980). The program is a finite-difference approximation that simulates drawdown in an aquifer radially from a pumped well; the values of vertical conductivity and specific storage are supplied to the program, as is anisotropy, expressed as the ratio of horizontal to vertical hydraulic conductivity. The pumping well is introduced, and values of drawdown at various distances and depths from the well at several time increments are generated. The program simulates two-dimensional radial flow and accounts for partial penetration as well as water released from lowering of the water table. Various values of hydraulic conductivity, specific storage, and anisotropy are used until the drawdowns observed in the pumping tests are duplicated by the computer program. The best match was produced with a hydraulic-conductivity value of 65 ft/d at test well 6 and 70 ft/d at test well 4. These values agree with those that would be expected from the particle-size distribution of the aquifer material (fig. 5).

Specific yield is equal to the effective porosity of an unconfined (water-table) aquifer. For sand, specific yield is generally 0.1 to 0.2. However, the pumping test analyses for site 4 and 6 resulted in values of 0.0012 and 0.008, respectively, which are more characteristic of a confined aquifer. According to Weeks (U.S. Geological Survey, written commun., 1981), low values of specific yield may result if, during pumping, the water table declines through zones of finer grained material. It is apparent from the geologic logs of site 4 (table 6, p. 33) and resistivity and seismic analyses that such zones are prevalent; also, although the silt layers are thinner at site 6 than at site 4, the aquifer contains silt and clay lenses throughout. Thus, the derived value for specific yield is not representative of the sand.

DESCRIPTION AND APPLICATION OF DIGITAL MODEL

Model Characteristics

The digital model used to simulate drawdowns produced by a pumping well in the Pine Bush surficial aquifer was developed by Trescott, Pinder, and Larson (1976). This model can simulate the two-dimensional flow of water in an unconfined aquifer with irregular boundaries. The area to be modeled is divided into rectangular blocks to which appropriate values representing the aquifer properties are applied. The aquifer properties for each block are averaged over each block. From the assigned hydrologic boundaries and aquifer characteristics, the model generates water-level values that would result from a stress applied to the system such as pumping at specific sites.

The model may be used to calculate either absolute heads (water-table altitudes) or drawdowns. Because the objective of this study was to calculate the drawdowns a well would impart and to determine the maximum pumpage the aquifer could withstand without excessive drawdowns, the latter approach, changes in water level, was taken. This approach generates a range of pumping rates that could be achieved from a reasonable range of hydraulic-conductivity values in the Pine Bush study area.

Assumptions

To simulate the system mathematically, the following simplifying assumptions were made:

1. The Pine Bush surficial sand aquifer is a homogeneous, porus medium.

2. The aquifer is unconfined and bounded at the base by less permeable silt and clay. (This assumption is valid because the aquifer is semiconfined only locally.)

3. The aquifer is horizontally isotropic with respect to hydraulic conductivity. Flow is two dimensional, with the vertical flow component negligible compared to the horizontal component.

4. Density of water is constant in time and space.

5. Flow is according to Darcy's Law.

6. Water is discharged from the aquifer by wells and leakage to streams. All streams are gaining (receiving water from the surrounding material).

7. The streams and seeps may be treated as fully penetrating the aquifer because they are sufficiently distant from the effects of pumping.

Grid Configuration and Boundaries

Boundaries must be fully defined to simulate a ground-water system. If the aquifer has no natural boundary, the model boundary must be established far enough from the area of interest that the effects of localized stresses on the system will not have a significant effect on the water levels near the boundary.

The boundaries of the system were considered as either constant head or constant flux. Constant-head boundaries were used where streams and seeps border the modeled area; this occurs along the entire western border, most of the northern and southern borders, and part of the eastern border (fig. 9). The use of constant-head boundaries assumes that the streams and seeps are far enough away from the pumping center that they will not be pumped dry.

A constant-flux boundary may be finite or zero flux; this study used only zero-flux (no-flow) boundaries. By assigning a value of zero to the hydraulic conductivity outside the boundary, flux across the boundary is zero. This type of boundary was used along the ground-water divides on the north and east edges and along the southern border, where the aquifer thickness becomes zero (fig. 9).

The ground-water system was simulated by a rectangular finite-difference grid with 24 rows and 43 columns representing an area of 32.42 mi^2. Variable grid spacing was used so that areas of greater interest and density of information could be defined in greater detail than other areas. The length and width of each block ranged from 500 to 2,000 ft. The ratio of the dimension of one block in any of the four directions to the same dimension of an adjacent block was not greater than 1.5. The theoretical center of each block is a node. The result was a node-centered finite-difference grid with variable grid spacing.

Each node represents a volume of aquifer material through which water is flowing. This volume is described as:

$$b\Delta x\Delta y$$

Where: b = saturated thickness of aquifer (L);

Δx = length of the block in the x-direction (L), and

Δy = length of the block in the y-direction (L).

Figure 9 depicts the grid configuration, node types, and boundary types.

Model Simulations

The blocks in the finite-difference grid were assigned values for each aquifer property. The initial conditions were as follows:

1. the average saturated thickness of each block was assigned to the node, with an initial drawdown of zero;

2. the well was simulated as fully penetrating, and

3. the actual drawdown in the pumping well was estimated from the Thiem formula, as documented by Trescott and others (1976).

A series of model runs was made, each with a different uniform value of hydraulic conductivity. A single 6-in-diameter well was simulated in the central region of the model, as shown in figure 9. Beginning with a hydraulic conductivity of 25 ft/d, simulated pumpage from the well was increased until the drawdown reached 80 percent of the saturated thickness of the aquifer (a drawdown of about 50 ft). The basic assumption is that a drawdown of 80 percent of the saturated thickness is the maximum allowable drawdown and hence indicates the maximum allowable pumpage. The procedure was repeated with hydraulic conductivities of 50 ft/d and 100 ft/d. Hydraulic conductivity values of 25, 50, and 100 ft/d were chosen because they represent the range of values that may be expected in the surficial sand. Table 3 presents the results of the model simulations; the graph in figure 10 illustrates the results. The model simulations indicate that at a continuously pumped well, the aquifer could supply from 150 to 600 gal/min (daily yield 216,000 to 864,000 gal/d), depending on hydraulic conductivity.

Although these derived values of potential yield apply only to the given well characteristics, well location, and hydraulic conductivity, they are a general indication of well yields available from the Pine Bush aquifer. The maximum pumpage that a particular site could support could be determined by incorporating the specific characteristics of that location and well installation and rerunning the model, provided that the well is an appropriate distance from the model boundary.

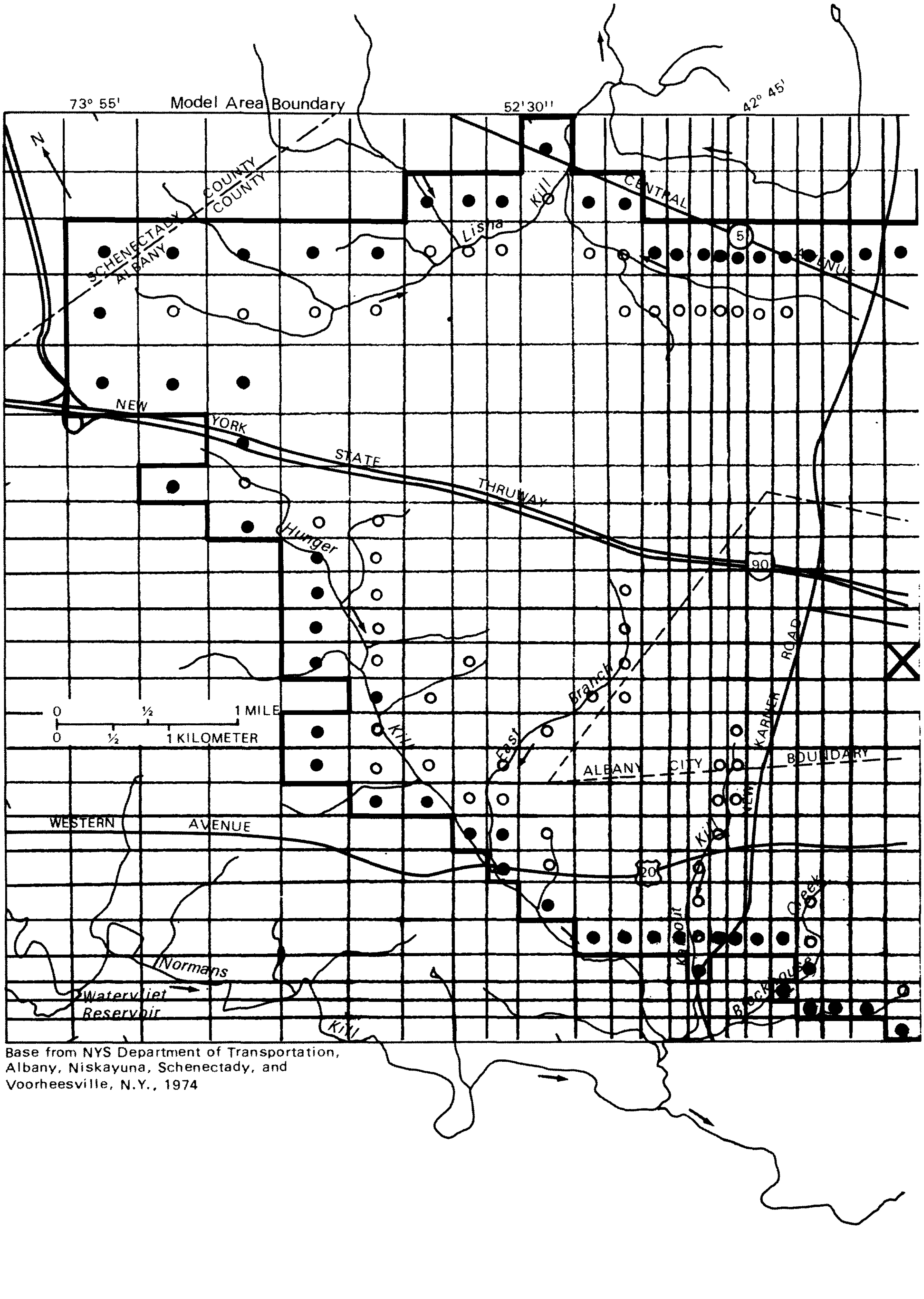
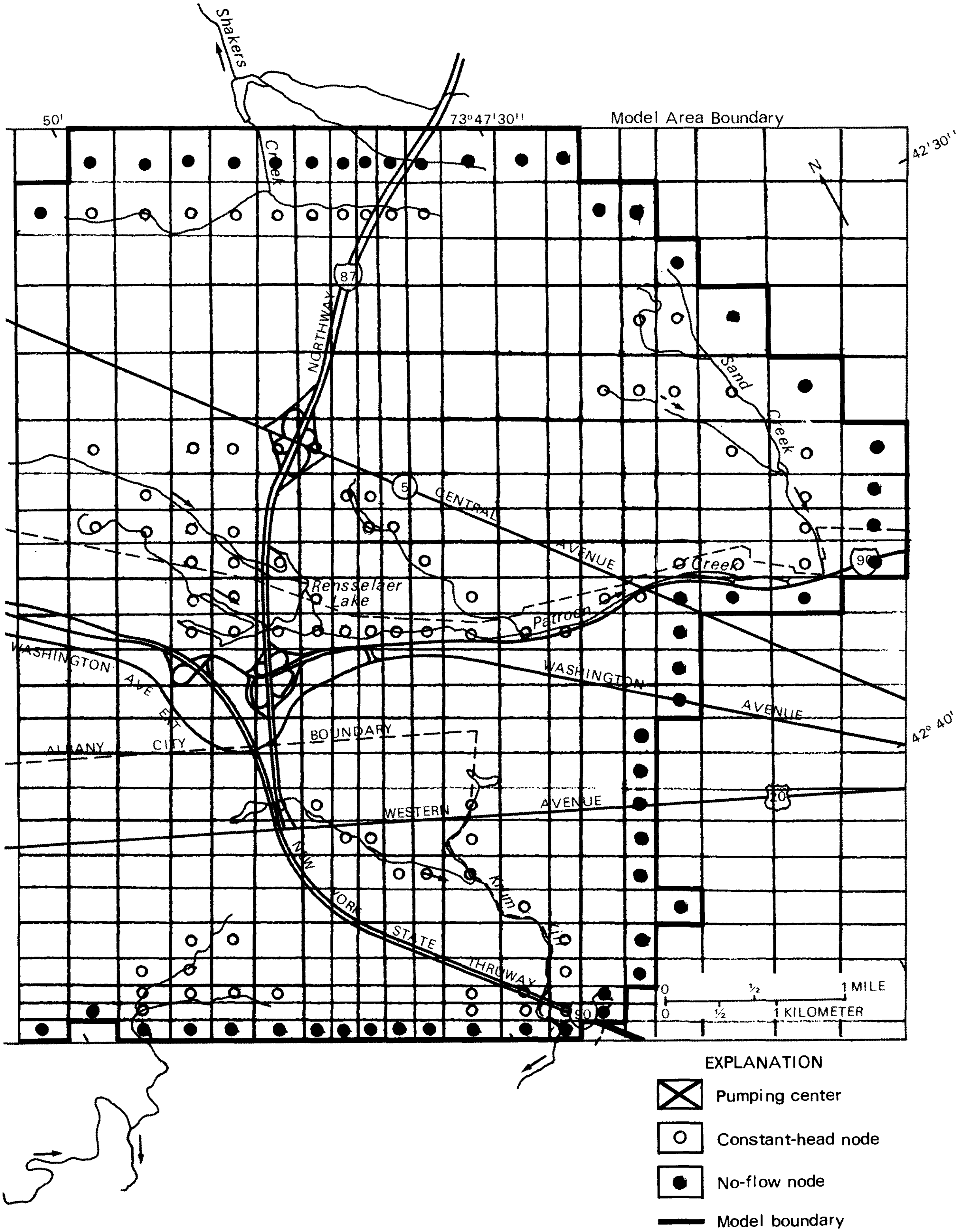


Figure 9.--Model grid configuration showing boundaries,



node types, and pumping center.

Although the preceding approach generated a range of yields that may be expected from one well tapping the Pine Bush aquifer, it does not indicate the yield of multiple wells. To determine the yields and associated drawdowns or interference of more than one well, multiple wells would have to be introduced into the model. The model also cannot be used for prediction without first completing a calibration procedure.

Table 3.--Results of digital-model simulations over a range of hydraulic-conductivity values

Hydraulic Conductivity (ft/d)	Pumpage (gal/min)	Pumpage (gal/d)	Drawdown (ft)
25	50	--	11.14
	75	--	17.69
	100	--	25.31
	150	216,000	49.28
50	75	--	8.15
	100	--	11.14
	150	--	17.69
	175	--	21.33
	200	--	25.31
	250	--	34.81
	300	432,000	49.28
100	100	--	5.31
	150	--	8.15
	200	--	11.14
	300	--	17.69
	400	--	25.31
	500	--	34.81
	600	864,000	49.28

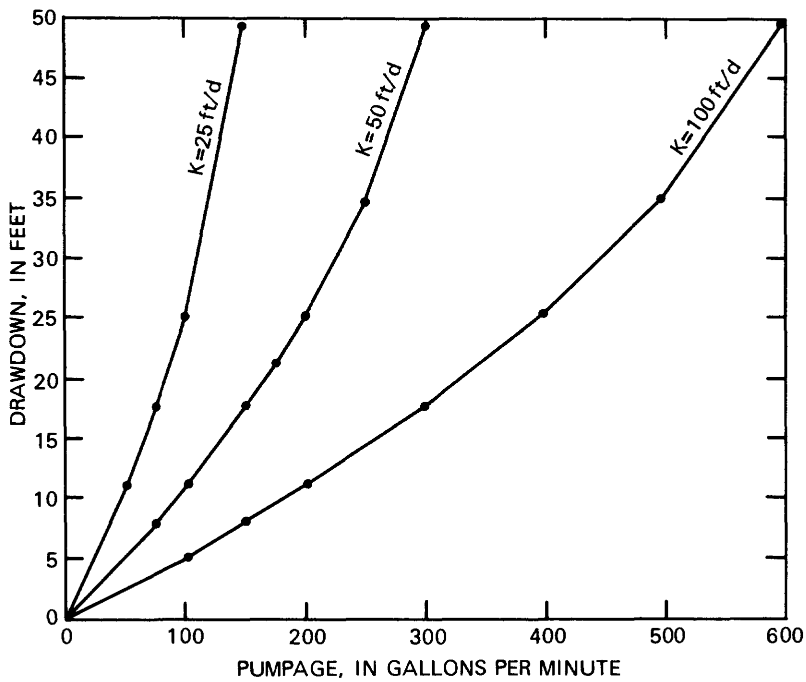


Figure 10.--Results of simulated pumping at various rates at hydraulic-conductivity (K) values of 25, 50, and 100 ft/d.

WATER QUALITY

Stream and ground-water samples from the Pine Bush were collected to assess water quality. The constituents of greatest concern were phosphorus, nitrogen, and chloride because they are the most common chemical contaminants from septic-tank effluent and sewer-pipe leakage. Chloride (fig. 11) was also of concern as an indicator of contamination from the nearby Albany landfill (fig. 2) and from road salting on the major highways. Tables 4-5 (p. 28-29) and 7-9 (p. 40-47) list results of the chemical analyses.

The surface-water samples were collected at base flow, when streamflow consisted only of ground water. The stream samples had phosphorus concentrations ranging from 0.00 to 0.09 mg/L and nitrogen concentrations (nitrite plus nitrate) ranging from 0.01 to 2.0 mg/L. Chloride concentrations ranged from 26 to 150 mg/L. The ground-water samples had phosphorus concentrations ranging from below detection limit (0.00 mg/L) to 0.02 mg/L, and nitrogen concentrations (nitrite plus nitrate) ranging from below detection limit (0.00 mg/L) to 7.7 mg/L. The few high nitrogen concentrations were in shallow private wells near septic tanks and in streams near discharge areas of nitrogen-rich ground water.

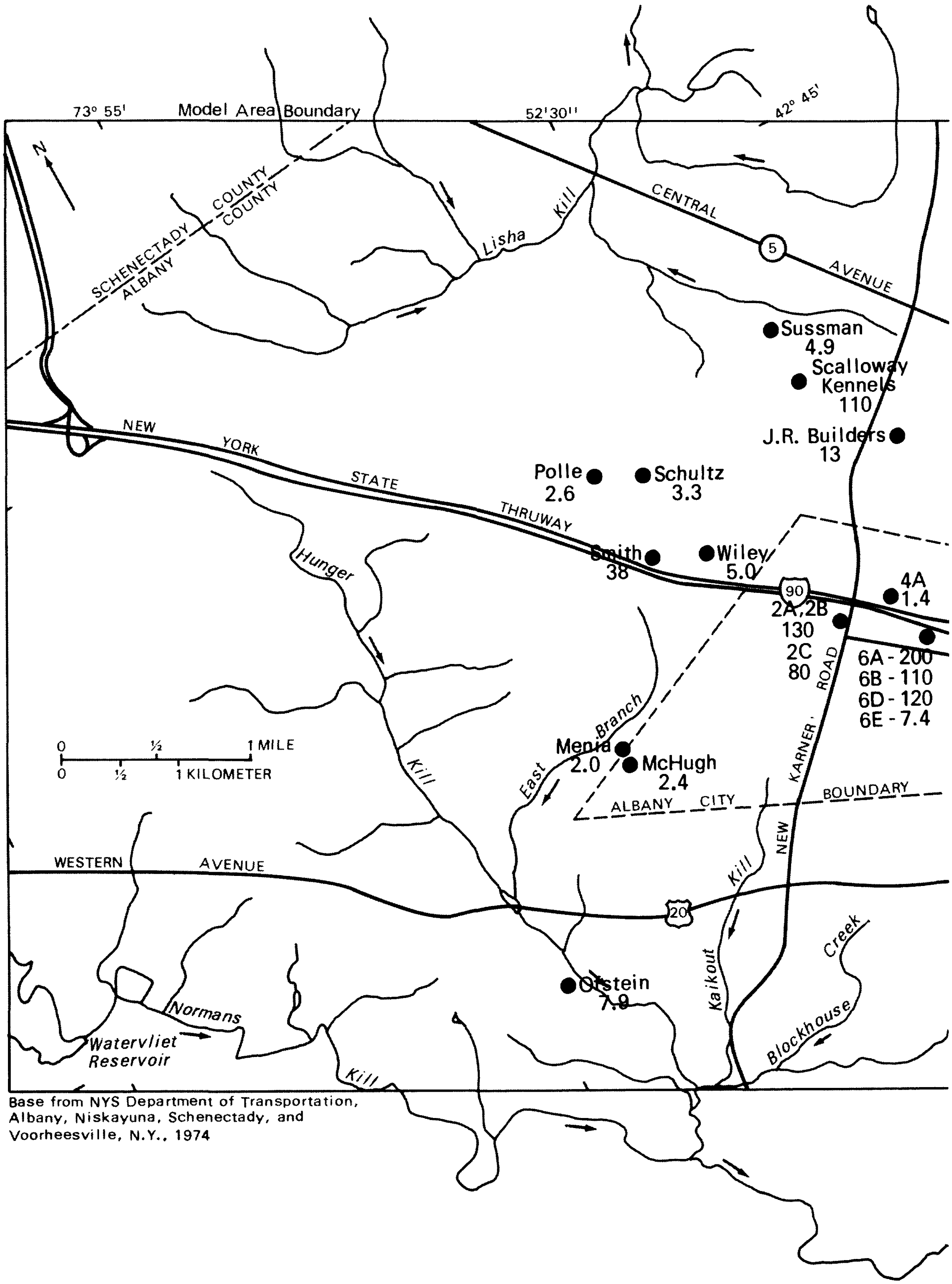
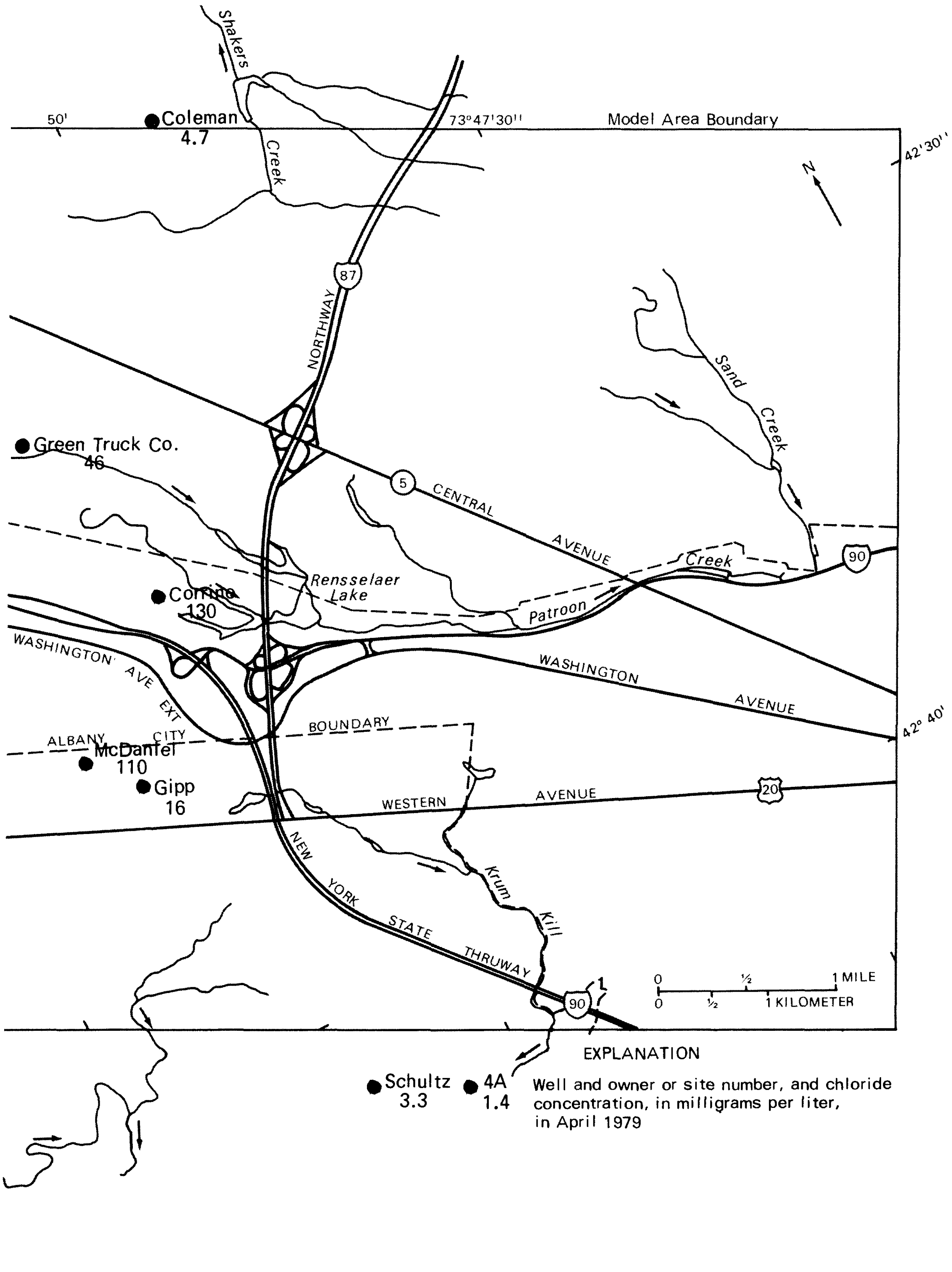


Figure 11.--Chloride concentrations at



selected wells in April 1979.

Chloride concentrations in well water ranged from 1.1 mg/L to 340 mg/L; three of the 30 wells sampled exceeded the 250-mg/L maximum level established by the State Sanitary Code (New York State Department of Health, 1979). Tables 4 and 5 list the sampling dates, place of collection, and chloride concentrations for all chloride analyses. The lowest concentrations were at site 4 (1.1 to 1.8 mg/L); the highest were from site 2 and 3 (63 to 340 mg/L). Chloride values at the observation well fields were higher in the deep wells than in the shallow ones, which suggests a stratification in the ground water. Figure 11 is a plot of the chloride concentrations in ground water in April 1979. The highest values were generally in the central part of the area near major highways. Because of this, road salting is suspected as the source of the higher chloride concentrations. Site 4 seems to have low chloride levels that are indicative of conditions before human development in the area. This site is far (1,400 ft) from the nearest major road and is also upgradient from the highway.

Table 4.--Chloride concentration of water from selected private wells in the Pine Bush, Albany County, N.Y.

[Values are in milligrams per liter; analysis by U.S. Geological Survey. Locations are shown in fig. 11.]

Well owner	Date of collection	Chloride, dissolved	Sampling depth, in feet below land surface
Paul Coleman	04-11-79	4.7	20
Paul Coleman	09-11-79	6.0	20
Corrine	04-11-79	130	39
Corrine	09-18-79	130	39
George Gipp	04-11-79	16	38
Green Truck Co.	04-11-79	46	25
J. R. Builders Supply Corp.	04-11-79	13	18
Albert McDaniel	04-13-79	110	35
Albert McDaniel	09-18-79	44	35
Peter McHugh	04-13-79	2.4	45
Robert Menia	04-13-79	2.0	40
Ofstein	04-13-79	7.9	20
Ofstein	09-18-79	7.9	20
Polle	04-19-79	2.6	30
Scalloway Kennels	04-19-79	110	30
Scalloway Kennels	09-18-79	120	30
Bill Schultz	04-19-79	3.3	30
C. B. Smith	04-19-79	38	30
Orin Susman	04-19-79	4.9	30
William Wiley	04-19-79	5.0	30

Table 5.--Chloride concentration of water from selected observation wells in the Pine Bush, Albany County, N.Y.

[Values are in milligrams per liter; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

U.S. Geological Survey well number	Date of collection	Chloride, dissolved	Sampling depth, in feet below land surface
2A	04-18-79	130	30
2A	09-19-79	110	30
2A	01-12-81	285	30
2A	03-19-81	320	30
2B	04-18-79	130	49
2B	09-19-79	250	49
2B	01-12-81	175	49
2B	03-19-81	290	49
2C	04-18-79	80	25
2C	09-19-79	63	25
2C	01-12-81	125	25
2C	03-19-81	120	25
3A	01-12-81	110	22
3A	03-19-81	340	22
4A	04-17-79	1.4	60
4A	09-19-79	1.5	60
4B	04-17-79	1.5	67
4C	04-17-79	1.8	44
4D	04-17-79	1.1	69
4E	04-17-79	1.7	32
4E	09-19-79	1.7	32
6	05-29-79	210	49
6	06-07-79	200	49
6A	04-18-79	200	49
6A	09-19-79	140	49
6A	01-12-81	220	49
6A	03-19-81	180	49
6B	04-18-79	110	48
6B	01-12-81	70	48
6B	03-19-81	120	48
6C	09-19-79	4.3	22
6C	01-12-81	2.6	22
6C	03-19-81	42	22
6D	04-18-79	120	49
6D	09-19-79	180	49
6E	04-18-79	7.4	22
6E	09-19-79	4.4	22

SUMMARY

The surficial sand aquifer of the Pine Bush ranges from 5 to 150 ft thick and consists of well-sorted fine sand with layers of silt and clay. Lake clay forms the base of the aquifer. Hydraulic conductivity of the sand varies with the thickness and extent of the silt and clay layers. Results of pumping tests indicate that hydraulic conductivity ranges from 65 to 70 ft/d.

Depth to the water table is generally 10 to 15 ft throughout the area and rarely exceeds 20 ft. The yearly fluctuation in water levels is approximately 2.4 ft except near Rensselaer Lake, where the level fluctuates by only 0.3 ft. The highest recorded level from 1979-81 in well 4A, for example, was 4.30 ft lower in 1981 than in 1979; that in well 6A in 1979 was 2.49 ft lower than in 1981.

Results of model simulations indicate that a single production well could yield from 150 to 600 gal/min (216,000 to 864,000 gal/d), depending on hydraulic conductivity. Hydraulic-conductivity values of 25, 50, and 100 ft/d were tested with a maximum drawdown of 80 percent of the saturated thickness in the production well. These predicted values indicate the range of well yields that can be expected from areas of the Pine Bush that are hydrologically similar to the simulated pump site.

Ground water was sampled for phosphorus, nitrogen, and chloride. The highest concentration of phosphorus was 0.02 mg/L, and the highest of nitrogen (nitrite plus nitrate) was 7.7 mg/L. The highest value of chloride was 340 mg/L; the lowest (background level) was 1.1 mg/L. Water from the deeper wells had higher chloride concentrations than that from the shallow wells, which suggests a chloride stratification in the ground water.

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TABLES 6-9

Abbreviations used in Tables 7-9

cond.	conductance	mg/L	milligrams per liter
est.	estimated	Nitr.	nitrogen
KJD	kjeldahl	org	organic
lab	laboratory	--	constituent not measured
0.00	concentration below detection limit		

Table 6.--Logs of observation wells

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 1A
LATITUDE: 42°43'02" LONGITUDE: 73°52'58"
ALTITUDE OF LAND-SURFACE DATUM: 312.79 ft above sea level
SCREENED INTERVAL: 22-26 ft below land-surface datum
WATER LEVEL: 14.10 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 20 March 1979

	Depth (ft)	Thickness (ft)
Fine sand, tan	0-32	32
Fine sand and silt, gray	32-37	5
Fine sand, grayish brown	37-52	15
Very fine sand and silt, gray	52-67	15
Silt, gray	67-69+	

IDENTIFICATION NUMBER: 2A
LATITUDE: 42°42'49" LONGITUDE: 73°52'18"
ALTITUDE OF LAND-SURFACE DATUM: 323.03 ft above sea level
SCREENED INTERVAL: 26.8-30.8 ft below land-surface datum
WATER LEVEL: 18.98 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 21 March 1979

	Depth (ft)	Thickness (ft)
Very fine sand and silt, yellow	0-17	17
Clay, tan	17-22	5
Fine sand and silt, tan	22-27	5
Fine to medium sand, black	27-33	6
Silt, black	33-34	1
Very fine sand and silt, black	34-61	27
Clay, gray, plastic	61-64+	

IDENTIFICATION NUMBER: 2B
LATITUDE: 42°42'50" LONGITUDE: 73°52'19"
ALTITUDE OF LAND-SURFACE DATUM: 324.31 ft above sea level
SCREENED INTERVAL: 45-49 ft below land-surface datum
WATER LEVEL: 20.37 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 5 April 1979

	Depth (ft)	Thickness (ft)
Very fine to fine sand, red	0-17	17
Very fine to fine sand, brown	17-27	10
Very fine to fine sand, grayish brown	27-32	5
Very fine to fine sand and silt, gray	32-37	5
Fine sand, some silt, gray	37-52	15
Clay, gray, plastic	52-54+	

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 2C
LATITUDE: 42°42'50" LONGITUDE: 73°52'19"
ALTITUDE OF LAND-SURFACE DATUM: 322.80 ft above sea level
SCREENED INTERVAL: 23-25 ft below land-surface datum
WATER LEVEL: 18.84 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 6 April 1979

	Depth (ft)	Thickness (ft)
Very fine to fine sand, red	0-17	17
Very fine to fine sand, brown	17-25+	

IDENTIFICATION NUMBER: 3A
LATITUDE: 42°41'43" LONGITUDE: 73°49'59"
ALTITUDE OF LAND-SURFACE DATUM: 264.14 ft above sea level
SCREENED INTERVAL: 18-22 ft below land-surface datum
WATER LEVEL: 13.95 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 21 March 1979

	Depth (ft)	Thickness (ft)
Very fine to fine sand, dark brown	0-10	10
Fine sand, reddish tan	10-21	11
Very fine to fine sand and silt, tan	21-26	5
Very fine sand, silt, clay	26-31	5
Clay, tan	31-32.5	1.5
Clay, bluish gray	32.5-42	9.5
Very fine sand and silt, tan	42-46	4
Clay, bluish gray	46-47	1
Very fine sand and silt, gray	47-56	9
Clay, light brown	56-57	1
Silt and clay, dark brown	57-58+	

IDENTIFICATION NUMBER: 4
LATITUDE: 42°42'47" LONGITUDE: 73°51'52"
ALTITUDE OF LAND-SURFACE DATUM: 326.38 ft above sea level
SCREENED INTERVAL: 55-60 ft below land-surface datum
WATER LEVEL: 18.89 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 28 June 1979

	Depth (ft)	Thickness (ft)
Very fine sand, reddish tan	0-17.5	17.5
Silt and clay, reddish tan	17.5-23	5.5
Silt and clay, gray	23-24	1
Clay, gray	24-28.9	4.9
Silt and clay, gray	28.9-29	0.1
Clay, gray	29-34	5
Fine sand, reddish tan	34-44	10
Very fine to fine sand, brown	44-49	5
Fine to medium sand, reddish brown	49-60+	11

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 4A
LATITUDE: 42°42'47" LONGITUDE: 73°51'52"
ALTITUDE OF LAND-SURFACE DATUM: 325.98 ft above sea level
SCREENED INTERVAL: 56-60 ft below land-surface datum
WATER LEVEL: 18.50 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 28 March 1979

	Depth (ft)	Thickness (ft)
Very fine sand, reddish tan	0-17.5	17.5
Silt and clay, red	17.5-19	1.5
Silt and clay, reddish tan	19-23	4
Silt and clay, gray	23-24	1
Clay, gray	24-28.9	4.9
Silt and clay, gray	28.9-29	0.1
Clay, gray	29-34	5
Fine sand, reddish tan	34-44	11
Fine sand, brown	44-63	19
Very fine sand and silt, grayish brown	63-69	6
Very fine sand and silt, dark gray	69-74+	

IDENTIFICATION NUMBER: 4B
LATITUDE: 42°42'48" LONGITUDE: 73°51'54"
ALTITUDE OF LAND-SURFACE DATUM: 322.13 ft above sea level
SCREENED INTERVAL: 63.5-67.5 ft below land-surface datum
WATER LEVEL: 14.20 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 28 March 1979

	Depth (ft)	Thickness (ft)
Fine sand, reddish brown	0-18.2	18.2
Clay, brown	18.2-18.5	0.3
Fine to medium sand, brownish gray	18.5-18.6	.1
Clay, gray	18.6-27.5	8.9
Clay, gray, trace of very fine sand and silt	27.5-28.8	1.3
Sand, some silt, grayish brown	28.8-29	.2
Clay, gray, some very fine sand and silt	29-38.9	9.9
Very fine to fine sand, reddish brown	38.9-47	8.1
Very fine sand, gray, trace of silt	47-52	5
Very fine to fine sand, grayish brown	52-68.8	16.8
Silt, gray, trace of sand and clay	68.8-72	3.2
Very fine sand to silt, gray	72-74+	

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 4C
LATITUDE: 42°42'48" LONGITUDE: 73°51'54"
ALTITUDE OF LAND-SURFACE DATUM: 321.84 ft above sea level
SCREENED INTERVAL: 40-44 ft below land-surface datum
WATER LEVEL: 13.95 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 28 March 1979

	Depth (ft)	Thickness (ft)
Fine sand, reddish brown	0-18.2	18.2
Clay, brown	18.2-18.5	0.3
Fine to medium sand, brownish gray	18.5-18.6	.1
Clay, gray	18.6-28.8	10.2
Sand, some silt, grayish brown	28.8-29	.2
Clay, gray	29-38.9	9.9
Very fine to fine sand, reddish brown	38.9-44+	

IDENTIFICATION NUMBER: 4D
LATITUDE: 42°42'47" LONGITUDE: 73°51'53"
ALTITUDE OF LAND-SURFACE DATUM: 324.83 ft above sea level
SCREENED INTERVAL: 65-69 ft below land-surface datum
WATER LEVEL: 17.18 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 3 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, tan	0-3	3
Fine sand, red	3-12	9
Silt, some sand, some clay, red	12-17	5
Clay	17-23	6
Fine to medium sand, gray	23-27	4
Silt, some sand, some clay, dark gray	27-37	10
Very fine sand, some silt, brown	37-42	5
Fine sand, trace of silt, brown	42-47	5
Fine to medium sand, grayish brown	47-52	5
Fine sand, grayish brown	52-67	15
Medium sand, some fine sand	67-72	5
Sand and silt, gray	72-74+	

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 4E
LATITUDE: 42°42'47" LONGITUDE: 73°51'53"
ALTITUDE OF LAND-SURFACE DATUM: 324.73 ft above sea level
SCREENED INTERVAL: 28-32 ft below land-surface datum
WATER LEVEL: 17.10 ft below land-surface datum DATE: 7 March 1980
DATE OF WELL COMPLETION: 3 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, tan	0-3	3
Fine sand, red	3-12	9
Silt, some sand, some clay, red	12-17	5
Clay	17-23	6
Fine to medium sand, gray	23-27	4
Silt, some sand, some clay, dark gray	27-34+	

IDENTIFICATION NUMBER: 5A
LATITUDE: 42°41'52" LONGITUDE: 73°50'19"
ALTITUDE OF LAND-SURFACE DATUM: 268.51 ft above sea level
SCREENED INTERVAL: 16-20 ft below land-surface datum
WATER LEVEL: 8.00 ft below land-surface datum DATE: 24 March 1980
DATE OF WELL COMPLETION: 23 March 1979

	Depth (ft)	Thickness (ft)
Fine sand, reddish tan	0-22	22
Very fine sand and silt, brown	22-32	10
Clay	32-74+	

IDENTIFICATION NUMBER: 6
LATITUDE: 42°42'32" LONGITUDE: 73°51'49"
ALTITUDE OF LAND-SURFACE DATUM: 314.43 ft above sea level
SCREENED INTERVAL: 44-49 ft below land-surface datum
WATER LEVEL: 12.16 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 23 May 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-29	29
Fine sand, grayish brown	29-49	20
Fine sand, trace of silt, brownish gray	49+	

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 6A
LATITUDE: 42°42'32" LONGITUDE: 73°51'49"
ALTITUDE OF LAND-SURFACE DATUM: 314.57 ft above sea level
SCREENED INTERVAL: 45-49 ft below land-surface datum
WATER LEVEL: 12.35 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 26 March 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-42	42
Fine sand, trace of silt, brownish gray	42-52	10
Very fine sand and silt, trace of fine sand and clay, gray	52-69±	

IDENTIFICATION NUMBER: 6B
LATITUDE: 42°42'31" LONGITUDE: 73°51'49"
ALTITUDE OF LAND-SURFACE DATUM: 315.42 ft above sea level
SCREENED INTERVAL: 44-48 ft below land-surface datum
WATER LEVEL: 13.30 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 4 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-24	24
Fine sand, trace of silt, gray	24-47	23
Very fine to fine sand and silt, gray	47-62	15
Very fine sand, silt, and clay, gray	62-67	5
Silt, some very fine sand, some clay, gray	67-82	15
Silt, trace of very fine sand, some clay, gray	82-84+	

IDENTIFICATION NUMBER: 6C
LATITUDE: 42°42'31" LONGITUDE: 73°51'49"
ALTITUDE OF LAND-SURFACE DATUM: 315.41 ft above sea level
SCREENED INTERVAL: 18-22 ft below land-surface datum
WATER LEVEL: 13.28 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 4 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-24	24

Table 6.--Logs of observation wells (continued)

[Logs by U.S. Geological Survey.
Locations shown in fig. 2.]

IDENTIFICATION NUMBER: 6D
LATITUDE: 42°42'32" LONGITUDE: 73°51'50"
ALTITUDE OF LAND-SURFACE DATUM: 313.43 ft above sea level
SCREENED INTERVAL: 45-49 ft below land-surface datum
WATER LEVEL: 11.13 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 5 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-27	27
Fine sand, gray	27-49	22
Silt and clay, trace of very fine sand, gray	49-52	3
Silt, some very fine sand, trace of clay, gray	52-57	5
Clay, gray	57-59+	

IDENTIFICATION NUMBER: 6E
LATITUDE: 42°42'32" LONGITUDE: 73°51'50"
ALTITUDE OF LAND-SURFACE DATUM: 313.90 ft above sea level
SCREENED INTERVAL: 18-22 ft below land-surface datum
WATER LEVEL: 11.60 ft below land-surface datum DATE: 14 March 1980
DATE OF WELL COMPLETION: 5 April 1979

	Depth (ft)	Thickness (ft)
Fine sand, brown	0-24	24

Table 7.--Chemical analyses of water from streams in the Pine Bush, Albany County, N.Y.

[All values represent dissolved constituents, in milligrams per liter; discharge is in cubic feet per second; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

	Stream name, station number, and date of sample collection								
	Lisha Kill at Maywood (01356160)			Shakers Creek near Colonie (01356280)			Shakers Creek tributary at Colonie (01356285)		
Constituent or characteristic	04/12/79	08/28/79	04/02/80	04/12/79	08/30/79	04/02/80	04/12/79	08/30/79	04/02/80
Calcium	--	--	50	--	--	46	--	--	56
Chloride	42	50	47	47	26	47	69	80	70
Hardness, total	--	--	160	--	--	150	--	--	190
Magnesium	--	--	9.7	--	--	8.2	--	--	11
Nitr. NH_3 as NH_4	0.01	0.17	0.26	0.04	0.01	0.15	0.03	0.06	0.21
Nitrogen org as N	0.19	0.34	0.14	0.47	0.00	0.26	1.1	0.60	0.43
Nitrogen as N	0.47	0.86	0.75	0.80	1.0	0.85	1.1	--	0.83
Nitrogen KJD	0.20	0.47	0.34	0.50	0.01	0.38	1.1	0.65	0.59
Nitrogen NH_4 as N	0.01	0.13	0.20	0.03	0.01	0.12	0.02	0.05	0.16
Nitrite + nitrate as N	0.27	0.39	0.41	0.30	1.0	0.47	0.01	--	0.24
Phosphorus as P	--	0.02	0.01	--	0.01	0.02	0.01	0.03	0.00
Potassium	--	--	2.0	--	--	1.6	--	--	3.0
Sodium	--	--	28	--	--	27	--	--	40
Discharge	20.42	0.42	--	4.41	0.26	--	1.40	0.01(est.)	--

Table 7.--Chemical analyses of water from streams in the Pine Bush, Albany County, N.Y. (continued)

[All values represent dissolved constituents, in milligrams per liter; discharge is in cubic feet per second; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

Constituent or characteristic	Stream name, station number, and date of sample collection				
	Krum Kill Tributary at Albany (01359523)			Rensselaer Lake at Six Mile Waterworks	
	04/12/79	08/28/79	04/02/80	04/19/79	04/02/80
Calcium	--	--	59	39	53
Chloride	150	120	130	57	99
Hardness, total	--	--	190	130	170
Magnesium	--	--	11	7.9	9.5
Nitr. NH_3 as NH_4	0.14	0.30	0.30	0.12	0.17
Nitrogen org as N	0.82	0.32	0.37	0.18	0.28
Nitrogen as N	1.5	0.82	1.2	0.31	0.69
Nitrogen KJD	0.93	0.55	0.60	0.27	0.41
Nitrogen NH_4 as N	0.11	0.23	0.23	0.09	0.13
Nitrite + nitrate as N	0.59	0.27	0.58	0.04	0.28
Phosphorus as P	--	0.09	0.01	0.01	0.00
Potassium	--	--	2.7	1.4	2.1
Sodium	--	--	77	44	61
Discharge	2.81	0.88	--	--	--

Table 8.--Chemical analyses of water from observation wells in the Pine Bush, Albany County, N.Y.

[All values represent dissolved constituents, in milligrams per liter; specific conductance in micromhos per centimeter at 25° Celsius; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

Constituent or characteristic	Well number, date of collection (1979), and sampling depth, in feet below land surface											
	2A	2A	2B	2C	2C	4A	4A	4B	4C	4D	4E	4E
	04/18	09/19	04/18	04/18	09/19	04/17	09/19	04/17	04/17	04/17	04/17	09/19
	30	30	49	25	25	60	60	67	44	69	32	32
Calcium	--	33	--	--	25	--	18	--	--	--	--	12
Chloride	130	110	130	80	63	1.4	1.5	1.5	1.8	1.1	1.7	1.7
Specific cond. (lab)	905	--	613	662	--	189	--	204	225	212	141	--
Magnesium	--	5.9	--	--	3.9	--	3.2	--	--	--	--	2.1
Nitr. NH_3 as NH_4	0.01	0.06	0.01	0.00	0.61	0.01	0.70	0.00	0.00	0.00	0.08	0.04
Nitrogen org as N	0.14	0.12	0.36	0.04	0.00	0.16	0.00	0.14	0.00	0.00	0.53	0.06
Nitrogen as N	0.16	0.78	0.37	0.04	0.48	0.21	1.2	0.14	0.01	0.00	0.65	0.10
Nitrogen KJD	0.15	0.17	0.48	0.04	0.13	0.17	0.09	0.14	0.00	0.00	0.59	0.09
Nitrogen NH_4 as N	0.01	0.05	0.01	0.00	0.47	0.01	0.54	0.00	0.00	0.00	0.06	0.03
Nitrite + nitrate as N	0.01	0.61	0.00	0.00	0.35	0.04	1.1	0.00	0.01	0.00	0.06	0.01
Phosphorus as P	--	0.02	0.01	--	0.01	0.01	0.01	--	--	--	--	0.02
Potassium	--	0.60	--	--	0.6	0.00	0.20	--	--	--	--	0.02
Sodium	--	46	--	--	15	--	1.1	--	--	--	--	1.5

Table 7.--Chemical analyses of water from streams in the Pine Bush, Albany County, N.Y. (continued)

[All values represent dissolved constituents, in milligrams per liter; discharge is in cubic feet per second; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

Constituent or characteristic	Stream name, station number, and date of sample collection								
	Patroon Creek at Central Avenue, Albany (01359131)			Sand Creek at Sand Creek Road, Albany (01359132)			Hunger Kill at Guilderland (01359513)		
	04/12/79	08/28/79	04/02/80	04/12/79	08/28/79	04/02/80	04/12/79	08/28/79	04/02/80
Calcium	--	--	62	--	--	73	--	--	50
Chloride	120	110	120	55	--	55	63	69	58
Hardness, total	--	--	200	--	--	250	--	--	160
Magnesium	--	--	11	--	--	16	--	--	8.3
Nitr. NH_3 as NH_4	0.10	0.04	0.18	0.03	0.13	0.14	0.01	0.00	0.08
Nitrogen org as N	0.15	0.28	0.15	0.30	0.11	0.17	0.18	0.18	0.13
Nitrogen as N	0.66	0.74	0.76	1.3	1.2	1.4	1.2	1.4	1.4
Nitrogen KJD	0.23	0.31	0.29	0.32	0.21	0.28	0.19	0.18	0.19
Nitrogen NH_4 as N	0.08	0.03	0.14	0.02	0.10	0.11	0.01	0.00	0.06
Nitrite + nitrate as N	0.43	0.43	0.47	0.96	0.99	1.1	0.96	1.2	1.2
Phosphorus as P	--	0.01	0.00	0.01	0.02	0.01	0.00	0.01	0.01
Potassium	--	--	2.5	--	--	3.2	--	--	1.6
Sodium	--	--	73	--	--	31	--	--	36
Discharge	14.2	5.97	--	3.32	2.07	--	16.5	8.78	--

Table 7.--Chemical analyses of water from streams in the Pine Bush, Albany County, N.Y. (continued)

[All values represent dissolved constituents, in milligrams per liter; discharge is in cubic feet per second; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

Constituent or characteristic	Stream name, station number, and data of sample collection								
	Blockhouse Creek at Westmere (01359515)			South Branch Blockhouse Creek at Westmere (01359516)			Blockhouse Creek near Guilderland (01359517)		
	04/12/79	08/30/79	04/02/80	04/12/79	08/30/79	04/02/80	04/12/79	08/30/79	04/02/80
Calcium	--	--	--	--	--	41	--	--	58
Chloride	60	81	69	36	43	28	53	74	60
Hardness, total	--	--	65	--	--	140	--	--	190
Magnesium	--	--	13	--	--	8.6	--	--	11
Nitr. NH_3 as NH_4	0.00	0.01	0.09	0.03	0.03	0.15	0.01	0.01	0.13
Nitrogen org as N	0.16	0.19	0.02	0.28	0.52	0.64	0.24	0.21	0.25
Nitrogen as N	1.7	1.9	2.1	0.80	2.4	1.5	1.1	1.8	1.6
Nitrogen KJD	0.16	0.20	0.09	0.30	0.54	0.76	0.25	0.22	0.35
Nitrogen NH_4 as N	0.00	0.01	0.07	0.02	0.02	0.12	0.01	0.01	0.10
Nitrite + nitrate as N	1.5	1.7	2.0	0.50	1.9	0.69	0.87	1.6	1.2
Phosphorus as P	0.01	0.03	0.01	--	--	0.01	--	0.03	0.01
Potassium	--	--	1.5	--	--	1.7	--	--	1.8
Sodium	--	--	61	--	--	19	--	--	38
Discharge	1.93	0.72	--	1.65	0.17	--	3.00	1.33	--

Table 8.--Chemical analyses of water from observation wells in the Pine Bush, Albany County, N.Y. (continued)

Constituent or characteristic	Well number, date of collection (1979) and sampling depth, in feet below land surface										
	6 05/29 49	6 06/07 49	6A 04/18 49	6A 09/19 49	6B 04/18 46	6B 09/19 48	6C 09/19 22	6D 04/18 49	6D 09/19 49	6E 04/18 22	6E 09/19 22
Calcium	--	52	--	30	--	27	1.8	--	50	--	6.0
Chloride	210	200	200	140	110	--	4.3	120	180	7.4	4.4
Specific cond. (lab)	860	897	889	--	558	--	--	606	--	103	--
Magnesium	--	10	--	5.9	--	5.7	1.7	--	11	--	2.0
Nitr. NH_3 as NH_4	0.01	--	0.01	0.04	0.00	0.03	0.01	0.00	0.17	0.00	0.06
Nitrogen org as N	0.10	--	0.07	0.10	0.04	0.07	0.19	0.18	0.38	0.05	0.26
Nitrogen as N	0.13	--	0.08	0.33	0.06	0.13	0.30	0.19	0.71	0.05	0.51
Nitrogen KJD	0.11	--	0.08	0.13	0.04	0.09	0.20	0.18	0.51	0.05	0.31
Nitrogen NH_4 as N	0.01	--	0.01	0.03	0.00	0.02	0.01	0.00	0.13	0.00	0.05
Nitrite + nitrate as N	0.02	--	0.00	0.20	0.02	0.04	0.10	0.01	0.20	0.00	0.20
Phosphorus as P	--	--	--	0.01	0.00	0.01	0.01	--	0.00	--	0.02
Potassium	--	0.90	--	0.40	--	0.80	0.20	--	1.0	--	0.40
Sodium	--	130	--	43	--	21	1.0	--	90	--	4.4

Table 9.--Chemical analyses of water from domestic wells in the Pine Bush, Albany County, N.Y.

[All values represent dissolved constituents, in milligrams per liter; specific conductance, in micromhos per centimeter at 25° Celsius; analysis by U.S. Geological Survey. Locations are shown in fig. 2.]

	Owner	Location: Latitude	Location: Longitude	Sampling depth in feet below land surface
A	Ralph Bentley	42°44'48"	73°53'52"	35
B	Paul Coleman	42°44'22"	73°49'30"	20
C	Corrine	42°42'15"	73°50'56"	39
D	George Gipp	42°41'32"	73°51'34"	38
E	Green Truck Co.	42°43'25"	73°51'30"	25
F	J. R. Builders Supply Corp.	42°43'25"	73°49'30"	18
G	Albert McDaniel	42°41'39"	73°51'45"	35
H	Peter McHugh	42°42'41"	73°53'52"	45

Constituent or characteristic	Well and date of collection (1979)										
	A 04/19	B 04/11	B 09/18	C 04/11	C 09/18	D 04/11	E 04/11	F 04/11	G 04/13	G 09/18	H 04/13
Calcium	--	--	41	--	170	--	--	--	--	45	--
Chloride	--	4.7	6.0	130	130	16	46	13	110	44	2.4
Specific cond. (lab)	330	--	--	--	--	317	--	473	790	--	326
Magnesium	--	--	5.9	--	42	--	--	--	--	9.6	--
Nitr. NH_3 as NH_4	0.04	0.00	0.03	0.01	0.06	0.01	0.00	4.4	0.04	0.09	0.00
Nitrogen org as N	0.01	0.10	0.26	0.21	0.33	0.02	0.00	0.40	0.04	0.23	0.00
Nitrogen as N	0.09	4.1	8.0	0.22	0.54	0.04	0.03	3.8	0.09	0.70	0.73
Nitrogen KJD	0.04	0.10	0.28	0.22	0.38	0.03	0.00	3.8	0.07	0.30	0.00
Nitrogen NH_4 as N	0.03	0.00	0.02	0.01	0.05	0.01	0.00	3.4	0.03	0.07	0.00
Nitrite + nitrate as N	0.05	4.0	7.7	0.00	0.16	0.01	0.03	0.00	0.02	0.40	0.73
Phosphorus as P	0.00	--	0.02	0.00	0.00	--	--	0.00	--	0.01	--
Potassium	--	--	6.6	--	1.5	--	--	--	--	1.6	--
Sodium	--	--	1.8	--	40	--	--	--	--	31	--

Table 9.--Chemical analyses of water from domestic wells in the Pine Bush, Albany County, N.Y. (continued)

	Owner	Location: Latitude	Location: Longitude	Sampling depth in feet below land surface
I	Robert Menia	42°42'44"	73°53'53"	40
J	Ofstein	42°41'55"	73°54'50"	20
K	Polle	42°43'57"	73°53'12"	30
L	Scalloway Kennels	42°43'48"	73°49'57"	30
M	Bill Schultz	42°43'47"	73°52'57"	30
N	C. B. Smith	42°43'27"	73°53'11"	30
O	Orin Susman	42°44'10"	73°51'53"	30
P	William Wiley	42°43'24"	73°52'55"	30

Constituent or characteristic	Well and date of collection (1979)									
	I 04/13	J 04/13	J 09/18	K 04/19	L 04/19	L 09/18	M 04/19	N 04/19	O 04/19	P 04/19
Calcium	--	--	1.3	--	--	49	--	--	--	--
Chloride	2.0	7.9	7.9	2.6	110	120	3.3	38	4.9	5.0
Specific cond. (lab)	356	817	--	306	--	--	397	425	--	214
Magnesium	--	--	0.3	--	--	5.3	--	--	--	--
Nitr. NH_3 as NH_4	0.00	2.8	0.18	0.01	0.00	0.36	0.05	0.00	0.01	0.00
Nitrogen org as N	0.00	0.70	0.18	0.10	0.37	0.00	0.46	0.00	0.12	0.12
Nitrogen as N	2.3	7.1	0.42	3.4	5.7	6.0	2.3	1.9	7.0	0.13
Nitrogen KJD	0.00	2.9	0.32	0.11	0.37	0.28	0.50	0.00	0.13	0.12
Nitrogen NH_4 as N	0.00	2.2	0.14	0.01	0.00	0.28	0.04	0.00	0.01	0.00
Nitrite + nitrate as N	2.3	4.2	0.10	3.3	5.3	5.7	1.8	1.9	6.9	0.01
Phosphorus as P	0.00	--	0.02	--	0.02	0.01	0.02	--	--	--
Potassium	--	--	2.6	--	--	2.6	--	--	--	--
Sodium	--	--	--	--	--	54	--	--	--	--