GROUND-WATER APPRAISAL OF THE FISHKILL-BEACON AREA

DUTCHESS COUNTY, NEW YORK

By Deborah S. Snavely

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL (SI) UNITS

Multiply inch-pound units	By	To obtain SI units
inch (in.)	2.540	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4.047	square meter (m^2)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic mile (mi^3)	4.17	cubic kilometer (km^3)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
cubic feet per second (ft^3/s)	0.02832	cubic meters per second (m^3/s)
gallons (gal)	3.785	liters (L)
gallons per minute (gal/min)	0.06308	liters per second (L/s)
gallons per day (gal/d)	3.785	liters per day (L/d)
gallons per day per square mile [(gal/d)/mi^2]	1.46	liters per day per square kilometer [(L/d)/km^2]
million gallons per day (Mgal/d)	3.785×10^6	megaliters per day (ML/d)

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ABSTRACT

The most productive aquifers in the Fishkill-Beacon area are the sand and gravel beds in the valleys of Fishkill and Clove Creeks. The average yield of these aquifers to wells is 190 gal/min (gallons per minute). The most productive bedrock aquifer is limestone, which yields an average of about 150 gal/min. Shale and granite each yield an average of less than 35 gal/min. About 4 billion gallons of available water is estimated to be in storage in the sand and gravel aquifers in the area.

In 1977, an average of 3.3 Mgal/d (million gallons per day) of water was withdrawn in June, July, and August and 2 Mgal/d during the remainder of the year.

INTRODUCTION

The U.S. Geological Survey, in cooperation with the Town of Fishkill, N.Y., evaluated the ground-water resources of the Fishkill-Beacon area, in southwestern Dutchess County, along the east bank of the Hudson River about 50 miles north of New York City. The area depends almost entirely on ground water for its water supply; individual wells supply farms, rural homes, and commercial establishments, whereas larger wells provide water for public systems.

Purpose and Scope

The purpose of this study was to delineate the aquifers of the area and to describe the availability of ground water.

The surficial and bedrock geology were mapped to delineate the extent of aquifers, and records of well yields and logs were compiled to further define the geology and the water withdrawal from each unit. The amount of precipitation recharging the aquifers and the amount of ground water in storage were estimated, and statistical analysis of the low-flow characteristics of Fishkill Creek was done to determine the amount of ground water discharging into the creek. Areas served by public water supplies and those that rely on individual wells were mapped to determine the total water use and ground-water withdrawal of the area.

Method of Study

The method of study included (1) geologic mapping, and (2) collection and analysis of available well data, including the depth, diameter, water level, yield, and aquifer type of about 160 private and public wells. Locations of selected wells and test holes are shown on plate 1; surficial geology and bedrock geology are depicted in plates 2 and 3, respectively.

Sources and Acknowledgments

Well information and data on total production and consumption were obtained from Simmons, Grossman, and Heath (1961), private well owners, municipal water-district superintendents, local builders and contractors, and the New York State Department of Health. The Department of Health also provided details on water-supply systems. Well logs were provided by local developers and well drillers. Maps of surficial geology (pl. 2) and bedrock geology (pl. 3) were compiled largely from unpublished field maps by R. G. LaFleur of Rensselaer Polytechnic Institute, Troy, N.Y. (1977) and were supplemented by maps of unconsolidated deposits and bedrock published in Simmons, Grossman, and Heath (1961). Geographic and water-supply information was supplied by the Town of Fishkill and the City of Beacon.

GEOGRAPHY

Location and Setting

The project area, in the Town of Fishkill, is bordered on the west by the Hudson River, on the east by the Town of East Fishkill, on the north by the Town of Wappinger, and on the south by the Town of Philipstown, in Putnam County. The location and major geographic features of the area are shown in figure 1.

Climate

The project area has a humid continental climate with long winters, short summers, and abundant rainfall. The U.S. Department of Commerce, Weather Bureau, has maintained a meteorological station at Glenham (fig. 1) since 1932. Data from this station for 1933-76 indicate a mean annual precipitation of about 45 in. with fairly even distribution throughout the year. The driest year on record was 1964, with about 28 in. of rain; the wettest was 1945, with about 59 in. Mean annual snowfall is approximately 50 in.

The mean monthly air temperature for 1933-76 at Glenham was 51°F. The coldest months are January and February; the warmest are July and August. The extremes in temperature during the period of record were 105°F on July 4, 1966 and -22°F on February 9, 1934 and on January 28, 1935.

Topography

The southern part of the area is a line of hills ranging from 500 to 1,600 ft above the valley floors. The highest point, South Beacon Mountain (fig. 1), reaches 1,602 ft above sea level.

The northern part of the area consists of low hills, lowlands, and swamps. Altitudes range from roughly 100 to 400 ft, and the slopes are considerably less steep here than in the southern part.

The central part includes the valleys of Fishkill and Clove Creeks (fig. 1). The broad alluvial valleys are roughly 3,000 ft wide. The valley walls slope gently except where the creeks abut the granitic hills to the south (pl. 1). The valley floor ranges from 100 to 200 ft in altitude and occasionally broadens to a swampy lowland.

Streams

The largest stream is Fishkill Creek, which has a total drainage area of 190 mi^2. It originates approximately 15 mi east of Beacon, and flows into the Hudson River (fig. 1). Fishkill Creek traverses the area from east to west, with a fall of approximately 23 ft/mi.

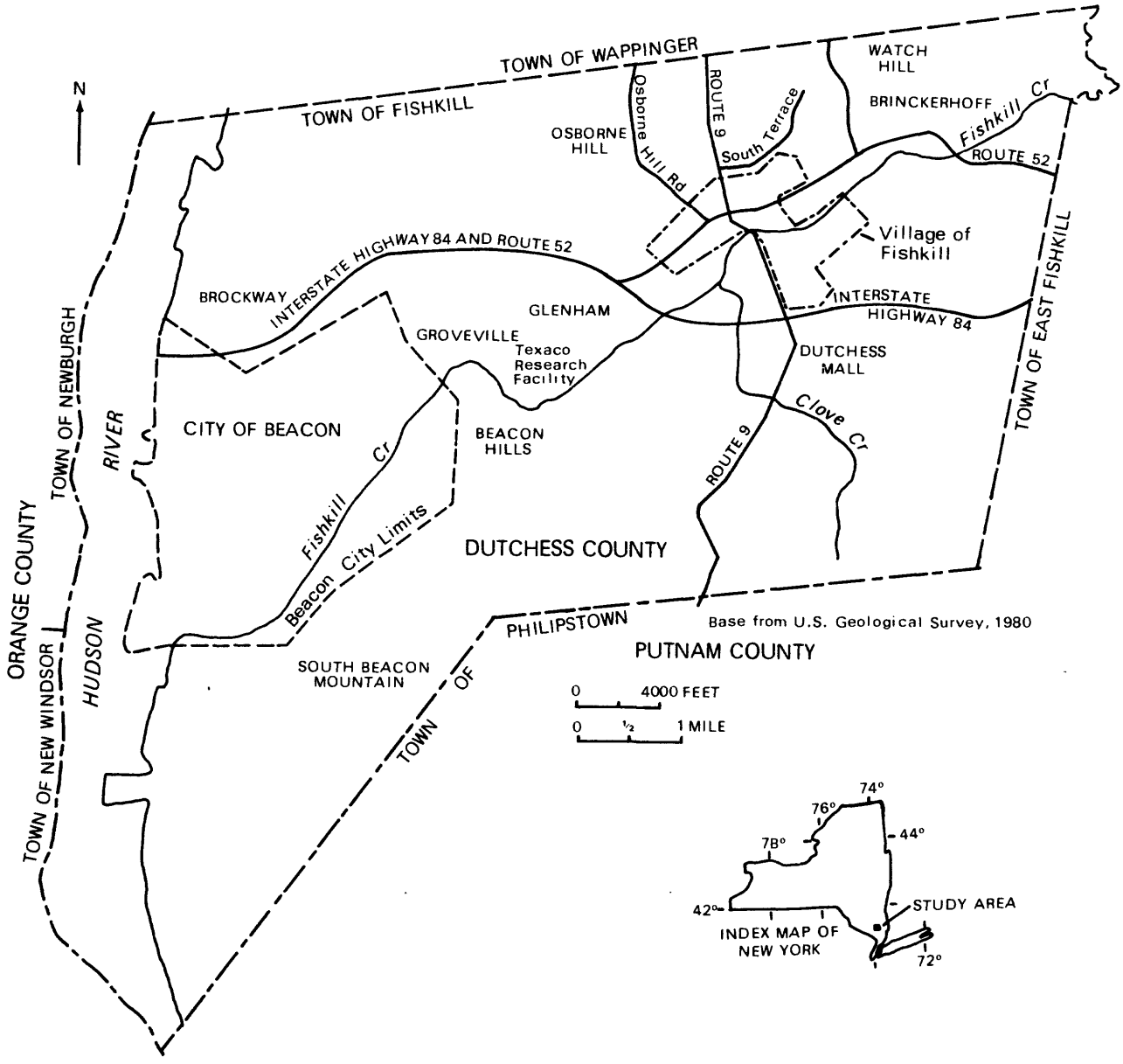

Figure 1.--Location and major geographic features of Fishkill-Beacon area.

The U.S. Geological Survey maintained a stream-gaging station on Fishkill Creek at Beacon from 1944-68. Streamflow ranged from 0.4 ft^3/s to 8,800 ft^3/s, with an average of 279 ft^3/s during 1944-65 (Ayer and Pauszek, 1968, p. 1). The flow duration curve of daily flow for Fishkill Creek at Beacon indicates that the creek exceeded 170 ft^3/s 50 percent of the time and equaled or exceeded 8.8 ft^3/s 99 percent of the time (Ayer and Pauszek, 1968, p. 23). The duration curves were adjusted to a standard period, 1931-60, so that curves for streams with different lengths of record could be compared.

The largest tributary to Fishkill Creek is Clove Creek, which flows north and enters Fishkill Creek about 4,000 ft south of the Village of Fishkill (fig. 1). The total drainage area of Clove Creek is approximately 13 mi^2; the discharge of Clove Creek near Beacon is at least 13 ft^3/s 50 percent of the time and at least 0.35 ft^3/s 99 percent of the time (Ayer and Pauszek, 1968, p. 28).

GEOLOGIC SETTING

Surficial Geology

Most of the unconsolidated deposits in the Fishkill-Beacon area are of glacial origin. The glacially deposited sands and gravels occur as outwash deposits on the floor of the present Fishkill valley and as a few kame deltas (pl. 2). Finer grained material of glacial origin occurs as clayey till and varved lake clay.

The area also contains alluvial deposits. Coarse sands and gravels are present in alluvial fans and finer grained sands and silts are found in the flood plains (pl. 2).

Bedrock Geology

The bedrock underlying the area consists of sedimentary, igneous, and metamorphic rocks. The sedimentary rocks are predominantly shale and limestone. Shale underlies the northwestern part of the area (pl. 3) and is interbedded with graywacke. Limestone and dolomite are found principally along a northeast-southwest-trending band across the area.

Large masses of granite dominate the eastern and southwestern sections of the area; granite forms the mountains in the southern part.

The metamorphic rocks that occur mainly in the western part of the area are slate and chert, although quartzite and gneiss are present along the mountains in the southern part of the project area.

GROUND-WATER RESOURCES

Occurrence

Approximately 160 wells and test holes were inventoried for analysis of aquifer systems in the Fishkill-Beacon area. Only those wells on which data were most complete (about 70) are depicted on plate 1. Each well on plate 1 is listed in table 1, which gives the aquifer type and designates the reported well yield in gallons per minute. Table 1 also gives average yield and range of yields for each water-bearing unit. Drillers' logs and information regarding the construction of selected wells in the area are presented in table 2.

Sand and Gravel

The aquifers with the highest yields are sand and gravel deposits that lie principally in the extreme northeastern part of the area and along the valley of Clove Creek (pl. 2). Wells 55 and 56, the two largest producing wells in the northeastern area, are owned by the Brinckerhoff Water Company. The driller's log of well 55 (table 2) reveals that the entire 59-ft well section penetrated sand and gravel. The lower 14 ft of the well is screened. The static water level at the time the well was drilled was 1.75 ft below land surface. An aquifer test with a pumping rate averaging 500 gal/min for 26 hours produced a drawdown of 4.9 ft in the well. The driller's log for well 56 (table 2) indicates the outwash deposit to be at least 56 ft thick.

Five of the six wells in alluvial sand and gravel that were inventoried along Clove Creek are owned and operated by the Village of Fishkill. They are all approximately 90 ft deep and yield about 200 gal/min with the exception of well 6, which is 115 ft deep and reportedly yields 660 gal/min.

Well 54 in Clove Creek valley, adjacent to the valley wall, penetrated sand but encountered bedrock at 32 ft, which indicates that the alluvium wedges out near the granite uplands.

Shale, Slate, Graywacke, and Chert

Shale and slate are the most extensive bedrock units in the area. The entire area north of Interstate Highway 84 and west of the Village of Fishkill obtains its ground-water supply from wells completed in shale and slate interbedded with graywacke and chert.

The average yield of wells in shale and slate is 30 gal/min, as table 1 indicates. With the exception of well 27, which reportedly yields 170 gal/min, the highest yielding well in shale produces 70 gal/min. Yields in excess of 30-40 gal/min generally occur only where the well intersects extensive fractures, faults, or joints that are hydraulically connected to permeable material. Although no specific information on the shale formation is available, the driller's log for well 27 notes 11 ft of loose shale, which may account for the higher yield of this well.

Wells 24 through 28 (pl. 1) are part of a well field consisting of 23 wells owned by the Hudson View Water Works. The 23 wells range in depth from 75.5 to 480 ft and reportedly yield from 11 to 170 gal/min. Well 28 is representative of many of these wells; it is 260 ft deep and yields about 75 gal/min (table 2). Wells in this area derive water from local fractures and joint sets in shale.

Domestic wells supplying individual homes in this unit average 100 ft in depth, and sustained yields rarely exceed 15 gal/min.

Carbonate Rocks (Limestone and Dolomite)

The carbonate rocks are the highest yielding bedrock aquifers in the Fishkill-Beacon area. A belt of limestone containing joints, fractures, and solution channels runs northeast-southwest beneath the area. Much of the limestone in the area is overlain by permeable sand and gravel that readily transmits water to the limestone.

The highest yielding limestone well inventoried is well 7, a Beacon municipal well that was drilled to a depth of 550 ft. The well reportedly yields 600 gal/min from the limestone aquifer.

A commercial well in the limestone aquifer is well 14, owned by Texaco, Inc. Well 14 was drilled to a depth of 463 ft in 1944 and reportedly yields 300 gal/min.

The other limestone wells inventoried are test wells and wells used for domestic supplies.

Crystalline Rocks (Granite and Gneiss)

The granite and gneiss water-bearing units yield the least water because the dense, crystalline rock is nearly impermeable; joints and fractures, which may be few in these competent rocks, provide the only permeability. Wells in granite and gneiss average 235 ft in depth and range from 101 to 780 ft. All of these wells are for domestic use, and three have been abandoned as dry holes.

Recharge, Discharge, and Storage

Estimates of the amounts of water entering or leaving the ground-water reservoir and the amount stored in the reservoir are an indication of the total amount of ground water available in an area.

Previous studies in southeastern New York indicate that, of the average annual precipitation of 45 in. at Fishkill, about 21 in. infiltrates the areas of sand and gravel by direct precipitation and runoff from adjacent till-covered hills, and about 8 in. infiltrates the areas of till and bedrock

(A. D. Randall, U.S. Geological Survey, written commun., 1975). These amounts represent about 1 and 0.4 (Mgal/d)/mi^2, respectively. The surficial geology map (pl. 2) indicates that about 6.3 mi^2 of the area is covered by sand and gravel deposits and about 18.8 mi^2 by till and bedrock. From these values, the estimated average recharge to sand and gravel is 6.3 Mgal/d and to till and bedrock, 7.5 Mgal/d, a total of approximately 14 Mgal/d. By the same method of calculation, recharge during the driest year in 30 years, with 28 in. of precipitation, would total about 8 Mgal/d.

If the volume of water in storage remains constant, discharge from the ground-water reservoir should approximately equal recharge. Discharge occurs as seepage to springs or streams, evapotranspiration, and withdrawal by wells. Ground-water withdrawals in the area are estimated to average about 3.3 Mgal/d during June through August, when the Beacon well is used, and about 2 Mgal/d during the nine months when the Beacon well is unused. The base flow (7-day, 10-year low flow) of Fishkill Creek and its six tributaries is about 0.8 Mgal/d in the area. Therefore, the remaining ground water (approximately 10 Mgal/d) is accounted for by evapotransporation and discharge to lakes and wetlands in the area.

A rough estimate of the amount of water in storage in the area can be made as follows: The 6.3 mi^2 of sand and gravel is assumed to be homogeneous and approximately 65 ft (0.012 mi) thick, which gives 0.08 mi^3 of sand and gravel. Assuming a 7-ft average depth to water leaves 0.07 mi^3 of saturated sand and gravel. Sand and gravel has a specific yield of approximately 20 percent; therefore about 0.01 mi^3 or 11 billion gallons should be available. However, as noted by A. D. Randall (written commun., 1978), even with the most practical arrangement of wells, probably only one-third of the water calculated as specific yield could actually be removed. Therefore, the amount of available water stored in the sand and gravel is estimated to be about 4 billion gallons.

A similar analysis could be done for the areas blanketed by till and bedrock in the area. However, the volume of till and the thickness of bedrock units are insufficiently known, which makes a plausible estimation virtually impossible.

Water Quality

Results of representative chemical analysis of water from six wells in the area are presented in table 3. The results indicate that the water is of acceptable quality for drinking.

SUMMARY

The aquifer system in the Fishkill-Beacon area consists of the following lithologic units: (1) sand and gravel aquifer, (2) shale, slate, graywacke, and chert aquifer, (3) limestone and dolomite aquifer, and (4) granite and gneiss aquifer. The most permeable unit is the sand and gravel aquifer, in the northeastern part of the area, along Clove Creek and bordering Fishkill Creek. The consolidated rocks are less permeable than the sand and gravel; the carbonate rocks have the highest average yield of the rock aquifers, and the crystalline rocks have the lowest. The yield of wells in each of these aquifers and the average and range of yields of wells in each aquifer are listed in table 1.

An average of 14 Mgal/d of water recharges the area during a year of average rainfall (45 in.). About 2 Mgal/d of water is withdrawn by wells in the area all year except during the summer, when an average of 3.3 Mgal/d is withdrawn. About 0.8 Mgal/d discharges into Fishkill Creek and its tributaries; about 10 Mgal/d is lost to evapotranspiration and wetlands. The sand and gravel aquifer has approximately 4 billion gallons of retrievable water in storage.

SELECTED REFERENCES

Ayer, G. R., and Pauszek, F. H., 1968, Streams in Dutchess County, New York: New York State Department of Environmental Conservation Water Resources Commission Bulletin 63, 105 p., 6 pl., 23 figs.

Cornell University, Remote Sensing Program, 1977, Aquifer Recharge Study--Town of Fishkill, New York: Ithaca, N.Y., Cornell University, 13 p., 1 fig., 6 maps.

Frederick P. Clark Associates, 1974, Town of Fishkill Development Plan-Town of Fishkill, Dutchess County, New York: Rye, N.Y., Frederick P. Clark Associates, 52 p.

Simmons, E. T., Grossman, I. G., and Heath, R. C., 1961, Ground-water resources of Dutchess County, New York: New York State Water Resources Commission Bulletin GW-43, 82 p., 5 figs., 3 pl.

Table 1.--Average and range of yields of selected wells, by aquifer type, in Fishkill-Beacon area

[All yields are in gallons per minute]

Well number	Yield	Well number	Yield	Well number	Yield
SAND AND GRAVEL					
1	200	29	70	57	*200
2	200	30	45	58	200
3	200	49	4	59	*8
4	200	50	20	60	?
6	660	54	?	61	?
8	?	55	500	62	10
16	14	56	500	64	?
Average = 189 gal/min; range = 4-660 gal/min					
SHALE AND SLATE (with interbedded graywacke and chert)					
12	1.5	23	8	33	15
13	*35	24	11	34	15
18	17	25	70	35	18
19	?	26	10.5	36	10
20	12	27	170	43	50
21	6	28	75	46	5
22	5	32	20		
Average = 30 gal/min; range = 1.5-170 gal/min					
LIMESTONE AND DOLOMITE					
7	600	11	11	44	10
9	*?	14	300	63	10
10	200	15	10	65	75
Average = 152 gal/min; range = 10-600 gal/min					
GRANITE AND GNEISS					
37	5	41	12	51	4
38	*45	42	14	52	25
39	10	45	3	53	30
40	1	48	30		
Average = 16 gal/min; range = 1-45 gal/min					

*Well not used

Table 2.--Logs of selected wells in Fishkill-Beacon area

[Locations are shown in plate 1.]

WELL 55. Owned by Brinckerhoff Water Co. Drilled in 1959. Water level 1.75 ft below land surface. Screened 45-59 ft.

Material	Thickness (ft)	Depth (ft)
Sand, coarse to fine; gravel; some boulders	20	20
Same as above; breaks down to yield water	28	48
Sand and gravel	11	59

WELL 56. Owned by Brinckerhoff Water Co. Drilled in 1971. Water level 11 ft below land surface. Screened 45 ft 1 in. - 55 ft 7 in.

Material	Thickness (ft)	Depth (ft)
Gravel	6	6
Dry sand and gravel	19	25
Water-bearing sand and gravel	31	56

TEST WELL NEAR WELL 6. Owned by Village of Fishkill. Drilled in 1971. Water level at land surface. Well 6 drilled Dec. 1971-Mar. 1972. Screened 95-115 ft.

Material	Thickness (ft)	Depth (ft)
Topsoil	2	2
Sand and silt	28	30
Gravel and silt	10	40
Silt and fine gravel	5	45
Sand, silt and fine gravel	25	70
Heavy gravel and silt	13	83
Silt and fine gravel	9	92
Heavy gravel	6	98
Coarse sand and gravel--water encountered	22	120
Sand and silt	41	161
Clay	2	163
Sand and fine gravel	9	172
Clay and silt	18	190
Clean fine gravel	23	213
Fine gravel and coarse sand	3	216

Table 2.--Logs of selected wells in Fishkill-Beacon area--Continued

WELL 28. Owned by Hudson View Water Works. Water level 18 ft below land surface.

Material	Thickness (ft)	Depth (ft)
Top soil	3	3
Shale	257	260

WELL 7. Owned by City of Beacon. Drilled in 1950. Water level approximately 7 ft below land surface.

Material	Thickness (ft)	Depth (ft)
Topsoil and loam, sandy	4	4
Sand and gravel	13	17
Clay	57	74
Gravel and some clay	8	82
Sand and clay	7	89
Clay, gravel and decayed rock fragments	52	141
Limestone "drillings" and clay	37	178
Limestone and clay	120	298
Shale	5	303
Limestone and clay	67	370
Shale and limestone	30	400
Shale	130	530
Fills in after drilling	20	550

Table 3.--Chemical analyses of water from selected wells in Fishkill-Beacon area

WELL 55. Owned by Brinckerhoff Water Company.
Date of analysis: July 8, 1971.1/

Chemical Component	Concentration (mg/L)
Carbon dioxide	3.1
Bicarbonate	183
Hardness	280
Chlorides	9.5
Nitrites (as N)	<0.005
Nitrates (as N)	2.2
Iron	<0.04
Sulfates	18

WELL 56. Owned by Brinckerhoff Water Company.
Date of analysis: June 16, 1976.2/

Chemical Component	Concentration (mg/L)
Ammonia free (as N)	0.15
Nitrates (as N)	1.08
Nitrites (as N)	<0.004
Hardness, total (as $CaCO_3$)	233
Alkalinity (as $CaCO_3$)	246
Iron	0.13
Manganese	<0.05
Chlorides	39.1
Total dissolved solids	390

WELL 6. Owned by Village of Fishkill.
Date of analysis: March 18, 1972.3/

Chemical Component	Concentration (mg/L)
Iron	0.08
Total solids	152
Nitrates (as N)	.12
Sulfates	28
Chlorides	4.0
Total hardness (as $CaCO_3$)	97
Alkalinity (as $CaCO_3$)	78
Calcium (as $CaCO_3$)	62
Magnesium	35

1/ Analysis by Bender Hygienic Laboratory.
2/ Analysis by Envirotest Laboratory.
3/ Analysis by Costello's Laboratory, Inc.

Table 3.--Chemical analyses of water from selected wells in Fishkill-Beacon area--Continued

WELL 28. Owned by Hudson View Water Works.
Date of analysis: March 13, 1975. 4/

Chemical Component	Concentration (mg/L)
Manganese	1.2
Iron	0.05
Sodium	8.9
Chloride	9.0
Sulfates as SO_4	160
Total dissolved solids	423

WELL 7. Owned by City of Beacon.
Date of analysis: Jan. 4, 1950. 4/

Chemical Component	Concentration (mg/L)
Iron	0.40
Bicarbonate	122
Chloride	10
Fluoride	0.05
Nitrate	0.1
Total hardness (as $CaCO_3$)	112

WELL 14. Owned by Texaco Inc.
Date of analysis: Dec. 22, 1944. 5/

Chemical Component	Concentration (mg/L)
Dissolved solids	138
Silica	9
Calcium	24
Magnesium	15
Bicarbonate	166
Total hardness (as $CaCO_3$)	133

4/ Analysis by New York State Department of Health.
5/ Analysis by Calgon, Inc.